

UACE PHYSICS SEMINAR SLATED FOR SATURDAY 28TH
SEPTEMBER 2024 AT SEETA HIGH SCHOOL MUKONO
(MBALALA CAMPUS)

Physics paper one (P510/1)

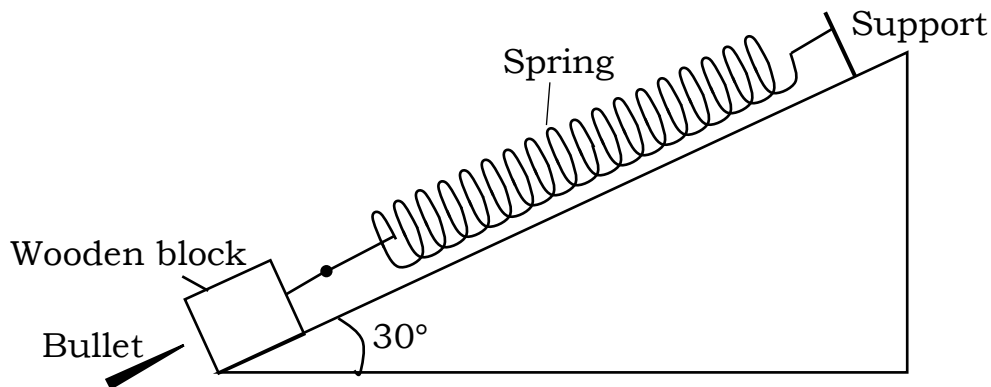
SECTION A

1. (a) (i) Define **density** and **relative density**.
(ii) Outline any **two** factors that affect the volume per second of a liquid flowing through a given pipeline.
- (b) (i) Explain the origin of viscosity in liquids and gases.
(ii) With the aid of a labelled diagram, describe an experiment to determine coefficient of viscosity of a liquid using Poiseuille's formula.
- (c) In a blood transfusion, blood flows from a bottle at atmospheric pressure into a patient's vein in which the pressure is 20 mmHg above the atmospheric pressure. The bottle is 95 cm higher than the vein and the vein has a length of 3.0 cm and internal diameter of 0.45 mm . Calculate the volume that flows into the vein in one minute.
(*Viscosity of blood is $4.0 \times 10^{-3} \text{ Nm}^{-2} \text{ s}$, densities of blood and mercury are 1005 kgm^{-3} and 13600 kgm^{-3} respectively*)
- (d) (i) State **Bernoulli's principle**.
(ii) Explain why an umbrella may be blown off when one holds it and moves over the wind.

[LUBIRI HIGH]

2. (a) State the **principle** of conservation of;
(i) linear momentum
(ii) energy
- (b) (i) Define **impulse** and state its units.
(ii) Sand is poured at a rate of 11.5 gs^{-1} onto a pan of direct reading balance calibrated in newtons. The sand falls from a height of 37.5 cm onto the pan and it does not rebound. Calculate the reading on the balance 18.0 s after the sand first hits the pan.
- (c) Distinguish between **elastic materials** and **plastic materials** using examples.

(d)



A wooden block of mass $880g$ resting at the bottom of a rough inclined plane making 30° with the horizontal and coefficient of friction between the block and plane is 0.32 . A bullet of mass $20g$ is fired at a close range and gets embedded into the block. The system moves up along the incline thereby compressing the spring of force constant $100Nm^{-1}$ through a distance of 60 cm .

- (i) State the energy changes that take place.
 - (ii) Calculate the velocity at which the bullet strikes the block.
 - (iii) Explain briefly why the block will return to its initial position.
- (e) (i) Define the terms **angular velocity**, **centripetal force** and **centrifugal force**.
- (ii) Explain briefly the action of a centrifugal force.

[**SEETA HIGH SCHOOL GREEN CAMPUS**]

3. (a) (i) Define **Inertia**.
- (ii) State the **work-energy theorem**.
- (b) A simple pendulum of length $0.5m$ has a bob of mass $0.2kg$. It is displaced from its mean position P to position Q so that the string makes an angle of 60° with the vertical. Calculate the;
- (i) maximum potential energy of the bob.
 - (ii) loss in potential energy when the angle made by the string with the vertical turns to 30° .
- (c) Define the following;
- (i) **Gravitational constant**.
 - (ii) **Escape velocity**.
- (d) (i) Explain briefly how world-wide television communication can be achieved using satellites.
- (ii) Account for the moon not having an atmosphere.

- (e) Describe an experiment to determine gravitational constant, **G**, in a school laboratory.

[ST. BALIKUDEMBE, KISOGA] [MAKERERE COLLEGE SCHOOL]

4. (a) (i) Define **surface tension** and **free surface energy**.
(ii) Explain why it is difficult to remove a dirt from a cloth without using soap.
- (b) Two soap bubbles of radii 1.5mm and 2.5mm coalesce under isothermal conditions to form a common interface. Calculate the;
(i) radius of the common curvature.
(ii) excess pressure inside the interface.
- (c) (i) Define **Young's modulus**, **work hardening** as used in properties of matter.
(ii) Derive an expression for the energy stored per unit volume of a stretched wire.
- (d) With the aid of a labelled diagram, describe an experiment to investigate the relationship between tensile stress and tensile strain.
- (e) A mass of 20g falls from a height of 200cm to the top of a spring of force constant 100Nm^{-1} . Calculate the resulting compression in the spring if the mass;
(i) sticks on top of the spring.
(ii) bounces off the spring with a speed of 2.0ms^{-1} .

[JINJA COLLEGE]

5. (a) Define;
(i) **Simple harmonic motion**.
(ii) **Period**.
- (b) (i) Show that energy in simple harmonic motion is conserved.
(ii) Sketch a graph to show the variation of acceleration with displacement for a body executing simple harmonic motion.
- (c) Describe an experiment to determine acceleration due to gravity using a spring of unknown force constant.
- (d) (i) Define **angular displacement**.
(ii) Explain why the maximum speed of a car on a banked road is higher than that on an unbanked road.
- (e) (i) Explain briefly the terms **stable** and **unstable** equilibrium of a body.

- (ii) A horizontal rod AB is suspended at the end by strings. The rod is $0.8m$ long and a mass of $5kg$ is attached $0.6m$ away from A so that the body attains a horizontal equilibrium. Find the tension in each string.

[**ST. JOSEPH'S GIRLS' NSAMBYA**]

SECTION B

6. (a) (i) Define **fixed points**, **fundamental interval**, **triple point of water** and **thermometric property**.
 (ii) State **four** qualities of a good thermometric property.
 (iii) Explain why it is wrong to use ice and steam points in modern thermometry.
- (b) Describe the structure and action of a **digital** thermometer.
- (c) (i) Define **latent heat** and **melting point**.
 (ii) State and explain **one** application of specific latent heat of vaporization.
- (d) $5kg$ of water were heated at constant pressure to produce steam at $100^{\circ}C$. If the density of steam is $0.58kgm^{-3}$. Calculate the;
 (i) external work done.
 (ii) internal energy, if the specific latent heat of vaporization of water is $2.259 \times 10^6 Jkg^{-1}$ and density of water is $1000kgm^{-3}$.

[**SEETA HIGH SCHOOL MAIN**]

7. (a) (i) Define **thermal conductivity**, **temperature gradient** and **heat current**.
 (ii) Explain the mechanism in heat transfer in a cork.
 (iii) Explain why metals are better conductors of heat than silk.
- (b) (i) Define **specific heat capacity**.
 (ii) Explain why water melon is always at lower temperature than the environment where it is placed.
- (c) Describe an experiment to determine the specific heat capacity of a liquid using the method of cooling.
- (d) A calorimeter containing first $50g$ and then later $110g$ of water is heated and suspended in the same constant temperature enclosure. It is found that the times taken to cool from $60^{\circ}C$ to $50^{\circ}C$ in the two cases are 17 minutes and 35 minutes respectively. Calculate the heat capacity of the calorimeter. [**BISHOP CYPRIAN KYABAKADDE**]

8. (a) (i) Distinguish between a **gas** and a **vapour**.
 (ii) State and explain the conditions under which a real gas will behave as an ideal gas.
- (b) Describe an experiment to determine the SVP of a liquid at 65°C .
- (c) (i) State the **laws of black body radiation**.
 (ii) Sketch a graph of intensity against wavelength and use it to explain why the center of a fire appears white.
- (d) An electric fire element of length 30cm , diameter 1.0cm emits 0.6 of the power it radiates at the same temperature. If it operates at a rate of 60W , estimate its working temperature.

[**SEROMA CHRISTIAN SCHOOL**]

9. (a) (i) State **Newton's law** of cooling.
 (ii) Explain briefly why small pieces of wood are used to light big logs.
- (b) (i) Describe an experiment to determine the specific heat capacity of silver using the electrical method.
 (ii) An electrical heater rated at 520W is used to raise the temperature of 2.5kg of a liquid from room temperature of 20°C to 100°C in 25 minutes and the rate of heat loss at 100°C is 16W . Estimate the specific heat capacity of the liquid.
- (c) Explain why metals feel cold to touch.
- (d) A rectangular roof $12\text{m} \times 10\text{m}$ has vertical walls 4m high for supporting a flat roof. The walls and roof are 25cm thick and are made of a material of thermal conductivity $0.25\text{Wm}^{-1}\text{K}^{-1}$. The doors and window cover an area of 16m^2 and are made of glass of thickness 5mm . The room is maintained at a constant temperature above its surroundings. If the percentage heat loss by conduction through the windows and doors is 94% , find the thermal conductivity of glass.
 (Neglect the heat loss through the floor).

[**ST. JULIANA HS GAYAZA**]

SECTION C

10. (a) Define the following terms; **Decay constant, Half-life, activity, Carbon-14 dating, Uranium dating.**
- (b) (i) Define **radio-active equilibrium.**
(ii) Potassium ${}^{44}_{19}\text{K}$ has a half-life of 1200 s and decays to form ${}^{44}_{20}\text{Ca}$, a stable isotope of calcium. Given a sample of 10mg of potassium, calculate the activity of the sample after one hour and the number of atoms of calcium after one hour.
- (c) Distinguish between **nuclear fission** and **nuclear fusion.**
- (d) The deuterium-tritium fusion reaction is shown below. ${}^2_1\text{H} + {}^3_1\text{H} \rightarrow {}^4_2\text{He} + {}^1_0\text{n}$.
Taking the masses of ${}^2_1\text{H} = 2.0141U$, ${}^3_1\text{H} = 3.0161U$, ${}^1_0\text{n} = 1.0087U$ and ${}^4_2\text{He} = 4.0026U$ and $1U = 931\text{MeV}$, Boltzmann's constant $K_B = 1.38 \times 10^{-23}\text{JK}^{-1}$, calculate the;
(i) amount of energy released in the reaction.
(ii) temperature when the gas must be heated to initiate the reaction if the radii of deuterium and tritium are each $1.5 \times 10^{-15}\text{m}$.

[KIIRA COLLEGE BUTIKI]

11. (a) (i) Distinguish between **photoelectric effect** and **binding energy per nucleon.**
(ii) Define **quantum theory** of matter based on photoelectric effect.
(iii) State and explain **three** evidences of quantum theory of matter.
- (b) Describe an experiment to provide the evidence for photoelectric effect.
- (c) (i) State **Bragg's law** of X-ray diffraction.
(ii) Describe briefly Bragg's law of diffraction of a crystal.
- (d) An alpha particle with initial kinetic energy of $1.6 \times 10^{-13}\text{J}$ is directed towards the nuclear charge of $+50e$. Calculate the nearest distance of approach of the alpha particle to the nucleus.

[NAALYA SS NAMUGONGO]

12. (a) (i) Define an **electron volt**, **unified atomic mass unit**, **specific charge** and **stopping potential**.
(ii) With the aid of a labelled diagram, describe how a charge on an oil drop can be obtained using Millikan's experiment.
- (b) An oil drop of radius $1.0 \times 10^{-3} \text{ cm}$ falls freely in air, midway between two vertical parallel metal plates which are 0.50 cm apart and its terminal velocity is 1.066 cm s^{-1} . When a potential difference of 3000 V is applied between the plates, the path of the drop becomes a straight line inclined at an angle of 31.6° to the vertical. Find the;
(i) horizontal velocity of the drop when the p.d on the plates is applied.
(ii) charge on the oil drop and density of air, given that $\eta = 1.82 \times 10^{-5} \text{ Pas}$, density of oil drop $= 880 \text{ kg m}^{-3}$.
- (c) (i) Explain briefly the motion of electrons in a magnetic and electric field.
(ii) Describe briefly how specific charge of an electron can be got using the fine beam method.
- (d) Sketch a graph of current-voltage for a discharge tube and explain its features.

[IGANGA SS]

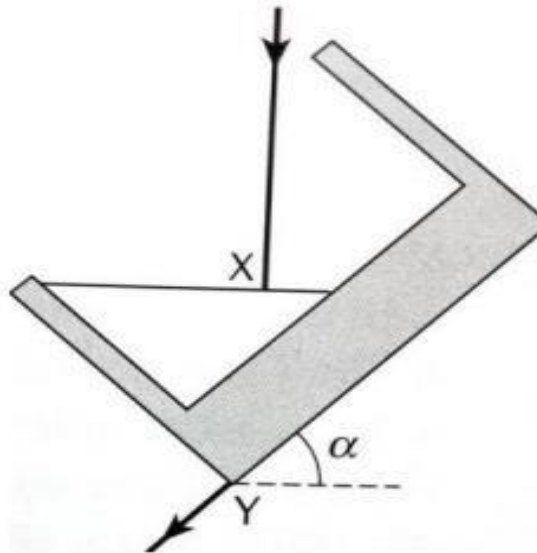
13. (a) Define the following terms as applied to electronic devices.
(i) **Semi-conductor**.
(ii) **Intrinsic** and **Extrinsic**
(iii) **Thermionic emission**.
- (b) (i) Explain briefly how a **P-N junction** is formed.
(ii) List **two** examples of impurities of elements used during the process of doping.
- (c) With the time-base switched off, an alternating voltage with root mean-square value 2.82 V is connected across the Y-plates of a CRO. If a vertical trace of length 40 cm is formed on the screen, find the voltage gain.
- (e) Explain briefly the structure of a transistor.

[JINJA SS]

Physics Paper two (P510/2)

SECTION A

1. (a) Define the term **refraction of light**.
(b) Describe an experiment to determine refractive index of water by critical reflection.
(c)



A glass container with thick bottom is half filled with water and a narrow beam of light is shone vertically down into the water. The glass is tilted until an angle α such that the light is refracted along the lower surface of the glass. If the refractive indices of water and glass are 1.33 and 1.5 respectively,

- (i) Copy and complete the diagram to show the path of light from when it enters water at X to when it leaves glass at Y.
(ii) Calculate the critical angle at the glass-air interface.
(iii) Calculate the value of α .
(d) Explain carefully why the apparent depth of the water tank changes with position of the observer.
(e) (i) What is meant by **limiting angle** of a prism.
(ii) Calculate the limiting angle of a prism of glass of material of refractive index 1.5.

[BUKEDEA SS]

2. (a) Define the terms **principal axis** and **focal plane** as applied to convex lenses.
- (b) (i) A convex lens of **focal length** f forms a real image I of real object O on a screen. If the distance between the object O and the screen is d , show that for the distance $d \leq 4f$, no image can be formed on the screen.
- (ii) State another condition apart from that derived in (i) above for which a convex lens cannot form a real image on a screen.
- (c) Describe an experiment to determine focal length of a concave lens using a concave mirror.
- (d) An astronomical telescope consisting of an objective lens of focal length 60cm and an eye piece of focal length 3cm is focused on the moon so that the final image is formed at minimum distance of distinct vision (25cm) from the eye piece.
- (i) Calculate the angular magnification.
- (ii) Assuming that the diameter of the moon subtends an angle of 0.5° at the objective, find the actual size of the image.

[**UGANDA MARTYR'S SS NAMUGONGO**]

SECTION B

3. (a) Distinguish between **longitudinal** and **transverse** wave motions.
- (b) A progressive simple harmonic wave of frequency 250Hz and velocity 30ms^{-1} propagates in the positive x direction in a time, t seconds, determine the;
- (i) equation of propagation of the progressive wave if its amplitude is 0.03 m .
 - (ii) phase difference between two vibrating points on the progressive wave which are 10cm apart.
- (c) Describe an experiment to determine the end correction of a resonance tube using a set of tuning forks.
- (d) The absorption spectrum of a faint galaxy is measured and the wavelength of one of the lines identified as the calcium H line is found to be 478 nm . The same line has wavelength of 397nm when measured in the laboratory.
- (i) is the galaxy moving towards or away from the earth.
 - (ii) explain your answer.
 - (iii) calculate the speed of the galaxy relative to the earth.
- (e) Explain why sound is easily heard at night than during the day.

[ELITE HIGH]

4. (a) Define the term interference of light and state the conditions for interference pattern to be observed.
- (b) (i) Describe an experiment to observe Newton's rings, and explain how they are formed.
- (ii) In young's double slit experiment, the distance between the center of the interference pattern and the 10^{th} bright fringe on either side is 3.44cm and the distance between the slit and the screen is 2.00cm . if the wave length of the light used is $5.89 \times 10^{-7}\text{m}$, determine the slit separation.
- (c) (i) What is meant by the terms; **diffraction** and **polarization** of light.

- (ii) Two Polaroid sheets are placed close together in front of a lamp so that no light passes through them. Describe and explain what happens when one sheet is slowly rotated, the other remaining in the original position.
- (iii) Calculate the polarizing angle for light travelling from water of refractive index 1.33, to glass, of refractive index 1.53.
- (d) Mention any **two** uses of polarizing devices.

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SECTION C

- 5. (a)** Define the term **magnetic field**.
- (b) A stripe of metal foil 1.2cm wide and $1.5 \times 10^{-3} \text{cm}$ thick carries a current of 0.5A along its length, and the metal contains 5×10^{22} free electrons per cm^3 . If the stripe is placed normal to the magnetic field of flux density 0.5T, a p.d is developed across the foil.
- (i) Explain why a p.d is developed across the stripe.
 - (ii) Calculate the mean drift velocity of the electrons.
 - (iii) Find the value of maximum p.d across the stripe.
- (c) Describe an experiment to show the variation of magnetic flux density at the center of a circular coil with current through it.
- (d) A rectangular coil of 50 turns and dimensions 5cm× 2cm hangs vertically inside a solenoid which carries a current of 4A and has 2000 turns per meter.
- (i) Calculate the magnetic flux density of the solenoid.
 - (ii) If the plane of the rectangular coil was initially at 60° to the axis of the solenoid, find the value of current that must be passed through the rectangular coil such that the initial torque on the coil is $3.0 \times 10^{-8} \text{Nm}$.
- (e) Explain the orientation of a freely suspended bar magnet at a position in southern hemisphere.

[SELONA SS MASAJJA]

6. (a) State the **laws** of electromagnetic induction.
- (b) A circular coil of 150 turns and cross-sectional area 0.3m^2 is placed with its plane perpendicular to a horizontal magnetic field of flux density $1.2 \times 10^{-2}\text{T}$. The coil is rotated about a vertical axis so that it turns through 70° in 2s. Calculate the:
- (i) initial flux linkage through the coil.
 - (ii) e.m.f induced in the coil.
- (c) (i) Explain how back e.m.f is produced in a coil in an electric motor.
- (ii) A metal air craft with a wing span of 40m flies with ground speed of 100kmh^{-1} in the direction due east at a constant altitude a region where the horizontal component of the earth's field is $1.6 \times 10^{-5}\text{T}$ and the angle of dip is 71.6° . find the potential difference that exists between the wing tips.
- (d) With the aid of a diagram, describe how a simple a.c generator works.
- (e) (i) Define **mutual induction**.
- (ii) Explain three main structural designs for an alternating current transformer that improves its efficiency.
- (iii) A lamp rated 30W, 0.5A is operated at full capacity using a transformer of efficiency 84%. If the current in the primary windings of the transformer is 2.38A, find the turn ratio and type of transformer used.

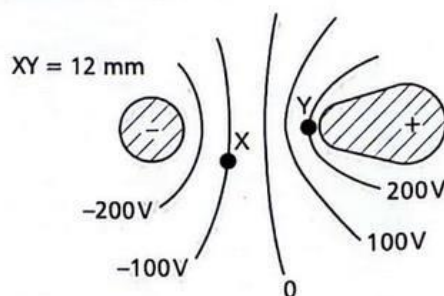
[**ST MARK NAMAGOMA**]

7. (a) Define the terms **peak** and **root mean square (r.m.s)** value of an alternating voltage.
- (b) An inductor of inductance, L , is connected across a source of alternating voltage, $V = V_0 \sin \omega t$.
- Derive the relationship between the reactance and the frequency of the supply.
 - Sketch using the same axes the variation of current through the inductor and the voltage across it, with time.
 - Explain the phase difference in the graphs in d(ii) above.
- (c) Describe with the aid of a diagram how a **thermal- couple meter** measures alternating current.
- (d) A resistor of 500Ω and a capacitor of capacitance C are connected in series with an ac supply of r.m.s value $15.0V$ and frequency $50Hz$. If the p.d across the resistor has r.m.s value $10.0V$, calculate the:
- p.d across the capacitor.
 - value of C .

[**BWEYOGERERE SS**]

SECTION D

8. (a) Define the terms **electric field intensity** and **electric potential**.
- (b)
 - A pin is placed on the cap of a positively charged gold leaf electroscope with its blunt end on the cap. Explain what is observed.
 - Describe an experiment to show that the surface of a pear-shaped conductor is an equipotential surface.
 - Derive an expression for electric field intensity perpendicular to a charged conductor of charge density δ in air.
- (c) The figure shows equi-potentials of the electric field between two oppositely charged conductors.



Calculate the:

- (i) potential energy of a $+2nC$ point charge at X.
- (ii) work done to move the $+2nC$ charge from X to Y.
- (d) With the aid of a diagram, describe how an electrophorus provides unlimited supply of electric charge.

[SEETA HIGH SCHOOL MUKONO]

9. (a) Define dielectric strength of a capacitor and state its units.
- (b) Describe an experiment to determine dielectric constant of a material.
- (c) A parallel air capacitor of area $25cm^2$ and with plate 1mm apart is charged to a potential of 100 V. The power supply is then disconnected and the plate moved a further 1 mm apart.
- (i) Calculate the energy change due to the movement of the capacitor plates.
 - (ii) Account for the energy change in (i) above.
- (d) (i) When capacitors are connected in series, the effective capacitance of the combination is less than the capacitance of either capacitor. Explain why?
- (ii) Explain the effect of a dielectric on capacitance of a charged capacitor.

[FOREST HILL COLLEGE]

10. (a) What is meant by the terms **electromotive force** and **terminal p.d** of a cell.
- (b) A voltmeter is connected in parallel with a variable resistance R , which is in series with an ammeter and a cell of emf E and internal resistance r . The ammeter and voltmeter readings are noted for several values of R .
- (i) Sketch a graph to show the variation of V with I , and use the graph to explain how E and r can be obtained.
- (ii) If in this experiment the ammeter had a resistance of 10Ω and the voltmeter a resistance of 100Ω , $R=2\Omega$, $E=2V$ and $r=2\Omega$, what would be the reading of the ammeter and the voltmeter?
- (c) Explain the principle of a potentiometer.
- (d) A meter bridge is balanced with a piece of aluminum wire of resistance 7.3Ω in the left-hand gap, the sliding contact being 42.6cm from the left end of the bridge wire and the temperature 17°C . If the temperature of the aluminium wire is raised to 57°C , find the new balance length.
(Temperature coefficient of resistance of aluminum is 3.8×10^{-3})
- (e) Explain why the balance point of the meter bridge should be close to the middle of the bridge wire.

[**SEETA HIGH SCHOOL A-CAMPUS**]

P510/3 (PHYSICS PRACTICAL)

- Given $\alpha = 58^\circ$ and $\beta = 98^\circ$, find μ from the expression $\mu = \frac{\tan \frac{\beta}{2}}{\tan \frac{\alpha}{2}}$
- Given $d = 0.0700\text{m}$, $h = 0.045\text{m}$, $\alpha = 0.35\text{N}$ and $W = 1.55\text{N}$. Find the density, β of the liquid from the expression $\beta = \frac{4(W-\alpha)}{\pi g h d^2}$,
where $\pi = 3.14$ and $g = 9.81\text{ms}^{-2}$
- Given $\theta = 43^\circ$, $\gamma = 38^\circ$, find λ from the expression $\lambda = \frac{\sin(\theta+\gamma)}{\sin \theta}$
- Given $V_0 = 0.95\text{V}$, $I_0 = 0.40\text{A}$, $d = 0.34\text{mm}$ and $y = 30.0\text{cm}$. Determine;

(i) the electrical resistivity, ϕ from the expression: $\phi = \frac{\pi d^2 S}{2}$

(ii) electrical resistance, R from the expression: $R = \frac{V_0}{I_0} - \frac{4\phi y}{\pi d^2}$

5. Given $t = 5.20\text{mm}$, $b = 2.40\text{cm}$, $S = 0.680\text{kgs}^{-2}$, and $l = 0.800\text{m}$. Determine the value of Young's modulus, E from the expression:

$$E = \frac{16\pi^2 l^3 S}{bt^3}$$

6. Consider the table of results below.

L(cm)	1.5	3.0	4.5	6.0	7.9	9.0
i(°)	29	63	79	90	102	112

Copy and complete the table including values of $\frac{1}{L^2}$ and $\frac{1}{\sin^2 i}$

7. Consider the table below;

I(A)	0.66	0.54	0.50	0.44	0.40	0.36
V(V)	0.65	0.80	0.95	1.00	1.20	1.30
X(m)	0.200	0.300	0.400	0.500	0.600	0.700

(i) copy and complete the table including values of $\frac{V}{I}$, $\frac{I}{V}$, VI , $\frac{1}{I}$, $\frac{1}{V}$

(ii) Plot a suitable graph and use it to determine the **electrical resistivity**, ρ of the material of the wire, given that the mean diameter, d of the wire is **0.36mm**.

8. Consider the table below;

d(m)	0.900	0.800	0.700	0.600	0.500	0.400
X(m)	0.076	0.076	0.063	0.055	0.040	0.033

(i) Copy and complete the table including values of $\log_{10} x$ and $\log_{10} d$

(ii) Plot a graph of $\log_{10} x$ against $\log_{10} d$

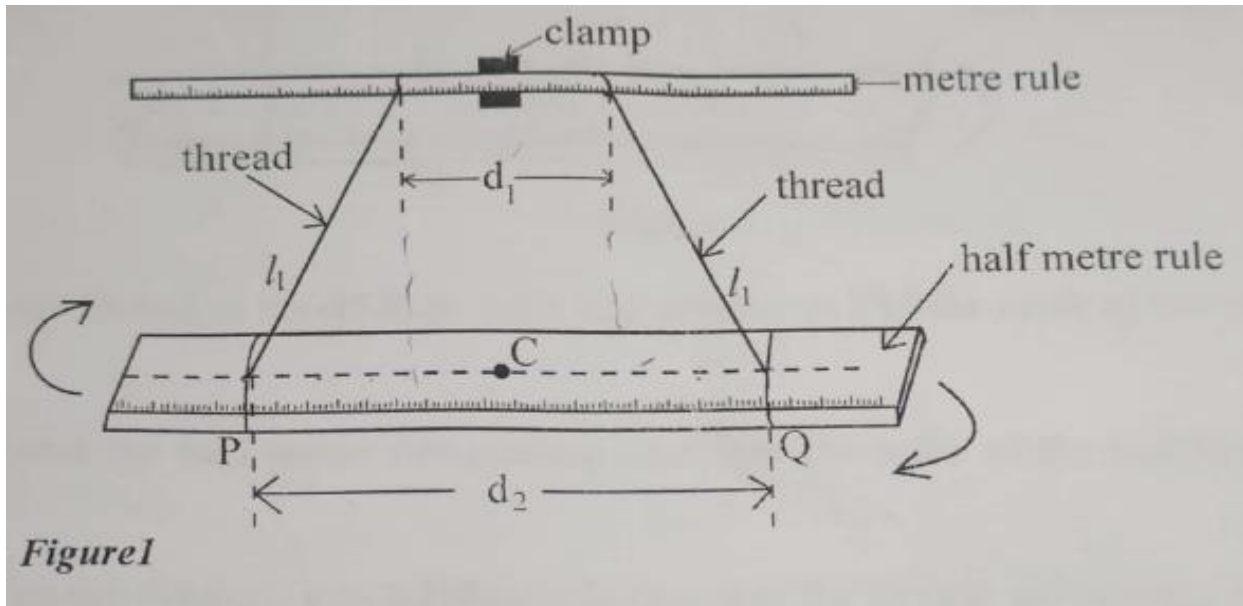
(iii) Determine the slope, K of the graph.

1. In this experiment, you will determine the moment of inertia, I , of the half metre rule provided by two methods.

METHOD I

- Measure and record the mass M of the half metre rule.
- Clamp the metre rule such that the scale is facing you.

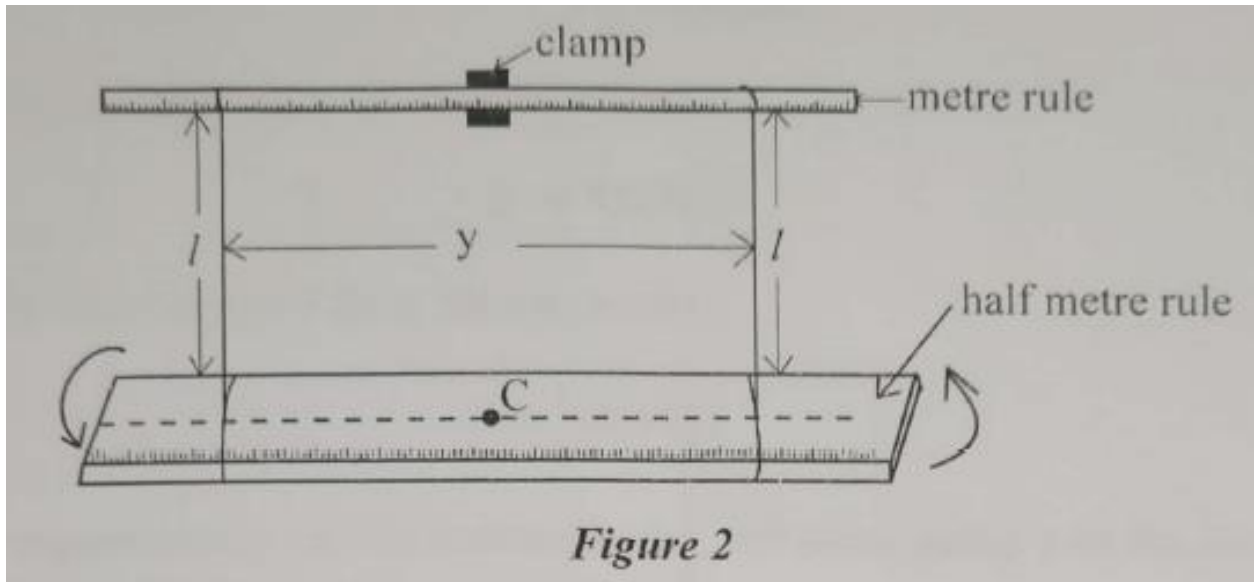
- c) Tie the threads at points **P** and **Q**, equidistant from the point **C**, the **25.0cm** mark of the half metre rule such that the distance $d_2 = 0.150\text{m}$.
- d) Suspend the half metre rule from the clamped metre rule as shown in **figure 1**, making sure that the scale of the half metre rule faces upwards.



- e) Adjust the length l_1 of the threads to **0.500m**
- f) Adjust the separation of the threads on the clamped metre rule to $d_1 = 0.100\text{m}$.
- g) Turn the half metre rule through a small angle about a vertical axis through its centre **C** and release it to oscillate.
- h) Measure and record the time, **t**, for 20 oscillations.
- i) Determine the period **T**.
- j) Calculate the value of K_1 from the expression: $K_1 = \frac{T}{4\pi} \sqrt{\frac{gd_1 d_2}{l_1}}$
Where $\pi = 3.14$ and $g = 9.81\text{ms}^{-2}$
- k) Calculate the value of I_1 from the expression: $I_1 = M(K_1)^2$

METHOD II

- a) Set up the apparatus as shown in **figure 2**.



- b)** Tie one thread at the **45.0cm** mark and another at the **55.0cm** mark of the clamped metre rule.
- c)** Suspend the half metre rule, making sure that the scale of the half metre rule faces upwards
- d)** Adjust the distance **y** to **y = 0.100m**, ensuring that the threads are parallel and equidistant from the point **C**, the **25.0cm** mark of the half metre rule.
- e)** Adjust the length **l** to **0.500m**.
- f)** Turn the half metre rule through a small angle about a vertical axis through its centre **C** and release it to oscillate.
- g)** Measure and record the time for 20 oscillations.
- h)** Determine the period **T**.
- i)** Repeat procedures (d) to (h) for values of **y = 0.150, 0.200, 0.250, 0.300 and 0.350m**
- j)** Tabulate your results including values of **T²** and $\frac{1}{y^2}$.
- k)** Plot a graph of **T²** against $\frac{1}{y^2}$
- l)** Find the slope, **S** of the graph.
- m)** Calculate the value of **K₂** from the expression: $K_2 = \frac{1}{4\pi} \sqrt{\frac{Sg}{l}}$
Where $\pi = 3.14$ and $g = 9.81\text{ms}^{-2}$
- n)** Calculate the value of **I₂** from the expression: **I₂ = M(K₂)²**
- o)** Calculate the moment of inertia, **I** of the metre rule from the expression:

$$I = \frac{1}{2}(I_1 + I_2)$$

2. In this experiment, you will determine the constant μ of the material of the glass block provided.

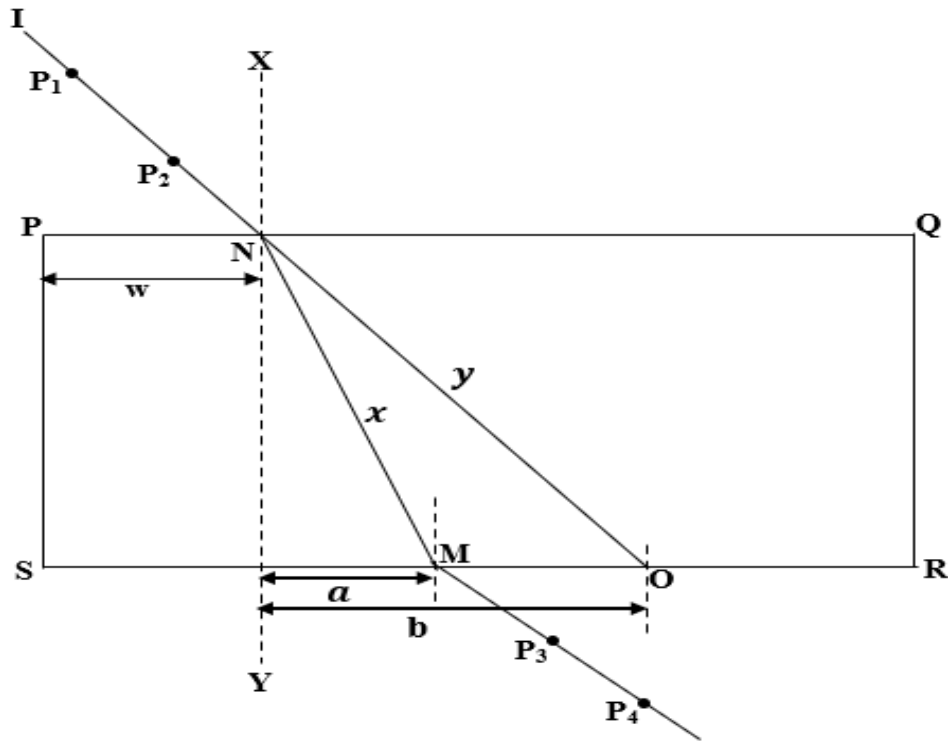


Figure 3

- a) Place the glass block centrally on the plain sheet of paper with its broadest face upper most and trace its outline **PQRS**. Remove the glass block.
- b) Construct a normal **XY** at **N** on **SR** such that **w = 1.5cm**
- c) Mark another point **O** on **PQ** such that **b = 5.0cm**.
- d) Join **O** and **N** and extend it to **I**.
- e) Replace the glass block. Fix optical pins **P1** and **P2** vertically on the line **IN**.
- f) Trace the path of light through the glass block using optical pins **P3** and **P4**.

- g) Remove the glass block and the optical pins.
- h) Join **P₃** and **P₄** and extend it to **M**. Join **M** to **N** as shown in **figure 3**
- i) Measure and record the distances x, y and a
- j) Calculate the value of μ from the expression: $\mu = \frac{ay}{bx}$

METHOD II

- a) Fix a fresh plain sheet of paper on the soft board using drawing pins.
- b) Place the glass block centrally on the sheet of paper with its broadest face upper most and trace its outline **WXYZ**.
- c) Remove the glass block.
- d) Construct a perpendicular **MN** at **B** where $WB = \frac{1}{4}(WX)$.

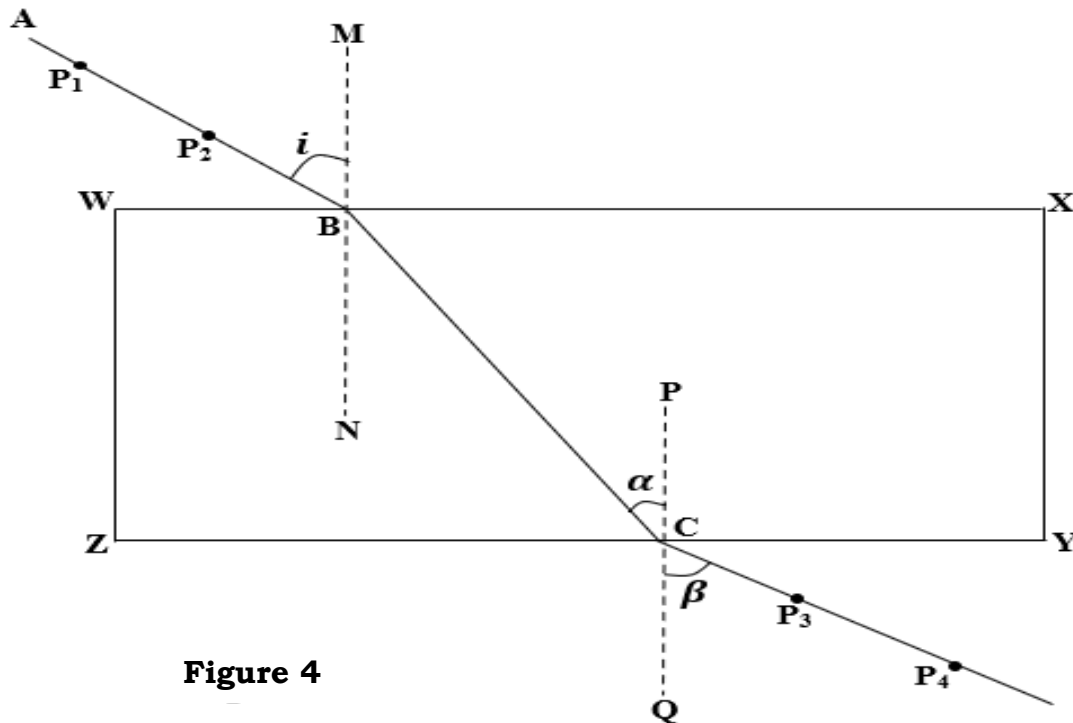


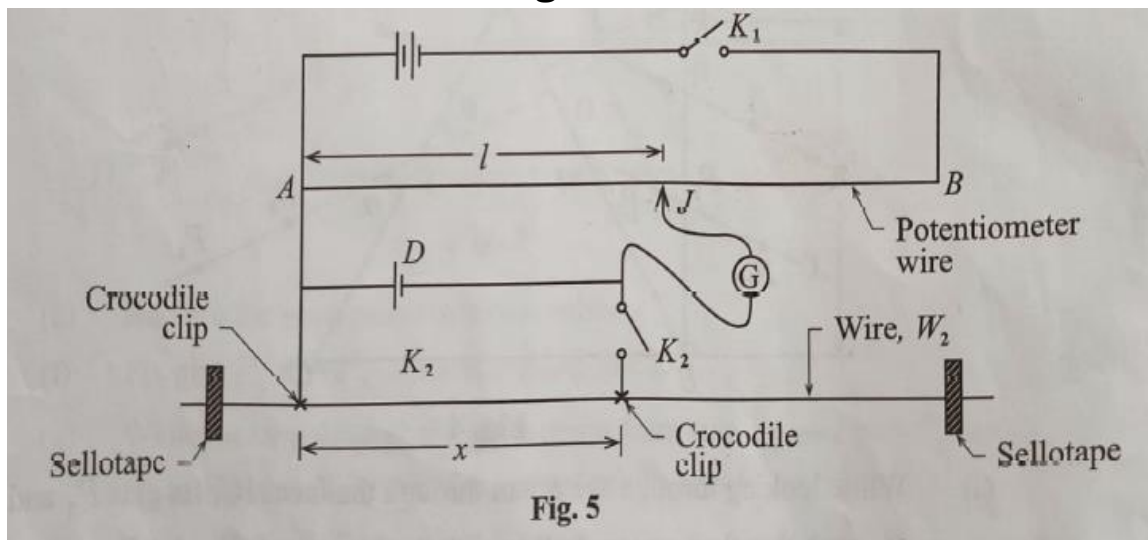
Figure 4

- e) Draw a line **AB** such that angle $i = 20^\circ$ as shown in **figure 4**
- f) Fix two optical pins **P₁** and **P₂** vertically on the line **AB**.
- g) While looking through the glass block from side **YZ**, fix optical pins **P₃** and **P₄** such that they appear in line with the images of **P₁** and **P₂**.

- h)** Remove the glass block and the pins.
- i)** Draw a line through **P₃** and **P₄** to meet **YZ** at **C**.
- j)** Join **B** to **C**.
- k)** Draw a normal **PQ** at **C**.
- l)** Measure and record the angles α and β .
- m)** Repeat procedures **(d)** to **(k)** for values of $i = 30^\circ, 40^\circ, 50^\circ, 60^\circ$ and 70°
- n)** Tabulate your results including values of values of $\cos^2 \alpha$, $\theta = \frac{1}{2}(i + \beta)$ and $\sin^2 \theta$
- o)** Plot a graph of $\cos^2 \alpha$ against $\sin^2 \theta$
- p)** Find the slope, K of the graph.
- q)** Calculate the value of μ from the expression : $\mu = \sqrt{-K}$
- r)** Given that the value of μ is **0.667 (approximately)**, assess the accuracy of the two methods

3. In this experiment, you will determine the constant, α , of the wire labelled **W₁**

- a)** Measure and record the diameter, **d₂** of the wire labelled **W₂**.
- b)** Connect the circuit as shown in **figure 5**



- c)** Starting with a length $x = 0.200m$ of the wire **W₂**, close switches **K₁** and **K₂**.
- d)** Move the sliding contact, **J**, along the potentiometer wire AB until a point is found where the centre zero galvanometer, G, shows no deflection.
- e)** Read and record the balance length, l , in metres.
- f)** Open switches **K₁** and **K₂**.
- g)** Repeat procedures **(c)** to **(f)** for values of $x = 0.300, 0.400, 0.500, 0.600$ and $0.700m$.
- h)** Tabulate your results including values of $\frac{1}{l}$ and $\frac{1}{x}$
- i)** Plot a graph of $\frac{1}{x}$ against $\frac{1}{l}$ for wire **W₂**.
- j)** Find the slope, **S₂** of the graph.
- k)** Replace the labelled wire **W₂** with labelled wire **W₁**.
- l)** Repeat procedures (c) to (g) with wire **W₁**.
- m)** Tabulate your results including values of $\frac{1}{l}$ and $\frac{1}{x}$
- n)** Plot using the same axes in (i) a graph of $\frac{1}{x}$ against $\frac{1}{l}$ for wire **W₁**.
- o)** Find the slope, **S₁** of the graph.
- p)** Find the constant , α of the wire **W₁** from the expression $\alpha = d_2 \sqrt{\frac{S_2}{S_1}}$
- q)** State any six sources of errors.

Qn 1.

METHOD I

(a) $M = 46.0\text{g}$ [$M = (30.0 - 75.0)\text{g}$]

(h) $t = 55.5\text{s}$ (SC) [$t = (30.0 - 80.0)\text{s}$]

(i) $T = 2.78\text{s}$

(j) $K_1 = \frac{T}{4\pi} \sqrt{\frac{gd_1d_2}{l_1}}$

METHOD II

Let t = time for 20 oscillations.

$y(m)$	$t(s)$
0.100	85.5
0.150	70.5
0.200	55.5
0.250	48.5
0.300	41.5
0.350	34.5

Qn 2

(i) $x = 7.1\text{cm}$, $y = 8.4\text{cm}$, $a = 2.8\text{cm}$

(j) $\mu = \frac{ay}{bx}$

$i(^{\circ})$	$\alpha(^{\circ})$	$\beta(^{\circ})$
20	13	19
30	20	30
40	25	40
50	31	50
60	36	60
70	39	70

Qn 3

$d_1(\text{mm})$	$d_2(\text{mm})$	$d_3(\text{mm})$
0.35	0.36	0.35

$d_2 = 0.35\text{mm}$

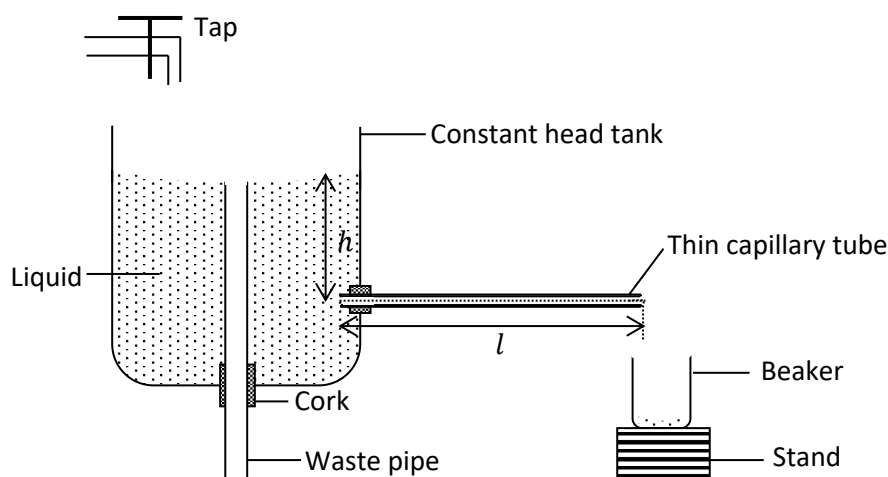
Wire W₂				Wire W₁			
$x(m)$	$\frac{1}{x}(m^{-1})$	$l(m)$	$\frac{1}{l}(m^{-1})$	$x(m)$	$\frac{1}{x}(m^{-1})$	$l(m)$	$\frac{1}{l}(m^{-1})$
0.200		0.350		0.200		0.320	
0.300		0.390		0.300		0.370	
0.400		0.435		0.400		0.415	
0.500		0.480		0.500		0.465	
0.600		0.521		0.600		0.511	
0.700		0.562		0.700		0.560	

END

**SOLUTIONS TO UACE PHYSICS SEMINAR HELD AT SEETA HIGH SCHOOL –
MUKONO ON SATURDAY 28TH SEPTEMBER 2024**

1. (a) (i) Density is mass per unit volume of a substance.
Relative density is the ratio of mass of substance to mass of an equal volume of water.
- (ii) - The radius or diameter of the pipeline.
- Length of pipeline or pressure difference (pressure gradient).
- Coefficient of Viscosity of the liquid or nature of the liquid.

(b)



- ✓ A constant head tap is set to given rate of liquid flow.
- ✓ The height, h , is measured and recorded, the tap is opened and the liquid under test flows at a constant rate.
- ✓ The liquid is collected for a flow time, t , and its volume, V , obtained.
- ✓ The length, l , and internal diameter are measured and recorded and radius, r , of the capillary tube is calculated.
- ✓ Density, ρ , of the liquid is noted.
- ✓ Experiment is repeated for different values of h , values are tabulated including $\frac{V}{t}$.
- ✓ A graph of $\frac{V}{t}$ against h plotted and its slope, S , calculated.
- ✓ Thus $\eta = \frac{\pi r^4 \rho g}{8Sl}$ is obtainable where g is acceleration due to gravity

(c)

$$P_1 = \rho g h = 1005 \times 9.81 \times 0.95 = 9366.0975 \text{ Pa}$$

$$P_2 = \rho_m g h = 13600 \times 9.81 \times 0.020 = 2668.32 \text{ Pa}$$

$$\Delta P = 9366.0975 - 2668.32 = 6697.775 \text{ Pa}$$

$$\frac{V}{t} = \frac{\pi r^4 \Delta P}{8 \eta l} = \frac{\pi [(0.225 \times 10^{-3})^4 \times 6697.775]}{(8 \times 4.0 \times 10^{-3} \times 3 \times 10^{-2})}$$

$$V = 5.617 \times 10^{-8} \times 60 = 3.37 \times 10^{-6} \text{ m}^3$$

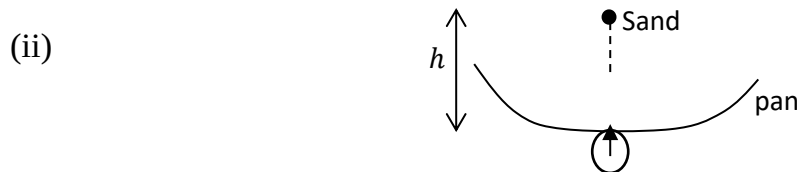
- (d) (i) For an incompressible, non-viscous fluid undergoing laminar flow, the sum of pressure and potential energy per unit volume and kinetic energy per unit volume is a constant.

- (ii) The curved shape of the aerofoil creates a fast flow of air over its upper surface than the lower surface.
 - From Bernoulli's principle the pressure of air below is greater than that above and this produces a lift on the aerofoil.

2. (a) (i) States that for a system of colliding bodies their total momentum is conserved provided no external force acts on the system.

(ii) States that energy is neither created nor destroyed but it changes from one form to another.

(b) (i) Impulse is the product of force and time for which it acts. Unit $kgms^{-1}$ or Ns .



Mass of sand pouring on a pan, $m = 11.5 \times 18.0 = 207 \text{ g}$

$$F = \frac{m(v-u)}{t}$$

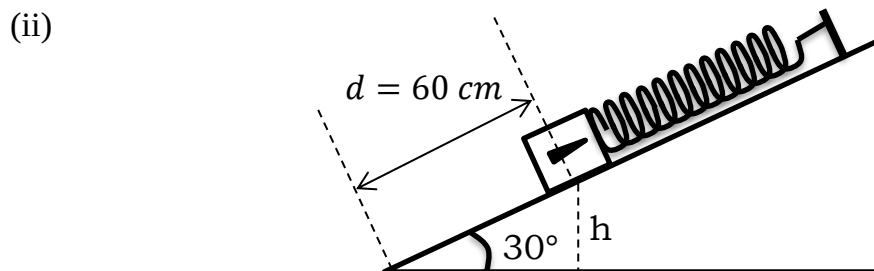
But from Potential energy lost = Kinetic energy gained,

$$mgh = \frac{1}{2}mV^2, \quad V = \sqrt{2 \times 0.375 \times 9.81} \quad V = \sqrt{7.3575} = 2.7124 \text{ ms}^{-1}$$

$$\text{Hence, the net force } F = \frac{207}{1000} \times 9.81 + \frac{207}{1000} \left(\frac{2.7124 - 0}{18} \right) = 2.0619 \text{ N}$$

- (c) - Elastic materials are the ones which can regain their original shape and size after a deforming force has been removed from them. E.g Rubber band, spring.
 - Plastic materials are the ones which have a tendency of remaining permanently stretched on removal of the applied force from them. E.g plasticine, mud.

(d) (i) K.E of the bullet $\longrightarrow$ K.E of the system $\longrightarrow$ gravitational P.E of the system + work done against friction + energy stored in the compressed spring + sound + heat.



K.E lost = P.E gained + work done against friction + work done in compressing the spring.

$$\frac{1}{2}mV^2 = mgh + Fxd + \frac{1}{2}Kd^2, \quad \text{but } h = d \sin 30$$

$$\frac{1}{2}0.9V^2 = 0.9 \times 9.81 \times 0.6 \sin 30 + (0.32 \times 0.6 \times 0.9 \times 9.81 \cos 30) + \frac{1}{2} \times 100 \times (0.6)^2$$

$$V = 49.6479 \text{ ms}^{-1}$$

(iii) - The force from the compressed spring, together with a component of gravity along the plane act to pull the block downwards.

- The frictional force opposes the two forces but is small, the block therefore moves downwards until it reaches the initial position.

(e) (i) Angular velocity is the rate of change of angular displacement.

OR: Is the angle swept per second by a body moving in a circular path.

- Centripetal force is the one which keeps the body moving around a circular path and is directed toward the centre of the path.

- Centrifugal force is the one which keeps the body moving round a circular path and is directed away from its centre.

(ii) - When the tube is rotated at constant speed in a horizontal circle about the vertical axis, the pressure at the closed end will be greater than that at the open end.

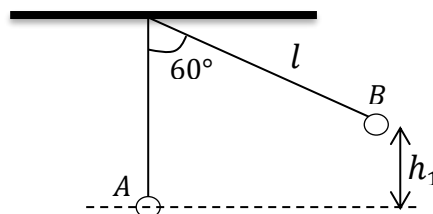
- A force due to pressure difference provides the centripetal force which makes matter of small density to move towards the centre of rotation while that of higher density to move to the closed end.

- When the rotation is stopped and the tube put vertical, less dense matter will be on top and can be separated from the dense matter.

3. (a) (i) Inertia is the tendency of a body to maintain its stable state of rest or of uniform motion in a straight line unless acted upon by some net external force.

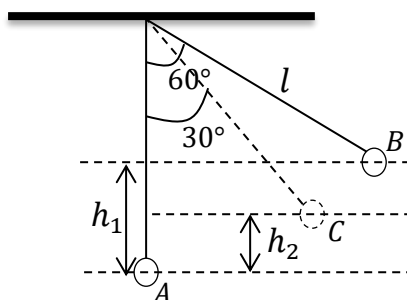
(ii) Work-energy theorem states that the work done by the resultant force on the body is equal to the change in its kinetic energy.

(b)



(i) $P.E_{max} = mgh_{max} = 0.2 \times 9.81 \times 0.5(1 - \cos 60) = 0.4905 \text{ J}$

(ii)



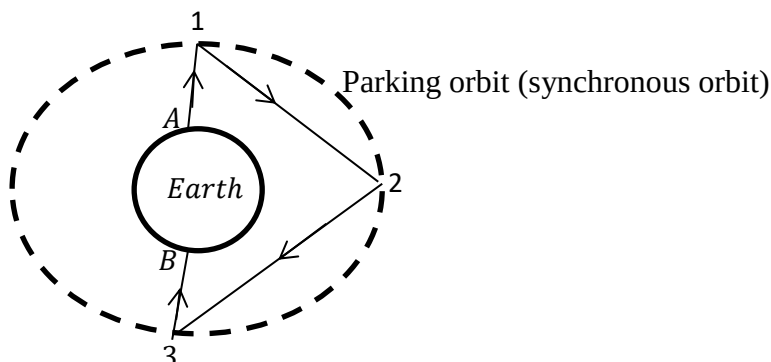
$$h_1 = 0.5(1 - \cos 60)$$

$$h_2 = 0.5(1 - \cos 30)$$

$$P.E \text{ lost} = mg(h_1 - h_2) = 0.5 \times 0.2 \times 9.81(0.866 - 0.5) = 0.359 \text{ J}$$

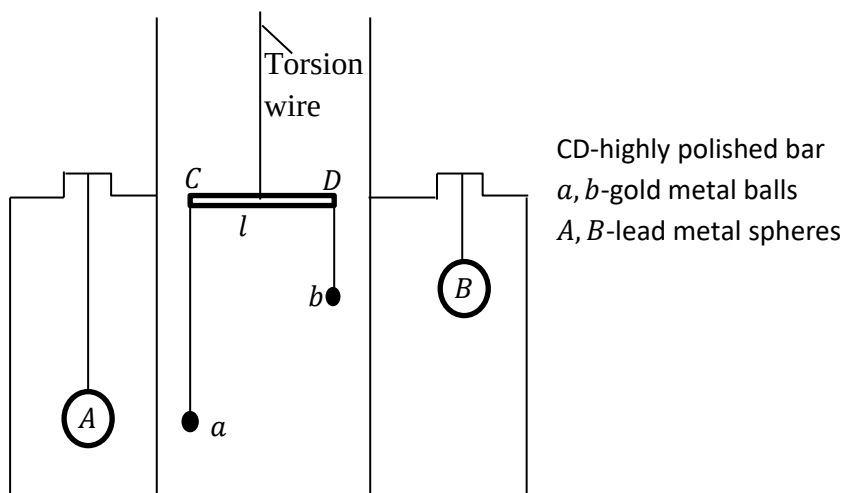
- (c) (i) Gravitation constant is the force of attraction between any two **particles** of matter in the universe each of mass 1kg placed at a distance of 1m apart.
- (ii) Escape velocity-is the minimum vertical velocity with which a body must be projected so as to enable it to just overcome the gravitational pull of a planet.

(d) (i)



- A set of three or more satellites are launched in a parking orbit as shown above.
 - A television signal from station A is transmitted to geosynchronous satellite 1.
 - From 1 its re-transmitted to 2 to 3 and then to the observer B finally.
- (ii) - Escape velocity is proportional to the mass of the planet, the moon has a small mass, so its escape velocity is very small.
- So, the atmospheric air molecules at the surface temperature of the moon is greater than the escape velocity, the air molecules escape leaving the moon with no atmosphere.

(e)



- (a,b) are gold metal balls while (A,B) are lead metal balls
- Two identical small gold spheres, (a,b) each of mass m is suspended from a highly polished bar CD of length, l , using long and short quartz strings.
- Two identical big lead spheres, (A,B) each of mass M are suspended in positions of a and b respectively.

- Due to attraction, a moves towards A and b moves towards B, this causes the bar CD to twist.

- Angle of twist θ is measured using lamp scale method and noted.

- If d is the measured distance between the large and small sphere, then

Moment of a couple = $C \theta$, where C- torsional constant and the gravitational constant G will be obtain using the expression. $\frac{GMml}{d^2} = C \theta$.

4. (a) (i) Surface tension is the tangential force per unit length acting normally on an imaginary line drawn on the liquid surface.

- Free surface energy is the work done to enlarge the liquid surface by 1m^2 under isothermal conditions.

(ii) - The dirt is held on a cloth by adhesive forces between the molecules of a cloth and dirt molecules.

- Without soap the adhesive forces between the cloth and dirt are stronger than that between the dirt and water molecules hence making it difficult to be removed.

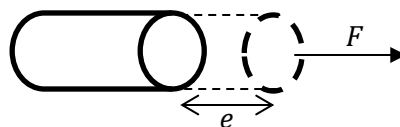
(b) (i) $r = \frac{r_1 r_2}{r_2 - r_1} = \frac{1.5 \times 2.5}{2.5 - 1.5} = 3.75\text{mm} = 3.75 \times 10^{-3}\text{m}$

(ii) $\Delta P = \frac{4\gamma}{r} = \frac{4(4.0 \times 10^{-2})}{3.75 \times 10^{-3}} = 42.667\text{Nm}^{-2}$

(c) (i) -Young's modulus is the ratio of tensile stress to tensile strain.

-Work hardening is the strengthening of a material by repeatedly deforming it such that atomic planes slide over each other and this increases plane dislocations which prevents further sliding of atomic planes.

(ii) Consider a wire of length, l , cross-sectional area, A , stretched by a force, F , through a distance, e .



Work done = average force x distance

$$= \left(\frac{0+F}{2}\right)e = \frac{1}{2} Fe$$

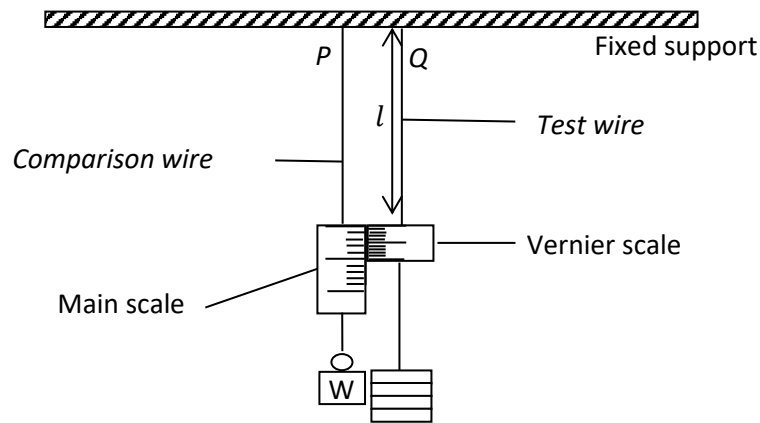
But Volume = Al .

Hence energy stored per unit volume is given by,

$$\frac{E}{V} = \frac{1}{2} \frac{F e}{A l} = \frac{1}{2} (\text{stress})(\text{strain})$$

OR: $\frac{E}{V} = \frac{1}{2} (\text{Young's modulus})(\text{strain})^2$

(d)



-Two identical long and thin wires P and Q of the same material are suspended from a common rigid support.

-The diameter of the test wire is measured using a micrometer screw gauge at three different positions and its average diameter, d , obtained and the cross-section area,

$$A = \frac{\pi d^2}{4}, \text{ calculated.}$$

-Initial loads are attached to scale pan and to the end of a comparison wire to remove kinks.

-The original length, l , of the test wire is noted.

-Known weight, W , is placed on the scale pan and the extension, e , produced is noted.

-Experiment is repeated with different known weights, W , and each time loading and unloading is done to check whether elastic limit is not exceeded.

-Results are entered in a suitable table including values of $\frac{W}{A}$ and $\frac{e}{l}$.

-A graph of $\frac{W}{A}$ against $\frac{e}{l}$ plotted which is a straight line through origin showing that $\frac{W}{A} \propto \frac{e}{l}$.

(c) (i) $P.E \text{ lost} = \text{energy stored in the spring compressed}$

$$mgh = \frac{1}{2} ke_1 \text{ Hence, } e_1 = \sqrt{\left(\frac{2 \times 0.02 \times 9.81 \times 2}{100}\right)} = 0.0886\text{m}$$

on sticking on the pan; $mg = \frac{1}{2} ke_2$

$$e_2 = \frac{0.02 \times 9.81}{100} = 0.001962\text{m}$$

Hence total compression, $e = (e_1 + e_2) = 0.0886 + 0.001962 = 9.06 \times 10^{-2}\text{m}$

on falling

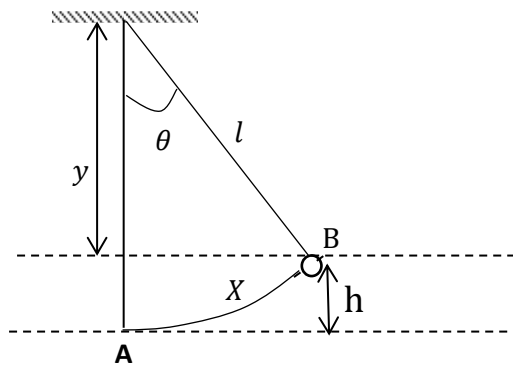
$$(ii) \quad mgh = \frac{1}{2}mV^2 \quad V = \sqrt{(2 \times 9.81 \times 2)} = 6.264 \text{ms}^{-1}$$

K.E lost by the spring = energy released by stretching the spring

$$\frac{1}{2}(0.02)(6.264^2 - 2^2) = \frac{1}{2} \times 100e^2, \quad e = 0.084 \text{m}$$

5. (a) (i) Simple harmonic motion is a periodic/repetitive motion whose acceleration is directly proportional to the displacement from a fixed point and directed towards a fixed point.
- (ii) Period is the time taken for a body to move round a circular path once.
- (b) (i) Consider a bob suspended from a rigid support using a thread of length, l , and of mass, m , being displaced through a small angle, θ and then released.

If X represents displacement,



$$\text{At A, } K.E = \frac{1}{2}mv^2; \quad P.E = 0.$$

$$M.E_A = K.E + P.E = \frac{1}{2}mv^2$$

$$\text{From } X = a \sin \omega t; \quad v = \frac{dX}{dt} = \omega a \cos \omega t$$

$$M.E_A = \frac{1}{2}m\omega^2 a^2 \cos^2 \omega t$$

$$\text{But } \omega t = 0, \quad \text{so that } \cos^2 \omega t = 1 \text{ and}$$

$$M.E_A = \frac{1}{2}m\omega^2 a^2, \text{ where } a = \text{amplitude.}$$

Thus the principle of conservation of mechanical energy applies to an oscillating bob.

$$\text{OR: At B, } M.E = K.E + P.E$$

$$M.E = \frac{1}{2}mv^2 + mgh$$

$$\text{From } \frac{x}{l} = \theta, \text{ in radians and } \cos \theta = \frac{y}{l} = 1 - \frac{1}{2}\theta^2, \text{ when } \theta \text{ is small,}$$

$$y = l(1 - \frac{1}{2}\theta^2)$$

$$h = l[1 - (1 - \frac{1}{2}\theta^2)] = \frac{1}{2}l\theta^2 = \frac{1}{2}\frac{x^2}{l}$$

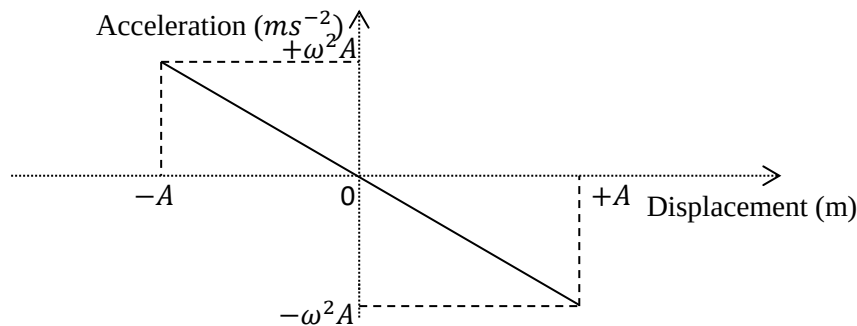
$$\text{Thus } \frac{1}{2}mg\frac{x^2}{l} + \frac{1}{2}m\omega^2 a^2 \cos^2 \omega t$$

$$\text{But } \omega^2 = \frac{g}{l}$$

$$\text{Hence } M.E_B = \frac{1}{2}\frac{mg}{l}a^2 \sin^2 \omega t + \frac{1}{2}\frac{mg}{l}a^2 \cos^2 \omega t$$

$$M.E_B = \frac{1}{2}\frac{mg}{l}a^2 = \text{constant.}$$

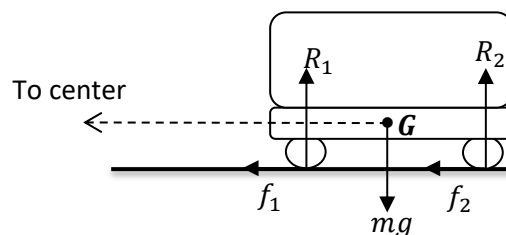
(ii)



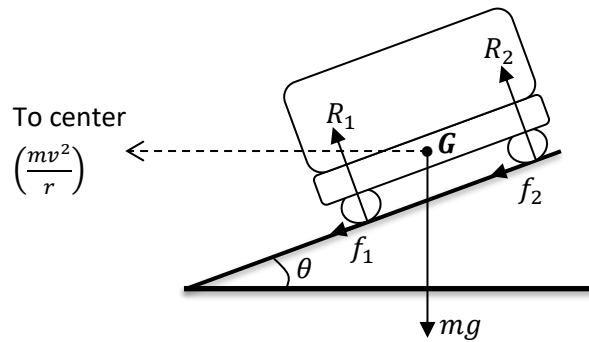
- (c)
- A spring is clamped from a retort stand with its pointer besides a metre rule.
 - The initial position, P_0 , of the pointer is read and recorded.
 - A known mass, m , is suspended from the end of the spring and the new position, P_1 of the pointer is noted.
 - The mass is slightly displaced and released and is allowed to oscillate.
 - The time, t , for 20 oscillations and the period, T , for one oscillation is determined.
 - The experiment is repeated for other known masses.
 - the results are entered in a suitable table including values of T^2 .
 - A graph of T^2 against e is plotted and the slope, S , is calculated.
 - The acceleration due to gravity, g , is then obtained from $S = \frac{4\pi^2}{g}$.

(d) (i) Angular displacement is the ratio of the arc length to the radius for a body moving in a circular path.

(ii)



On a level road, the centripetal force is provided by frictional force, i.e $f_1 + f_2 = \frac{mv^2}{r}$.



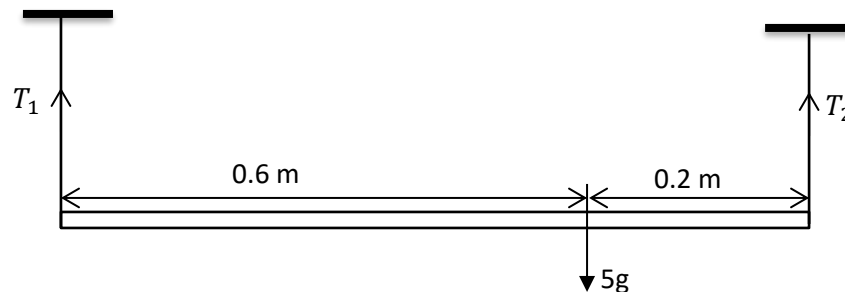
On a banked track, the centripetal force is provided by both the components of the normal reaction and the frictional forces towards the centre of the circular path, i.e

$(R_1 + R_2)\sin\theta + (f_1 + f_2)\cos\theta = \frac{mv^2}{r}$. This results into a greater speed hence travelling faster.

- (e) (i) Stable equilibrium is one in which when a body is displaced slightly, the position of its centre of gravity and potential energy rises such that on removal of the displacing force, the body returns to its original position.

Unstable equilibrium is one in which when a body is displaced slightly, the position of its centre of gravity and potential energy is lowered such that when the displacing force is removed, it does not return to its original position.

(ii)



Resolving vertically, $T_1 + T_2 = 5g$

Taking moments at A, $5g \times 0.6 = T_2 \times 0.8$ $T_2 = 36.79N$

$T_1 + T_2 = 5 \times 9.81$ $T_1 = 12.26N$

- 6a) (i) Fixed points are temperatures at which a particular physical event is expected to occur.

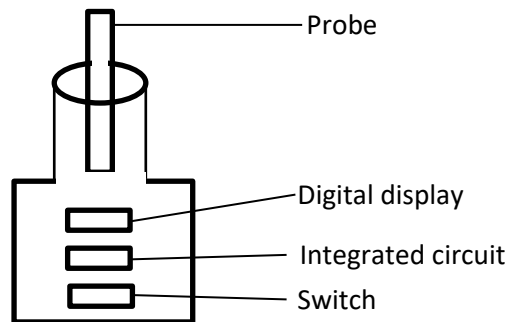
Fundamental interval is the difference between the upper fixed point and the lower fixed point of a thermometer.

Triple point of water is a unique temperature and pressure at which pure melting ice, pure water and pure water vapour co-exist in equilibrium.

Thermometric property is a physical property of a substance whose value varies linearly, uniformly and continuously with temperature changes.

- (ii) - It should vary linearly with temperature changes.
 - It should vary continuously with temperature change.
 - It should be measurable over a wide range using a fairly simple apparatus.
 - It should be sensitive to small changes in temperature.
- (iii) - The melting point of ice and the boiling point of water are not unique temperatures.
 - This is because they change with pressure and the presence of impurities in ice and water.

b)



- The probe is placed in contact with the body whose temperature is required.
- The temperature changes cause a large variation in the electrical resistance of the probe
- The probe is connected to the electrical circuit.
- The circuit receives temperature reading from the probe in form of electrical signal.
- The signals are changed to digits when appears in display.

- c) (i) Latent heat is the amount of heat required to change any mass of a substance from one state to another without change in temperature.

Melting point -is the process by which a substance changes at a constant temperature and pressure from solid to liquid state.

- (ii) - Cooking by steaming method;

Since water has a higher specific latent heat of vaporization. This property enables steam to be used for cooking when it condenses on the food, latent heat is released directly onto the food which enables the food to be cooked at a faster rate.

- Our bodies feel cool after sweating (temperature regulation)

On a hot day the body sweats, evaporation occurs at the surface of the body, the temperature of the sweat falls to maintain evaporation. Latent heat is constantly drawn from the body and the body cools.

d) (i) $\Delta W = P(V_{stem} - V_W) = 1.01 \times 10^5 \left(\frac{5}{0.58} - \frac{5}{1000} \right) = 8.7022 \times 10^5 \text{ J}$

(ii) $\Delta Q = \Delta U + \Delta W$ But $\Delta U = 5 \times 2.25 \times 10^5 - 8.7022 \times 10^5 = 2.593 \times 10^5 \text{ J}$

7. (a) (i) Thermal conductivity, K , is the rate of heat flow per unit cross-sectional area per unit temperature gradient.

Temperature gradient, $(\frac{\theta_1 - \theta_2}{l})$ is the rate of temperature fall per unit length.

Heat current, $\frac{Q}{t}$, is the rate of heat flow through a substance.

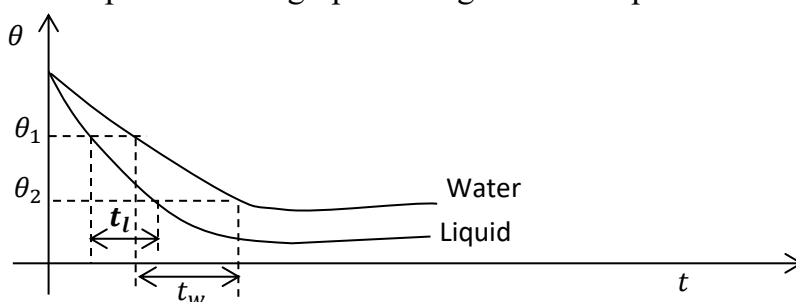
(ii) When one end of a cork is heated the adjacent atoms gain energy and vibrate with increased amplitude and loses its energy to the neighboring atoms which also ends up vibrating with increased amplitude until it reached the cold end.

(iii) When one end of metal is heated the free mobile electrons gain kinetic energy and move with increased speeds along the lattice of the metal as colliding with atoms until heat reaches the cold end. But silk lacks mobile electrons so heat flow is aided only by inter atomic vibrations only whereas in metals by both mobile electrons and inter atomic vibrations.

(b) (i) Specific heat capacity is the amount of heat required to raise the temperature of a 1kg mass of a substance by 1K.

(ii) Watermelon has got a large water content. This results into having a high s.h.c, so requires to absorb larger amount of heat to change the temperature, hence always at lower temperature.

- (c)
- An empty calorimeter is weighed and its mass, m_c noted.
 - It is then filled with water initially at about 80°C and is then allowed to cool under standard conditions.
 - Its temperature, θ is then recorded every after a suitable time, t .
 - A graph of θ against t is plotted
 - Then calorimeter and water are weighed to find the mass of water, m_w .
 - It is then emptied and dried and equal volume of the specimen liquid initially at about 80°C is put in the calorimeter.
 - The experiment repeated and a graph of θ against t also plotted on the same axis.



(Heat lost by water + calorimeter in cooling from θ_1 to θ_2) = (heat gained by liquid + calorimeter for the same temperature change)

$$\frac{(m_w c_w + m_c c_c)(\theta_1 - \theta_2)}{t_w} = \frac{(m_l C_l + m_c c_c)(\theta_1 - \theta_2)}{t_l} \quad \text{where } C_l \text{ can be determined.}$$

where c_c , c_w are specific heat capacities of the calorimeter and water respectively.

$$(d) \quad \frac{\left(\frac{50}{1000} \times 4200 + C\right)(60 - 50)}{17 \times 60} = \frac{\left(\frac{110}{1000} \times 4200 + C\right)(60 - 50)}{35 \times 60}$$

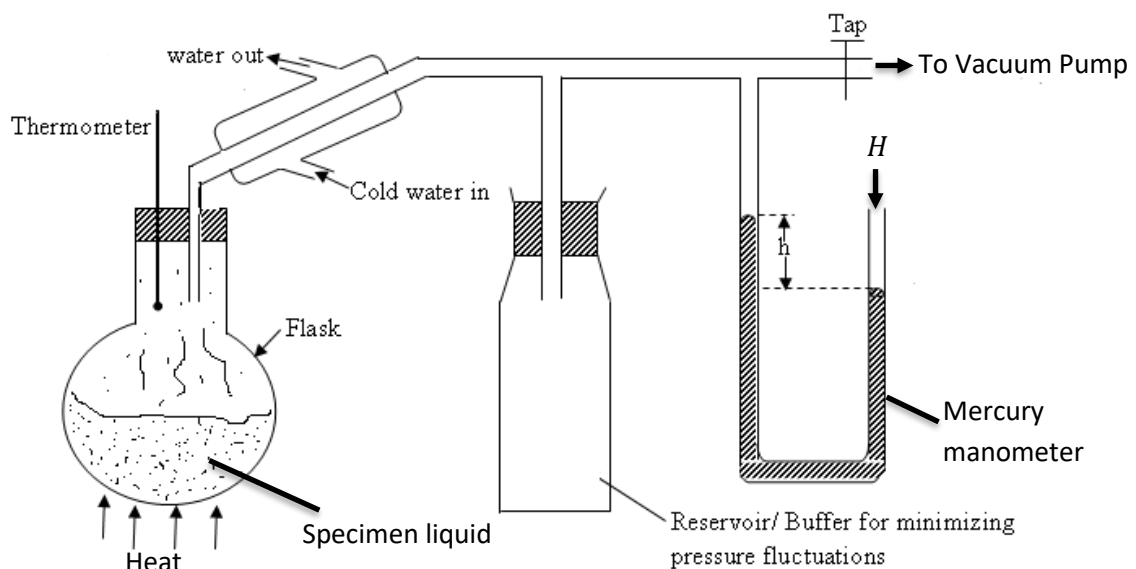
$$35(21000 + 10C) = 17(4620 + 10C)$$

$$73500 + 350C = 78540 + 170$$

$$C = 28 \text{ J K}^{-1}$$

8. (a) (i) A gas is a gaseous state of a substance above its critical temperature
A vapour is a gaseous state of a substance below its critical temperature.
- (ii) At lower pressure the molecules become few for the volume of the container and relatively far apart thus volume of molecules themselves becomes negligible compared with the volume of the container.
- At high temperature, the molecules become far apart and intermolecular forces of attraction become very weak. Hence intermolecular forces become negligible.

(b)



- A vacuum pump is used to withdraw air from the reservoir to a pressure lower or above the atmospheric pressure, H .
- The tap is closed and the liquid heated gently until it boils
- The temperature, θ , of the vapour and the difference in mercury level, h , are noted.

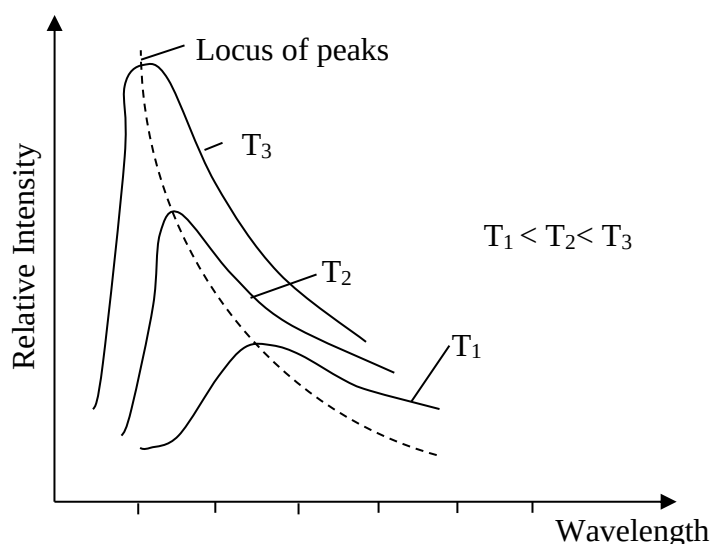
Thus $SVP = H \pm h\rho g$ found, g is acceleration due to gravity,
 ρ , is density of the liquid.

- The tap is opened and apparatus allowed to cool for a few minutes.
- The experiment is repeated for different values of pressure above or below the liquid.
- A graph of SVP against θ is plotted and SVP at any temperature can be read from the graph corresponding to 65°C .

(c) (i) $\frac{P}{A} \propto T^4$ (*Stefan's law*); The total power radiated by a black body per unit surface area is directly proportional to the fourth power of its absolute temperature.

$\lambda_{max} \propto \frac{1}{T}$ (*Wien's law*); Wavelength of radiation emitted by a black body at maximum intensity reduces as its absolute temperature increases.

(ii)



- As temperature increases, the wavelength of most intense radiation decreases.
- For visible spectrum from a furnace as temperature increases the wavelength shifts from Red to Yellow to Green to Blue.
- At the center of the furnace where the temperatures are very high when Red, Green and Blue combine they appear white.

(d) $P = \epsilon A \delta T^4$, Where $A = \pi dl$,

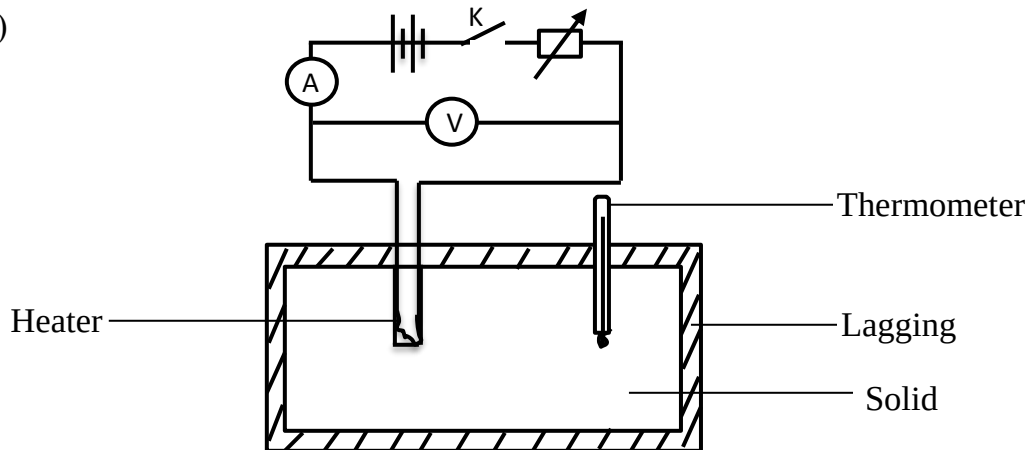
$$60 = 0.6\pi \times 1.0 \times 10^{-2} \times 30 \times 10^{-2} \times 5.7 \times 10^{-8} T^4, T = 656.85K$$

9. (a) (i) Under conditions of forced convection, the rate at which a body loses heat is directly proportional to the excess temperature of the body over that of the surrounding.

- (ii) - The rate of heat flow depends on surface area to volume ratio.

- Small pieces of wood or charcoal have a higher surface area to volume ratio than larger surfaces making them absorb heat at high rate than larger pieces.

(b) (i)



- Drill the solid into two holes, one for the heater and the other for the thermometer
- Weigh and record the mass, m_s , fill the holes with mercury to improve the thermal contact and insert the heater and thermometer in their respective holes.
- Read and record the initial temperature, θ_1 .
- Close switch k and at the same time start the stop watch, and leave the experiment until a maximum temperature is reached and noted as, θ_2 and time taken, t .
- The ammeter and the voltmeter reading I and V are read noted.

$$m_s c (\theta_2 - \theta_1) = VIt; c \text{ can then be calculated}$$

(ii) $VIt = mcd\theta + \left(\frac{0+16}{2}\right)t$

$$520 \times 25 \times 60 = 2.5 \times c \times (100 - 20) + 8 \times 25 \times 60$$

$$780000 - 12000 = 200c$$

$$c = 3840 JK^{-1} kg^{-1}$$

- (c) Because metals have low s.h.c, they absorb heat quickly from the hand leaving it a lower temperature hence feeling cold.

OR; Metals are good conductors of heat so absorbs heat from the body leaving it at lower temperature hence feeling cold.

(d) $Total\ surface\ area = (12 \times 10) + (10 \times 4)2 + (4 \times 12)2$

$$120 + 80 + 96 = 296m^2$$

$$Area\ of\ walls\ and\ roof = 296 - 16 = 280m^2$$

Rate of heat flow through windows and doors

$$\frac{Q}{t} = K_g \times 16 \times \frac{\Delta\theta}{5 \times 10^{-3}} = 3200K_g \Delta\theta$$

Rate of heat flow through roofs + walls

$$\begin{aligned} \frac{Q}{t} &= K_{wr} A \frac{\Delta\theta}{l} = 0.25 \times 280 \frac{\Delta\theta}{25 \times 10^{-2}} \\ &= 280\Delta\theta \end{aligned}$$

$$\% \text{ of heat loss by conduction through doors + windows} = \left(\frac{3200K_g \Delta\theta}{3200K_g \Delta\theta + 280\Delta\theta} \right) \times 100\%$$

$$\frac{94}{100} = \frac{3200K_g \Delta\theta}{3200K_g \Delta\theta + 280\Delta\theta}$$

$$0.94 = \frac{3200K_g}{3200K_g + 280}$$

$$3008K_g + 263.2 = 3200K_g$$

$$K_g = 1.37Wm^{-1}K^{-1}$$

10. (a)
- Decay constant is the fractional number of radioactive particles decaying per second.
 - Half-life is the time taken for a radioactive sample to decay to a half of its original number of nuclei present.
 - Activity is the number of disintegrations per second.
 - Carbon-14 dating is the method of obtaining age of a fossil. Carbon -14 is radioactive with half-life, $t_{\frac{1}{2}}$, of 5600years.

It is absorbed by plants during photosynthesis, when a plant dies carbon -14 starts to decay, its activity, A_t of a dead plant is measured and noted.

The activity of a living plant of the same species is measured and recorded as A_0 .

From $A_t = A_0(0.5)^n$, where $n = \frac{t}{t_{\frac{1}{2}}}$, then, t , is obtained.

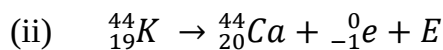
- Uranium dating is the method of obtaining age of a rock. Every atom of uranium that decays turns into a lead atom.

When a mineral grain is formed say in the fossil below its trapping temperature, it sets the uranium – lead clock to zero.

The lead atoms created are trapped in the crystal and build up in concentration with time, the lead – uranium proportion is determined in terms of mass and from

$$Nu = (Nu + Npb) e^{-\lambda t}, \quad \lambda = \frac{\ln 2}{t_{\frac{1}{2}}}, t_{\frac{1}{2}} \text{ is the half-life of a rock. Then } t \text{ is obtained.}$$

- (b) (i) Radio-active equilibrium is a condition where the species and its successive radioactive products all disintegrate at the same numerical rate and maintain their proportions constant.



$$\lambda = \frac{\ln 2}{20 \times 60}$$

$$N_0 = \frac{m}{M} N_A = \left(\frac{10 \times 10^{-3}}{44} \right) \times 6.02 \times 10^{23} = 1.3682 \times 10^{20} \text{ atoms}$$

$$\text{After } 1 \text{ hr} = 60 \times 60 \text{ s}$$

$$N = 1.3682 \times 10^{20} e^{\frac{-\ln 2}{20} \times 60} = 1.71 \times 10^{19} \text{ atoms}$$

$$A = \lambda N = \left(\frac{\ln 2}{20 \times 60} \right) \times 1.71 \times 10^{19} = 6.76 \times 10^{18} \text{ atoms per second.}$$

$$N_k + N_c = N_0; N_c = 1.3682 \times 10^{20} - 1.71 \times 10^{19} = 1.1972 \times 10^{20} \text{ atoms}$$

- (c) Nuclear fission is the breaking of unstable nucleus into two lighter nuclei with release of energy

Nuclear fusion is the union of two lighter nuclei to form one heavier nucleus with release of energy.

$$(d) (i) \quad \text{Energy released} = \frac{Q_1 Q_2}{4\pi \epsilon_0 x_0} = \frac{1.6 \times 10^{-19} \times 1.6 \times 10^{-19} \times 9 \times 10^9}{1.5 \times 10^{-15}} = 1.536 \times 10^{-14} \text{ J.}$$

$$(ii) \quad K.E = \frac{3}{2} k_B x T; 1.536 \times 10^{-14} = \frac{3}{2} \times 1.38 \times 10^{-23} T; T = 7.42 \times 10^8 \text{ K.}$$

11. (a) (i) Photoelectric effect – is the process by which electrons are emitted from a clean metal surface when illuminated with radiation of high enough frequency .

Binding energy per nucleon – is the minimum energy required to split the nucleus into its constituent nucleon to the mass number.

- (ii) -States that light is emitted and absorbed in discrete amounts or packets called quanta . the energy of each quantum is hf where f –frequency of light and h - Planck's constant

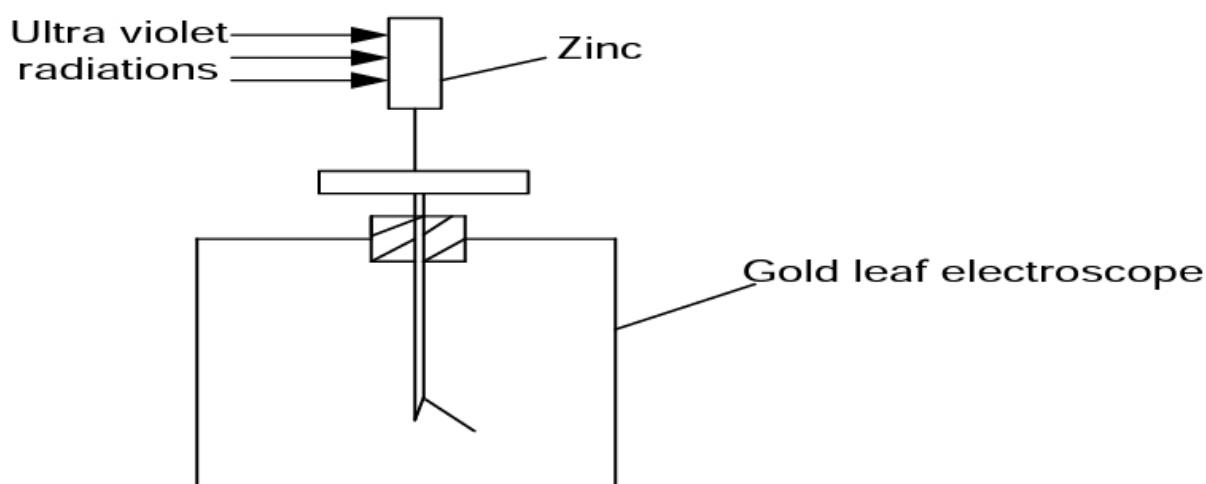
-When light is incident on a metal surface ,each quantum of light /photon interacts with one and only one electron in the surface of the metal giving it all its energy or none at all.

- If the photons energy $hf < \phi$ – work function and hence dislodging electrons from the the metal surface .

- (ii) photoelectric effect – to liberate an electron from a metal surface ,a quantum (Or packet)of energy work function which is the characteristics of the metal which has to be supplied .

Optical spectra – a line in the optical emission spectrum indicates presence of a particular frequency f of light considered in an excited atom when an electron jumps from a higher to a lower energy level .

x-ray line spectra- electron transitions from one shell to another leads to liberation of energy in packets which are characteristics of the target atom.



b)

-a cleaned negatively zinc plate is connected to the cap a negatively charged G.L.E

- The U.V is the directly incident on the zinc plate

- the gold leaf is seen to collapse ,showing that both gold leaf and plate have lost charge hence photo electric emission effect.

- c) (i) Braggs law states that for constructive interference, the path difference of diffracted x-rays is equal to the integral multiple of their wavelength.

- II) -When a parallel beam of x-rays is incident on a crystal whose inter atomic spacing of the atom, d , is comparable to the wavelength of x-rays.

x-ray beam undergo scattering due to diffraction producing black spot at the center due to destructive interference and the reflected x-rays beam undergoes constructive interference producing a bright spot whose path difference is an integral multiple of wavelength of the x-rays ($n\lambda$), for $n=1,2,3,\dots$

d)

initial k.e of ${}^4_2\text{He} = \text{electrostatic potential}$

$$1.6 \times 10^{-3} = \frac{2 \times 50 \times 1.6 \times 10^{-19} \times 1.6 \times 10^{-19} \times 9 \times 10^9}{x^0}$$

$$X_0 = 1.44 \times 10^{-13} \text{m}$$

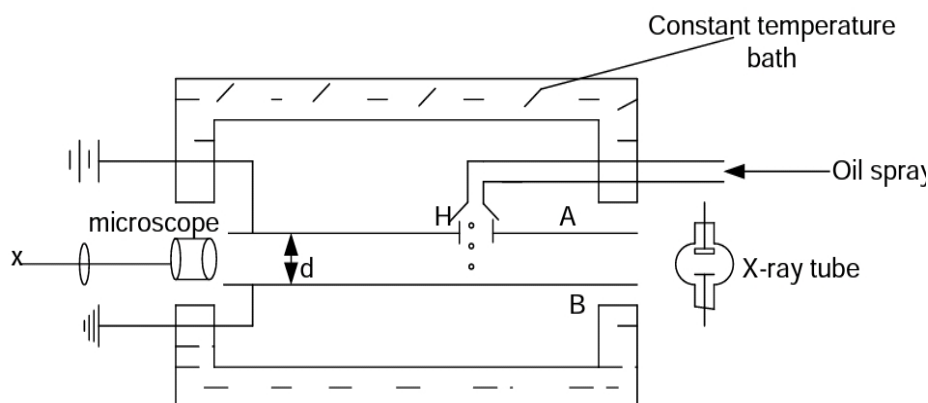
12a) i) electron volt – is the energy gained by an electron accelerated through a p.d of 1 volt .

Unified atomic mass unit – is the $(\frac{1}{12})^{\text{th}}$ of the mass of one atom of carbon-12 isotope .

Specific charge – is the ratio of charge to mass of atom, /particle /ion/an electron .

Stopping potential - is the minimum p.d which reduces the photocurrent to zero.

ii)



-oil droplets are allowed to fall through the tiny hole from the oil spray into the space between metal plate AB.

-with p.d off, one oil drop is observed as it falls between the distance x , fallen in time t is obtained ,the terminal velocity $V_0 = \frac{x}{t}$ is found.

$$\frac{4}{3}\pi r^3 \rho_o g = \frac{4}{3}\pi r^3 \rho_a + 6\pi \eta r V_0 \dots\dots\dots(i)$$

$$r = \left(\frac{9\eta V_0}{2g(\rho_o - \rho_a)} \right)^{1/2} \text{ where } \rho_o - \text{density of oil, } \rho_a - \text{density of air, } \eta - \text{Air resistance}$$

-a second oil drop is selected and given a charge ,Q by x-rays

- Then p.d is switched on, and adjusted until a drop becomes stationary.

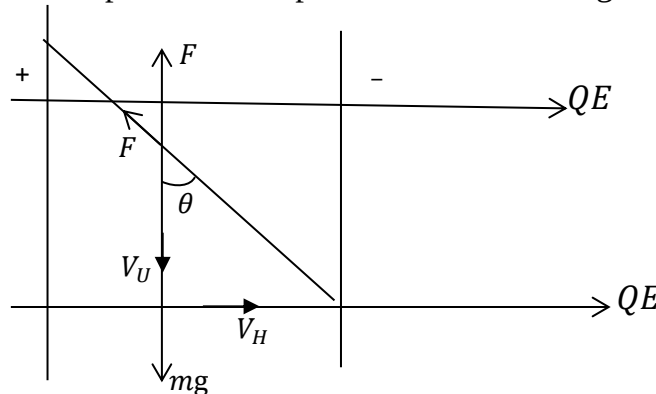
-p.d, v and separation, d, between the plates are measured and noted , electric field intensity $E = \frac{V}{d}$ is found.

$$\frac{4}{3}\pi r^3 \rho_o g = \frac{4}{3}\pi r^3 \rho_a + QE \dots\dots\dots(ii)$$

$$Q = \frac{6\pi\eta V_o}{E} \left(\frac{9\eta V_o}{2g(\rho_o - \rho_a)} \right)^{1/2}$$

-using several drops ,the experiment is repeated until the the highest multiple of charge is obtained .

b (i)



For constant velocity , $mg = F$

$$\tan \theta = \frac{V_H}{V_U}$$

$$V_H = \frac{1.066}{100} \tan 36.6^\circ = 0.0079168 \text{ms}^{-1}$$

$$(ii) \quad \frac{VQ}{d} = 6\pi\eta r V_H$$

$$Q = \frac{6\pi(1.82 \times 10^{-5})(1.0 \times 10^{-7})(0.0079168) \times 0.5 \times 10^{-2}}{3000 \times 100} = 4.52 \times 10^{-19} \text{ C}$$

c (i) in magnetic field ,

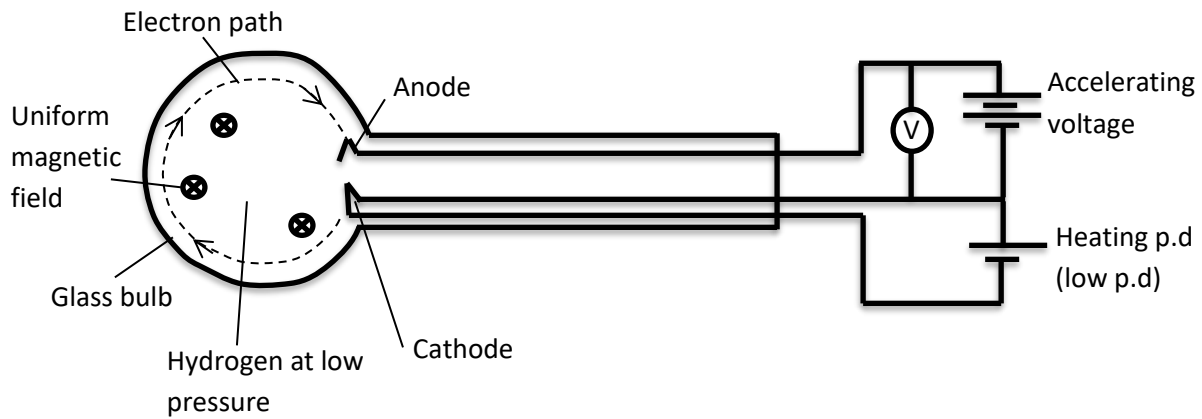
-when an electron enters a region of uniform magnetic field experiences a magnetic force $\vec{B}e\vec{U}$ which is perpendicular to both $\vec{B}$ and $\vec{U}$ vectors whose direction is given by Flemings left hand rule which provides a centripetal force causing them to describe a circular path of radius , $r = \frac{mU}{Be}$ whose velocity remain unchanged.

in electric field ,

-The electron experiences an electric force towards the positive plate and move with a vertical acceleration $\frac{eE}{m}$ which is uniform.

-And describe a parabolic path between the plates while the component of their velocity in horizontal direction remains constant.

ii)



-the cathode is heated by low voltage to emit electrons thermionically.

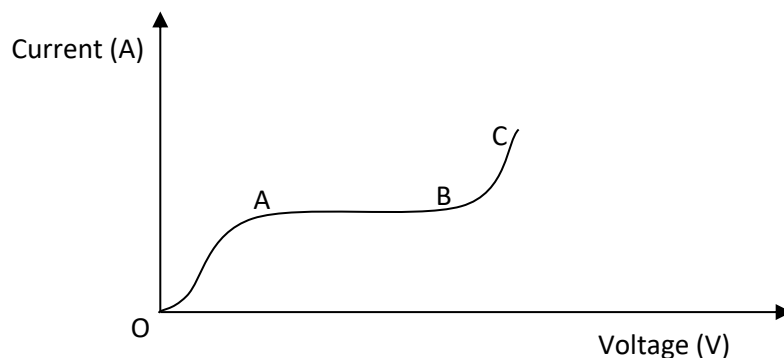
-emitted electrons are accelerated by voltage, V , towards the anode.

-on their way they collide with hydrogen atoms causing them to emit light and so reveal the path of the electrons.

-magnetic fields provide centripetal force which causes them to describe a circular path of radius, r , measured using a plane mirror

-specific charge, $e/m = \frac{2V}{B^2 r^2}$ is obtained.

d)



-OA – as the applied voltage increases, the number of electrons reaching the anode increases, leading to increase in the current gradually.

- Along AB –the electron released all reach the anode at the same time so that the current through the tube appears constant.

-Along BC – The number electrons due to ionization increase rapidly and not all electrons reach the anode at the same time, current increases gradually.

At the breaking point, a large number of electrons reach the anode and current rises sharply.

13.a(i) semiconductor –is one in which the electrical conductivity lies between that of an insulator and a conductor .

ii) Intrinsic –is a pure semiconductor

Extrinsic – is one with impurities in its crystal structure.

iii) Thermionic emission – is the production of electrons from hot metal surface.

b) The p-type semiconductor is formed by dropping a semi-conductor with a group three element (trivalent) where by the holes become the majority charge carriers .

Then the n-type semiconductor is formed by doping a semiconductor with a group five element (pentavalent) ,where by the electrons become the majority carrier.

-now a p-n junction is formed by fusing together the p-type and n-type pieces.

(ii) group iii elements- aluminum, boron.

Group iv element – Sulphur, nitrogen

c) $V_{rms} = 2.82$, $V_o = \sqrt{2} V_{rms} = \sqrt{2} \times 2.82$, $V_o = 3.988v$

$V_o \propto l$, $V_o = \beta l$, $3.988 = \beta \times 2$, $\beta = 1.994 \text{ vm}^{-1}$

d) -consists of 3 terminals ,emitter ,collector and base which is the thinnest and formed when melting/fusing two p-types and n-type in which n-type is the base and one ptype is emitter and another one is the collector. Or two n-tpes and a p-type in which p-type becomes the base

-and always the base is always in the middle.

UACE PHYSICS SEMINAR SLATED FOR
5th OCTOBER 2024 AT
UGANDA MARTYRS S.S. NAMUGONGO

Physics Paper One (P510/1)

Section A

-
1. (a) (i) Distinguish between *elastic* and *inelastic* collisions. (2 marks)
- (ii) Define the terms; *momentum* and *impulse*. (2 marks)
- (iii) Derive the relation between impulse and linear momentum of the body on which it acts. (2 marks)
- (b) (i) State the law of conservation of linear momentum. (1 mark)
- (ii) Using Newton's laws of motion, show that when two bodies collide, their total momentum is conserved. (4 marks)
- (c) A ball of mass 0.5kg is allowed to drop from rest, from a point a distance of 5.0m above a horizontal concrete floor. When the ball first hits the floor, it rebounds to a height of 3.0m .
- (i) What is the speed of the ball just after the first collision with the floor? (3 marks)
- (ii) If the collision lasts 0.01 seconds, find the average force which the floor exerts on the ball. (3 marks)
- (d) Giving two examples of each, distinguish between conservative and non-conservative forces. (3 marks)
- [UGANDA MARTYRS S.S. NAMUGONGO]**
2. (a) Define *surface tension* and derive its dimensions. (2 marks)
- (b) (i) Calculate the amount of energy liberated when 1000 droplets of water, each of diameter $1.0 \times 10^{-1} \text{ cm}$ coalesce under isothermal conditions, to form a bigger drop. [Surface tension of water = $7.2 \times 10^{-4} \text{ Nm}^{-1}$] (4 marks)
- (ii) Derive an expression for the pressure difference between the inside and outside of a soap bubble in air given that the radius of the bubble is r and surface tension of soap solution is γ (3 marks)
- (iii) Two soap bubbles of diameters d_1 and d_2 respectively are attached to each other to form an interface of radius r , if $d_1 < d_2$, derive the expression for r in terms of d_1 and d_2 . (4 marks)
- (c) (i) Distinguish between streamline flow and turbulent flow of a liquid. (2 marks)

- (ii) Describe an experiment to demonstrate streamline and turbulent flows. (5 marks)

[Mt. St. MARY'S COLLEGE, NAMAGUNGA]

3. (a) (i) State **Bernoulli's principle**. (1 mark)
- (ii) Derive Bernoulli's equation. (5 marks)
- (b) (i) Define **coefficient of viscosity** and state its units. (2 marks)
- (ii) Explain the temperature dependence of viscosity of a liquid. (3 marks)
- (iii) Water of negligible viscosity flows steadily through a horizontal pipe of varying cross-sectional area. At a point A of cross-sectional area 10cm^2 , the velocity is 0.2ms^{-1} . What is the pressure difference between A and B if the cross section area of point B is 2.5cm^2 ?
(Given that the density of water = 10^3kgm^{-3}) (4 marks)
- (c) (i) Distinguish between **laminar** and **turbulent flow** of a fluid. (2 marks)
- (ii) Briefly explain any one application of Bernoulli's principle. (3 marks)

[St. HENRY'S COLLEGE, KITOVU]

4. (a) (i) Define **limiting friction**. (1 marks)
- (ii) Draw a graph of friction against force for a body initially at rest, acted on by a gradually increasing force until it starts to move with constant velocity. (2 marks)
- (b) A car of mass $2,000\text{kg}$ moves up a road inclined at 20° to the horizontal with a constant velocity of 15ms^{-1} . If the coefficient of friction between the road and the tires of the car is 0.2 , find;
- (i) The force exerted by the car's engine. (3 marks)
- (ii) The power developed in the engine. (3 marks)
- (c) State the conditions for a rigid body to attain mechanical equilibrium. (2 marks)
- (d) A 3m long ladder rests at an angle of 60° to the horizontal against a smooth vertical wall on a rough ground. The ladder weighs 5kg and its center of gravity is one-third from the bottom of the ladder.
- (i) Draw a sketch diagram to show the forces acting on the ladder. (2 marks)
- (ii) Find the reaction of the ground on the ladder. (2 marks)
- (e) (i) Define **a couple**. (1 mark)
- (ii) A wheel of radius 0.60m is pivoted at its center. A tangential force of 4.0N acts on the wheel so that the wheel rotates with uniform velocity. Find the work done by the force to turn the wheel through 10 revolutions . (4 marks)

[SEETA HIGH SCHOOL, MUKONO]

5. (a) (i) Define ***moment of inertia*** and state its units. (2 marks)
- (ii) Derive an expression for rotational kinetic energy of a body about an axis in terms of its moment of inertia ***I***, mass ***m*** and distance ***r*** from the axis of rotation. (4 marks)
- (b) A weightless rod of length ***1.0 m*** has four masses each of ***10.0g*** attached to it at distances of ***0.0 cm***, ***25.0 cm***, ***75.0 cm*** and ***100.0 cm*** from one end respectively. The rod is made to rotate in a horizontal plane about a vertical axis at its center. If the rod makes ***8.0 rev/s***, find;
- (i) Rotational kinetic energy of the system. (3 marks)
- (ii) Moment of inertia for the system. (4 marks)
- (c) (i) Draw a sketch diagram of a car moving round a circular track on level ground and indicate the forces acting on the car. (3 marks)
- (ii) If the track is of radius ***r***, derive an expression for the maximum speed with which the car can move round the track without overturning. (4 marks)

[WAMPEEWO NTAKE]

6. (a) (i) State ***Kepler's laws of planetary motion***. (3 marks)
- (ii) State ***Newton's law of Universal gravitation***. (1 mark)
- (b) (i) Sketch a graph showing the variation of acceleration due to gravity with distance from the center of the earth. (2 marks)
- (ii) Derive an expression for the acceleration due to gravity ***g***, inside the earth at a distance ***r***, from the earth's surface given that the earth has a uniform density ***ρ***. (3 marks)
- (c) The orbital radius of Mars about the Sun is ***1.53 times*** that of the earth about the Sun. How many days does Mars take to move once round the Sun? (3 marks)
- (d) (i) Define ***a parking orbit***. (1 mark)
- (ii) State any two uses of artificial satellites. (2 marks)
- (e) A satellite of mass ***100kg*** is in a circular orbit at a height of **$3.59 \times 10^7 m$** above the earth's surface.
- (i) Find the mechanical energy of the satellite. (3 marks)
- (ii) Explain what would happen if the satellite encountered resistance to its forward motion. (2 marks)

[St. PETER'S S.S, NSAMBYA]

Section B

7. (a) Define **specific heat capacity** and state its units. (2 marks)
- (b) (i) With use of a well labelled diagram, describe the continuous flow method to determine the specific heat capacity of a liquid. (6 marks)
- (ii) State any **two** advantages of the continuous flow method over the method of mixtures. (2 marks)

- (c) In an experiment to determine the specific heat capacity of a liquid by the continuous flow method, the following two sets of readings were obtained.

	Set 1	Set 2
Voltage V(v)	35.0	26.0
Current I(A)	2.0	2.0
Mass m, of liquid (kg) collected in 10.0 seconds	4.07×10^{-2}	3.0×10^{-2}
In flow temperature ($^{\circ}\text{C}$)	25	25
Out flow temperature ($^{\circ}\text{C}$)	29	29

Use the information provided and find the;

- (i) Specific heat capacity of the liquid. (2 marks)
- (ii) Rate of heat loss by the apparatus. (4 marks)
- (d) Steam at 100°C is passed into a copper calorimeter of mass 150g containing 340g of water at 15°C . This is done until the temperature of the calorimeter and its contents is 71°C . If the mass of the calorimeter and its contents is found to be 525g , calculate the specific latent heat of vaporization of water. (4 marks)
[St. CYPRIAN HIGH SCHOOL, KYABAKADDE]
8. (a) (i) Define **isobaric** and **iso - volumetric** processes of a gas. (2 marks)
- (ii) Write down the equations representing isobaric and an iso - volumetric processes. (2 marks)
- (b) An ideal gas of temperature 25°C and pressure $1.01 \times 10^5\text{ Pa}$, undergoes an isobaric expansion to twice its volume, followed by an iso-volumetric change to a temperature -73°C . The gas is then compressed adiabatically to its original volume.
- (i) Draw a pressure-volume sketch graph to show the above processes. (3 marks)
- (ii) Calculate the final temperature and pressure of the gas. (6 marks)
- (d) (i) State **Boyle`s law**. (1 mark)

- (ii) With a labelled diagram, describe an experiment to verify Boyle's law.

(6 marks)

[GREEN LIGHT S.S, NANSANA]

9. (a) (i) State the assumptions made in the derivation of the gas equation

$$P = \frac{1}{3} \rho \overline{c^2}$$

(2 marks)

- (ii) State **Dalton's law** of partial pressures.

(1 mark)

- (iii) Use the expression $P = \frac{1}{3} \rho \overline{c^2}$ to deduce Dalton's law stated in (ii) above.

(3 marks)

- (b) Explain:

- (i) what happens to the pressure of a fixed mass of a gas in a sealed container when the temperature of that gas is raised.

(4 marks)

- (ii) why water on top of a high mountain boils at a lower temperature than that at the bottom of the mountain.

(4 marks)

- (c) Two hollow spheres A and B of volume 500cm^3 and 250cm^3 respectively are connected by a narrow tube fitted with a tap. Initially the tap is closed and A is filled with an ideal gas at 10°C at a pressure of $3.0 \times 10^5 \text{ Pa}$ and B is filled with an ideal gas at 100°C at a pressure of $1.0 \times 10^5 \text{ Pa}$. Calculate:

- (i) the equilibrium pressure when the tap is opened.

(3 marks)

- (ii) the resulting temperature when the tap is opened.

(3 marks)

[IGANGA S.S]

10. (a) (i) Define a cooling correction as used in calorimeter experiments. (1 mark)

- (ii) State Newton's law of cooling.

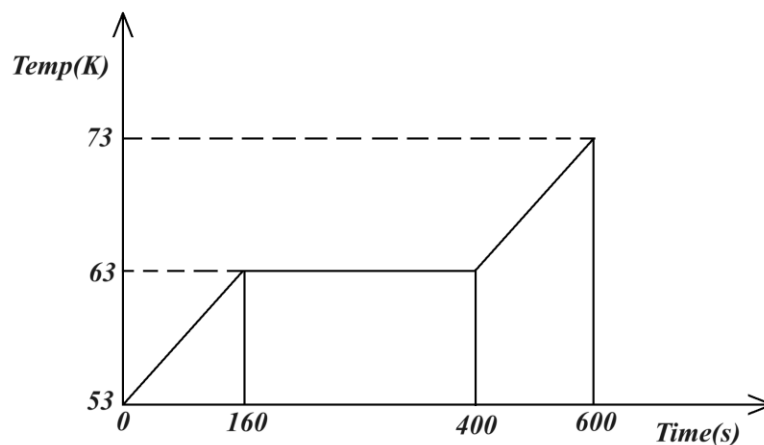
(1 mark)

- (b) (i) Using a well labeled diagram, describe an experiment to determine the specific heat capacity of a solid by the method of mixtures. (6 marks)

- (ii) State any assumption made in the experiment described in b(i) above.

(1 mark)

- (c) The graph in figure below refers to an experiment in which solid nitrogen absorbs heat at a constant rate and melts at 63 K



Given that the specific heat capacity of solid nitrogen is $1.6 \times 10^3 \text{ J kg}^{-1} \text{ K}^{-1}$, calculate the;

- (i) specific latent heat of fusion of nitrogen. (4 marks)
- (ii) specific heat capacity of liquid nitrogen. (3 marks)
- (d) Explain why cloudless nights feel cooler than cloudy ones. (4 marks)

[NAALYA S.S, BWEYOGERERE CAMPUS]

Section C

11. (a) (i) Draw a well labelled diagram of a Cathode Ray Oscilloscope (C.R.O) and state the operation of the major parts indicated. (6 marks)
- (ii) With the time base switched off, a sinusoidal voltage of root-mean-square value 7.072V is connected across the Y-plates, and a vertical trace of 4.0cm length is formed on the screen. Find the y-sensitivity setting of the C.R.O. (4 marks)
- (b) An alpha particle is accelerated through a potential difference of $3,000\text{V}$ to enter a magnetic field of flux density 0.6T at right angles. Given that the mass of the alpha particle is $6.64 \times 10^{-27} \text{ kg}$, find;
 - (i) The speed of the alpha particle as it enters the magnetic field. (3 marks)
 - (ii) The radius of the path taken by the particle within the magnetic field. (2 marks)
 - (iii) The electric field intensity that would be crossed with the magnetic field to cause the particle to move in a straight line within the magnetic field. (2 marks)
- (c) State any three differences between Cathode rays and Gamma rays. (3 marks)

[St. JOSEPH'S S.S, NAGGALAMA]

12. (a) Define the following: (3 marks)
 (i) A mole. (ii) Faraday's constant, (iii) Avogadro's number.
- (b) With use of a labelled diagram, describe Millikan's oil drop experiment to determine the charge of an electron. (6 marks)
- (c) An oil drop of radius $1.0 \times 10^{-3} \text{ cm}$ falls freely in air, mid-way between two vertical parallel metal plates, which are 0.50 cm apart, and its terminal velocity is 1.066 cms^{-1} . When a potential difference of $3,000 \text{ V}$ is applied between the plates, the path of the drop becomes a straight line inclined at an angle of $31^\circ 36'$ to the vertical. Find;
 (i) The horizontal velocity of the drop when the potential difference is applied on the plates. (2 marks)
 (ii) The charge on the oil drop. (3 marks)
 (iii) The density of air. (2 marks)
(Assume the viscosity of air to be $1.816 \times 10^{-5} \text{ kg m}^{-1} \text{ s}^{-1}$, density of oil $= 880 \text{ kgm}^{-3}$)
- (d) In Bohr's model of the Hydrogen atom, the ground state energy level is 13.6 eV . Find the frequency of the photon emitted when the electron transits from the third energy level to the ground state. (4 marks)
[CRANE HIGH SCHOOL, ENTEBBE]
13. (a) State the laws of photoelectric emission. (4 marks)
- (b) With use of a labeled diagram, describe a simple experiment to demonstrate photoelectric emission. (3 marks)
- (c) A metal surface has a work function of 4.0 eV . Calculate,
 (i) the longest wavelength of light that will cause emission of photoelectrons from the metal surface. (3 marks)
 (ii) the velocity of the most energetic photoelectrons emitted from the metal surface when radiation of wavelength $0.2 \mu \text{ m}$ is incident on it. (3 marks)
- (d) (i) Define mass defect of a nucleus. (1 mark)
 (ii) Explain the observations of Rutherford's scattering of alpha particles by a gold foil. (3 marks)
 (iii) Calculate the closest distance of approach when a 5.0 MeV proton approaches a gold nucleus. *(Atomic number of gold = 79)* (3 marks)
[JINJA PROGRESSIVE ACADEMY]
14. (a) Define **binding energy** of a nuclide (1 mark)
- (b) (i) Sketch a graph showing how binding energy per nucleon varies with mass number. (1 mark)

- (ii) Describe the main features of the graph in b (i) above. **(3 marks)**
- (c) Distinguish between **nuclear fission** and **nuclear fusion** and account for energy released. **(3 marks)**
- (d) With the aid of a labelled diagram, describe the working of an ionization chamber. **(6 marks)**
- (e) (i) What is meant by **half-life** and **decay constant** as applied to radioactivity? **(2 marks)**
- (ii) A Geiger Muller (GM) tube placed **20cm** from a **2.0g** of Radon $^{222}_{86}\text{Rn}$ gives a count rate of **85 counts per second**. If the entrance window of the GM tube has an area of **10cm²**, calculate the half-life of Radon. **(4 marks)**

[St. MARY'S COLLEGE, KISUBI]

Physics Paper Two (P510/2)

Section A

1. (a) (i) With the aid of a diagram explain what is meant by **chromatic aberration**. (2 marks)
- (ii) Explain how chromatic aberration is minimized. (3 marks)
- (b) (i) What is meant by **refractive index** of a material? (1 mark)
- (ii) Derive an expression for the focal length of a convex lens in terms of the radii of curvature of its surfaces and its refractive index. (4 marks)
- (c) A thin biconvex lens is illuminated a narrow beam of light of two colours; red and blue. If the refractive indices of the lens for red and blue light are respectively 1.514 and 1.524 and if the radii of curvature of its faces are 30cm and 20cm, calculate the separation of the foci for red and blue lights? (4 marks)
- (d) Describe an experiment to determine refractive index of a small quantity of a liquid using a convex lens and plane mirror. (4 marks)
- (e) Explain why an observer sees a spectrum of colors through raindrops during a sunny rain shower? (2 marks)

[SEETA HIGH SCHOOL, MAIN CAMPUS]

2. (a) (i) Define **principal focus** of a convex mirror. (1 mark)
- (ii) Show that the radius of curvature of a convex mirror is twice the focal length of the mirror. (3 marks)
- (b) Explain why parabolic mirrors instead of concave mirrors are used as reflectors in search lights. (2 marks)
- (c) Explain the terms **magnifying power** and resolving power in relation to a microscope? (2 marks)
- (d) A compound microscope consists of two thin lenses, an objective of focal length 20mm an eye piece of focal length 50mm, placed 220mm apart. If the final image is at infinity, Calculate the,
- (i) distance of the object from the objective. (4 marks)
- (ii) magnifying power of the system if the near point distance is 250mm from the eye. (2 marks)
- (e) (i) Derive an expression for magnifying power of an astronomical telescope in normal adjustment. (3 marks)
- (ii) Describe how an astronomical telescope can be modified to produce erect images of a distant object on earth. (3 marks)

[St. JOSEPH'S GIRLS S.S, NSAMBYA]

3. (a) (i) Define prism with reference to light propagation through a prism. **(1 mark)**
- (ii) Describe an experiment to determine the angle of minimum deviation of a prism using optical pins. **(5 marks)**
- (b) Define principal focus and radii of curvature of a convex lens. **(2 marks)**
- (c) (i) Show that the focal length, f , of a converging lens is given by $\frac{1}{f} = (n-1)\left(\frac{1}{r_1} + \frac{1}{r_2}\right)$, where n , is the refractive index of the material of the lens and r_1 and r_2 are the radii of curvature of the lens surfaces. **(4 marks)**
- (ii) A biconvex lens of radii of curvature 23cm is placed on a liquid film on a plane mirror. A pin clamped horizontally above the lens coincides with its image at a distance of 37.3cm above the lens. If the refractive index of the liquid is 1.4 , what is the refractive index of the material of the lens? **(4 marks)**
- (d) (i) Explain what is meant by spherical aberration. **(2 marks)**
- (ii) Explain why a parabolic mirror is used in search lights instead of a concave mirror. **(2 marks)**
- [NAMILYANGO COLLEGE]**

Section B

-
4. (a) (i) Distinguish between a **progressive wave** and a **stationary wave**. **(3 marks)**
- (ii) What are the main characteristics of a progressive wave motion? Give your reasons for believing that sound is propagated through the atmosphere as a longitudinal wave motion. **(2 marks)**
- (b) Describe an experiment to determine the end correction of a resonance tube. **(4 marks)**
- (c) A narrow tube of length 0.400m is closed at one end. A tuning fork of frequency 960Hz set into vibration just above the open end of the tube causes air in the tube to resonate with the tuning fork. If the speed of sound in air is 330ms^{-1} , determine the mode of vibration of air in the tube. **(3 marks)**
- (d) (i) Define **Doppler effect** and **beats**. **(2 marks)**
- (ii) Describe how the velocity of a star may be determined using the Doppler effect. **(3 marks)**
- (e) An observer, standing by a railway track, notices that the pitch of an engine's whistle changes in the ratio 5:4 on passing him. What is the speed of the engine? (*Velocity of sound in air = 340 m s^{-1}*) **(4 marks)**

[NABISUNSA GIRLS SCHOOL]

5. (a) Define the following as applied to sound (3 marks)
- (i) A tone
 - (ii) A harmonic
 - (iii) An overtone
- (b) (i) Describe an experiment to show that a stretched wire plucked in the middle vibrates in more than one mode simultaneously. (4 marks)
- (ii) A wire of length $0.3m$ and mass $5g$ is stretched to a tension of $170N$. When sounding its third harmonic, the wire resonates with an open pipe sounding its fundamental note. If the velocity of sound in air is $340ms^{-1}$, find the length of the pipe. (3 marks)
- (c) (i) Explain what is meant by beats. (2 marks)
- (ii) A pedestrian moving in a straight line between two stationary sources of sound, each of frequency $425Hz$, hears beats at the rate of $5.0s^{-1}$. Calculate the speed of the pedestrian, if the velocity of sound in air is $340ms^{-1}$. (3 marks)
- (d) (i) Distinguish between sound and light waves. (2 marks)
- (ii) Describe an experiment to show that sound is a mechanical wave. (3 marks)

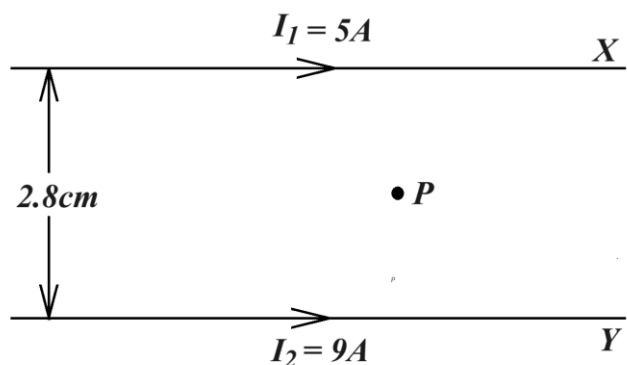
[St. MARIA GORRETI S.S, KATENDE]

6. (a) (i) State **Huygens's principle**? (1 mark)
- (ii) A beam of light is refracted at the boundary of two media. Using Huygen's principle show that the ratio of the sine of the angle of incidence to the sine of the angle of refraction is a constant. (3 marks)
- (b) What is meant by **diffraction** and **polarization** of light waves? (2 marks)
- (c) A transmission diffraction grating of spacing d is illuminated normally with light of wavelength λ . Derive the condition for occurrence of diffraction maxima. (3 marks)
- (d) Describe how polarized light can be produced by reflection. (4 marks)
- (e) Explain why it is possible to observe sound interference effects using two whistles, but not light interference using two lamps, even if the dimensions of the apparatus are suitably modified. (3 marks)
- (f) In a Young's double-slit experiment a total of 23 bright fringes occupying a distance of $3.9mm$ were visible in the travelling micro-scope. The microscope was focused on a plane which was 31 cm from the double slit and the wavelength of the light being used was $5.5 \times 10^{-7} m$. What was the separation of the double slit? (4 marks)

[KIWAWU S.S, MITYANA]

Section C

7. (a) Define **magnetic field strength** and **magnetic flux**. **(2 marks)**
- (b)



The figure above shows two parallel wires X and Y carrying currents of 5A and 9A respectively in the same direction, placed 2.8cm apart in air.

- (i) Sketch the magnetic field pattern around the wires. **(2 marks)**
 - (ii) Find the magnetic field strength at position P distance 0.9cm from Y. **(3 marks)**
 - (iii) Find the force on a wire 5m long through P and parallel to Y carrying current of 3A. **(3 marks)**
 - (iv) Explain the origin of force on wire P in (iii) above. **(3 marks)**
- (c) Define the following as applied to the earth's magnetic field:
- (i) Angle of dip **(1 mark)**
 - (ii) Magnetic meridian **(1 mark)**
- (d) Describe how the angle of dip in the earth's magnetic field can be determined using a search coil and a ballistic galvanometer. **(5 marks)**

[KABOWA HIGH SCHOOL]

8. (a) (i) State the **laws of electromagnetic induction**. **(2 marks)**
- (ii) A metal block suspended by an insulating thread is set to oscillate across a field from electromagnetic source. Explain why the oscillation takes only a short time when the field is on and yet lasts longer when the field is off. **(3 marks)**
- (b) A coil of N turns and area A is connected to a ballistic galvanometer and then suspended with its plane perpendicular to a magnetic field of flux density B. If the total resistance of the coil's circuit is R, Show that when the coil is rotated

through 180° , about its diameter, the charge, Q , caused to circulate in the circuit is given by $Q = \frac{2NBA}{R}$. (4 marks)

- (c) Describe how a d.c generator works. (5 marks)
- (d) (i) Define **back emf**. (1 mark)
- (ii) A coil of a motor has *100 turns* each of area 12cm^2 and total resistance 3Ω . The coil is mounted in a radial magnetic field of flux density 0.74T . When the coil is connected to a d.c supply of 220V , it draws a current of 1.5A . Calculate the maximum angular velocity the motor attains. (3 marks)
- (e) An iron cored coil is connected in series with a switch and d.c source of large voltage. Explain why sparks are observed at the contacts when the switch is opened. (2 marks)

[St. JOSEPH OF NAZARETH HIGH SCHOOL]

9. (a) (i) Distinguish between **self induction** and **mutual induction**. (3 marks)
- (ii) An air- cored inductor is connected in series with a switch and a d.c source. The switch is closed and left for some time. Explain why a spark is observed across the switch contacts when the switch is reopened. (3 marks)
- (b) Describe with the aid of a diagram, how the magnetic flux density between the poles of a strong magnet can be measured. (5 marks)
- (c) (i) Explain how eddy currents are produced. (2 marks)
- (ii) Describe one application of eddy currents. (3 marks)
- (d) A coil of *500 turns* and mean area $3.0 \times 10^{-2}\text{m}^2$ is rotated at a uniform rate of *400 revolutions per minute* about an axis perpendicular to a uniform magnetic field of flux density 0.7T . If the terminals of the coil are connected across a resistor of 1.5Ω , calculate the maximum current that flows in the circuit. (4 marks)

[BULO PARENTS S.S.]

10. (a) Define **impedance** and **root mean square value** as applied to a.c (2 marks)
- (b) (i) Explain what is meant by **resonance** in an alternating current circuit containing an indicator, resistor and capacitor in series. (2 marks)
- (ii) Give an application of effect in *b(i)* and explain it (3 marks)
- (c) An alternating current of $I = I_0 \sin \omega t$ is supplied in a circuit containing a capacitor of capacitance C .
- (i) Derive the expression for the voltage across the capacitor. (2 marks)
- (ii) Sketch the variation of voltage across the capacitor and current in the circuit with time and explain the phase relationship. (3 marks)

- (d) A $100\mu F$ capacitor is joined in series with a $2.5V$, $0.30A$ lamp and a 50 Hz supply. Calculate the p.d ($r.ms$) of the supply to light the lamp to its normal brightness. **(4 marks)**
- (e) Describe how a full wave rectifier meter works. **(4 marks)**
[TRINITY COLLEGE, NABBINGO]

Section D

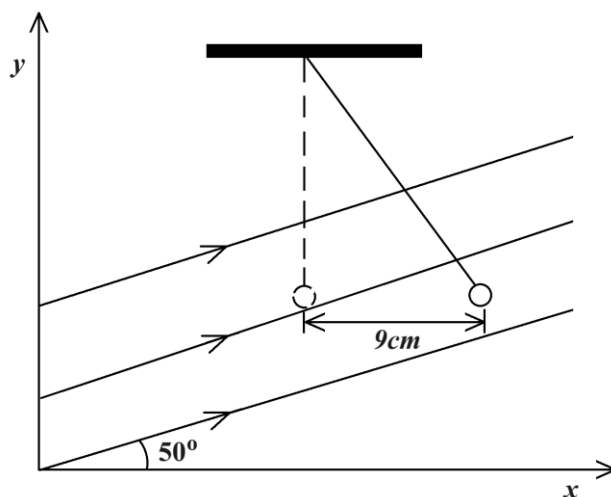
11. (a) Define **electrical resistivity** and show that its **S.I unit is Ωm** . **(2 marks)**
- (b) A cell of *e.m.f*, E , and internal resistance, r , drives current through a resistor of resistance, R , connected in series with it. Derive the expression for the efficiency of the circuit. **(3 marks)**
- (c) (i) Explain the principle of operation of a slide wire potentiometer. **(3marks)**
(ii) Explain the modifications necessary to use an ordinary slide wire potentiometer for measuring thermoelectric emf. **(2 marks)**
- (d) Describe how a potentiometer is used to measure unknown resistance. **(4 marks)**
- (e) In an experiment to investigate the variation of resistance with temperature, a nickel wire and a 10Ω standard resistor were connected in the gaps of a metre bridge. When the nickel wire was at $0^\circ C$, a balance point was found $40cm$ from the end of the bridge adjacent to the nickel wire. When it was at $100^\circ C$, the balance point occurred at $50cm$. Calculate the;
(i) temperature of the nickel wire when the balance point was $42cm$. **(4 marks)**
(ii) resistivity of nickel at this temperature if the wire was then $150cm$ long and of cross – sectional area $2.5 \times 10^{-4} cm^2$. **(3 marks)**
- (f) State and explain one important property of a conductor used to make heating elements. **(2 marks)**

[UGANDA MARTYRS S.S. NAMUGONGO]

12. (a) (i) What is meant by **action at a point**. **(2 marks)**
(ii) A negatively charged rod is placed on the cap of a neutral gold leaf electroscope, and then after it is withdrawn. A sharp pin, while resting on its flat surface is placed on the cap of this gold leaf electroscope with its sharp end pointing away. Explain what is observed. **(3 marks)**
- (b) (i) State **Gauss' law** of electrostatics **(1 mark)**

- (ii) Use the law in b(i) above to show that the electric flux, ϕ , due to a charged metal plate is given by $\phi = \frac{\sigma}{\epsilon_0}$, where σ , and ϵ_0 are surface charge density and permittivity of free space respectively. (2 marks)

- (c) The figure below shows a small sphere of mass $60g$ initially hanging vertically from an insulating thread $16cm$ long. A uniform electric field of magnitude $1.24 \times 10^5 NC^{-1}$ applied at 50° to the horizontal displaces the sphere by $9cm$ horizontally.



Determine the;

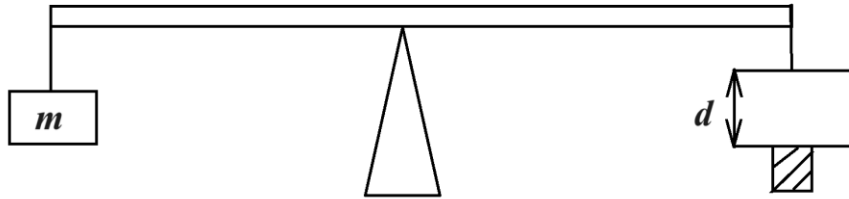
- (i) tension in the thread. (3 marks)
 (ii) magnitude of the charge on the sphere. (4 marks)
- (d) (i) What is meant by the term **equipotential surface** and give two examples of equipotential surfaces. (2 marks)
 (iii) Show that electric field lines are always perpendicular to the surface of charged conductors. (3 marks)

[SEROMA CHRISTIAN HIGH SCHOOL]

13. (a) What is meant by **capacitance of a capacitor** and define the S.I unit in which it is measured. (2 marks)
- (b) (i) Show that when a battery is used to charge a capacitor through a resistor, the heat dissipated in the circuit is equal to the energy stored on the capacitor. (4 marks)
 (ii) Explain how the strength of the electric field at any point is related to the electric potential at and near the point. (3 marks)
- (c) The circular plates A and B of a parallel plate air capacitor have each an effective diameter of $10.0cm$ and are $2.0mm$ apart. The plates C and D of a similar capacitor have each an effective diameter of $12.0cm$ and are $3.0mm$ apart. A is

earthed, B and C are connected together and D is connected to the positive pole of a 120V battery whose negative pole is earthed. Calculate the;

- (i) The combined capacitance of the arrangement. (3 marks)
- (ii) The energy stored in the arrangement. (2 marks)
- (d) Describe an experiment to determine permittivity of a dielectric using a vibrating reed switch circuit. (5 marks)
- (e) One of the plates of a parallel plate capacitor is suspended at one end of a light uniform rod pivoted at its middle point carrying mass m at the other end.

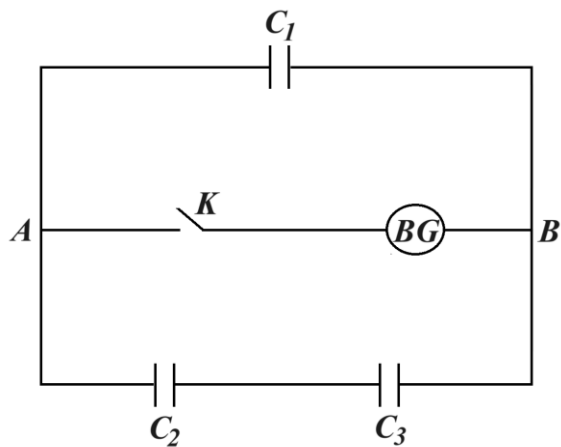


The plates have 120cm^2 each and are separated by $d = 40\text{cm}$. Calculate the;

- (i) p.d across the plates required to balance the rod horizontally when $m = 2.66 \times 10^{-6}\text{kg}$. (3 marks)
- (ii) surface charge density in the plates. (2 marks)

[KIBULI S.S.]

14. (a) Define **dielectric strength**. (1 mark)
- (b) Describe an experiment to investigate the effect of increasing the area of overlap of the plates of a capacitor on capacitance, using a ballistic galvanometer. (4 marks)
- (c) (i) Derive the expression for the energy stored in a capacitor of capacitance C carrying charge of Q . (4 marks)
- (ii) A parallel plate capacitor is charged by connecting it to a battery. Explain the effect on energy stored when the plate separation is now reduced, when the battery is still on. (3 marks)
- (iii) Explain how presence of a dielectric in a capacitor affects capacitance. (4 marks)
- (d) The figure below shows three identical capacitors, of capacitance $3\mu\text{F}$ each, with air between the plates, connected in parallel with a ballistic galvanometer of charge sensitivity 4 divisions per μC . With switch K open, a dielectric of relative permittivity 2.3 is inserted in C_3 and the system is charged so that the p.d across AB is 60V



Find the maximum deflection of the BG when K is closed. **(4 marks)**

[BLESSED SACRAMENT S.S, KIMAANYA]

END

Important information to note

- 1. All presentations are to be done in power point.**
- 2. Font type of “Times New Roman” preferred and font size 44 at minimum for better visibility.**
- 3. All power point documents are to be received at a central desk on arrival**

SOLUTIONS FOR THE

A' LEVEL PHYSICS SEMINAR

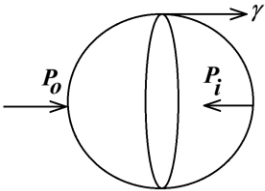
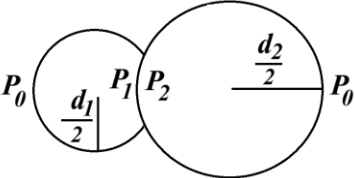
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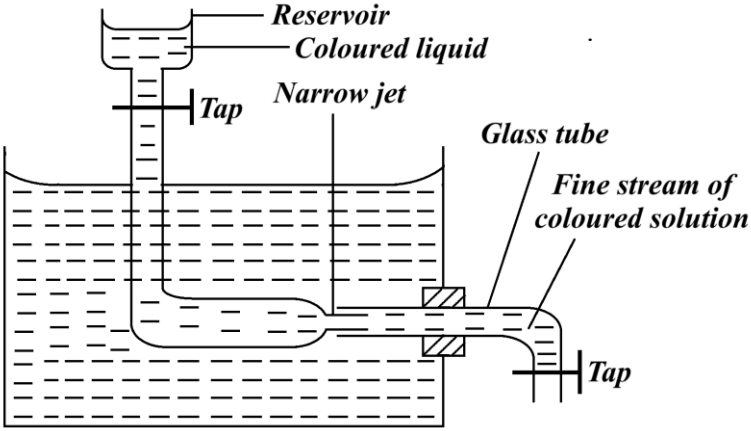
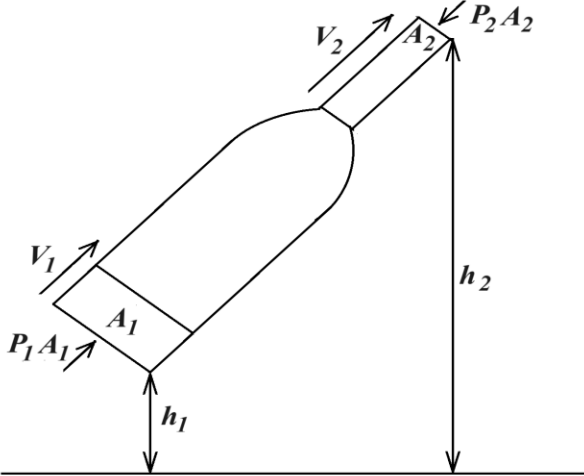
NAMUGONGO

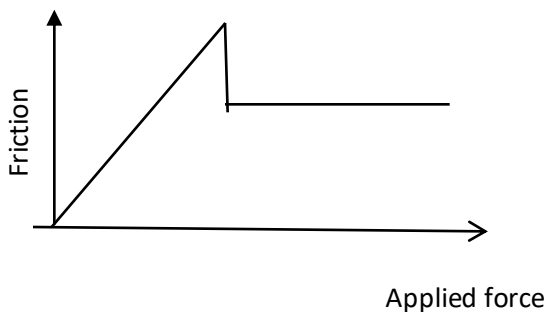
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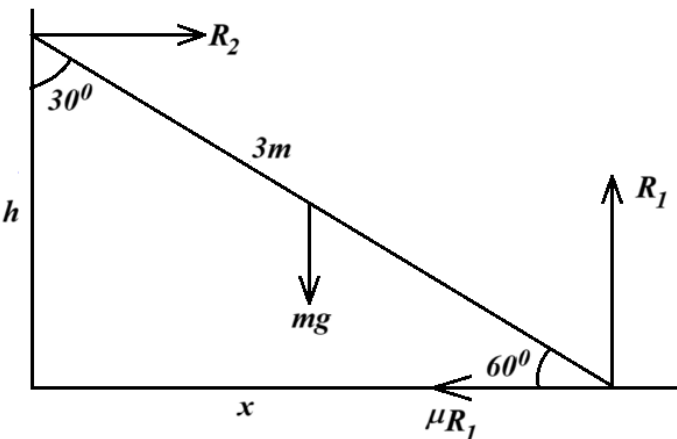
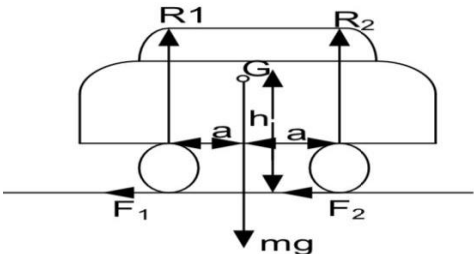
PHYSICS PAPER ONE

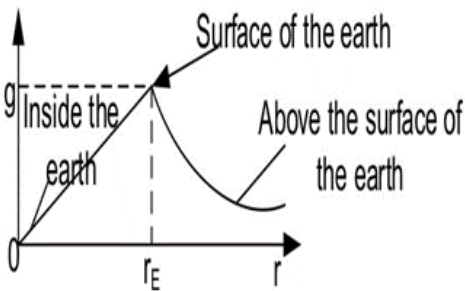
Qn.	Approach	Remarks
1. a i)	During an elastic collision , kinetic energy is conserved but during an inelastic collision , kinetic energy is not conserved	
ii)	Momentum is the product of mass of a body and its velocity Impulse is the change in the momentum of a body.	
iii)	$F \propto \frac{mv - mu}{t}$, $F = \frac{mv - mu}{t}$, hence $mv - mu = Ft$	
b i)	If no external force acts on a system of colliding bodies, their total momentum before collision is equal to their total momentum after collision.	
ii)	If two bodies of masses m_1 and m_2 moving with respective velocities u_1 and u_2 collide for a time t and move with velocities v_1 and v_2 after collision, then from Newton's 3 rd law, <i>body1</i> exerts a force F_{12} on <i>body2</i> and <i>body2</i> reacts with force F_{21} From Newton's 2 nd law $F_{12} = k \frac{(m_2 v_2 - m_2 u_2)}{t} \text{ and } F_{21} = k \frac{(m_1 v_1 - m_1 u_1)}{t}$ From 3 rd law, $F_{12} = -F_{21}$ $k \frac{(m_2 v_2 - m_2 u_2)}{t} = -k \frac{(m_1 v_1 - m_1 u_1)}{t}$ $m_2 v_2 - m_2 u_2 = -m_1 v_1 + m_1 u_1$ $m_2 v_2 + m_1 v_1 = m_1 u_1 + m_2 u_2$	
c i)	$mgh = \frac{1}{2}mv^2$, $v = \sqrt{2gh} = \sqrt{2 \times 9.81 \times 3} = \underline{\underline{7.67ms^{-1}}}$	
ii)	$u = \sqrt{2 \times 9.81 \times 5} = 9.90 ms^{-1}$ $F = \frac{mv - mu}{t} = \frac{0.5(7.67 + 9.90)}{0.01} = \underline{\underline{878.5N}}$	
d.	Conservative forces are ones for which the work done to move a body through a closed loop is zero, whereas non-conservative forces are ones for which the work done to move a body through a closed loop is not zero e.g. Conservative – Gravitational force, magnetic force, electric force, non-conservative – Friction, Viscous force.	
2. a.	Surface tension is the force acting normally per unit length on one side of a line drawn in the liquid surface.	
b.i)	Radius of the small drop = $0.5 \times 10^{-3}m$ Volume of the big drop $= 1000 \times \frac{4}{3} \times 3.14 \times (0.5 \times 10^{-3})^3 = \frac{4}{3} \times 3.14 \times R^3$ Radius of big drop = $[1000 \times (0.5 \times 10^{-3})^3]^{\frac{1}{3}} = 5 \times 10^{-3}m$ Surface area of big drop	

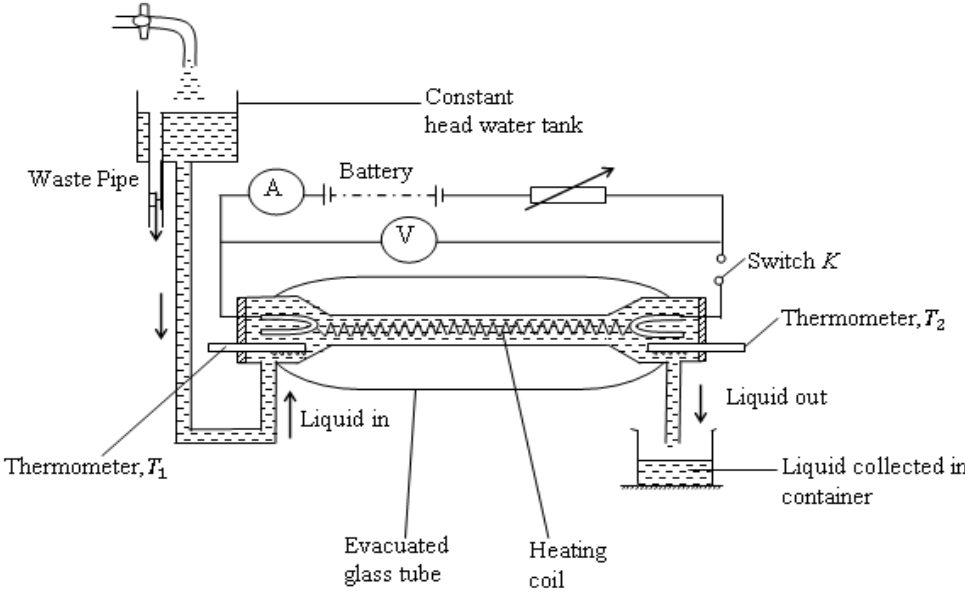
	$= 1000 \times 4 \times 3.14 \times (5 \times 10^{-3})^2 = 3.14 \times 10^{-4} m^2$ $\text{Area of small drops} = 1000 \times 4 \times 3.14 \times (0.5 \times 10^{-3})^2$ $= 3.14 \times 10^{-3} m^2$ $\text{Change in Area} = 3.14 \times 10^{-3} - 3.14 \times 10^{-4}$ $= 2.826 \times 10^{-3} m^2$ $\text{Energy released} = \gamma \Delta A = 2.826 \times 10^{-3} \times 7.2 \times 10^{-4}$ $= \underline{\underline{2.035 \times 10^{-6} J}}$	
ii)	 $\pi r^2 P_o + 2(2\pi r)\gamma = \pi r^2 P_i$ $\Rightarrow P_i - P_o = \frac{4\gamma}{r}$	
iii)	 $P_2 - P_o = \frac{4\gamma}{d_2/2} = \frac{8\gamma}{d_2}, \quad P_1 - P_o = \frac{4\gamma}{d_1/2} = \frac{8\gamma}{d_1}$ $\frac{4\gamma}{r} = P_1 - P_o = \frac{8\gamma}{d_1} - \frac{8\gamma}{d_2} = 8\gamma \frac{(d_2 - d_1)}{d_1 d_2}$ $\Rightarrow r = \frac{d_1 d_2}{2\gamma(d_2 - d_1)}$	
c i)	Streamline flow is the flow of a fluid in which molecules that are equidistant from the axis of flow move with the same velocity parallel to the axis of flow while, Turbulent flow is the flow of a fluid in which molecules that are equidistant from the axis of flow move with different velocities	

ii)	 • When the taps are opened at low velocities of flow, a thin coloured stream of liquid is observed flowing along the horizontal tube and this indicates streamline flow. • As the rate of flow of water is increased, a stage is attained when the colouring fills the whole tube and this indicates turbulent flow	
3. a. i)	Bernoulli's principle states that the sum of the pressure at any of an incompressible non-viscous fluid under streamline flow plus the kinetic energy per unit volume plus the potential energy per unit volume is constant	
ii)	 $P_1 A_1 V_1 - P_2 A_2 V_2 - \frac{1}{2} A_2 V_2 \rho V_2^2 - \frac{1}{2} A_1 V_1 \rho V_1^2 + A_2 V_2 \rho g h_2 - A_1 V_1 \rho g h_1$ But, $A_1 V_1 = A_2 V_2$ Therefore, $P_1 - P_2 = \frac{1}{2} \rho V_2^2 - \frac{1}{2} \rho V_1^2 + \rho g h_2 - \rho g h_1$ $P_1 + \frac{1}{2} \rho V_1^2 + \rho g h_1 = P_2 + \frac{1}{2} \rho V_2^2 + \rho g h_2$	
b i)	Coefficient of viscosity is the tangential force per unit area per unit velocity gradient. Units: Nsm^{-2}	

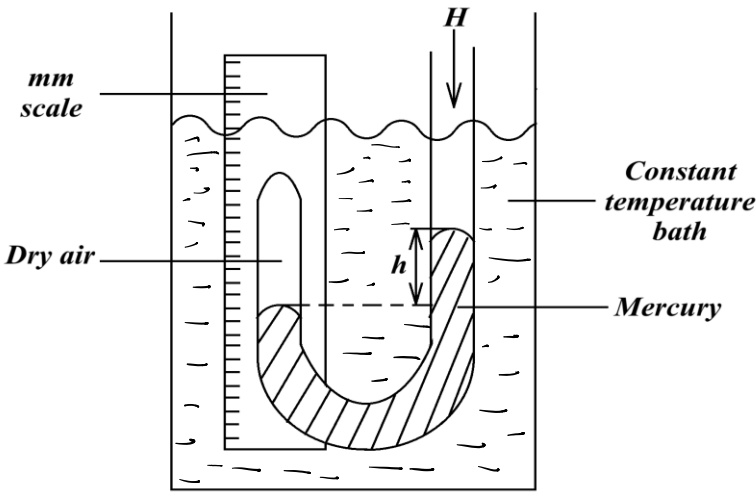
ii)	In liquids, viscosity depends on intermolecular forces of attraction. As temperature increases, the intermolecular forces reduce, hence viscosity reduces.	
iii)	$A_1 V_1 = A_2 V_2$ $10 \times 0.2 = 2.5 V_2$ $V_2 = 0.8 \text{ ms}^{-1}$ $P_A - P_B = \frac{1}{2} \rho (0.8^2 - 0.2^2)$ $= \frac{1}{2} \times 1000 \times (0.8^2 - 0.2^2) = 300 \text{ Pa}$	
c i)	Lamina flow is the flow of a fluid in which layers of fluid that are equidistant from the axis of flow move with the same velocity parallel to the axis of flow. Turbulent Flow is the flow of a fluid in which layers of the fluid that are equidistant from the axis of flow move with different velocities.	
ii)	The Filter pump The filter pump has a narrow section in the middle so that water from the tap flows faster here. This causes a drop in pressure near it and air therefore flows in from the side tube to which the vessel is connected. The air and water together are expelled through the bottom of the pump.	
4. a i)	Limiting friction is the maximum friction that exist between two surfaces in contact just before relative motion starts	
ii)		
b i)	$F = mg \sin \theta + mg \cos \theta$ $= 2000 \times 9.81(\sin 20 + 0.2 \cos 20) = \underline{10397.8 \text{ N}}$ $P = FV = 10397.8 \times 15 = 1.56 \times 10^5 \text{ W}$	
c	- The resultant force on the body is zero. - The sum of the clockwise moments about any point is equal to the sum of the anticlockwise moment about the same point	
d i)		

		
ii)	$h = 3 \cos 30 = 2.6m$ $x = 3 \cos 60 = 1.5m$ $R_1 = mg = 5 \times 9.81$ Taking moment about P: $F \times 2.6 + 5 \times 9.8 \times 1 = R_1 \times 1.5$ $2.6F = 5 \times 9.81(1.5 - 1)$ $F = \underline{9.3N}$ Reaction at the ground $R = (9.43^2 + (5 \times 9.81)^2)^{\frac{1}{2}} = \underline{49.95N}$	
e i)	A couple is a pair of equal parallel forces acting points on a body in opposite directions	
ii)	$W = F \times D$ $D = 10 \times 2\pi = 37.68m$ $W = 4 \times 37.68 = \underline{150.72J}$	
5. a i)	Moment of inertia is the sum of the product of the masses of the particles of a rotating body and the square of their respective distances from the axis of rotation. $\sum mr^2$	
b i)	$I = (0.01 \times 0.25^2) + (0.01 \times 0.25^2) + (0.01 \times 0.5^2)$ $+ (0.01 \times 0.5^2)$ $= 6.25 \times 10^{-3} kgm^2$	
ii)	$8rev/s = 8 \times 2\pi rad s^{-1}$ $\Rightarrow kE = \frac{1}{2} I \omega^2 = \frac{1}{2} \times 6.25 \times 10^{-3} \times (8 \times 2\pi)^2 = 7.89J$	
c i)	 R_1 and R_2 are Normal Reactions F_1 and F_2 are Frictional Forces	

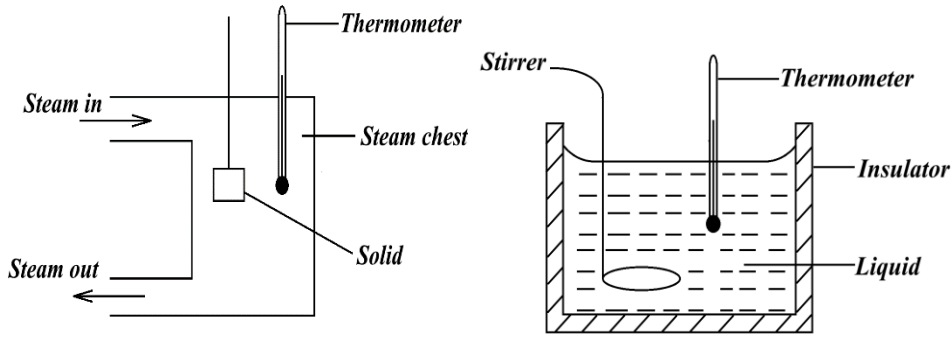
	Mg is the Weight of the Car	
ii)	$F_1 + F_2 = \frac{mV^2}{r} \dots\dots (i)$ $R_1 + R_2 = mg \dots\dots (ii)$ $F_1 h + F_2 h + R_1 a = R_2 a \Rightarrow R_2 - R_1 = \frac{mV^2 h}{ra} \dots\dots (iii)$ $(ii) - (iii), mg - \frac{mV^2 h}{a} = 2R_1 = m \left(g - \frac{V^2 h}{ra} \right)$ For safety of the car, $\frac{V^2 h}{ra} \leq g \Rightarrow V_{\max} = \sqrt{\frac{gra}{h}}$ Where a, is the distance half way between the tyres and h, is the height of the centre of gravity above the ground.	
d.	Racing cars can move faster on banked circular tracks than on level tracks because there is a larger value of Centripetal force since it is provided by both the component of friction and the component of normal reaction.	
6. a i)	✓ Planets describe ellipses about the sun as one focus ✓ The line joining a planet to the sun sweeps out equal areas in equal time intervals ✓ The square of the period of revolution of the planet round the sun, is proportional to the cube of their mean distance of separation.	
ii)	For any two bodies in the universe, there is a force of attraction between them which is proportional to the product of their masses and inversely proportional to the square of their distance of separation.	
b i)		
ii)	$\frac{GMm}{r^2} = mg \Rightarrow g = \frac{GM}{r^2}$ Effective mass of the Earth $= \frac{4}{3} \pi (R_e - r)^3 \rho$ $\Rightarrow g = G \times \frac{4}{3} \pi \frac{(R_e - r)^3 \rho}{(R_e - r)^2}$ $g = \frac{4}{3} G \pi (R_e - r) \rho$	

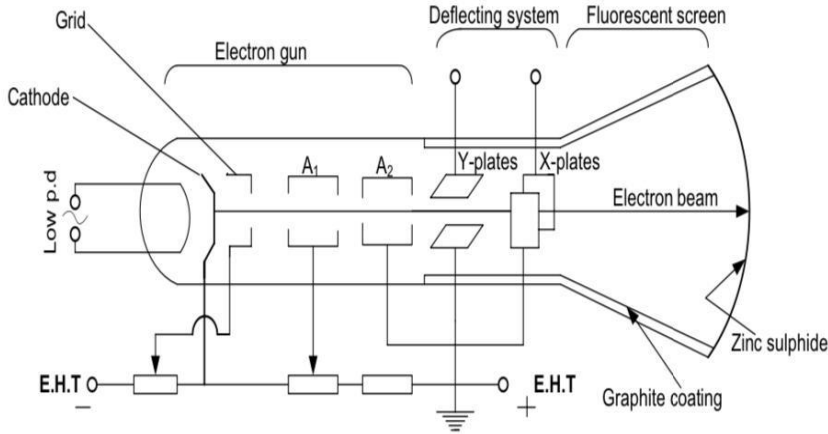
c i)	If orbital radius of the Earth is R_e, then orbital radius of Mars $R_m = 1.53R_e$ $\frac{GMm}{R_e^2} = m\omega^2 R_e, \text{ but } \omega = \frac{2\pi}{T_e} \Rightarrow GM = \frac{4\pi^2}{T_e^2} R_e^2$ Also, $GM = \frac{4\pi^2}{T_m^2} R_m^2 \Rightarrow \frac{4\pi^2}{T_e^2} R_e^3 = \frac{4\pi^2}{T_m^2} (1.53R_e)^2$ $\Rightarrow T_m = \sqrt{(1.53^3 T_e^2)} = \sqrt{1.53^3 \times 365^2} = \underline{690.8 \text{ days}}$	
d i)	Parking orbit is the path of a satellite about the Earth, whose period of revolution is the same as the period of rotation of the Earth about its axis i.e. 24hours	
ii)	Artificial satellites are used for; Navigation, Global communication, Weather forecast, Study of the universe, Scientific research	
e i)	$M.E = \frac{GMm}{2R}$, but $R = 6.4 \times 10^6 + 3.59 \times 10^7$ $= 4.23 \times 10^7 \text{ m}$ $\Rightarrow M.E = \frac{6.67 \times 10^{-7} \times 5.97 \times 10^{24} \times 100}{2 \times 4.23 \times 10^7} = \underline{4.71 \times 10^8 \text{ J}}$	
ii)	Satellite will move to an orbit of smaller radius and its velocity or kinetic energy increases.	
7. a	Specific heat capacity is the amount of heat required to raise the temperature of a 1kg mass of a substance by 1K. Unit: $\text{JKg}^{-1}\text{K}^{-1}$	
b	 The diagram shows a specific heat capacity apparatus. A constant head water tank feeds liquid into a waste pipe and a main tube. The main tube contains an evacuated glass tube with a heating coil inside. Liquid flows from left to right through the tube. Thermometers T_1 and T_2 are placed before and after the heating coil. A battery, ammeter (A), voltmeter (V), and switch K are connected to the heating coil. Liquid exits the tube and is collected in a container. - The liquid is allowed to flow through the apparatus at a constant rate. - The switch is closed and the current I and voltage V are recorded. - The experiment is left to run until a steady state is attained.	

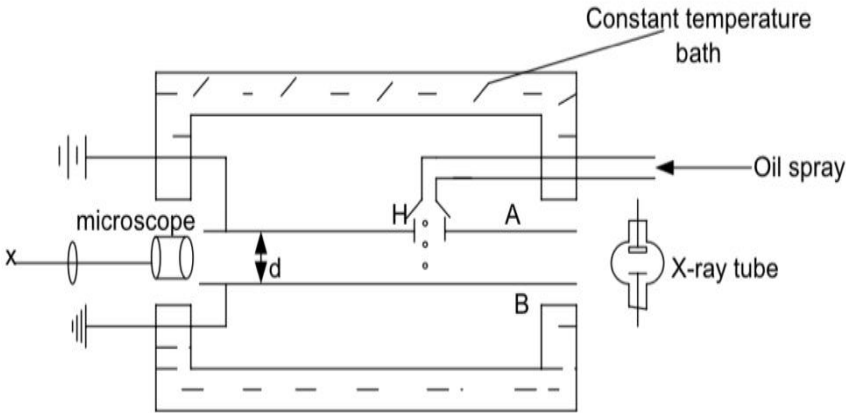
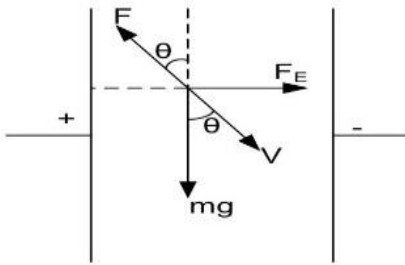
	- The steady state temperatures θ_1 and θ_2 are recorded from the thermometers T_1 and T_2 respectively. - The mass M, of the liquid collected in time t is recorded. - The rheostat is adjusted for new values of current I' and voltage V'. - The rate of flow is adjusted so as to have the same steady temperatures θ_1 and θ_2. The new mass M' collected in the same time t is recorded. - The specific heat capacity of the liquid; $C = \frac{(V'I' - VI)t}{(M' - M)(\theta_2 - \theta_1)}$	
c i)	$IV = mc(\theta_2 - \theta_1) + h$ $\Rightarrow 35 \times 2 = 4.07 \times 10^{-2}c(29 - 25) + h$ $h = 70 - 68.47 = 1.53 \text{Js}^{-1}$	
ii)	From $C = \frac{(V'I' - VI)t}{(M' - M)(\theta_2 - \theta_1)}$ $C = \frac{(35 \times 2 - 26 \times 2)10}{(1.07 \times 10^{-2})(29 - 25)} = 4.206 \times 10^3 \text{JKg}^{-1}\text{K}^{-1}$	
iii)	$0.035L_v + 4263 = 79,968 + 3360$ $L_v = \frac{79065}{0.035} = 2.259 \times 10^6 \text{JKg}^{-1}$	
8. a i)	Isobaric - compression or expansion at constant pressure Isovolumetric – change in pressure and temperature at constant volume	
ii)	Isobaric: $\frac{V}{T} = \text{Constant}$ Isovolumetric: $\frac{P}{T} = \text{Constant}$	
b. i)		
ii)	$T_1 = 25^\circ\text{C} = 298\text{K}, V_1 = V, P_1 = 1.01 \times 10^5 \text{Pa}$ $T_2 = 596\text{K}, V_2 = 2V, P_2 = 1.01 \times 10^5 \text{Pa}$ $T_3 = 200\text{K}, V_3 = 2V, P_3 = 3.39 \times 10^4 \text{Pa}$ $T_4 = 263.9\text{K}, V_4 = V, P_4 = ??$ $\frac{V}{298} = \frac{2V}{T_2} \Rightarrow T_2 = 2 \times 298 = 596\text{K}$	

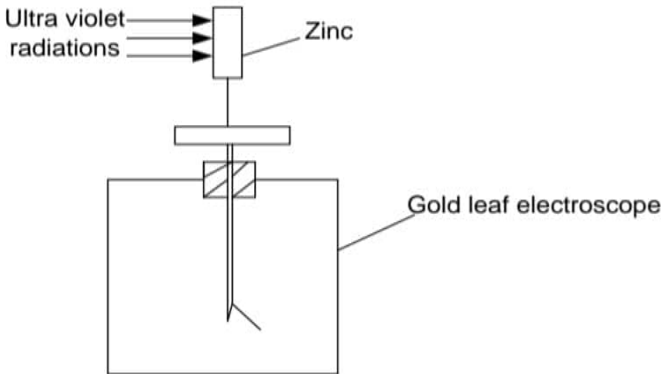
	$\frac{P_2}{T_2} = \frac{P_3}{T_3}, \quad T_4 V_4^{\gamma-1} = T_3 V_3^{\gamma-1} \text{ and } P_4 V_4^{\gamma} = P_3 V_3^{\gamma}$ $\frac{1 \cdot 01 \times 10^5}{596} = \frac{P_3}{200} \Rightarrow P_3 = 3.39 \times 10^4 \text{ Pa}$ $T_4 = \frac{200 \times 2^{0.4} \times V^{0.4}}{V^{0.4}} = 263 \cdot 9 \text{ K}$ $P_4 = \frac{P_3 V_3^{\gamma}}{V_4^{\gamma}} = \frac{3.39 \times 10^4 \times 2^{1.4} \times V^{1.4}}{V^{1.4}} = 8.95 \times 10^4 \text{ Pa}$	
d.i)	Boyle's law states that the pressure of a fixed mass of a gas is inversely proportional to its volume at constant temperature	
ii)	 • Pressure of the dry air, $H + h$ is measured and recorded • The volume V is obtained from the mm scale • The procedure is repeated by adding more mercury in the open limb • A graph of pressure against $\frac{1}{V}$ is plotted. • A straight line shows that $P \propto \frac{1}{V}$	
9. a. i)	✓ Intermolecular forces of attraction are negligible ✓ The volume of the molecules is negligible compared to the volume of the gas ✓ Molecules are like perfect elastic spheres ✓ The duration of a collision is negligible compared to the time between collision	
ii)	Dalton's law states that the pressure of a mixture of gases that do not chemically react is equal to the sum of the partial pressures of the individual gases.	
iii)	$P = \frac{1}{3} \rho \overline{c^2} \Rightarrow P = \frac{1}{3} \frac{Nm}{V} \overline{c^2} \Rightarrow N = \frac{3VP}{m\overline{c^2}}$ For a mixture of gases, $N = N_1 + N_2 + N_3$	

	$\Rightarrow N = \left(\frac{3VP_1}{m_1 \overline{c_1^2}} \right) + \left(\frac{3VP_2}{m_2 \overline{c_2^2}} \right) + \left(\frac{3VP_3}{m_3 \overline{c_3^2}} \right)$ But at the same temperature, $m_1 \overline{c_1^2} = m_2 \overline{c_2^2} = m_3 \overline{c_3^2} = m \overline{c^2}$ $\Rightarrow \frac{m \overline{c^2} N}{3v} = P_1 + P_2 + P_3 \text{ but } \frac{m \overline{c^2} N}{3v} = P$ $\Rightarrow P = P_1 + P_2 + P_3$	
b. i)	When the temperature increases, the pressure will increase. This is because the kinetic energy of the gas molecules increases and they collide with the walls of the container with a higher velocity thus a higher rate of change in momentum. Since the volume is constant, the molecules will move to the walls in a shorter time and the number of collisions made per second will also increase hence a high pressure.	
ii)	Water boils when its S.V.P is equal to the atmospheric pressure. The atmospheric pressure at the top of a mountain is smaller than that at the bottom of the mountain. Therefore, water and the top of the mountain will boil at a lower S.V.P than at the bottom of the mountain. S.V.P increases with increase in temperature, this implies that lower S.V.P is attained at a lower temperature hence water boils at a lower temperature on top of a mountain than at the bottom.	
c. i)	For A $\frac{3 \times 10^5 \times 500}{283} = \frac{P_A \times 750}{283}, \quad P_A = 2 \times 10^5 Pa$ For B $\frac{1 \times 10^5 \times 250}{373} = \frac{P_B \times 750}{373}, \quad P_B = 3.3 \times 10^4 Pa$ Total Pressure <u>$= 2.33 \times 10^5 Pa$</u>	
ii)	$PV = nRT \Rightarrow n = \frac{PV}{T}$ $n = n_A + n_B$ $\left(\frac{3 \times 10^5 \times 500}{8.31 \times 283} \right) + \left(\frac{1 \times 10^5 \times 250 \times 10^{-6}}{8.31 \times 373} \right)$ $= \frac{2.33 \times 10^{-6} \times 750 \times 10^{-6}}{8.31 \times T}$ $\Rightarrow T = \underline{\underline{292.7K}}$	
10.a i)	Cooling correction is a small temperature added to the observed maximum temperature during a heat experiment to account for the amount of heat lost to the surrounding during the experiment.	

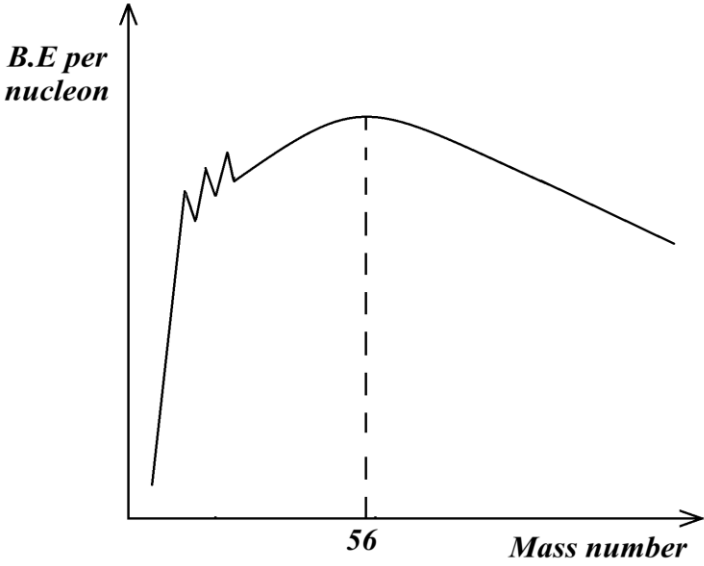
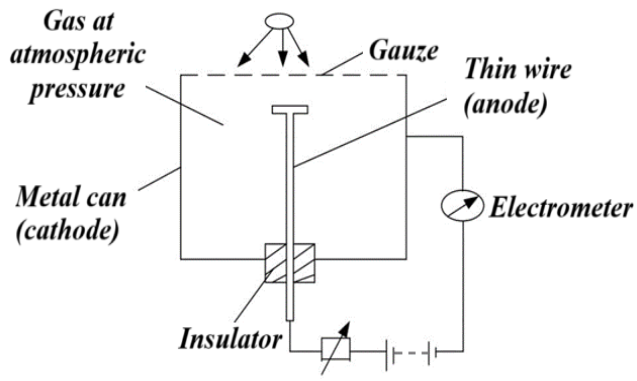
ii)	Newton's Law of Cooling states that the rate of heat loss of a body under forced convection, is proportional to the body's excess temperature above that of the surrounding	
b. i)	 Procedure ✓ The mass m_s of the solid whose heat is required capacity is measured and recorded. ✓ The solid is heated in a stem chest to a temperature θ_3. ✓ It is then transferred into a calorimeter of mass m_c and specific heat capacity c_c containing a liquid of m_L and specific heat capacity c_L at initial temperature θ_1. ✓ The contents of the calorimeter are stirred and continuously and the observed temperature θ_2 is recorded. <i>Heat lost by the solid</i> <i>= heat gained by liquid + calorimeter</i> $m_s c_s (\theta_3 - \theta_2) = m_L c_L (\theta_2 - \theta_1) + m_c c_c (\theta_2 - \theta_1)$ $c_s = \frac{(m_L c_L + m_c c_c)(\theta_2 - \theta_1)}{m_s (\theta_3 - \theta_2)}$	
ii)	No heat lost to the surrounding	
c. i)	$mc \frac{\Delta\theta}{\Delta t} = \frac{m \times 1600 \times 10}{(160 - 0)} = 100m = \text{rate of absorption}$ <i>Heat absorbed during melting</i> = $100m \times (400 - 160)$ = mL $L = 100 \times 240 = 24,000 \text{ J kg}^{-1}$	
ii)	Let the specific heat capacity of liquid nitrogen be c . <i>Heat absorbed</i> ; $mc \times 10 = 100m \times (600 - 400)$ = $2000 \text{ J kg}^{-1} \text{ K}^{-1}$	
d	During the day, the earth absorbs heat from the sun and at night when the temperature falls, it radiates heat to the atmosphere. On a cloudless night, the heat radiated is lost to the atmosphere and the earth cools. On a cloudy night, the radiated heat is reflected back to the earth and it feels warm.	

11.a i)	 ✓ The filament heats the cathode to emit electrons by thermionic emission. ✓ The anodes accelerate the electrons and focus them into a fine beam. ✓ X-plates deflect the electrons horizontally. ✓ Y-plates deflect the electrons vertically. ✓ The screen displays the beam formation. ✓ The grid controls the number of electrons striking the screen per second and hence controls the brightness of the spot formed on the screen.									
ii)	$\frac{V_0}{\sqrt{2}} = 7.072 \rightarrow V_0 = 10.001 \text{ V}$ $V_0 \propto \frac{L}{2} = 2 \text{ cm} \rightarrow Y - \text{sensitivity} = \frac{10}{2}$ $Y - \text{sensitivity} = 5.0 \text{ V cm}^{-1}$									
b. i)	$V_a = 3,000 \text{ V}$ $B = 0.6 \text{ T}$ $m = 6.64 \times 10^{-27} \text{ kg}$ $qV = \frac{1}{2}mu^2, u = \sqrt{\frac{2qV}{m}} = \left(\frac{2 \times (3.2 \times 10^{-19}) \times 3,000}{6.64 \times 10^{-27}} \right)^{\frac{1}{2}}$ $= 5.38 \times 10^5 \text{ ms}^{-1}$									
ii)	$Bqu = \frac{mu^2}{r} \Rightarrow r = \frac{mu}{Bq} = \frac{6.64 \times 10^{-27} \times 5.38 \times 10^5}{0.6 \times 3.2 \times 10^{-19}}$ $= 1.82 \times 10^{-2} \text{ m}$									
iii)	$Eq = Bqu \Rightarrow E = Bu = 0.6 \times 5.38 \times 10^5$ $= 3.23 \times 10^5 \text{ V cm}^{-1}$									
e.	<table><tr><th>Cathode rays</th><th>γ-rays</th></tr><tr><td>✓ Carry a negative charge</td><td>✓ Have no charge</td></tr><tr><td>✓ Less penetrative</td><td>✓ Highly penetrative</td></tr><tr><td>✓ Fast moving electrons</td><td>✓ Electromagnetic radiations</td></tr></table>	Cathode rays	γ -rays	✓ Carry a negative charge	✓ Have no charge	✓ Less penetrative	✓ Highly penetrative	✓ Fast moving electrons	✓ Electromagnetic radiations	
Cathode rays	γ -rays									
✓ Carry a negative charge	✓ Have no charge									
✓ Less penetrative	✓ Highly penetrative									
✓ Fast moving electrons	✓ Electromagnetic radiations									

	✓ Slower	✓ Faster	
12.a i)	A mole is the amount of substance that contains 6.02×10^{23} elementary units		
ii)	Faraday constant is the amount of charge required to liberate one mole of singly ionized ions in electrolysis		
iii)	Avogadro's number is the number of particles in one mole		
b	 - Oil is sprayed and fine oil drops fall through a small hole in plate A. - A particular drop is observed and its terminal velocity V_0 measured by timing its fall through a measured distance using the microscope. Therefore, $\frac{4}{3}\pi r^3 \rho_{oil} g = \frac{4}{3}\pi r^3 \rho_{air} g + 6\pi \eta r V_0 \dots \dots \dots (i)$ - A pd is applied across the plates and adjusted until the drop remains stationary. Therefore, $\frac{4}{3}\pi r^3 \rho_{oil} g = \frac{4}{3}\pi r^3 \rho_{air} g + Eq \dots \dots \dots (ii)$ $Eq = 6\pi \eta r V_0, \Rightarrow q = \frac{6\pi \eta r V_0}{E}$ $\text{from (i), } q = \left(\frac{9\eta V_0}{2g(\rho_{oil} - \rho_{air})} \right)^{\frac{1}{2}}$ - Working with many oil drops, Millikan found that each value of charge obtained was an integral multiple of $1.6 \times 10^{-19}C$ and he concluded that the charge of an electron was $1.6 \times 10^{-19}C$		
c. i)	 $\theta = \left(31 + \frac{36}{60} \right) = 31.6^\circ$		

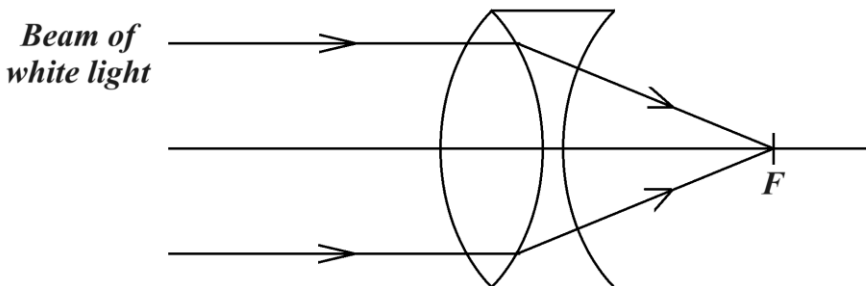
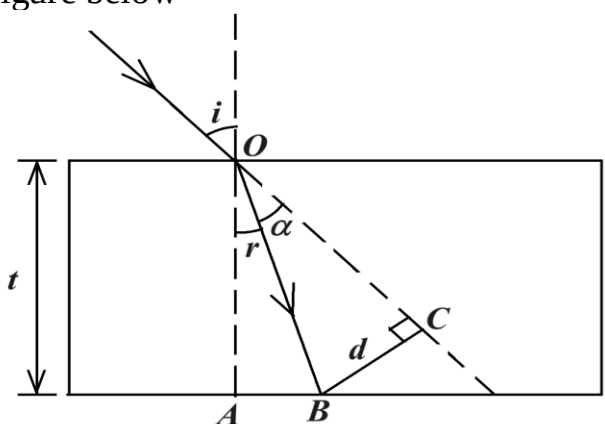
	$\frac{V_H}{1.066} = \tan 31.6^\circ \Rightarrow V_H = 1.066 \tan 31.6^\circ = \underline{0.656 \text{ cms}^{-1}}$	
ii)	$Eq = 6\pi\eta r V_o, \quad E = \frac{3000}{0.005} = 6 \times 10^5 \text{ Vm}^{-1}$ $q = \frac{6 \times 3.14 \times 1.816 \times 10^{-5} \times 1 \times 10^{-5} \times 0.656 \times 10^{-2}}{6 \times 10^5} = \underline{3.741 \times 10^{-17} \text{ C}}$	
iii)	$\frac{4}{3}\pi r^3(\rho_{oil} - \rho_{air})g$ $= 6 \times 3.14 \times 1.816 \times 10^{-5} \times 1 \times 10^{-5} \times 1.066 \times 10^{-2}$ $\frac{4}{3} \times 3.14 \times (1 \times 10^{-5})^3 \times 9.81(880 - \rho_{air}) = 3.647 \times 10^{-11}$ $880 - \rho_{air} = 888$ $\rho_{air} = -8 \text{ kgm}^{-3}$	
d	$E_1 = 13.6 \text{ eV}, \quad E_3 = \frac{-13.6}{3^2} = -1.51 \text{ eV}$ $E_3 - E_1 = -1.51 + 13.6 = 12.09 \text{ eV}$ $hf = 12.09 \times 1.6 \times 10^{-19} = 1.9344 \times 10^{-18}$ $f = \frac{1.9344 \times 10^{-18}}{6.6 \times 10^{-34}} = 2.93 \times 10^{15} \text{ Hz}$	
13.a	✓ For every metal surface, there is a minimum frequency of the incident radiation below which photoelectric emission will not take place. ✓ There is no detectable time lag between irradiation of the metal and emission of electrons. ✓ The kinetic energy of emitted electrons ranges from zero to a definite maximum value which is proportional to the frequency of the incident radiation. ✓ The number of electrons emitted per second (photo current) is proportional to the intensity of the incident radiation for a given frequency.	
b.	 Ultra violet radiations → Zinc Gold leaf electroscope • When U.V radiation is incident on the clean zinc plate, the negatively charged GLE collapses • The collapsing stops when Ultra Violet radiation is blocked.	

	The leaf collapses because the zinc plate emits electrons and negative charge is lost from the GLE	
c. i)	Work function $\phi_0 = \frac{hc}{\lambda} = 4 \times 1.6 \times 10^{-19} J$ $\lambda = \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{4 \times 1.6 \times 10^{-19}} = 3.094 \times 10^{-7} m$	
ii)	$hf = \phi + \frac{1}{2}mv^2 \Rightarrow \frac{1}{2}mv^2 = \frac{hc}{\lambda} - \phi$ $= \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{0.2 \times 10^{-6}} - 6.4 \times 10^{-19}$ $= 3.5 \times 10^{-19}$ $V = \sqrt{\frac{2 \times 3.5 \times 10^{-19}}{9.11 \times 10^{-31}}} = \underline{8.77 \times 10^5 ms^{-1}}$	
d. i)	Mass defect of the nucleus is the difference between the mass of the nucleus and the sum of the masses of its individual nucleons	
ii)	✓ Most of the alpha particles went through the gold foil undeflected because most of the space of an atom is empty space. ✓ Some alpha particles were deflected through angles less than 90°, implying that the positive charge of the atom was concentrated at the centre of the atom, in the nucleus ✓ Very few alpha particles were deflected through angles greater than 90° and did not go through the foil because the nucleus occupies a very small volume of the atom and the mass of the atom is concentrated at the nucleus.	
iii)	$Energy = \frac{Q_1 Q_2}{4\pi\epsilon_0 r} = \frac{1.6 \times 10^{-19} \times 79 \times 1.6 \times 10^{-19} \times 9 \times 10^9}{r}$ $= 5 \times 10^6 \times 1.6 \times 10^{-19} J$ $r = \frac{1.6 \times 10^{-19} \times 79 \times 1.6 \times 10^{-19} \times 9 \times 10^9}{5 \times 10^6 \times 1.6 \times 10^{-19}} = \underline{2.2752 \times 10^{-14} m}$	
14.a i)	Binding Energy is the minimum energy released when individual nucleons combine to form a nucleus	

ii)	 • Binding energy increases sharply with mass number up to mass number ≈ 20 • The peaks at ≈ 20 represent elements that are more stable compared to the neighbouring elements • B.E increases gently after 20 to a maximum value at mass number ≈ 60 • After 60 (mass number) B.E decreases slowly with mass number	
c.	Nuclear fission is the splitting of a large unstable nucleus into two almost equal fragments that are more stable with release of energy while Nuclear fusion is the combining of two small unstable nuclei to form a bigger more stable nucleus with release of energy.	
d.	 ✓ When radiation enters the chamber through the gauze, it causes ionization of the gas at atmospheric pressure. ✓ Electrons move towards the anode and the positive ions to the cathode. ✓ When they get to the respective electrodes, discharge occurs. ✓ Current flows and is detected by the electrometer	

e. i)	Half-life is the time taken for half the number of atoms (nuclei) in a radioactive sample to decay Decay constant is the ratio of number of nuclei disintegrating per second to the number of active nuclei in the sample.	
ii)	$N_0 = \frac{2}{222} \times 6.02 \times 10^{23} = 5.42 \times 10^{21} \text{ atoms}$ Spherical Area on which radiation falls = $4 \times 3.14 \times 20^2$ $= 5024 \text{ cm}^2$ $\frac{A_0}{5024} = \frac{85}{10} \Rightarrow A_0 = 42704 \text{ Bq}$ $A_0 = \lambda N_0 \Rightarrow \lambda = \frac{42704}{5.42 \times 10^{21}} = \underline{\underline{7.87 \times 10^{-18}}}$ $t_{\frac{1}{2}} = \frac{\ln 2}{\lambda} = \underline{\underline{8.8 \times 10^{16} \text{ s}}}$	

PHYSICS PAPER TWO

Qn.	Approach	Remarks
1(a)(i)	Chromatic aberration is a defect in lenses which occurs when the constituent colours of white light are brought at different foci instead of one focus leading to the production of coloured images. This is so because different colours have different refractive indices with the red light being deviated least and violet the most.	
(ii)	Chromatic aberration is corrected by placing a suitable diverging lens besides a converging lens to form a combination called achromatic doublet. This recombines the colours of white light after refraction through the lens combination as illustrated in the diagram below; 	
(b) (i)	Refractive index of a material is the ratio of sine of angle of incidence to the sine of the angle of refraction for a ray of light travelling from a vacuum/air to a material. OR it is the ratio of speed of light in air (vacuum) to speed of light in a material.	
(ii)	Consider a monochromatic ray of light incident on a glass block of refractive index, n at an angle of incidence, i. On striking the glass block, it undergoes refraction through an angle, r as shown in the figure below  Consider triangle OAB	

$$\cos r = \frac{t}{OB}$$

$$OB = \frac{t}{\cos r} \text{-----(i)}$$

Consider triangle OBC

$$\sin \alpha = \frac{d}{OB}$$

$$OB = \frac{d}{\sin \alpha} \text{-----(ii)}$$

Considering (i) and (ii)

$$d = \frac{t \sin \alpha}{\cos r} \text{-----(*)}$$

At point O

$$i = r + \alpha \Rightarrow \alpha = i - r$$

$$\sin \alpha = \sin(i - r) = \sin i \cos r - \cos i \sin r \text{----- (iii)}$$

$$\text{But } \sin^2 r + \cos^2 r = 1$$

$$\Rightarrow \cos r = \sqrt{1 - \sin^2 r} \text{----- (iv)}$$

Substitute (iii) and (iv) in (*)

$$d = \frac{t(\sin i \cos r - \cos i \sin r)}{\sqrt{1 - \sin^2 r}} \text{-----(**)}$$

Also, applying snell's law at O

$$n_a \sin i = n \sin r$$

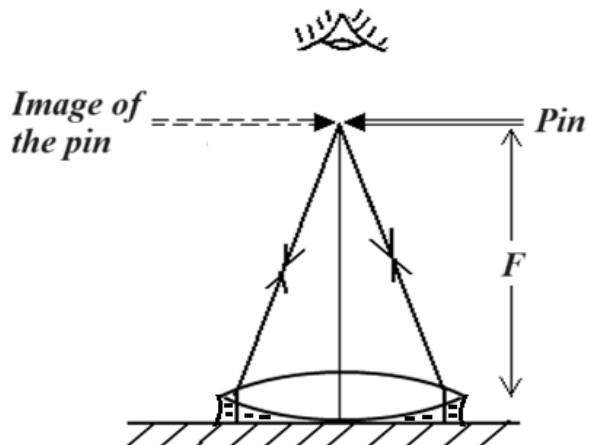
$$\Rightarrow \sin r = \frac{\sin i}{n} \text{----- (v)}$$

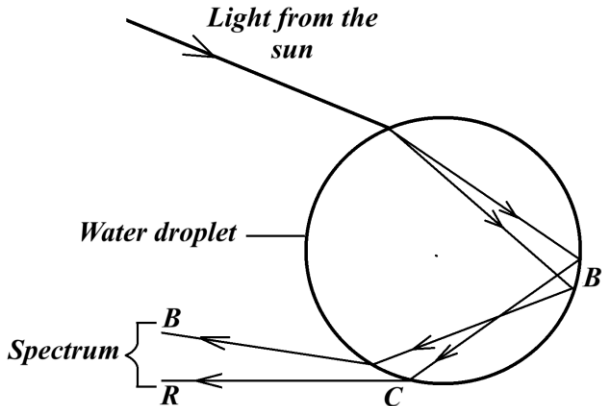
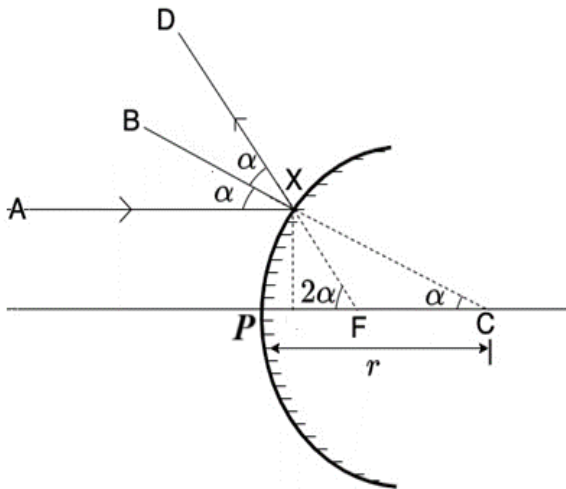
Substitute (iv) and (v) into (**)

$$d = \frac{t \left(\left(\sqrt{1 - \left(\frac{\sin i}{n} \right)^2} \right) \sin i - \frac{\sin i}{n} \cos i \right)}{\sqrt{1 - \left(\frac{\sin i}{n} \right)^2}}$$

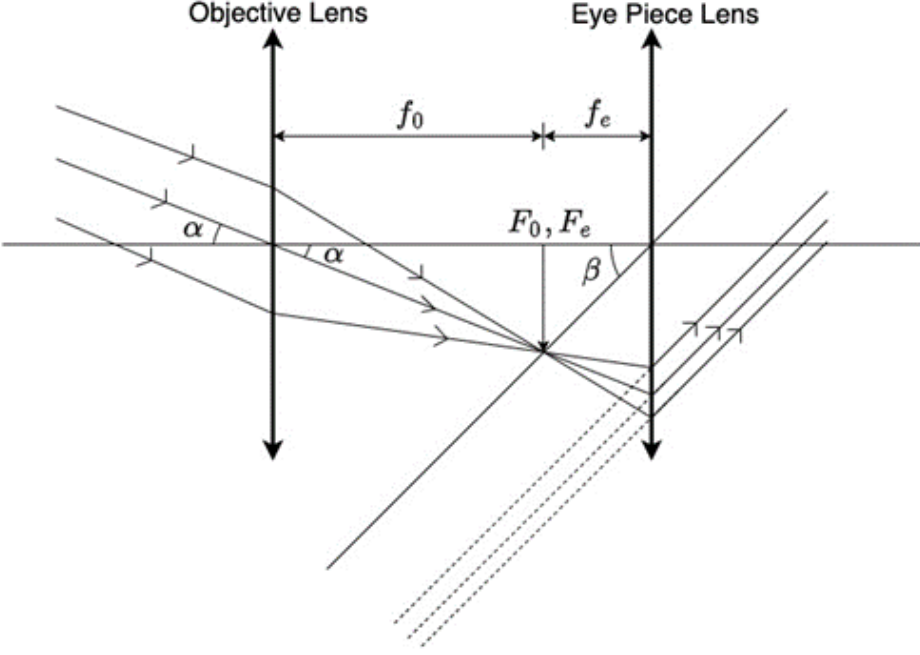
$$d = \frac{t \sin i}{n} \left(\frac{\left(\sqrt{n^2 - \sin^2 i} - \cos i \right)}{\frac{1}{n} \sqrt{n^2 - \sin^2 i}} \right)$$

$$d = t \left(1 - \frac{\cos i}{\sqrt{n^2 - \sin^2 i}} \right) \sin i$$

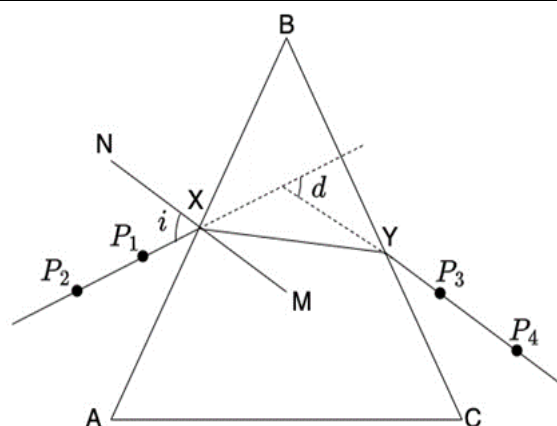
(c)	For red $\frac{1}{f_R} = (n_R - 1) \left(\frac{1}{r_1} - \frac{1}{r_2} \right)$ $\frac{1}{f_R} = (1 \cdot 514 - 1) \left(\frac{1}{30} + \frac{1}{20} \right)$ $\frac{1}{f_R} = 0 \cdot 514 \left(\frac{1}{30} + \frac{1}{20} \right)$ $f_R = 23.35 \text{ cm}$ For blue $\frac{1}{f_B} = (n_B - 1) \left(\frac{1}{r_1} - \frac{1}{r_2} \right)$ $\frac{1}{f_B} = (1 \cdot 524 - 1) \left(\frac{1}{30} + \frac{1}{20} \right)$ $\frac{1}{f_B} = 0 \cdot 524 \left(\frac{1}{30} + \frac{1}{20} \right)$ $f_B = 22.9 \text{ cm}$ The separation, f between the foci of red and blue is; $f = f_R - f_B$ $f = 23 \cdot 35 - 22 \cdot 9$ $= 0 \cdot 45 \text{ cm}$	
(d)	 • An object pin is clamped horizontally with its tip along the axis and moved up and down until it coincides with its own image. • The distance PC is measured and recorded. • The measured and recorded distance is the focal length f_l of the convex lens. • A small amount of a liquid whose refractive index, n_L is to be determined is poured on the plane mirror. • A convex lens is then placed on top of the liquid. • An object pin is again clamped horizontally and moved up and down until it coincides with its own image. • The distance $P^l C^l$ is measured and recorded.	

	- The measured and recorded distance is the focal length, F of the combination of the lens. - The refractive index of the liquid n_L is then obtained from $n_L = 1 + \frac{r}{f_2}$, where r is the radius of curvature of the biconvex liquid surface and f_2 is the focal length of the lens. f_2 is obtained from the expression $\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2}$	
(e)	When white light is incident on a rain drop, it is refracted and dispersed. The refracted light is reflected at B and emerges at C. The light viewed is a spectrum of colours. 	
2(a) (i)	Principal focus of a convex mirror is a point on the principal axis where rays parallel and close to the principal axis appear to diverge from after reflection by the mirror.	
(ii)	Consider a ray AX parallel and close to the principal axis incident onto the mirror.  FP = Focal length (f) If C is the Centre of curvature, then CP is the radius of curvature of the mirror. From the diagram; $\angle AXB = \angle BXD = \alpha$ (Law of reflection)	

	$\angle AXB = \angle XCP = \alpha$ (alternate angles) $FC = FX$ (isosceles triangle FXC) For X very close to P, $FX \approx FP$ Therefore, $CF = FP$ $2FP = CP = r$ $r = 2f$	
(b)	When a lamp is placed at the principal focus of a parabolic mirror, all rays from this lamp that strike the mirror at points close to and far from the principle axis will be reflected parallel to the principle axis and the intensity of the reflected beam remains practically undiminished as the distance from the mirror increases unlike for a concave mirror where rays from a lamp at its focus is reflected at different directions therefore the intensity of the reflected beam diminishes as the distance from the mirror increases. Therefore, parabolic mirrors instead of concave mirrors are used as reflectors in search lights.	
(c)	Magnifying Power is the ratio of the angle subtended by the final image at the eye when using an optical instrument to the angle subtended by the object at the eye when the object is at the near point. Resolving Power is the ability of an optical instrument to produce separate images of close objects.	
(d) (i)	Given $f_o = 20mm$, $f_e = 50mm$ Lens separation, $d = 220cm$ $d = V_o + f_e$ $220 = V_o + 50$ $V_o = 170mm$ Action of the objective $\frac{1}{f_o} = \frac{1}{U_o} + \frac{1}{V_o}$ $\frac{1}{20} = \frac{1}{U_o} + \frac{1}{170}$ $\frac{1}{U_o} = \frac{1}{20} - \frac{1}{170}$ $U_o = 22.67mm$	
(ii)	$M = \frac{D}{f_e} \left(\frac{V_o}{f_o} - 1 \right)$ $M = \frac{250}{50} \left(\frac{170}{20} - 1 \right)$ $M = 37.5$	

(e) (i)	 Angular Magnification, $M = \frac{\beta}{\alpha}$(1) From the diagram; $\tan \beta = \frac{h}{f_e} \text{ and } \tan \alpha = \frac{h}{f_0}$ But for small angles measured in radians; $\alpha \approx \tan \alpha \text{ and } \beta \approx \tan \beta$ $\Rightarrow \alpha = \frac{h}{f_0} \text{ and } \beta = \frac{h}{f_e}$ Substitute α and β in (1) $M = \frac{\frac{h}{f_e}}{\frac{h}{f_0}}$ $M = \frac{f_0}{f_e}$	
(ii)	This is done by introducing an erecting lens of focal length, f between the objective and the eye piece lenses. The erecting lens has no effect on the magnitude of angular magnification produced and it is placed a distance $2f$ after the principal focus of the objective lens and a distance $2f$ before the principal axis of the eye piece lens. The objective lens forms a real inverted image of a distant object at its focal point, F_0 and this image acts as a real object of the erecting lens which forms a real erect image of the same size as the image formed by the objective. The final image formed is also erect.	
3 (a)(i)	Deviation of light by a prism is the change in direction of light due to refraction at the prism's two non - parallel faces.	

(ii)



- The prism is placed on a plane sheet of paper on a soft board and its outline ABC is traced out as shown above.
- A normal NM is drawn through point X on side AB of the prism and a line PX is drawn making an angle i .
- Two optical pins P_1 and P_2 are placed along the lines that make different angles of incidence i .
- Pins P_3 and P_4 are placed such that they appear to be in line with the images of P_1 and P_2 as seen through the prism.
- The angles of deviation d are measured for different angles of incidence.
- A graph of d against i is plotted to give a curve whose angle of deviation at its turning point is the angle of minimum deviation d_{min} of the prism.

(b)

Principal focus of a convex lens is a point on the principal axis where rays originally parallel and close to the principal axis converge after refraction by the lens.

Radii of curvature of a convex lens are radii of the spheres of which the convex lens surfaces form part.

(c)(i)

Consider a paraxial ray incident on a convex lens as shown below

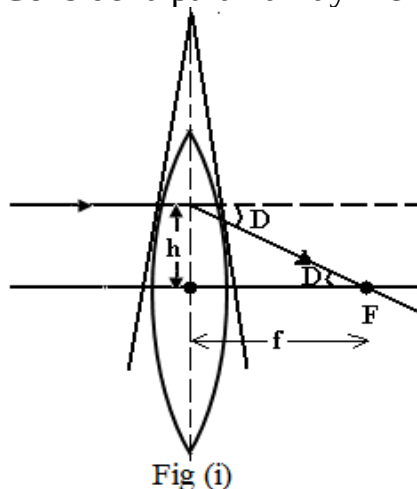


Fig (i)

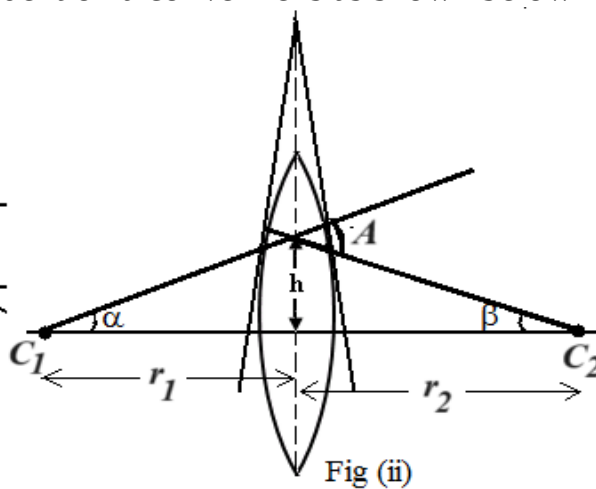
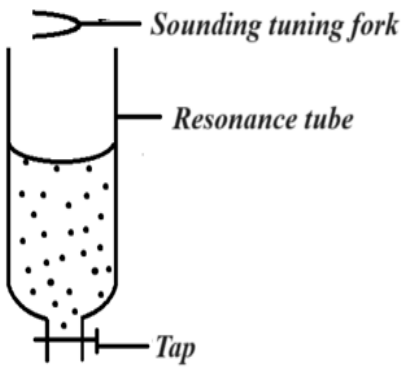


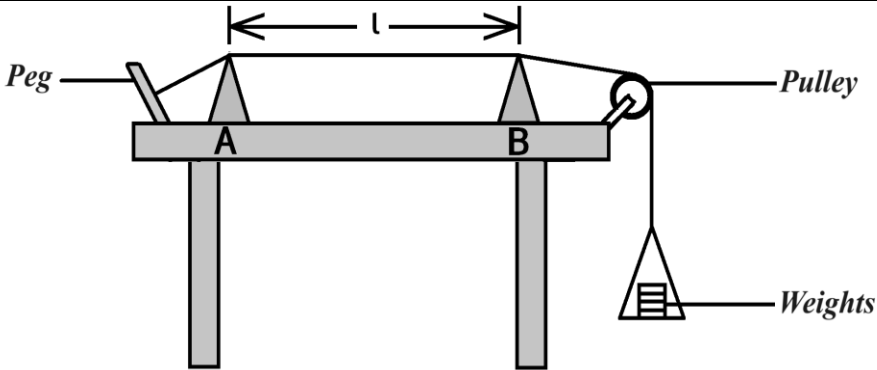
Fig (ii)

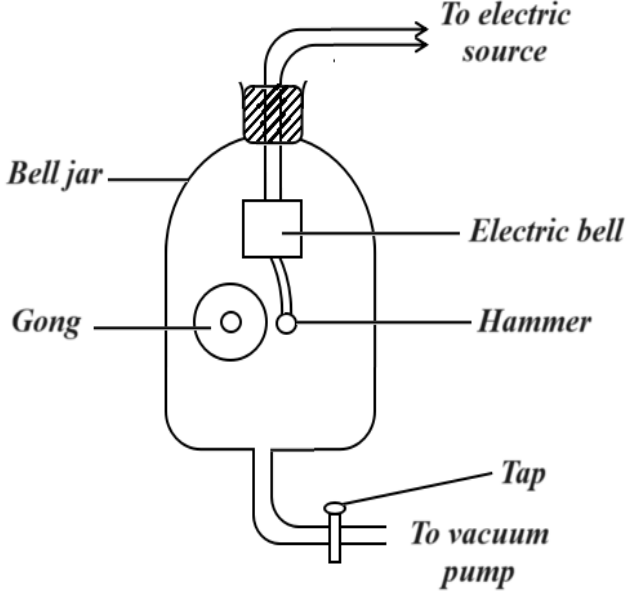
	From the Fig. (i) above; $\tan D = \frac{h}{f}$ But for small angles in radians; $\tan D \approx D$ $\Rightarrow D = \frac{h}{f} \dots \dots \dots (1)$ Consider normals at points Q and R going through centres of curvature C_1 and C_2 respectively as shown Fig.(ii). The normal meet the tangents to the lens surfaces at points P and Q respectively. From the diagram; $\alpha + \beta = A \dots \dots \dots (2)$ Also $\tan \alpha = \frac{h}{r_1} \text{ and } \tan \beta = \frac{h}{r_2}$ But for small angles in radians; $\tan \alpha \approx \alpha \text{ and } \tan \beta \approx \beta$ $\Rightarrow \alpha = \frac{h}{r_1} \text{ and } \beta = \frac{h}{r_2} \dots \dots \dots (*)$ Substituting (*) in 2 gives; $\frac{h}{r_1} + \frac{h}{r_2} = A \dots \dots \dots (3)$ For a prism of small refracting angle, A. $d = (n - 1)A$ From (1) $\Rightarrow \frac{h}{f} = (n - 1)A \dots \dots \dots (**)$ Equation 3 and (**) give; $\frac{h}{f} = (n - 1) \left(\frac{h}{r_1} + \frac{h}{r_2} \right)$ $\frac{1}{f} = (n - 1) \left(\frac{1}{r_1} + \frac{1}{r_2} \right)$	
(ii)	Consider the liquid lens $\frac{1}{f_l} = (n_l - 1) \left(\frac{1}{r_1} + \frac{1}{r_2} \right)$ $\frac{1}{f_l} = (1.4 - 1) \left(-\frac{1}{23} + \frac{1}{\infty} \right)$ $f_l = -57.5 \text{ cm}$ For the combination	

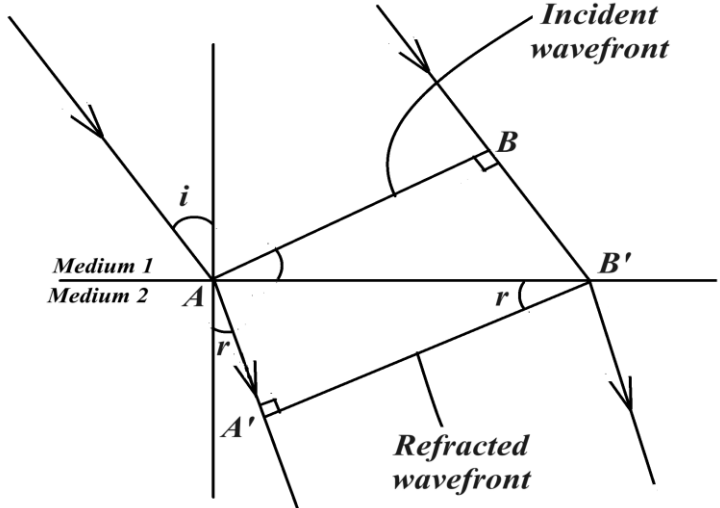
	$\frac{1}{f} = \frac{1}{f_l} + \frac{1}{f_g}$ $\frac{1}{37.3} = \frac{1}{-57.5} + \frac{1}{f_g}$ $\frac{1}{f_g} = \frac{1}{37.3} + \frac{1}{57.5}$ $f_g = 22.62 \text{ cm}$ Consider the glass lens $\frac{1}{f_g} = (n_g - 1) \left(\frac{1}{r_1} + \frac{1}{r_2} \right)$ $\frac{1}{22.62} = (n_g - 1) \left(\frac{1}{23} + \frac{1}{23} \right)$ $n_g - 1 = 0.51$ $n_g = 1.51$		
(d)(i)	Spherical aberration is a defect produced in both lenses and spherical mirrors. It occurs when rays which are parallel and far from the principal axis fail to converge a single focal point but instead converge at different focal points which results into a blurred and distorted final image.		
(ii)	- Prisms don't tarnish or deteriorate as plane mirrors do because plane mirrors lose the silvering surface with time. - Prisms form brighter images than plane mirrors. This is because mirrors absorb more of the incident light and produce fainter images. - Prisms produce clear images than plane mirrors. This is because plane mirrors produce blurred images due to the formation of multiple images.		
4 (a)(i)	Progressive waves	Stationary waves	
	Transfer energy from one end to another along the medium.	Doesn't transfer energy along the medium.	
	The amplitude of vibration of the particles is constant.	The amplitude of vibration of particles varies from place to place.	
	They consist of crests and troughs/ consist of compressions and rarefactions.	Consist of nodes and antinodes.	

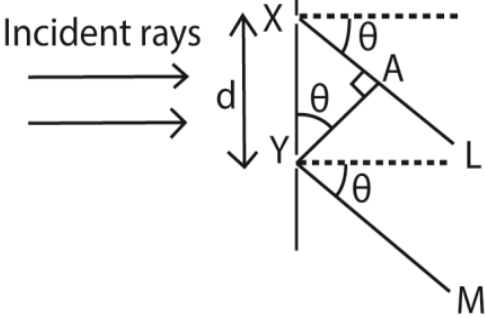
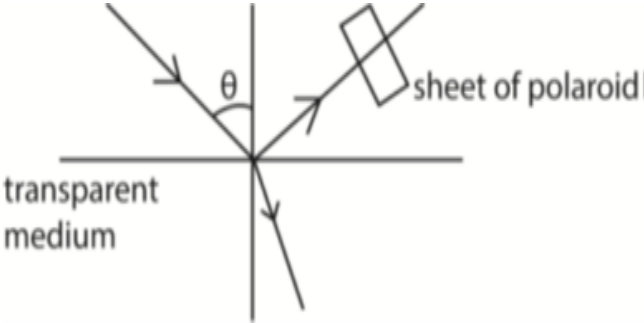
	The phase of vibration varies from point to point along the wave profile.	The phase of vibration of particles is constant between nodes.	
(ii)	• They have constant amplitude • They move with constant speed • They have constant frequency • They transfer energy along the profile The transfer of sound energy is possible when vibrating molecules hit the next layer of molecules in the atmosphere in a direction parallel to that of propagation of the sound wave. Thus, a longitudinal wave motion.		
(b)	 • The resonance tube is filled with water and a sounding tuning fork of known frequency, f is held over the open end of the tube. • The tap is opened and water is allowed to flow gradually until a loud sound is heard. • The tap is immediately closed and the length, l of the air column is measured and recorded. • The experiment is repeated with different tuning forks of known frequencies. The results are tabulated including values of $\frac{1}{f}$. • A graph of l against $\frac{1}{f}$ is plotted and the intercept, C on the l axis is obtained. • The end correction of the tube, $e = -C$.		
(c)	Given: $l = 0.4m$, $f_n = 960Hz$, $v = 330ms^{-1}$ $f_n = \frac{nv}{4l}$ $960 = \frac{n \times 330}{4 \times 0.4}$ $n = 4.65$ $n \approx 5$ The air column is vibrating producing the 2nd overtone.		

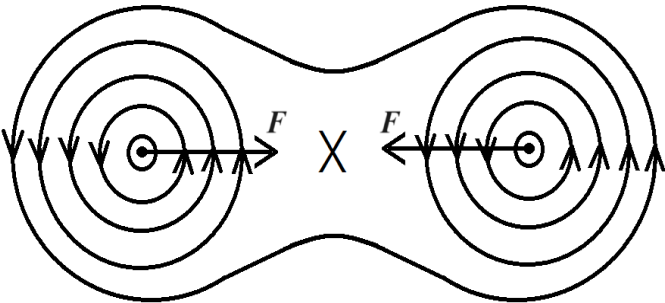
(d) (i)	Doppler effect is the apparent change in the frequency of a wave due to relative motion between the source and the observer. Beats are a periodic rise and fall in the intensity of sound heard when two notes of nearly equal frequencies but similar amplitudes are sounded together.	
(ii)	- A spectral photograph of an arc or spark of light from an element known to be in the star is taken in a laboratory and its wavelength, λ is recorded. - A spectral photograph of the star is taken and the corresponding wavelength, λ^1 is noted. - Velocity of the star is calculated from $u_s = \frac{c \lambda^1 - \lambda }{\lambda}$. Where c is the speed of light in air/vacuum	
(e)	Given: $\frac{f_1'}{f_2^1} = \frac{5}{4}$ Case 1 $f_1^1 = \left(\frac{v}{v - u_s} \right) f$ $f_1^1 = \left(\frac{340}{340 - u_s} \right) f \text{ --- (i)}$ Case 2 $f_2' = \left(\frac{v}{v + u_s} \right) f$ $f_2' = \left(\frac{340}{340 + u} \right) f \text{ --- (ii)}$ $\frac{f_1'}{f_2^1} = \frac{5}{4} = \frac{\left(\frac{340}{340 - u_s} \right)}{\left(\frac{340}{340 + u} \right)}$ $(340 + u_s) = \frac{5}{4} (340 - u_s)$ $\frac{9u_s}{4} = \frac{340}{4}$ $U_s = 37.8 \text{ ms}^{-1}$	
5 (a)(i)	A tone is a sound with a regular frequency produced by a musical instrument	
(ii)	A harmonic is a note whose frequency is an integral multiple of the fundamental frequency.	
(iii)	An overtone is a note with a frequency higher than the fundamental frequency produced along with the fundamental note.	

(b) (i)	 • A tuning fork of low frequency is sounded and brought near the wire. • The wire is plucked and the bridge B is moved towards A until a loud sound is heard. • The frequency f of the fork is recorded. • Keeping the length, l and mass of the pan constant, a tuning fork of frequency $2f$ is sounded and brought near the wire and plucked. A loud sound is heard. • Therefore a stretched wire plucked in the middle vibrates in more than one mode simultaneously.	
(ii)	Given: $l = 0.3m$, $m = 5g = 5 \times 10^{-3}kg$, $T = 170 N$ For a stretched string vibrating at its third harmonic $f_3 = 3f_1 = \frac{3}{2l} \sqrt{\frac{T}{\mu}} \text{------(i)}$ For an open pipe vibrating at its fundamental note; $f_1 = \frac{v}{2L} \text{------(ii)}$ But (i) = (ii) $\frac{3}{2l} \sqrt{\frac{T}{\mu}} = \frac{v}{2L}$ $\frac{3}{2 \times 0.3} \sqrt{\frac{170 \times 0.3}{5 \times 10^{-3}}} = \frac{340}{2L}$ $L = 0.3367m$	
(c) (i)	When two notes of nearly equal frequencies but similar amplitudes are sounded together, they superpose. When they meet while in phase, reinforcement takes place and a loud sound is heard. When they meet while completely out of phase, cancellation occurs and a soft sound or no sound is heard. That happens alternately causing a periodic rise and fall in the intensity of sound heard, which leads to formation of beats.	

(ii)	Case 1 $f_1^1 = \left(\frac{v - u_o}{v}\right) f \text{ --- (i)}$ Case 2 $f_2' = \left(\frac{v + u_o}{v}\right) f \text{ --- (ii)}$ $f_2' - f_1^1 = 5$ $\left(\left(\frac{v + u_o}{v}\right) - \left(\frac{v - u_o}{v}\right)\right) f = 5$ $\frac{2fu_o}{v} = 5$ $\frac{2 \times 425u_o}{340} = 5$ $u_o = 2 \text{ ms}^{-1}$											
(d) (i)	<table><tr><th>Sound waves</th><th>Light waves</th></tr><tr><td>They are longitudinal in nature</td><td>They are transverse in nature</td></tr><tr><td>They are mechanical waves</td><td>They are electromagnetic waves</td></tr><tr><td>They travel at relatively low speed</td><td>They travel at very high speed</td></tr><tr><td>They have relatively longer wavelength</td><td>They have very short wavelength</td></tr></table>	Sound waves	Light waves	They are longitudinal in nature	They are transverse in nature	They are mechanical waves	They are electromagnetic waves	They travel at relatively low speed	They travel at very high speed	They have relatively longer wavelength	They have very short wavelength	
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(ii)	 When an electric bell inside a bell jar is switched on, a loud sound is heard.											

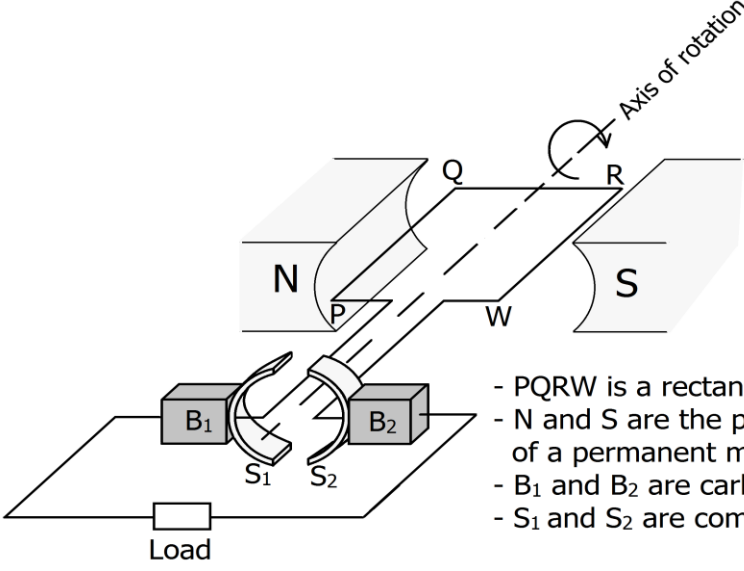
	- The air inside the bell jar is gradually removed by means of a vacuum pump, and the loudness is observed to fade out. - When all the air is completely removed from the bell jar, no sound is heard even though the hammer is seen hitting the gong. - When air is again allowed in the bell jar, sound is heard again. - This shows that sound requires a material medium for its transmission, thus a mechanical wave.	
6(a)(i)	Huygen's principle states that every point on a wave front may be regarded as a source of secondary spherical wavelets which spread out with the wave velocity. The new wave front is the envelope of the secondary wavelets	
(ii)	Consider a plane wave front of light AB which is about to cross from one medium into another  Let v_1 and v_2 be the velocities of light in air and the medium respectively. If the wave particle at B takes time t to move to B^1, then the distance $BB^1 = v_1 t$. In the same time interval wave particle at A moves to A^1, distance $AA^1 = v_2 t$ From triangle ABB^1 and AA^1B^1 $\frac{\sin i}{\sin r} = \frac{\left(\frac{BB^1}{AB^1}\right)}{\left(\frac{AA^1}{AB^1}\right)} = \frac{BB^1}{AA^1} = \frac{v_1 t}{v_2 t} = \frac{v_1}{v_2}$	
(b)	Diffraction is the spreading of light into the geometrical shadow leading to interference Polarization is a process by which vibration of electric vector is restricted to take place in only one plane.	

(c)	 The path difference $XA = d\sin\theta$ For constructive interference, diffraction maxima occurs when the path difference is an integral multiple of wavelength, λ. i.e. path difference = $n\lambda$ Thus $d\sin\theta = n\lambda$ where $n = 0, 1, 2, 3, \dots$	
(d)	 • Unpolarized light is made incident on a transparent medium at an angle θ. • The reflected light is viewed through a sheet of polaroid while turning the sheet about an axis perpendicular to its plane until light is just cut off from the observer as the polaroid is being rotated. • The procedure is repeated for various angles of incidence until the reflected ray is cut off from object. • At this particular angle θ, the reflected light is completely polarized	
(e)	Sound interference effects can be observed using two sources because sound waves are typically coherent and have a consistent phase relationship when emitted from similar sources. This coherence allows constructive and destructive interference patterns to form which can be detected by our ears. On the other hand, light emitted from two lamps is generally incoherent, this means the light waves do not maintain a consistent phase relationship, making it impossible to observe clear interference patterns.	

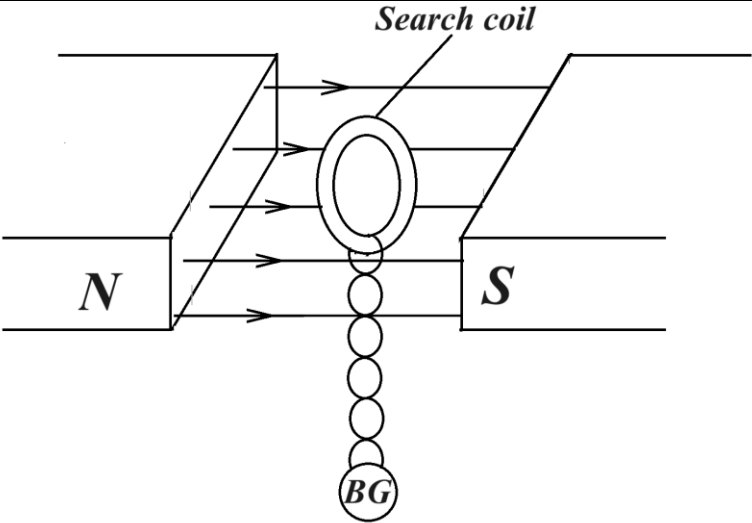
(f)	Fringe separation $y = \frac{3.9 \times 10^{-3}}{23}$ $y = 1.70 \times 10^{-4} \text{m}$ $a = \frac{\lambda d}{y}$ where d is the distance from the slits, a is the slit separation $a = \frac{5.5 \times 10^{-7} \times 0.31}{1.70 \times 10^{-4}}$ $a = 1.003 \times 10^{-3} \text{m}$	
7(a)(i)	Magnetic field strength is the force experienced by a straight conductor of length 1m carrying a current of 1A when it is placed perpendicular to a uniform magnetic field.	
(ii)	Magnetic flux is the product of the magnetic flux density and the area element perpendicular to the field at that point.	
(b) (i)		
(ii)	Magnetic field strength at P From $B_x = \frac{\mu_0 I_x}{2\pi r_{px}}$ $B_x = \frac{\mu_0 I_x}{2\pi r_{px}} = \frac{4\pi \times 10^{-7} \times 5}{2\pi \times 0.019} = 5.2632 \times 10^{-5} \text{T}$ $B_y = \frac{\mu_0 I_y}{2\pi r_{py}} = \frac{4\pi \times 10^{-7} \times 9}{2\pi \times 0.009} = 2 \times 10^{-4} \text{T}$ $B_p = B_y - B_x$ $= 2 \times 10^{-4} - 5.2632 \times 10^{-5}$ $= 1.4737 \times 10^{-4} \text{T}$	
(iii)	$F_{Px} = B_x I_p L_p = \frac{\mu_0 I_x I_p L_p}{2\pi r_{px}}$ $= \frac{4\pi \times 10^{-7} \times 5 \times 3 \times 5}{2\pi \times 1.9 \times 10^{-2}}$ $= 7.8947 \times 10^{-4} \text{N}$ Attractive $F_{Py} = B_y I_p L_p = \frac{\mu_0 I_y I_p L_p}{2\pi r_{py}}$ $= \frac{4\pi \times 10^{-7} \times 9 \times 3 \times 5}{2\pi \times 9 \times 10^{-3}}$ $= 3 \times 10^{-3} \text{N}$ Attractive $F_p = F_{py} - F_{px} = 3 \times 10^{-3} - 7.8947 \times 10^{-4}$	

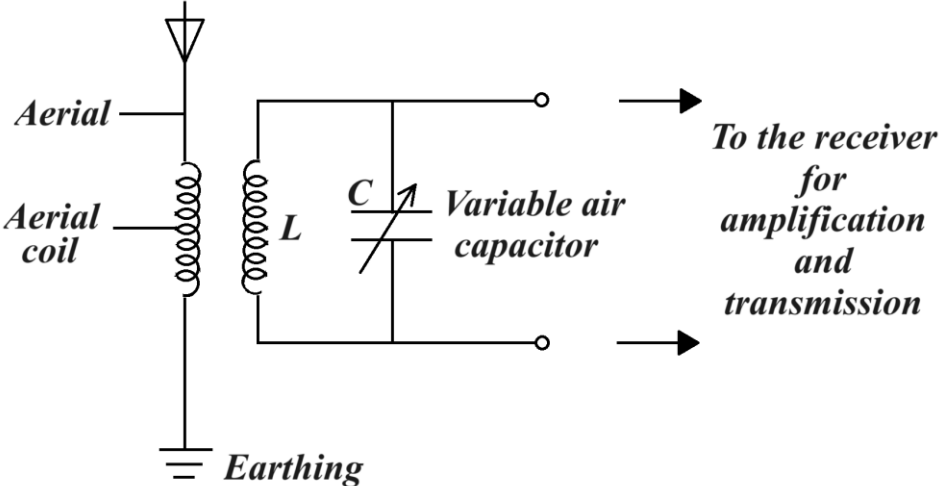
	$= 2.21053 \times 10^{-3} \text{ N towards X}$	
(iv)	- If a current carrying conductor, P is placed in the field of wires X and Y due to currents I_X and I_Y, also a wire P sets a field around it due to current. - The setup field due to current through P interacts with the field of X and Y which results into a greater magnetic flux density on one side of the conductor P than the other. - The resultant force is created from the side with a stronger field to the side with a weaker field and it is this force that tends to move the conductor P.	
(c)(i)	Angle of dip is the angle between the magnetic axis of a freely suspended magnet at rest and the horizontal.	
(ii)	Magnetic meridian is the vertical plane containing the magnetic axis of a freely suspended magnet under the action of the earth's magnetic field. OR It is a vertical plane in which a freely suspended magnet sets itself. OR It is a vertical plane containing the magnetic poles of the earth.	
(d)	The diagram illustrates the setup for measuring the vertical component of the Earth's magnetic field. A rectangular coil is suspended by a central vertical wire, allowing it to rotate. A plotting compass needle is shown in two positions: one horizontal and one deflected downwards by an angle α. Magnetic field vectors are labeled: B_H (horizontal), B_V (vertical), and B_R (resultant). The coil is connected to two terminals labeled BG (Balanometer Galvanometer). - The coil of the earth inductor of negligible resistance is connected to a B.G of known sensitivity, k and resistance, R. - The coil is placed with its plane horizontal and perpendicular to B_V as well as the magnetic meridian using a plotting compass needle. - The coil is then rotated through 180° along the horizontal axis and the deflection, Θ_v of the B.G is noted. - The B_v of the earth's magnetic field is then obtained from the expression, $B_v = \frac{K\theta_v R}{2AN}$.	

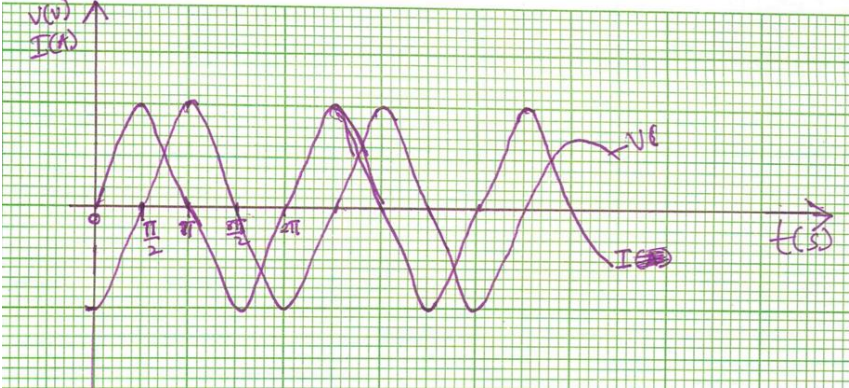
	- The coil is again placed with its plane vertical and perpendicular to B_H as well as the magnetic meridian using a plotting compass needle. - The coil is then rotated through 180° along the vertical axis and the deflection, θ_H of the B.G is noted. - The B_H of the earth's magnetic field is then obtained from $B_H = \frac{K\theta_H R}{2AN}$ - The angle of dip is then obtained from $\tan \theta = \frac{B_V}{B_H} = \frac{\theta_V}{\theta_H}$ $\theta = \tan^{-1} \left(\frac{\theta_V}{\theta_H} \right)$	
8 (a)(i)	Faraday's law states that the magnitude of emf in a coil is directly proportional to the rate of change of magnetic flux linking it. Lenz's law states that the induced current flows always in such a direction to oppose the change causing it.	
(ii)	- When the field is on, as the block oscillates it cuts the magnetic field lines which results into changing magnetic flux and an emf is induced in it creating eddy current to circulate with in the metal - The eddy current generates the magnetic field which opposes the original field that causes the opposition to the motion of the metal hence coming to rest in a short time - When the field is off, there is no eddy currents generated which results into the electromagnetic damping of the oscillation of the metal. Its motion is only opposed by weaker mechanical friction and air resistance with less impact hence oscillating for a longer time.	

(b)	When the coil is rotated, the flux linkage starts to change and an emf induced is given by; $E = -N \frac{d\phi}{dt}$.....(1) And current that flows , $I = \frac{E}{R} = -\frac{N}{R} \frac{d\phi}{dt}$.....(2) Since time is changing, $I = \frac{dQ}{dt}$.....(3) Equating (2) and (3), $\frac{dQ}{dt} = -\frac{N}{R} \frac{d\phi}{dt}$ $dQ = -\frac{N}{R} d\phi$ $\int_0^Q dQ = \int_{\phi_i}^{\phi_f} -\frac{N}{R} d\phi$ $Q = -\frac{N}{R} (\phi_f - \phi_i)$ But $\phi_f = BA \cos 180^\circ$ and $\phi_i = BA \cos 0^\circ$ $Q = -\frac{N}{R} (BA \cos 180^\circ - BA \cos 0^\circ)$ $Q = \frac{2NBA}{R}$	
(c)	 - PQRW is a rectangular coil. - N and S are the poles of a permanent magnet. - B₁ and B₂ are carbon brushes. - S₁ and S₂ are commutators or split rings. • When the coil is rotated with uniform angular speed and emf is induced in it. The resulting current is tapped through the carbon brushes B₁ and B₂	

	- As side PQ moves up and RW down, an emf is induced in the coil in the direction PQRW. In the vertical position, emf induced is zero. - As PQ begins to move down and RW up, emf is induced in the direction WRQP, so current reverses in the coil. But at the same time commutators change contacts with the carbon brushes S_1 to B_2 and S_2 to B_1. - Hence current continues flowing in the same direction in the load.	
(d)(i)	Back emf is an induced emf which opposes the applied voltage in the circuit.	
(ii)	Using $V_a = E_b + I_r a$ $220 = E_b + 1.5 \times 3$ $E_b = 215.5V$ But $E_b = BAN\omega$ $\omega = \frac{215.5}{0.74 \times 12 \times 10^{-4} \times 100} = 2426.8 \text{ rads}^{-1}$	
9(a)(i)	Self induction is the process of generating an emf in the coil due to changing current in the same coil Mutual induction is the process of generating an emf in the coil due to changing current in the nearby coil.	
(ii)	When the switch is closed, current flows in the coil and a magnetic field is established. When it is opened, magnetic flux in the coil collapses creating an emf which appears as a large p.d between the contact points of the switch. Since the contacts are very close, a high electric field intensity is created which ionizes the air between the contacts producing negative and positive ions that collide and neutralize violently causing a spark	

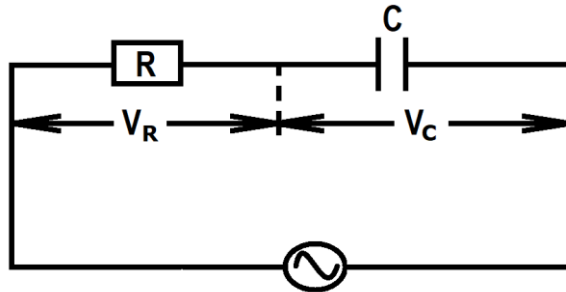
(b)	 • A search coil of N turns and cross-section area A is connected in series with a ballistic galvanometer of known charge sensitivity k and resistance R • A search coil is positioned at right angles to the field to be measured such that it enters the coil normally. The coil is then pulled completely out of the field and the first throw θ of the galvanometer is noted. • The charge that passes round the circuit is proportional to θ i.e $Q = k\theta$ and the magnetic flux density B is obtained from; $B = \frac{k\theta R}{AN}$.	
(c)(i)	When a piece of metal moves in a magnetic field, a magnetic force acts on the delocalized electrons thereby displacing them in a particular direction in accordance to Fleming's Right Hand Grip rule. The electron deficient atoms (positive charges) attract electrons from other atoms. The movement of these electrons causes current loops that are called eddy currents.	
(ii)	Used in melting metal scrap. Thick copper wire is wound round the furnace and alternating current is passed through the wire. A changing magnetic field is established in the furnace which links the scrap, producing eddy currents in it. The eddy currents dissipate heat that is adequate to melt the scrap.	
(d)	$E = BAN\omega = 0.7 \times 3 \times 10^{-2} \times 500 \times 2\pi \times \frac{400}{60} = 439.823V$ But $E = IR$	

	$439.823 = I \times 1.5$ $I = 293.22\text{A}$	
10 (a)	Impedance is the total opposition to the flow of a.c through a circuit containing resistive and reactive components Root mean square value of an alternating current is the value of direct (steady) current that dissipates energy (heat) in a given resistor at the same rate as the A.C.	
(b)(i)	Resonance is a condition when the total opposition to the flow of alternating current flowing through a circuit containing resistive and reactive components is minimum. OR It is the condition when the alternating current flowing through a circuit containing resistive and reactive components is maximum.	
(ii)	 • Radio waves from the different transmitting radio or T.V stations induce e.m.fs of different frequencies at the aerial coil, which in turn induce currents of the same frequency in the inductor, L by mutual induction and connected in series with the variable air capacitor, C. • By altering or tuning the variable air capacitor, C, the circuit is tuned to resonate with the frequency of the desired signal. • At a particular frequency, it responds and stores a large amount of energy that passes on to and fro between the electric field and magnetic fields of the inductor. • The currents due to unwanted signals are negligibly small in comparison to the desired values. At resonance, the impedance whose value $Z = R$ is very small	

	in comparison to X_L and X_C , thus making the circuit highly selective and clear signals are obtained.	
(c)(i)	$I = I_0 \sin \omega t$ $I = \frac{dQ}{dt} = \frac{dCV}{dt} = C \frac{dV}{dt}$ $dV = \frac{I}{C} dt$ $dV = \frac{I_0}{C} \sin \omega t dt$ $\int dV = \frac{I_0}{C} \int \sin \omega t dt$ $V = -\frac{I_0}{\omega C} \cos \omega t = -V_0 \cos \omega t$ $V = -V_0 \sin \left(\omega t + \frac{\pi}{2} \right)$	
(ii)	 • The current and voltage are out phase by a phase angle $\frac{\pi}{2}$, i.e the current leads voltage by $\frac{\pi}{2}$. • When the P.d between the plates is minimum the current flowing is maximum because there is no charge on the plates to oppose the arrival of electrons. • As the P.d increases the current flowing decreases because the already existing electrons oppose the arrival of more charges hence rate of flow of charge decreases.	

- When the capacitor is fully charged, the P.d is maximum, the rate of flow of charge is zero hence current is zero. Thus the current reads the voltage by $\frac{\pi}{2}$.

(d)



a.c source

$$C = 100\mu F, V_R = 2.5V, I = 0.3A, f = 50Hz$$

$$\text{For the lamp } V_R = IR \Rightarrow 2.5 = 0.3R$$

$$R = 8.33\Omega$$

$$Z = \sqrt{R^2 + X_C^2} = \sqrt{8.33^2 + \left(\frac{1}{2\pi \times 50 \times 100 \times 10^{-6}}\right)^2}$$

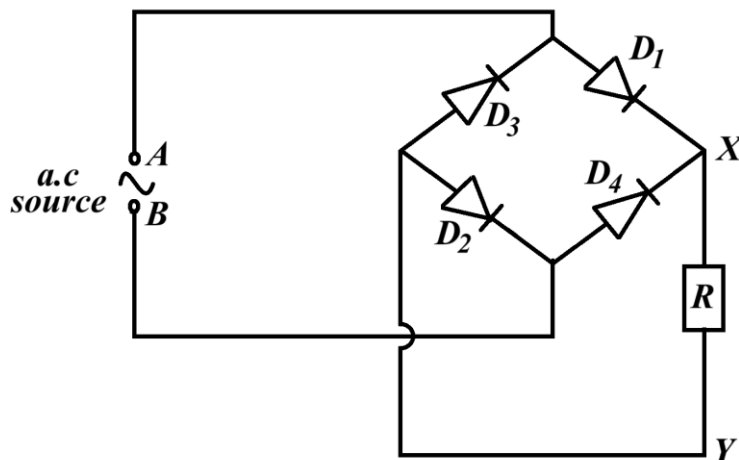
$$Z = 32.902\Omega$$

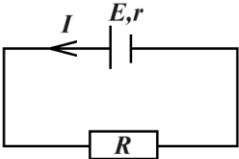
$$V_{rms} = IZ$$

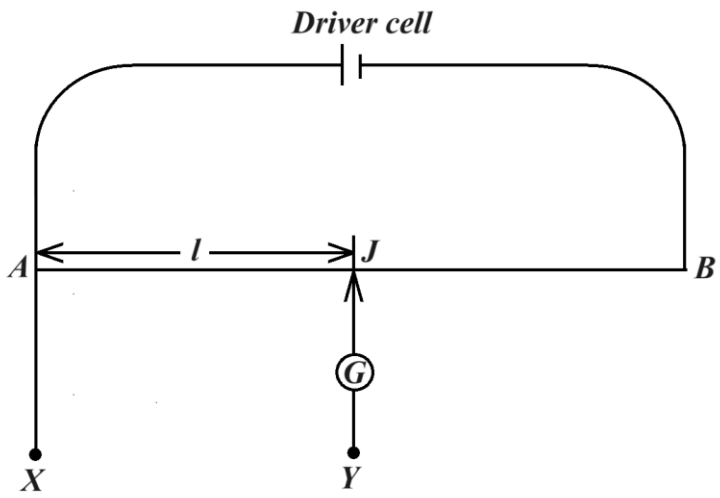
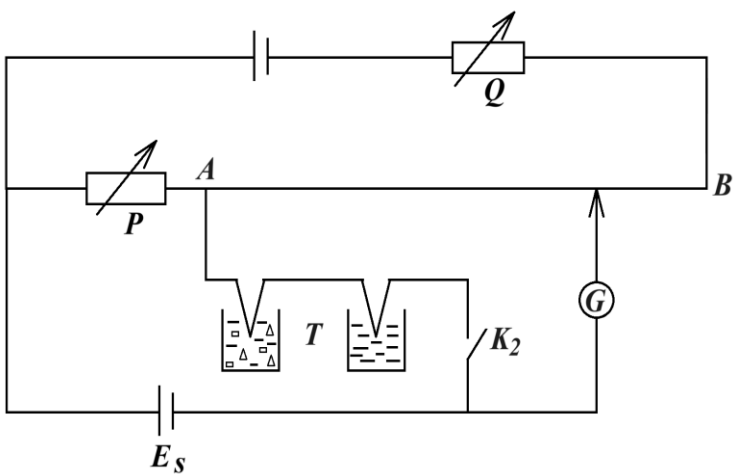
Since in series I is the same,

$$V_{rms} = 0.3 \times 32.902 = 9.87V$$

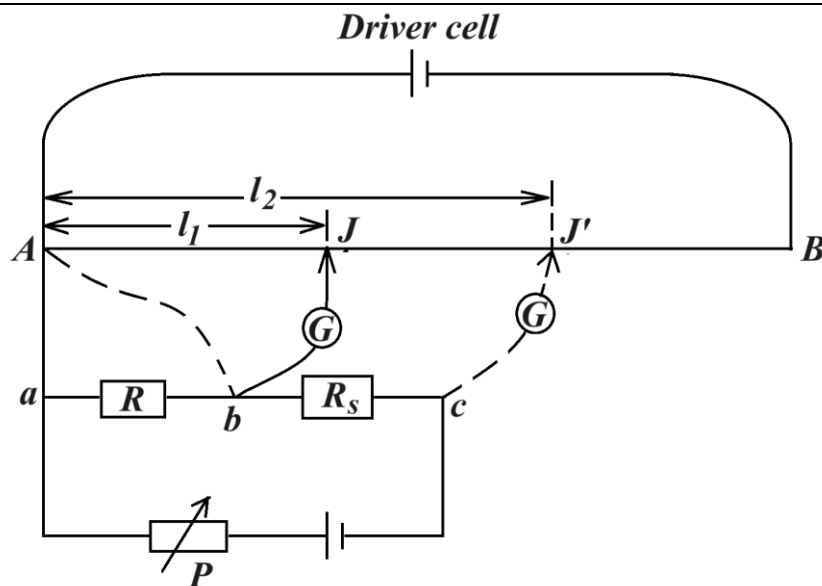
(e)



	• In the first half cycle when A is positive relative to B diodes D_1 and D_2 are in forward bias and current flows through R in the direction <u>XY</u>, while D_3 and D_4 are reverse biased. • In the next half cycle when B is positive relative to A, diodes D_3 and D_4 are forward biased and current flows through R in the direction XY again while D_1 and D_2 are reverse biased. • During both cycles current is passed through the ammeter in one direction.	
11 (a)	Resistivity is the resistance between the opposite faces of a $1m^3$ of a material. From $\rho = \frac{RA}{l} = \frac{\Omega m^2}{m} = \Omega m$. Thus its <i>S.I unit</i> is the Ωm	
(b)	Consider a resistor, R connected in series with a cell of <i>emf</i>, E and internal resistance, r  $E = I(R + r) \text{----- (1)}$ Power output, $P_{out} = I^2 R$ Power input, $P_{in} = IE$ Efficiency, $\eta = \frac{P_{out}}{P_{in}} \times 100\% = \frac{I^2 R}{IE} \times 100\%$ $\eta = \frac{IR}{E} \times 100\% = \frac{IR}{I(R + r)} \times 100\%$ $\eta = \frac{R}{(R + r)} \times 100\%$	

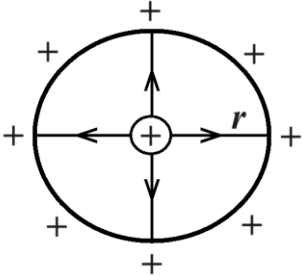
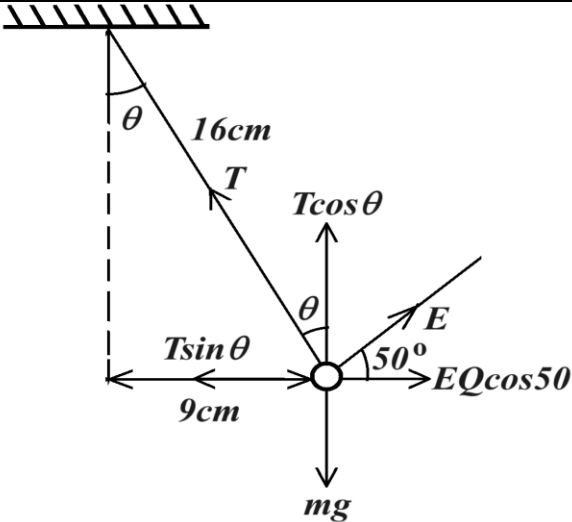
(c) (i)	 ✓ The driver cell maintains a steady current through slide wire. ✓ The slide wire has uniform resistance, hence the <i>p.d per cm</i> is uniform and any test p.d can be balanced across an appropriate length along the slide wire.	
(ii)	By connecting a large resistance boxes in the driver circuit as shown below.  P and Q are connected to reduce current through the wire AB to a suitable small emf of the thermocouple to be balanced. Q also helps raise the p.d in this section to enable a balance point to be found for E_s.	

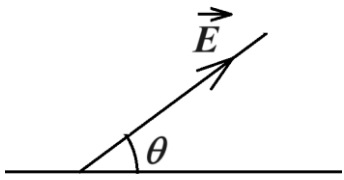
(d)



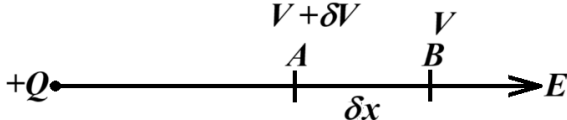
- ✓ The test resistor, R and a standard resistor, R_s are connected in series so that the same current passes through them as shown in the circuit above.
- ✓ With contacts at a and b the jockey J is tapped at different points along the slide wire AB until a point is reached when the galvanometer shows no deflection. The balance length, l_1 is measured and recorded.
- ✓ The galvanometer is then disconnected from b to c and b is connected directly to A as shown by the dotted lines in the diagram above.
- ✓ The jockey is again tapped along AB until a balance point is obtained. The new balance length, l_2 is measured and recorded.
- ✓ The unknown resistance, R is then calculated from $R = \left(\frac{l_1}{l_2}\right)R_s$

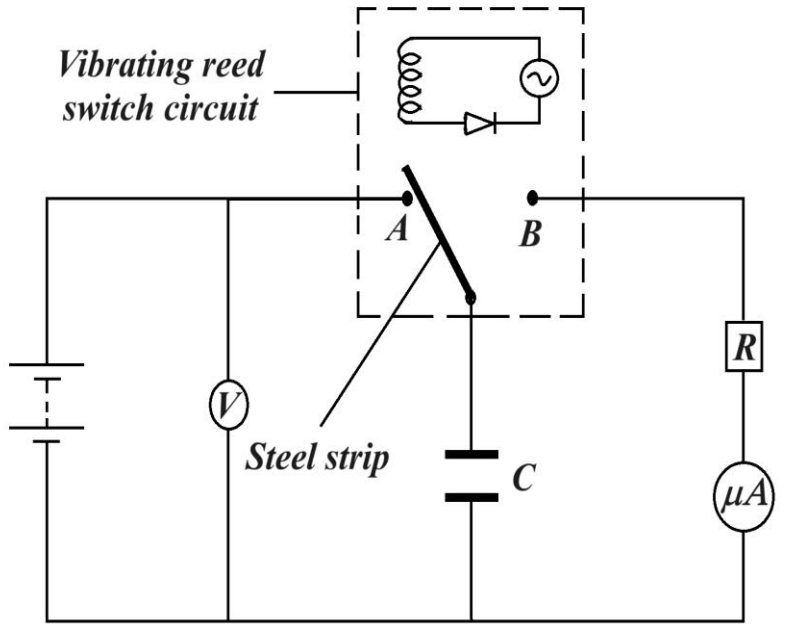
(e) (i)	$R_s = 10\Omega$ At 0°C, $l_1 = 40\text{cm}$, $l_2 = 60\text{cm}$ At balance point, $\frac{R_0}{R_s} = \frac{l_1}{l_2} \Rightarrow R_0 = \frac{40}{60} \times 10 = \frac{20}{3} \Omega$ At 100°C, $l_1 = 50\text{cm}$, $l_2 = 50\text{cm}$ $\frac{R_{100}}{R_s} = \frac{l_1}{l_2} \Rightarrow R_{100} = \frac{50}{50} \times 10 = 10\Omega$ At $\theta^\circ\text{C}$, $l_1 = 42\text{cm}$, $l_2 = 58\text{cm}$ $\frac{R_\theta}{R_s} = \frac{l_1}{l_2} \Rightarrow R_\theta = \frac{42}{58} \times 10 = \frac{210}{29} \Omega$ From $R_\theta = R_0(1 + \theta\alpha)$ $R_\theta = R_0(1 + \theta\alpha) \Rightarrow \frac{210}{29} = \frac{20}{3}(1 + \theta\alpha) \text{---(1)}$ $R_{100} = R_0(1 + 100\alpha)$ $10 = \frac{20}{3}(1 + 100\alpha) \Rightarrow \alpha = 5 \times 10^{-3} \text{K}^{-1}$ $\text{From (1), } \theta = \frac{\left(\frac{210 \times 3}{29 \times 20} - 1\right)}{5 \times 10^{-3}}$ $\theta = 17.24^\circ\text{C}$	
(ii)	$\rho_\theta = \frac{R_\theta A}{l} = \frac{210}{29} \times \frac{2.5 \times 10^{-4} \times 10^{-4}}{1.5} = 1.207 \times 10^{-7} \Omega\text{m}$	
(f)	<i>Positive temperature coefficient of resistance.</i> This will result into increase in resistance of the heating element due to increase in its temperature when current flows through it.	
12(a)(i)	Action at a point is the apparent loss of charge at the sharp points of a charged conductor. The high charge density at sharp points causes high electric field intensity that ionizes surrounding air molecules. Ions of similar charge are repelled and ions of opposite charge are attracted hence neutralizing the charge on the conductor.	
(ii)	When a negatively charged metal rod is placed on a neutral gold leaf, the leaf diverges because the electroscope gets charged by contact. When a sharp pin is placed on its cap with its sharp end facing away, the divergence of the leaf decreases with time. At the sharp point of the pin, there is a high charge density that causes a high electric field intensity that ionizes surrounding air molecules, the	

	positive ions are attracted to neutralize the negative charge on the electroscope hence the leaf falls	
(b)(i)	Gauss' law states that the total flux passing normally through an area is equal to the relation of the charge enclosed to the permittivity of the medium.	
(ii)	Assuming we consider a radius, r, concentric with a positive charge Q in free space.  Electric field intensity on the surface of the sphere is given by $E = \frac{Q}{4\pi\epsilon_0 r^2} \dots\dots\dots (i)$ But $\phi = EA \dots\dots\dots (ii)$ Substituting (i) into (ii) $\phi = \frac{Q}{4\pi\epsilon_0 r^2} A$ For a sphere, $A = 4\pi r^2$ $\phi = \left(\frac{Q}{4\pi\epsilon_0 r^2}\right) 4\pi r^2$ $\phi = \frac{Q}{\epsilon_0}$	
(c)		
(i)	Let the tension in the thread be T, θ be the angle the string makes with the vertical. Resolving vertically, $T \cos \theta + EQ \sin 50 = mg$ $T \cos \theta = mg - EQ \sin 50 \dots\dots\dots (i)$	

	But $\theta = \sin^{-1}\left(\frac{9}{16}\right) = 34.24^\circ$ Resolving horizontally, $T \sin \theta = EQ \cos 50$ — — — (ii) (ii) $\div$ (i) $\frac{T \sin \theta}{T \cos \theta} = \frac{EQ \cos 50}{mg - EQ \sin 50}$ $\frac{EQ \cos 50}{mg - EQ \sin 50} = \tan 34.24$ $EQ \cos 50 = mg \tan 34.24 - EQ \sin 50 \tan 34.24$ $EQ (\cos 50 + \sin 50 \tan 34.24) = mg \tan 34.24$ $Q = \frac{mg \tan 34.24}{E (\cos 50 + \sin 50 \tan 34.24)}$ $Q = \frac{60 \times 10^{-3} \times 9.81 \tan 34.24}{1.24 \times 10^5 (\cos 50 + \sin 50 \tan 34.24)}$ $Q = 2.77 \times 10^{-6} \text{ C}$	
(ii)	From (i) $T \sin \theta = EQ \cos 50$ $T = \frac{1.24 \times 10^5 \times 2.77 \times 10^{-6} \cos 50}{\sin 34.24}$ $T = 0.3924 \text{ N}$	
(d)(i)	Equipotential surface is surfaces is one in which the potential is the same at all points. Examples include; Any spherical shell concentric with a point charge. The surface a charged conductor.	
(ii)	Suppose $\vec{E}$ due to the charged surface makes an angle θ with the equipotential surface.  The work done to move 1C of a positive charge through a distance, x along the surface is; Work = Force $\times$ distance $W = Fx$	

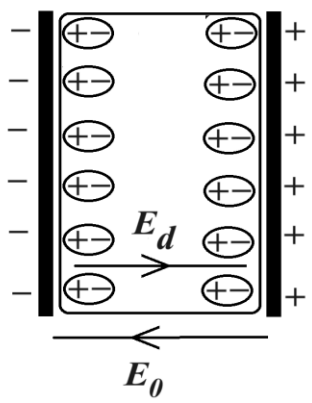
	But $\vec{F} = \vec{E} \times 1 = \vec{E}$ where $Q = +1C$ Along the surface, $\vec{E} = E \cos \theta$ $\Rightarrow W = (E \cos \theta)x$ For an equipotential surface, Work, $W=0$ $\Rightarrow Ex \cos \theta = 0$ If $E \neq 0$ and $x \neq 0$, then, $\cos \theta = 0$ $\Rightarrow \theta = \cos^{-1}(0)$ $\therefore \theta = 90^\circ$ Hence $\vec{E}$ is perpendicular to the equipotential surface	
13 (a)	Capacitance of a capacitor is the ratio of magnitude of charge on either plate of the capacitor to the potential difference between the plates. A farad is the capacitance of a capacitor when the magnitude of charge of $1C$ is stored on either plate and the p.d between the plates is $1V$.	
(b)(i)	Consider a battery with pd V, if it charges the capacitor to charge Q, then <i>Energy supplied by the battery $E = VQ$</i> <i>Heat dissipated in the circuit</i> <i>= energy supplied by the battery</i> <i>– energy stored in the capacitor</i> The small work δw done to move a small charge δq from one plate to another is given by $\delta w = V\delta q$ The total work W done to charge the capacitor to Q from zero is given by. $W = \int_0^Q V dq = \int_0^Q \frac{Q}{C} dq$ $W = \frac{Q^2}{2C}$ But $C = \frac{Q}{V}$ $W = QV$ The work done is stored as energy. Thus $E = QV$ <i>Energy stored in the capacitor $E_1 = \frac{QV}{2}$</i> <i>Heat dissipated $= E - E_1$</i> <i>Energy lost $= QV - \frac{QV}{2} = \frac{QV}{2}$</i>	

	$Heat\ dissipated = energy\ stored = \frac{QV}{2}$	
(b)(ii)	Consider a charge $+Q$ at a distance x from A in an electric field where electric field strength is E.  Suppose the points A and B are so close a small distance δx apart such that the electric field intensity is constant. Work done to move a charge of $+1C$ from B to A is $W = (V + \delta V) - V = \delta V$ Also Work, $W = E \times 1 \times (-\delta x) = -E\delta x$ $\Rightarrow W = -E\delta x$ $-E\delta x = \delta V$ $E = -\frac{\delta V}{\delta x}$ Electric field intensity at any point is equal to the potential gradient at and near the point	
(c)(i)	$A_1 = \frac{\pi d^2}{4} = \frac{\pi \times (0.1)^2}{4} = 7.854 \times 10^{-3} m^2$ $A_2 = \frac{\pi d^2}{4} = \frac{\pi \times (0.12)^2}{4} = 1.131 \times 10^{-2} m^2$ $C_1 = \frac{A\epsilon_0}{d} = \frac{7.854 \times 10^{-3} \times 8.85 \times 10^{-12}}{2.0 \times 10^{-3}} = 3.477 \times 10^{-11} F$ $C_2 = \frac{A\epsilon_0}{d} = \frac{1.131 \times 10^{-2} \times 8.85 \times 10^{-12}}{3.0 \times 10^{-3}} = 3.338 \times 10^{-11} F$ Effective capacitance $C = \frac{C_1 C_2}{C_1 + C_2} = \frac{3.477 \times 10^{-11} \times 3.338 \times 10^{-11}}{3.477 \times 10^{-11} + 3.338 \times 10^{-11}} = 1.705 \times 10^{-11} F$ $C = 1.705 \times 10^{-11} F$	
(ii)	Energy stored in the system, $E = \frac{CV^2}{2} = \frac{120^2 \times 1.705 \times 10^{-11}}{2}$ $E = 1.227 \times 10^{-7} J$	

(d)	 • The apparatus is set up as shown above. • A capacitor with free space between its plates is connected at position C. • The reed switch is then activated so that the capacitor alternately charges and discharges through a sensitive microammeter at a known frequency f of the low a.c supply energizing the reed switch. • The voltmeter reading V and microammeter reading I_0 are noted. • The dielectric whose relative permittivity is required is then inserted between the plates of the capacitor. • Keeping the plate separation and area of overlap constant, the procedure is repeated and new microammeter reading I_1 is recorded. • The relative permittivity ϵ_r is determined from $\epsilon_r = \frac{I_1}{I_0}$	
(e) (i)	At equilibrium, <i>The sum of clockwise moments</i> <i>= sum of anticlockwise moments</i> $EQx = mgx$ $\frac{V}{d} CV = mg$ $\frac{CV^2}{d} = mg$ $\frac{A\epsilon_0}{d^2} V^2 = mg$ $\frac{120^{-4} \times 8.85 \times 10^{-12}}{0.4^2} V^2 = 2.66 \times 10^{-6} \times 9.81$ $V = 6.27kV$	

(ii)	Charge density, $\delta = \frac{Q}{A}$ $\delta = \frac{cV}{A}$ $= \frac{A\epsilon_0 V}{Ad} = \frac{\epsilon_0 V}{d}$ $= \frac{8.85 \times 10^{-12} \times 6.27 \times 10^3}{0.4}$ $\delta = 1.387 \times 10^{-7} \text{ Cm}^{-2}$	
14 (a)	Dielectric strength is the maximum potential gradient a dielectric can withstand before it starts conducting.	
(b)	The diagram shows a circuit with a d.c source labeled 'V' at the top. A switch labeled 'K₁' is on the right side of the top wire. Below the source, there is a parallel arrangement. One branch contains a capacitor labeled 'Capacitor'. The other branch contains a switch labeled 'K₂' in series with a ballistic galvanometer labeled 'BG' (represented by a circle with 'BG' inside). The bottom wire connects the capacitor and the BG branch. • The circuit is connected as shown above • A capacitor is connected to position C. • With switch K₂ open, K₁ is closed and the capacitor charges fully to the p.d V of the source. • Switch K₁ is opened and K₂ is closed and the capacitor discharges through the ballistic galvanometer. • The maximum deflection θ_0 of the ballistic galvanometer is recorded. • Keeping the plate separation constant, one of the plates is slightly displaced to reduce the effective area of overlap. • The procedure is repeated and the new deflection θ_1 of the ballistic galvanometer is recorded. • It is observed that $\theta_1 < \theta_0$ thus the capacitance of the capacitor reduces when the area of overlap is reduced. Hence $C \propto A$.	

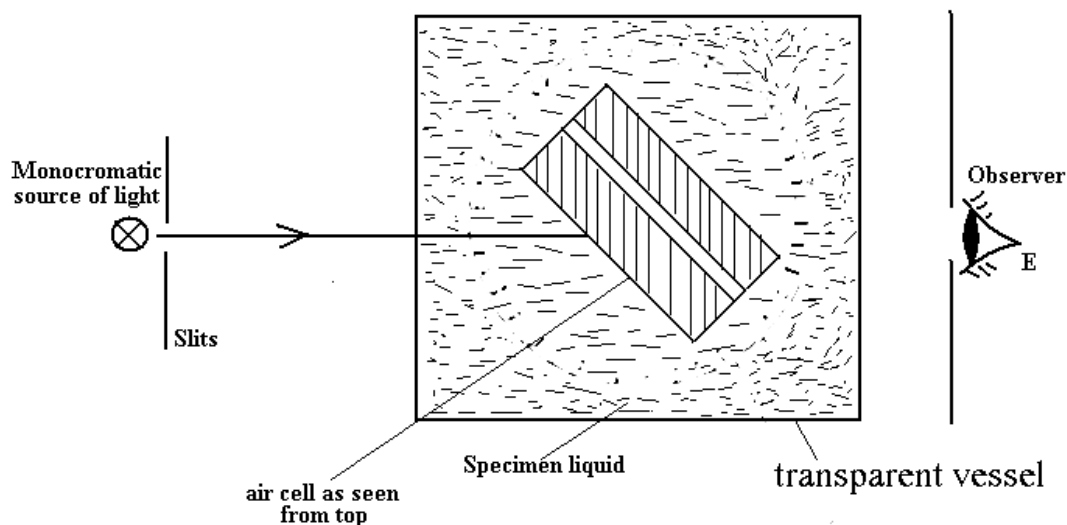
(c) (i)	Consider a capacitor connected to a battery and charged to a p.d V The small work δw done to move a small charge δq from one plate to another is given by $\delta w = V\delta q$ The total work W done to charge the capacitor to Q from zero is given by. $W = \int_0^Q V dq$ $W = \int_0^Q \frac{Q}{C} dq$ $W = \frac{Q^2}{2C}$ The work done is stored as electrostatic energy between the plates of the capacitor. <i>Energy stored in the capacitor $E = \frac{Q^2}{2C}$</i> <i>But $C = \frac{Q}{V}$</i> $E = \frac{Q^2}{2\left(\frac{Q}{V}\right)}$ $E = \frac{1}{2} QV$	
(ii)	From $C_2 = \frac{A\epsilon_0}{d}$, when the separation d is reduced, the capacitance C of the capacitor increases. Also <i>Energy $E = \frac{CV^2}{2}$ thus $E \propto C$</i>. Therefore, the energy reduces when the distance of separation reduces. This is because, when the capacitor is connected to the battery, the decrease in capacitance results in a decrease in the amount of charge stored by the capacitor since $Q = CV$ and V is constant. This charge is returned to the battery thus a decrease in energy is as a result of the capacitor discharging.	

(iii)	 • When a dielectric is inserted between the plates of the capacitor, the molecules of the capacitor get polarized forming positive charge near the negative plate and negative charge near the positive plate. These charges are bound charges so they can't be neutralized. This creates an electric field intensity E_d in a direction opposite to that of the applied electric field intensity E_0. • This reduces the electric field intensity $E = E_0 - E_d$ between the plates of the capacitor. • Since $E = \frac{V}{d}$, a reduction in E reduces the P.d, V between the plates. • From $C = \frac{Q}{V}$, a decrease in V increases the capacitance of the capacitor. Hence presence of a dielectric increases capacitance of a capacitor.	
(d)	For C_2 and C_3 with a dielectric $C' = \frac{C_2 \epsilon_r C_3}{C_2 + \epsilon_r C_3} = \frac{3 \times 2.3 \times 3}{3 + 2.3 \times 3} = 2.091 \mu F$ For C' and C_1 Total capacitance, $C = C' + C_1$ $C = 3 + 2.091$ $C = 5.091 \mu F$ Total charge, $Q = CV$ $Q = 5.091 \times 60$ $Q = 305.46 \mu C$ But $Q = k\theta$ $305.46 = 4\theta$ $\theta = 76.365 \text{ divisions}$	

END

1. (a) Refraction is the bending of light as it moves from one medium to another.

(b)



Two plane-parallel glass plates are cemented together to make an air cell.

The air cell is put in water whose refractive index is to be determined.

Monochromatic light is directed normal to the air cell, and observed from the opposite side at E.

The air cell is rotated about a vertical axis until light is suddenly cut off from E

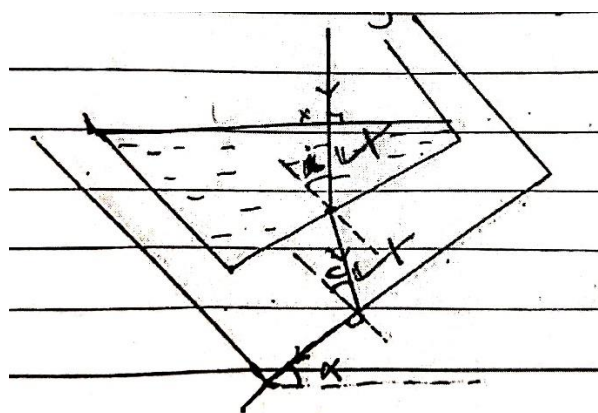
The angle of rotation θ_1 of the air cell is noted

The air cell is rotated back to its original position and then rotated in opposite direction until light is again cut off from E

The angle of rotation θ_2 of the air cell is noted

The refractive index of water is then obtained from, $n = \frac{1}{\sin(\frac{\theta_1 + \theta_2}{2})}$

(c) i)



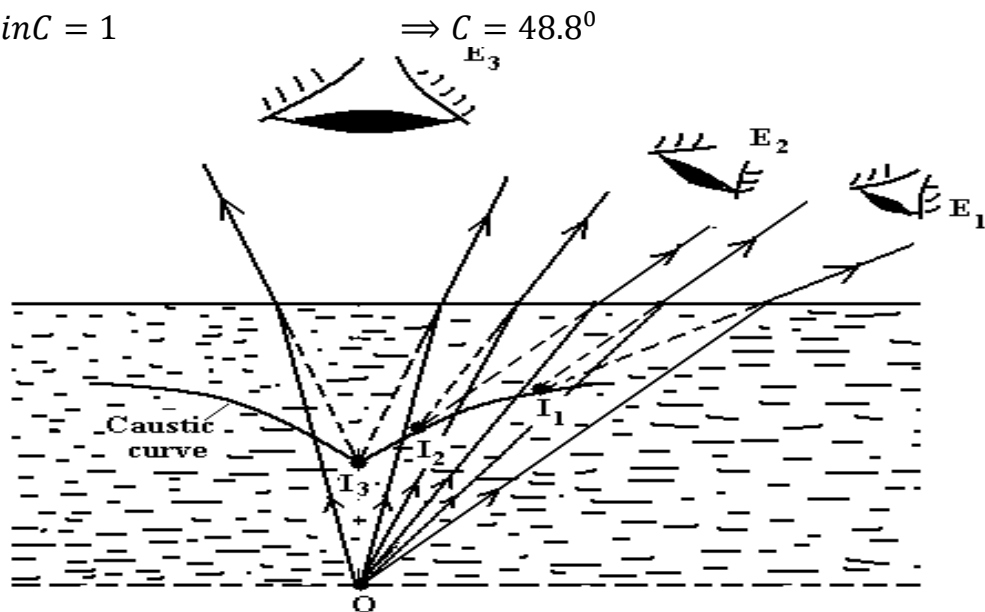
(ii) $1.5 \sin C = 1$

$$\sin^{-1}\left(\frac{1}{1.5}\right) = 41.8^\circ$$

(iii) The angle of tilting of the container is equal to the angle of incidence, i at the water-glass boundary.

$$1.33 \sin C = 1$$

(d)

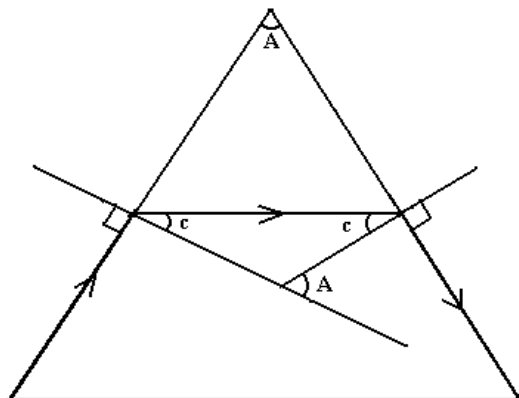


With the point O observed from above at E_3 , rays of light are refracted away from the normal at the water-air interface and appears to be at I.

With O observed obliquely from E_2 , the angle of incidence increased the apparent depth decreased and the water tank appears shallow.

(e) (i) Limiting angle is the refracting angle of a prism for which there is grazing incidence and grazing emerges for light passing through the prism.

(ii)

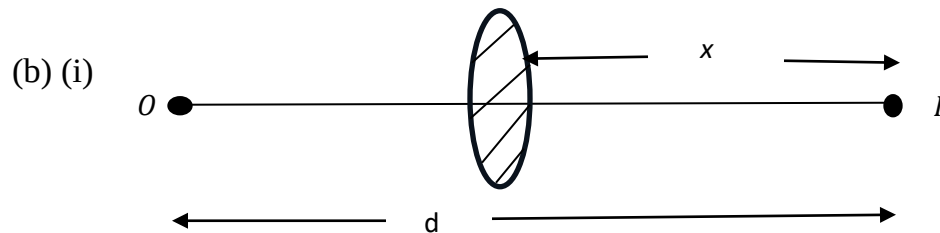


$$c = \sin^{-1} \frac{1}{1.5} = 41.8^\circ$$

$$\text{Limiting angle } A = 2c = 83.6^\circ$$

2. (a) Principal axis is a line through the optical center of the lens and joins the Centre of curvature of the lens surface.

Focal plane is a plane perpendicular to the principal axis and through the focal point of the lens.



Let the image distance be x , the object distance is $(d-x)$

$$\frac{1}{f} = \frac{1}{d-x} + \frac{1}{x}$$

$$\frac{1}{f} = \frac{d}{dx-x^2}$$

$$dx - x^2 = fd, \quad x^2 - dx + fd = 0$$

for real values of x , for real image

$$b^2 > 4ac$$

$$\text{for } ax^2 + bx + c = 0$$

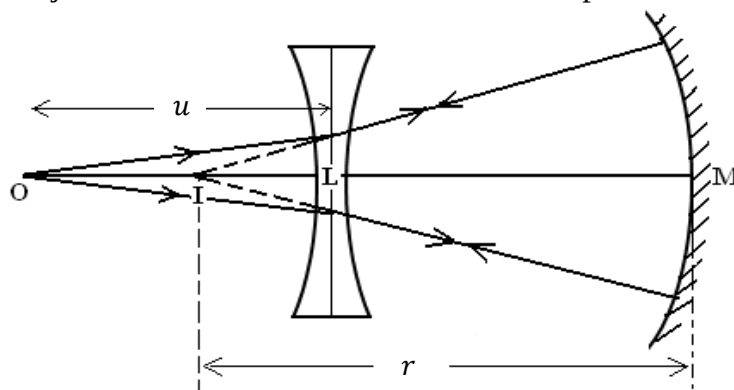
$$d^2 > 4fd$$

$$d > 4f$$

So for non-real values, $d \leq 4f$. No image is formed on the screen.

(ii) When the object is closer to the lens than the focal point.

(c)



An illuminated object is placed in front of a concave lens and a concave mirror is placed behind L

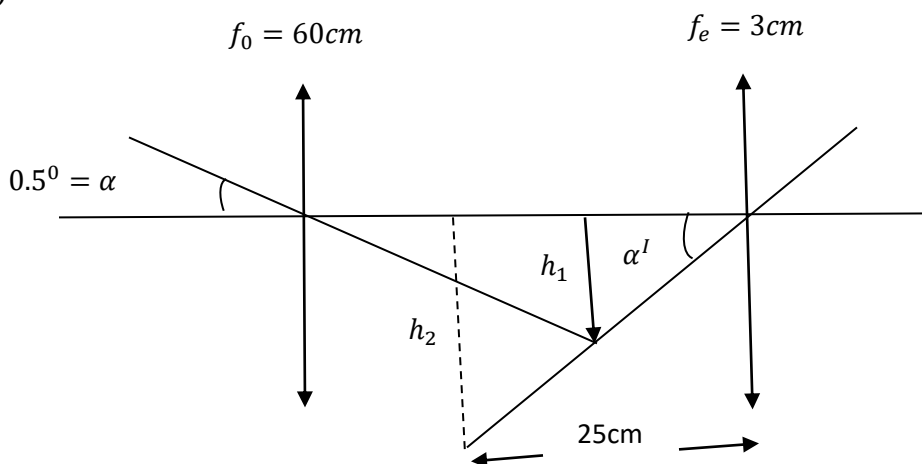
M is adjusted until, the final image coincides with the object, O

The distance LM, and OL are measured.

The image distance $IL = (r - LM)$, r is the radius of the curvature of the mirror M

The focal length of the lens is obtained from $\frac{1}{f} = \frac{1}{OL} - \frac{1}{r-LM}$

(d) (i)



For the eye piece, $\frac{1}{f_e} = \frac{1}{u_e} + \frac{1}{v_e}$

$$\frac{1}{3} = \frac{1}{u_e} - \frac{1}{25},$$

$$u_e = \frac{75}{28},$$

$$u_e = 2.679 \text{ cm}$$

Angular magnification, $M = \frac{f_0}{u_e} = \frac{60}{2.679} = 22.4$

$$(ii) M = \frac{\alpha^I}{\alpha}, \quad \alpha^I = (22.4 \times 0.5), \quad \alpha^I = 11.2^\circ, \quad \tan \alpha^I = \frac{h_2}{25}, \quad h_2 = 4.95 \text{ cm}$$

SECTION B

3. (a). In longitudinal wave motion, the wave particles vibrate parallel to the direction of travel of the wave.

In transverse waves, the wave particles vibrate perpendicular to the direction of travel of the wave.

- (b). (i) $f=250\text{Hz}$, $V=30\text{ms}^{-1}$

From the general wave equation, $y = A \sin\left(\omega t - \frac{2\pi x}{\lambda}\right)$

$$\omega = 2\pi f = 2\pi \times 250 = 500\pi \text{ rad}^{-1}$$

$$\lambda = \frac{v}{f} \quad \lambda = \frac{30}{250} = \frac{3}{25}$$

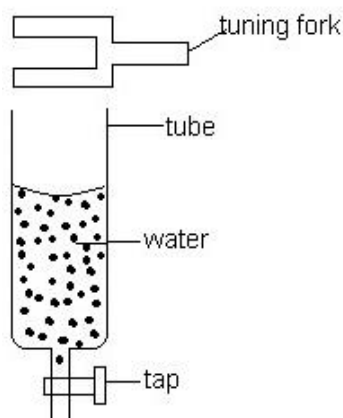
$$y = 0.03 \sin(500\pi t - \frac{50\pi x}{3})$$

(ii) Phase difference $\Delta \Phi = \frac{50\pi \Delta x}{3}$

$$\Delta \Phi = \frac{50\pi(10 \times 10^{-2})}{3}$$

$$\Delta \Phi = \frac{5\pi}{3} \text{ radians}$$

(c)



A tall glass jar is filled with water, and a vibrating tuning fork of frequency f held above the tube.

The tap is opened, and water is allowed to flow out until a loud sound is heard

The length L of the air column is measured,

The experiment is repeated for different values of f and the corresponding values of L determined.

Results are tabulated including values of $\frac{1}{f}$

A graph of L against $\frac{1}{f}$ is plotted, and the intercept C on the L axis is recorded

The end correction $e = -C$

(d) $\lambda = 397\text{nm}$ $\lambda^1 = 478\text{nm}$

(i) The Galaxy is moving away from the earth

Increase in apparent wavelength shows red shift in the spectrum. Thus the galaxy is moving away.

$$V = \left(\frac{\lambda^1 - \lambda}{\lambda} \right) C$$

$$V = \left(\frac{478 \times 10^{-9} - 397 \times 10^{-9}}{397 \times 10^{-9}} \right) 3.0 \times 10^8$$

$$V = \frac{81}{397} \times 3.0 \times 10^8$$

$$V = 6.127 \times 10^7 \text{ ms}^{-1}$$

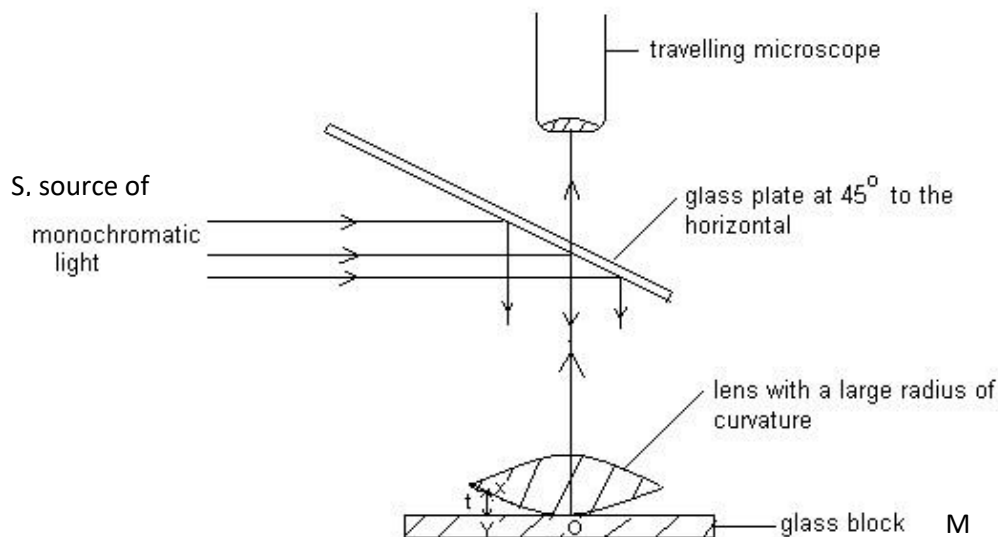
(e) At night the air near the earth's surface is cold compared to the air progressively above. Since sound travels faster at high temperature, sound is progressively refracted away from the normal. Sound thus bends downward towards the earth. During the day, the air near the earth is hot, compared to air progressively above. Sound is refracted towards the sky

4. (a) interference of the light is the superposition of light from coherent source leading to alternate regions of maximum and minimum intensity

Interfering lights must;

- have same frequency
- have equal or comparable amplitude
- have constant phase relationship

(b) (i)



Monochromatic light from S is reflected by the glass plate on to the convex lens placed on to the glass block labeled M

A travelling microscope is focused on to the lens, alternate bright and dark rings are observed.

When light is incident on the lens, some light is reflected from the lower surface of the lens, and the light transmitted is reflected from the upper surface of the glass block.

The reflected wave trains are coherent they overlap and interference takes place.

Alternate bright and dark rings formed.

Due to reflection on the glass block, there is a phase change of 180° (extra path difference of $\lambda/2$)

At the center of the pattern, path difference is $\lambda/2$, a dark band is formed.

At the positions, where $2t = n\lambda$, $n = 0, 1, 2, 3, \dots$ where t is the thickness of the air film between the lens and glass block, dark rings are formed

At positions where $2t = \left(n - \frac{1}{2}\right)\lambda$, $n = 1, 2, 3, \dots$ bright rings are formed

$$(ii) y_{10} = 3.44 \text{ cm}, \quad D = 2 \text{ cm} \quad \lambda = 5.89 \times 10^{-7} \text{ m}$$

$$y_n = \frac{n\lambda d}{a}$$

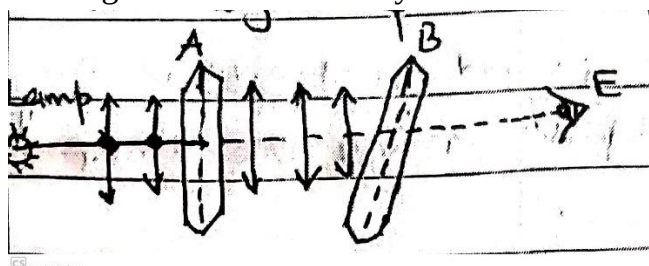
$$a = \frac{n\lambda d}{y_n} = \frac{10 \times 5.89 \times 10^{-7} \times 2 \times 10^{-2}}{3.44 \times 10^{-2}}$$

$$a = 3.424 \times 10^{-6} \text{ m}$$

(c) (i) Diffraction is the spreading of light beyond the geometric shadow leading to interference pattern at the edge of the shadow.

Polarization of light is when the vibration of the electric vector of light is restricted in only one plane perpendicular to the direction of travel of light.

(ii) No light passes through the Polaroid if they are crossed



As B is rotated, intensity of light increases and reaches maximum after 90° rotation of B. As B is rotated, a component of the electric vector of polarized light passes through it. After 90° , the orientation of A and B is the same. All the polarized light passes through.

$$(ii) \tan i = \frac{1.53}{1.33}, \quad i = \tan^{-1} \frac{1.53}{1.33}, \quad i = 49^\circ$$

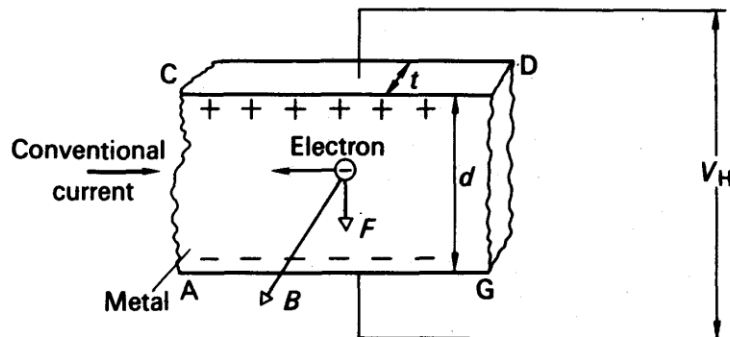
(d)-used in sun glasses to reduce glare

-Stress analysis

-Measurement of concentration of sugar solution

5.(a) Magnetic field is a space in which a magnetic force is experienced .

(b)



- (i) When a magnetic field is applied, each electron experiences a magnetic force , perpendicular to magnetic field and current .

One face of the strip becomes negative relative to the opposite face p.d is developed across the strip.

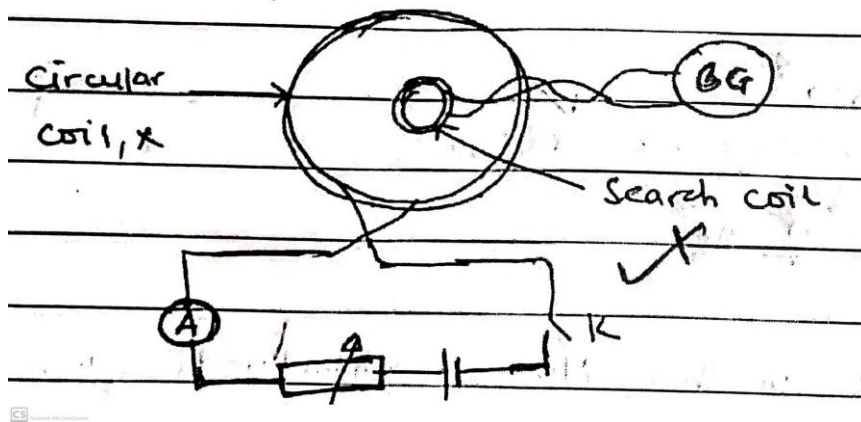
(ii) drift velocity, $v = \frac{I}{neA} = \frac{0.5}{5 \times 10^{22} \times 10^{-6} \times 1.6 \times 10^{-19} (1.2 \times 10^{-2} \times 1.5 \times 10^{-5})} = 3.47 \times 10^{-4} \text{ms}^{-1}$

- (iii) p.d is maximum when a magnetic force is equal to electrostatic force on an electron.

$$E = BV, \quad \frac{V_H}{d} = BV, \quad V_H = 0.5 \times 3.47 \times 10^{-4} \times 1.2 \times 10^{-2} = 2.082 \times 10^{-6} \text{V}.$$

$$V_H = \frac{BI}{net} = \frac{0.5 \times 0.5}{5 \times 10^{22} \times 10^{-6} \times 1.6 \times 10^{-19} \times 1.5 \times 10^{-5}} = 2.08 \times 10^{-6} \text{V}.$$

(c)



Switch k, is closed and the ammeter reading, I, is noted.

A search coil connected to a ballistic galvanometer is placed at the center of a circular coil x, such that the magnetic field of the coil enters it normally.

The search coil is quickly turned through 90° and the deflection θ noted on the ballistic galvanometer.

The experiment is repeated for different values of I and the corresponding values of θ noted.

A graph of θ against I is plotted and a straight line through the origin is obtained.

(d)

$$\begin{aligned} \text{i)} \quad B &= \mu_0 n I \\ &= 4\pi \times 10^{-7} \times 2000 \times 4 \\ &= 1.0053 \times 10^{-2} \text{T} \end{aligned}$$

$$\begin{aligned} \text{ii)} \quad \tau &= B I A N \cos \theta, I = \frac{\tau}{B A N \cos \theta} \\ I &= \frac{3.0 \times 10^{-8}}{1.0053 \times 10^{-2} \times 5 \times 10^{-2} \times 2 \times 10^{-2} \times 50 \cos 60} = 1.194 \times 10^{-4} \text{A} \end{aligned}$$

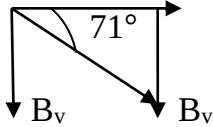
(e) The bar magnet rests in the north –south direction, and dips southwards .north pole of the magnet points northwards. In the southern hemisphere, the magnetic field of the earth dips southwards .a freely suspended magnet rests along the magnetic field of the earth.

6. (a) The magnitude of induced emf is directly proportional to the rate of change magnetic flux linkage

The direction of the induced current is in a such a way as to oppose the change causing it.

$$\begin{aligned} \text{(b) (i)} \quad B &= 1.2 \times 10^{-2} \text{T} \\ A &= 0.3 \text{m}^2 \\ \text{initial flux, } \phi_o &= B A N = 1.2 \times 10^{-2} \times 0.3 \times 150 \\ \phi_o &= 0.54 \text{Wb} \\ \text{(ii)} \quad \text{Final flux, } \phi_t &= B A N \cos 70^\circ \\ &= 0.54 \cos 70^\circ \\ &= 0.1847 \text{Wb} \\ \text{Emd induced} &= \phi_o = \frac{0.54 - 0.1847}{2} \\ \varepsilon &= 0.17765 \text{V} \end{aligned}$$

(c) (i) As the coil of the motor rotates it cuts the magnetic field and an emf is induced in it. The induced emf opposes the applied voltage of the motor. This induced emf is called back emf.

(ii)  $B_H = 1.6 \times 10^{-5} \text{ T}$ $l = 40 \text{ m}$ $v = \frac{100 \times 1000}{60 \times 60} = 27.8 \text{ ms}^{-1}$

$$B_v = 1.6 \times 10^{-5} \times \tan 71.6^\circ$$

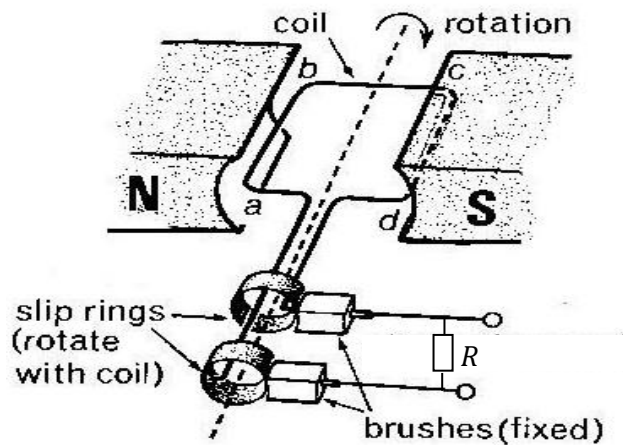
$$B_v = 4.81 \times 10^{-5} \text{ T}$$

$$\text{Induced emf, } \varepsilon = Blv$$

$$\varepsilon = 4.81 \times 10^{-5} \times 40 \times 27.8$$

$$\varepsilon = 5.349 \times 10^{-2} \text{ V}$$

(d)



When the coil is rotated about the axis, the coil cuts the magnetic field, and an emf is induced in the coil. The induced current flows through the load R.

When the coil reaches vertical position, no emf is induced. Beyond the vertical position, the emf induced in the coil and the direction of the flow of current reverses

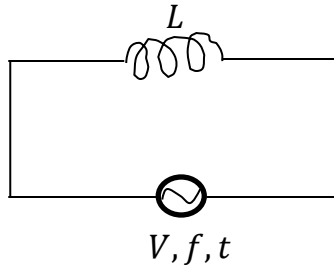
Each carbon brush remains in contact with its split ring, an alternating current then flows through the load R

The emf induced produced is given by $E = BAN\omega \sin \omega t$.

7. (a) Peak value of alternating voltage is the maximum value of the voltage.

Root mean square value is the value of direct voltage that dissipates heat in a given resistor at the same rate as the alternating voltage.

(b) (i)



$$\text{Back emf in the coil: } \varepsilon = -L \frac{dI}{dt}$$

$$\text{For current to flow, } \varepsilon = -V$$

$$V = L \frac{dI}{dt}$$

$$I = \frac{V_0}{L} \int \sin \omega t dt$$

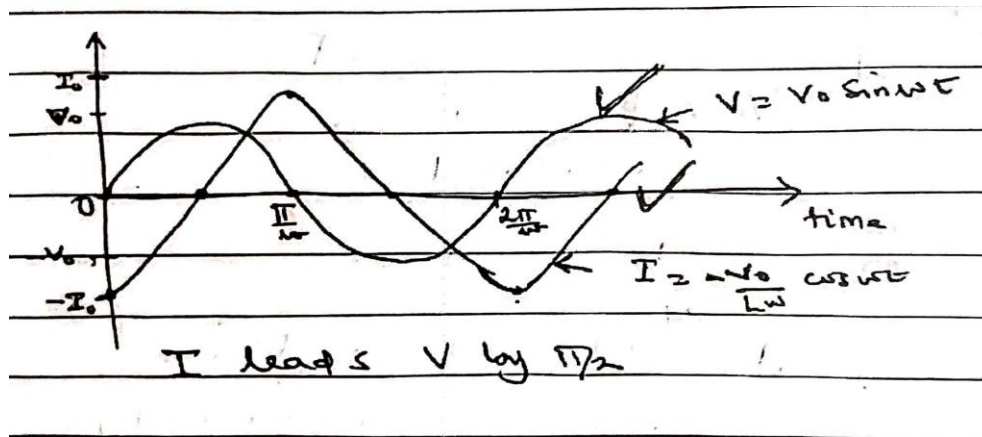
$$I = -\frac{V_0}{L\omega} \cos \omega t$$

$$\text{Peak value } I_0 = \frac{V_0}{\omega L}$$

$$\text{Reactance } X_L = \frac{V_0}{I_0} = L\omega \quad \text{But } \omega = 2\pi f$$

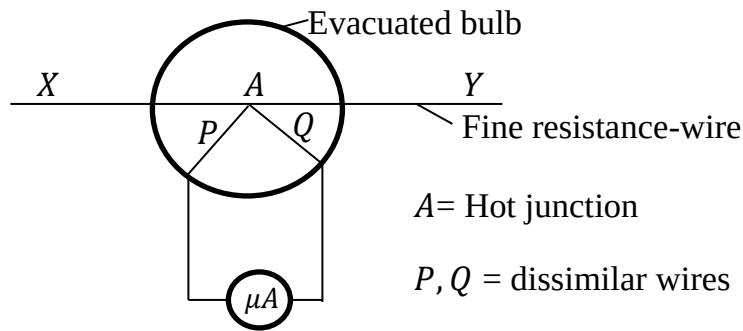
$$X_L = 2\pi fL$$

(ii)



(iii) When current is maximum, it is momentarily constant. Since back emf $\varepsilon = -L \frac{dI}{dt}$, back emf is zero when the current is zero, its the rate of flow is maximum, back emf is maximum since back emf $\varepsilon = -V$ applied voltage is zero when the current is maximum and voltage is maximum when current is zero.

(c)



One junction is connected to the center of the resistance wire, the other junction is at room temperature.

Current to be measured is passed through the resistance wire, the wire gets hot and A becomes the hot junction

Thermal emf is created, a direct current then flows and is received by the moving coil meter.

The hot junction is enclosed in an evacuated bulb to protect it from draughts.

(d) (i)

$$V^2 = V_R^2 + V_C^2$$

$$V_C = \sqrt{15^2 - 10^2} = 11.8V$$

(ii)

$$I = \frac{V}{R}$$

$$I = \frac{10}{500} = 0.02A$$

$$V_C = IX_C$$

$$11.18 = 0.02x \frac{1}{2\pi fC}$$

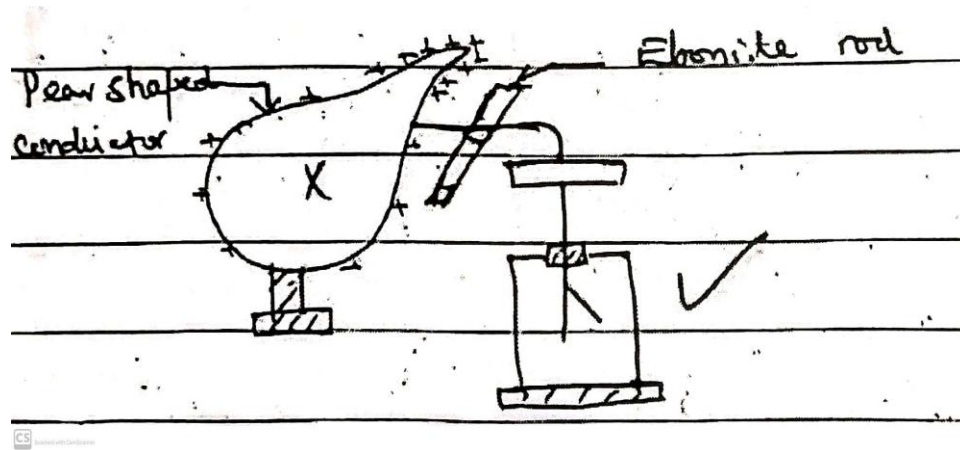
$$C = \frac{0.02}{11.18x2\pi x50} = 5.69x10^{-6}F$$

8. (a) Electric field intensity is the force experienced by one coulomb of charge at a point in an electric field.

Electric potential is the work done in moving one coulomb of electric charge from infinity to a point in an electric field.

(b) (i) At the pointed end of the pin, there is high charge density and high electric field intensity. Air around the pin gets ionized, negative ions get attracted to the pin and neutralize some of the positive charges there. The electroscope is gradually discharged. The gold leaf falls gradually.

(ii)



A wire is connected on the cap of neutral gold leaf electroscope

The free end of the wire is put on the surface of charge pear shaped conductor, divergence on the gold leaf electroscope is noted.

The free end of the wire is moved, on the surface of conductor X, divergence on the electroscope remains the same, potential on the surface of X is constant.

(iii) Electric flux through an area A

$$\Phi = EA$$

$$\text{Electric flux, } \Phi = \frac{\sigma}{\epsilon} \dots \dots (i)$$

$$\text{But total charge } Q = \sigma \cdot A$$

$$EA = \frac{Q}{\epsilon}$$

$$E = \frac{\sigma}{\epsilon}$$

(c) (i) *Potential energy* = $V_x x \propto$

$$= -100 \times 2 \times 10^{-9}$$

$$= -2 \times 10^{-7} J$$

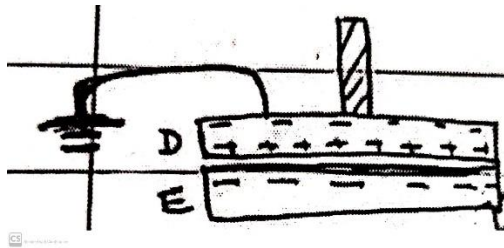
$$p.d; V_{xy} = -100 - 200 = -300 J$$

workdone = $V_{xy} \cdot \propto$

$$= 300 \times 2 \times 10^{-9}$$

$$= 6 \times 10^{-7} J$$

(d)



E-ebonite base, D-metal disc

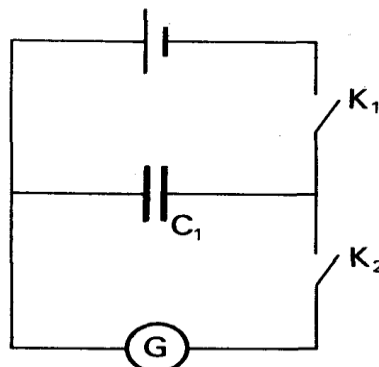
-A metal disc D is placed on a negatively charged ebonite base E; positive charge is induced on the lower surface D and Negative charge is induced on the upper surface.

-The metal disc is then earthed; the disc can then be moved and carries with it the positive charge.

9. (a) Dielectric strength is the maximum potential gradient beyond which the insulation of dielectric breaks down and starts to conduct.

S.I unit of dielectric strength is V/m or N/C

(b)



A parallel plate capacitor is connected in the circuit as shown above.

Switch k1 is closed for a short time and then opened, switch K2 is closed and the first flow direction, θ_0 is noted on the Ballistic galvanometer

A dielectric material is inserted between the plates of the capacitor and the experiment repeated

The first throw deflection θ is noted from the Ballistic galvanometer

Dielectric constant $\epsilon_r = \frac{\theta}{\theta_0}$

$$(c) C = \frac{\epsilon_0 A}{d} = \frac{8.85 \times 10^{-12} \times 25 \times 25^{-4}}{1 \times 10^{-3}}$$

$$C = 2.2125 \times 10^{-11} F$$

$$Q = CV = 2.2125 \times 10^{-11} \times 100$$

$$Q = 2.2125 \times 10^{-9} C$$

$$C' = \frac{\epsilon_0 A}{d'} = \frac{8.85 \times 10^{-12} \times 25 \times 10^{-4}}{2 \times 10^{-3}}$$

$$C' = 1.10625 \times 10^{-11} F$$

By conservation of charge:

$$V' = \frac{Q}{C'} = \frac{2.215 \times 10^{-9}}{1.10625 \times 10^{-11}} = 199.1 V$$

$$\text{Initial energy, } E_1 = \frac{1}{2} C_1 V_1^2 = \frac{1}{2} \times 2.215 \times 10^{-11} \times 100^2$$

$$E_1 = 1.10625 \times 10^{-7} J$$

$$\text{Final energy, } E_2 = \frac{1}{2} \times 1.10625 \times 10^{-11} \times (199.1)^2$$

$$E_2 = 2.1926 \times 10^{-7} J$$

$$\Delta E = 1.0864 \times 10^{-7} J$$

(ii) As plates are moved apart, work is done to overcome the force of attraction between the plates. This work is converted into electrostatic energy thus increase in energy stored by the capacitor.

(d) (i) when capacitors are connected in series, charge on either of the capacitors is equal and same as the total charge. p.d across each capacitor is less than the total p.d across the combination since $C = \frac{Q}{V}$, capacitance of the combination is thus less than capacitance of either capacitor.

(ii) When a dielectric is placed between plates of a charged capacitor, the molecules of the dielectric get polarized.

Negative charges in the dielectric appear near the positive plate, positive charge appear near the negative plate.

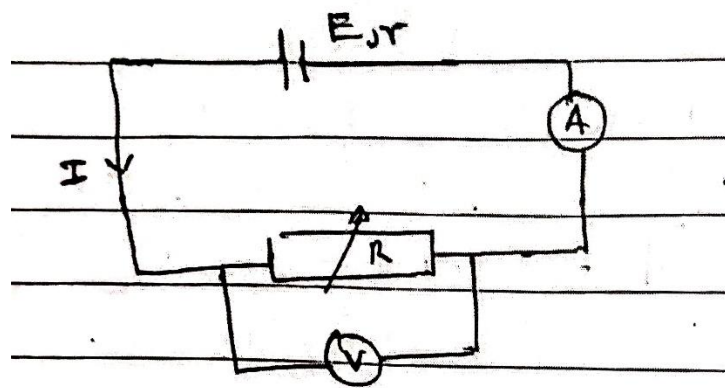
Potential on the positive plate decreases and that on the negative plate increases.

P.d, V between the plates reduced since $C = \frac{Q}{V}$, capacitance increases.

10. (a) E.m.f of a cell is the p.d across the terminals of the cell in an open circuit.

Terminal p.d of a cell is the p.d across the terminals of the cell in a closed circuit.

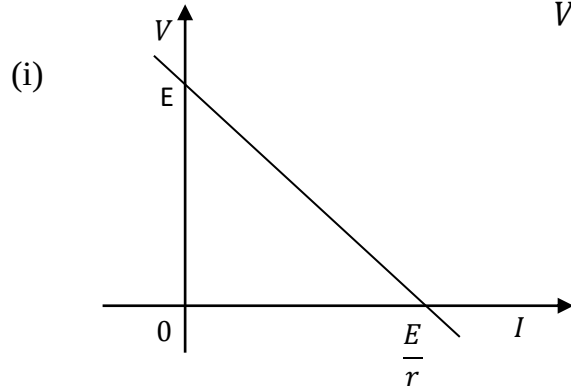
(b)



$$E = I(R + r)$$

$$E = V + Ir$$

$$V = E - Ir$$



-The intercept on V-axis is the emf of the cell

-Slope s of the graph is determined

$$- \quad r = -s$$

(ii) $r = 2\Omega$

$$R_T = 10 + \left(\frac{2 \times 100}{2 + 100} \right)$$

$$= 11.96\Omega$$

$$emf = I(R + r)$$

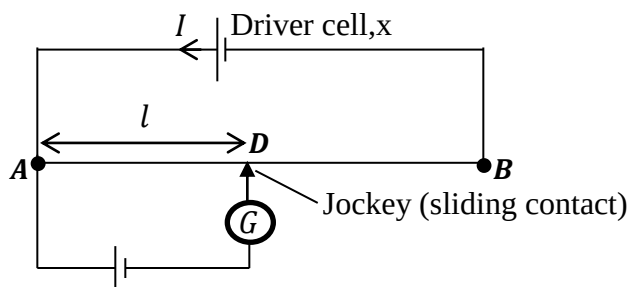
$$Ammeter, I = \left(\frac{2}{11.96 + 2} \right)$$

$$= \frac{2}{13.96} = 0.143A$$

$$Voltmeter: V = IR;$$

$$V = 0.143 \left(\frac{2 \times 100}{2 + 100} \right) = 0.28V$$

(c)

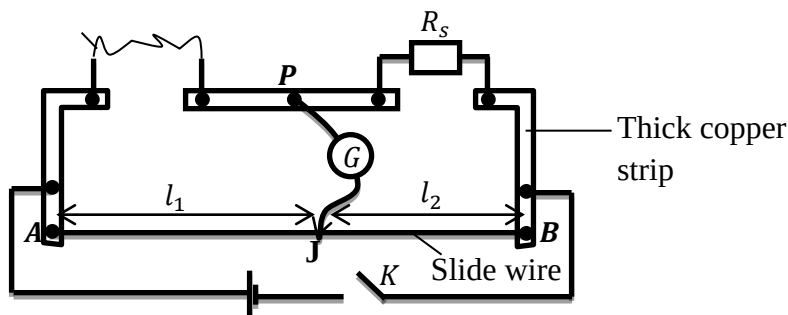


-A driver cell, x maintains a steady current through a uniform resistance wire AB

-Since AB is uniform, its resistance is constant, thus p.d/cm is a constant

-The p.d between two points l distance apart is proportional to the length l , $V_{AB} = kl$

(d)



At 17°C : $R_{17} = 7.3\Omega$

$$l_1 = 42.6\text{cm}$$

$$\frac{R_{57}}{R_{17}} = \left(\frac{1 + 57\alpha}{1 + 17\alpha} \right)$$

$$R_{57} = \left(\frac{1 + 57 \times 3.8 \times 10^{-3}}{1 + 17 \times 3.8 \times 10^{-3}} \right) 7.3$$

$$R_{57} = \frac{1.2166}{1.0646} \times 7.3 = 8.34\Omega$$

For the meter bridge; At 17°C ; $\frac{R_s}{7.3} = \frac{57.4}{42.6}$

$$R_s = 9.84\Omega$$

$$\text{At } 57^\circ\text{C}; \frac{8.34}{9.84} = \left(\frac{l_1}{100 - l_1} \right)$$

$$l_1 = 0.8476(100 - l_1); \quad \therefore l_1 = 45.88\text{ cm}$$

(ii) The balance point is taken near the middle to increase sensitivity of the meter bridge.

For small balance length, resistance of copper strips becomes significant.

END

**UACE PHYSICS SEMINAR HELD AT UGANDA MARTYRS S.S.S,
NAMUGONGO ON 24TH SEPTEMBER 2022
P510/1 & P510 /2
PHYSICS PAPER 1 & 2**

Assume where necessary;

Acceleration due to gravity	=	9.81ms ⁻²
Electron charge, e	=	$1.6 \times 10^{-19}\text{C}$
Electron mass	=	$9.11 \times 10^{-31} \text{ kg}$
Gas constant R	=	$8.31\text{Jmol}^{-1}\text{K}^{-1}$
Radius of the earth	=	$6.4 \times 10^6\text{m}$
Radius of the sun	=	$7.0 \times 10^8\text{m}$
Radius of earth's orbit about the sun	=	$1.5 \times 10^{11}\text{m}$
Mass of the earth	=	$5.97 \times 10^{24} \text{ kg}$
Universal gravitational constant, G	=	$6.67 \times 10^{-11}\text{Nm}^2\text{kg}^{-2}$
Specific heat capacity of water	=	$4,200 \text{ Jkg}^{-1}\text{K}^{-1}$
Specific latent heat of vaporization of water	=	$2.26 \times 10^6\text{Jkg}^{-1}$
Speed of light in vacuum	=	$3.0 \times 10^8\text{ms}^{-1}$
Plank's constant, h	=	$6.6 \times 10^{-34} \text{ Js}$
Stefan's- Boltzmann's constant, σ	=	$5.7 \times 10^{-8} \text{ Wm}^{-2}\text{K}^{-4}$
Avogadro's number N_A	=	$6.02 \times 10^{23}\text{mol}^{-1}$
Permeability of free space, μ_0 ,	=	$4.0\pi \times 10^{-7} \text{ Hm}^{-1}$.
Permittivity of free space, ϵ_0 ,	=	$8.85 \times 10^{-12} \text{ Fm}^{-1}$.
The constant $\frac{1}{4\pi\epsilon_0}$	=	$9.0 \times 10^9 \text{ F}^{-1}\text{m}$.
One electron volt (eV)	=	$1.6 \times 10^{-19} \text{ J}$.

PAPER ONE (P510/1)

SECTION A

1. (a) (i) Define the following **angular velocity** and **centripetal acceleration**. [2]
(ii) Derive the expression for the acceleration of a body moving with angular velocity ω through a circular path of radius r . [4]
(b) (i) What is meant by banking of a road in circular motion? [1]
(ii) Draw a sketch diagram to show forces acting on a car moving round a banked track. [2]
(iii) A car moves along a circular track of radius 100 m, banked at an angle of 10° . If the coefficient of friction between the tires of the car and the ground is 0.3, find the maximum speed at which the car can move without overturning. [4]
(c) A conical pendulum has a string of length 1.2 m and describes a horizontal circular path of radius 0.6 m. If the tension in the string is 22.66 N, find the;
(i) Mass of the body attached to the string [3]
(ii) Angular speed of the mass. [2]
(d) Explain why a motor cyclist leans towards the centre of a circular path. [2]

[Mt. St. Mary's College Namagunga]

2. (a) (i) State Newton's law of gravitation. [1]
(ii) Explain why acceleration due to gravity at different points on the earth's surface differs. [4]
(b) Describe an experiment to determine the universal gravitational constant G . [6]
(c) A communication satellite of mass 200 kg is launched at a height of 4.6×10^6 m above the surface of the earth. Calculate the;
(i) Speed of the satellite in its orbit [3]
(ii) Mechanical energy of the satellite [2]
(d) Explain what happens to the satellite if its forward motion is resisted. [4]

[Namilyango College]

3. (a) (i) Define **simple harmonic motion**. [1]
(ii) Show that a simple pendulum executes simple harmonic motion. [3]
(b) Outline the steps taken to determine acceleration due to gravity using a simple pendulum. [4]
(c) Draw a sketch graphs of velocity against displacement and acceleration against displacement during simple harmonic motion. [4]
(d) A body executing simple harmonic motion has a velocities of 0.13 ms^{-1} and 0.19 ms^{-1} while at displacements of 0.03 m and 0.01 m respectively from the equilibrium position. If the body has mass of 0.2 kg, find the;
(i) Amplitude of its motion. [2]

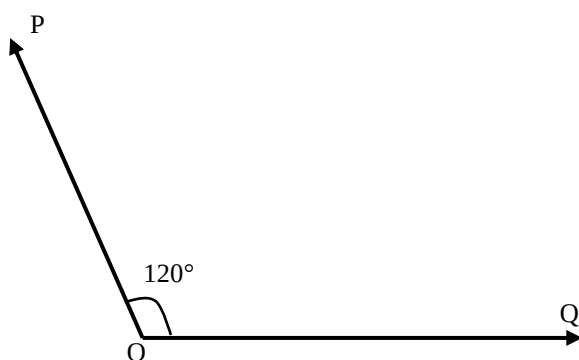
- (ii) Angular velocity of the body. [2]
- (iii) The potential energy of the body while at a displacement of 0.03 m from the equilibrium position. [2]
- (e) State any two practical uses of simple harmonic motion. [2]

[Uganda Martyrs S.S.S. Namugongo]

4. (a) (i) Define **Young's modulus**. [1]
- (ii) State Hooke's law. [1]
- (b) (i) Show that when a wire is stretched, the energy E stored per unit volume is given by $E = \frac{1}{2} \text{Stress} \times \text{Strain}$. [3]
- (ii) A copper wire of length 1.000 m is joined at one end to a steel wire of same length and diameter to form a composite wire of length 2.000 m. The composite wire is subjected to a tensile stress until its length becomes 2.002 m. Calculate the tensile stress applied to the wire. [5]
[Young's moduli for copper and steel are 1.2×10^{11} Pa and 2.0×10^{11} Pa respectively]
- (c) (i) Describe an experiment to determine Young's modulus for a wire. [5]
- (ii) State any two precautions taken in c (i) above to ensure accurate results. [2]
- (d) (i) Distinguish between **ductile** and **brittle** materials. [2]
- (ii) State the circumstance under which a brittle material can be used during construction. [1]

[St. Henry's Kitovu]

5. (a) (i) What is projectile motion? [1]
- (ii) Define the terms, **Range** and **Time** of flight as used in projectile motion. [2]
- (iii) A bomb is dropped from an aero plane when it is directly above a target at a height of 1402.5 m. the aero plane is moving horizontally with a speed of 500 kmh^{-1} . Determine whether the bomb will hit the target [5]
- (b) (i) Define relative velocity. [1]
- (ii) A car X starts to move from city P which is 70km from city Q. Car Y starts to move from city Q. If the cars move towards each other they take one hour to meet. And if they move in the same direction they take seven hours to meet. Find the magnitudes of the velocities of the cars. [4]
- (c) Two forces P and Q act on a particle at O. The angle between the lines of action of P and Q is 120° as shown in the figure below.



The force P has a magnitude 20N and Q has a magnitude of X newtons. The resultant of P and Q is 3X newtons. Find;

- (i) The resultant of P and Q. [4]
- (ii) The displacement of O after 15 seconds of actions of the forces given that O has a mass of 3kg and is initially at rest. [3]

[Seeta High School, Main Campus]

6. (a) (i) Distinguish between **elastic** and **inelastic** collisions. [2]
- (ii) Define the terms; **momentum** and **impulse**. [2]
- (iii) Derive the relation between impulse and linear momentum of the body on which it acts. [2]
- (b) (i) State the law of conservation of linear momentum. [1]
- (ii) Using Newton`s laws of motion, show that when two bodies collide, their total momentum is conserved. [4]
- (c) A ball of mass 0.5kg is allowed to drop from rest, from a point a distance of 5.0m above a horizontal concrete floor. When the ball first hits the floor, it rebounds to a height of 3.0 m.
- (i) What is the speed of the ball just after the first collision with the floor? [4]
- (ii) If the collision lasts 0.01 seconds, find the average force which the floor exerts on the ball. [5]

[Uganda Martyrs S.S.S. Namugongo]

SECTION B

7. (a) (i) Define a **thermometric property**. [1]
- (ii) Explain why different thermometers give different values for temperature of a body. [2]
- (b) With use of a labeled diagram, describe how a constant-volume thermometer is used to determine absolute temperature of a body. [6]

- (c) (i) Define specific latent heat of vaporization and state its units. [2]
- (ii) Explain why specific latent heat of a substance is bigger than its specific latent heat of fusion. [3]
- (d) (i) State Newton's law of cooling. [1]
- (ii) A metal sphere when suspended in a constant temperature enclosure cools from 80° C to 70° C in 5 minutes and to 62° in the next 5 minutes. Calculate the temperature of the enclosure. [5]

[Uganda Martyrs S.S.S. Namugongo]

8. (a) (i) Define thermal conductivity of a material. [1]
- (ii) Draw sketch graphs of temperature distribution along lagged and un-lagged conducting rods at steady state. [3]
- (iii) Explain the graphs in a (ii) above. [4]
- (b) (i) State Wien's displacement law. [1]
- (ii) With use of a diagram, describe how a thermopile is used to detect thermal radiation. [5]
- (c) Pluto is a planet whose distance from the sun is forty times that of the earth from the sun. If the equilibrium temperature of Pluto is 41K, find;
- (i) The frequency of the most intense radiation from Pluto. [3]
- (ii) The temperature of the sun. [3]
- [Wien's displacement constant = $2.9 \times 10^{-3} \text{mk}$]

[Namilyango College]

9. (a) (i) State Boyle's law. [1]
- (ii) Given that $P = \frac{1}{3} \rho c^2$ deduce Boyle's law from $\frac{1}{2} mc^2 = \frac{3}{2} KT$. [4]
- (b) (i) Distinguish between real and ideal gases. [4]
- (ii) Draw a labeled diagram showing P-V isothermal for a real gas above and below the critical temperature. [3]
- (iii) Define a reversible process of a gas. [1]
- (c) An ideal gas is trapped in a cylinder by a movable piston. Initially it exerts a pressure of 108 KPa. The gas undergoes a reversible isothermal expansion until its volume is three times bigger. It is then compressed adiabatically to half its original volume.
- (i) Draw and label a P-V diagram for the above processes. [2]
- (ii) Calculate the final pressure of the gas. [5]
- [Ratio of molar heat capacities of the gas = 7:5]

[Seeta High School, Main Campus]

10. (a) Define the following terms; **thermometric property**, **fixed point** and **a kelvin** as used in thermometry. [3]
- (b) (i) Explain why two different thermometers may read different values when used to measure temperature of a substance. [2]
- (ii) The resistance R_θ of platinum varies with temperature $\theta^\circ \text{C}$ as measured by a constant volume gas thermometer according to the equation $R_\theta = R_0(1+8000\beta\theta-\beta\theta^2)$ where β is a constant. Determine the platinum temperature corresponding to 400°C on the gas scale. [4]
- (c) (i) With a labelled diagram describe the continuous flow method to determine the specific heat capacity of a liquid. [6]
- (ii) State two advantages of the continuous flow method over the method of mixtures in the determination of specific heat capacity. [2]
- (iii) In a continuous flow calorimeter experiment, water flows at a rate of 5.0g s^{-1} and a liquid Y must flow at 8.0g s^{-1} to maintain the same temperature difference and power supply as in the case of water. Find the specific heat capacity of liquid Y. [3]

[Mt. St. Mary's College Namagunga]

11. (a) (i) Define **molar heat capacity of a gas at constant pressure** C_p and state its units. [2]
- (ii) Derive an expression for the difference between molar heat capacity at constant pressure C_p and molar heat capacity at constant volume C_v for a gas of n moles. [3]
- (b) A vessel of volume $1.0 \times 10^{-2} \text{m}^3$ contains an idea gas at a temperature of 300K and pressure $1.5 \times 10^5 \text{Pa}$.
- (i) Calculate the mass of the gas if its density at temperature 285K and pressure $1.0 \times 10^5 \text{Pa}$ is 1.2kg m^{-3} [3]
- (ii) 750J of heat is suddenly released into the gas and its pressure rises to $1.8 \times 10^5 \text{Pa}$. Assuming no heat is taken up by the vessel, calculate the temperature rise and the specific heat capacity of the gas at constant volume. [4]
- (c) Explain why the pressure of a gas increases when the gas is heated at constant volume. [2]
- (d) One mole of an ideal gas is initially at a pressure of $1.0 \times 10^5 \text{Pa}$ and temperature 25°C . It undergoes a reversible adiabatic expansion to twice its volume followed by a reversible isothermal compression to its original volume.
- (i) Draw a P-V sketch graph to show the two processes. [2]
- (ii) Calculate the final temperature and pressure of the gas. [4]
(Ratio of molar Heat Capacities of the gas is 1.4)

[St. Henry's Kitovu]

SECTION C

12. (a) (i) State any three differences between **cathode rays** and **positive rays**. [3]
(ii) Explain two main failures of Rutherford's model of the atom. [3]
- (b) Explain how Millikan's experiment for measuring the charge of an electron proves that charge is quantized. [3]
- (c) In a Millikan's oil drop experiment, a charged oil drop of radius $9.2 \times 10^{-7} \text{m}$ and density 800kgm^{-3} is held stationary in an electric field of intensity $4.0 \times 10^4 \text{Vm}^{-1}$.
(i) What is the charge on the drop? [4]
(ii) Find the electric field intensity that can be applied vertically to move the drop with velocity 0.005ms^{-1} upwards. [3]
[Density of air = 1.29kgm^{-3} ; coefficient of viscosity of air = $1.8 \times 10^{-5} \text{Nsm}^{-1}$]
- (d) A particle of charge $3.2 \times 10^{-19} \text{C}$ is accelerated from rest through a potential difference of 10^4V . It enters a region of uniform magnetic field of flux density 0.5T . The particle describes a circular path of radius 8.94cm . Find the mass of the particle. [4]

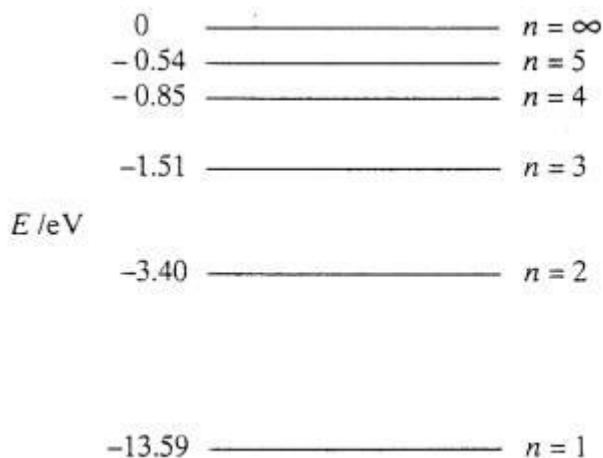
[Mt. St. Mary's College Namagunga]

13. (a) State the characteristics of photoelectric emission. [4]
(b) Define the following terms as used in photoelectric emission.
(i) Work function [1]
(ii) Stopping potential. [1]
(c) With use of a labeled diagram describe an experiment to determine Plank's constant. [5]
(d) (i) A metal has a threshold wavelength of $9.09 \times 10^{-7} \text{m}$. Calculate the stopping potential for the photoelectrons when light of frequency $8.2 \times 10^{14} \text{Hz}$ is incident on the metal. [3]
(ii) What will be the maximum velocity of photoelectrons when the metal in d (i) above is illuminated with light of frequency $9.0 \times 10^{14} \text{Hz}$? [3]
(e) Explain any one use of photoelectric effect. [3]

[St. Henry's Kitovu]

14. (a) Define the following terms as used in the study of radioactivity.
(i) Activity (ii) Decay constant (iii) Atomic Mass Unit. [3]
- (b) (i) Sketch a graph showing how binding energy per nucleon varies with mass number. [1]
(ii) Describe the main features of the graph in b (i) above. [3]
- (c) A fresh sample of radioactive $^{54}_{26}\text{Fe}$, weighs 15g , and its activity is 8.5×10^{14} disintegrations per second. Find the:
(i) Half-life of $^{54}_{26}\text{Fe}$. [4]
(ii) The activity of 15g sample after two years [3]

- (d) State the observations and conclusions made from Rutherford's Alpha particle scattering experiment. [3]
- (e) The diagram below shows some of the energy levels of hydrogen atom.



- (i) Calculate the ionisation energy for the hydrogen atom. [1]
- (ii) Calculate the wave length of the radiation emitted by the electron transition from the 4th to 2nd energy level. [2]

[Seeta High School, Main Campus]

15. (a) (i) With the aid of a diagram describe how cathode rays are produced. [4]
- (ii) Explain how the sign of the charge of cathode rays may be determined. [2]
- (b) An electron is projected with a speed of $3.0 \times 10^7 \text{ ms}^{-1}$ in the direction of a uniform electric field. After traveling a distance of 40cm the electron reverses its direction.
- (i) Why does the electron reverse its direction [1]
- (ii) Calculate the magnitude of the electric field. [4]
- (c) With the aid of a labeled diagram, describe the operation of the Bainbridge mass spectrometer in the measurement of specific charge of positive ions. [6]
- (d) A beam of positive ions is accelerated through a potential difference of $1 \times 10^3 \text{ V}$ into a region of uniform magnetic field of flux density 0.2T. While in the magnetic field it moves in a circle of radius 2.3cm. Calculate charge to mass ratio of these ions. [3]

[Uganda Martyrs S.S.S. Namugongo]

PAPER TWO (P510/2)

1. (a) Define the following with reference to a convex mirror.
- (i) Principal focus [1]
 - (ii) Aperture [1]
- (b) A concave mirror forms an image of magnification 2 when the object is placed in front of it. When the object is moved 6cm towards the mirror, the magnification becomes 2.5. Find focal length of the mirror. [4]
- (c) An object coincides with its image when it is placed 30cm from a concave mirror. When a concave lens is placed 20cm from the object the concave mirror has to be moved 5cm farther away to make the image coincide with the object.
- (i) Sketch a ray diagram to represent the final situation. [2]
 - (ii) Calculate focal length of the concave lens. [4]
- (d) (i) A pin held above a concave mirror containing a small quantity of liquid coincides with its image when it is at height h above the mirror. Show that refractive index of the liquid, $n = \frac{R}{h}$, where R is radius of curvature of the mirror. [5]
- (ii) A concave mirror is placed at the base of a stand and a pin clamped above the mirror coincides with its image when it is 15cm above the mirror. When a liquid is put in the mirror to a depth of 3cm the pin coincides with its image when it is 12.6 cm above the mirror. Calculate refractive index of the liquid. [3]

[Uganda Martyrs S.S.S. Namugongo]

2. (a) (i) With aid of ray diagrams distinguish between chromatic and spherical aberration. [3]
- (ii) Distinguish between a microscope and a telescope. [2]
- (b) (i) Draw a ray diagram to show how the final image is formed by a compound microscope in normal adjustment. [3]
- (ii) Derive the expression for magnification produced by a microscope in normal adjustment. [4]
- (iii) State **one** limitation of the microscope in normal adjustment. [1]
- (c) A microscope consists of an objective lens of focal length 6cm and an eyepiece of focal length 10cm. The final virtual image of an object placed 8cm from the objective is formed 30cm from the eyepiece. Calculate the;

- (i) separation of the lenses [4]
- (ii) linear magnification produced [3]

[Namilyango College]

3. (a) State the laws of refraction of light. [2]
- (b) (i) A monochromatic light is incident on one of the refracting surfaces of an equilateral glass prism of refractive index 1.5, submerged in a liquid of refractive index 1.25. Find the angle of incidence for which the deviation of light through the prism is a maximum. [4]
- (ii) Describe an experiment to determine the angle of minimum deviation of light through a prism. [6]
- (c) An astronomical telescope consists of two thin lenses of focal lengths 10cm and 100cm. The telescope forms the image of a distant object on a screen placed 20cm from the eye-piece lens. Find the magnification produced by the telescope. [4]

[Mt. St. Mary's College Namagunga]

SECTION B

4. (a) (i) Define a wave front. [1]
- (ii) State Huygens's construction principle. [1]
- (iii) Use Huygens's principle to show that for light travelling from one medium to another, $\frac{\sin i_1}{\sin i_2} = \frac{c_1}{c_2}$, where c_1 and c_2 are the respective speeds in the media. [5]
- (b) (i) What is meant by Doppler's effect? [1]
- (ii) Explain how Doppler's effect is applied in the traffic radar speed gun. [5]
- (c) (i) An observer standing by the road hears sound of frequency 600HZ coming from the horn of an approaching car. When the car passes, the frequency appears to change to 560HZ. Given that the speed of sound in air is 320ms^{-1} , calculate the speed of the car. [4]
- (ii) A radar speed gun emitting radio waves of frequency 10GHz is directed toward an approaching vehicle. The gun registers beats at the rate of 0.6Hz. Find speed of the vehicle. [3]

[Seeta High School, Main Campus]

5. (a) (i) State the principle of superposition of waves. [1]
- (ii) Define beats [1]
- (b) (i) Use the general equation of waves to explain how beats are formed. [5]
- (ii) The displacement y of a wave, $y = 4\sin 2\pi\left(\frac{t}{0.1} - \frac{x}{2}\right)$ meters. Find the velocity of the wave. [3]

- (c) (i) Distinguish between division of wave front and division of amplitude. [2]
- (ii) Describe how spectra are produced by a plane transmission grating. [5]
- (iii) In Young's double slit experiment, the slits were placed 0.18mm apart and the fringes were observed on a screen 50cm from the slits. It was found that for a certain monochromatic light, the third fringe was situated 8.1mm from the central bright fringe. Calculate the wave length of the light. [3]
- (d) Explain why the setting sun appears red. [4]

[St. Henry's Kitovu]

6. (a) Define the terms;
- (i) Frequency, [1]
- (ii) Phase of vibration as applied to waves. [1]
- (b) A progressive wave of wavelength, λ , and amplitude, a , travels in a medium with a speed, v , in the positive x -direction.
- (i) Show that the displacement, y of the wave particle at a distance l from the source of wave is $y = a \sin \frac{2\pi}{\lambda} (vt + l)$ [5]
- (ii) The wave in b(i) is directed normally on a plane reflector. State three characteristics of the resultant wave formed due to overlap of the incident wave and the reflected wave. [3]
- (c) Describe an experiment to determine the velocity of sound in free air by interference method. [5]
- (d) A loud sound is heard when a vibrating tuning fork of frequency 1564Hz is held near the mouth of a cylindrical tube of length 29cm closed at one end. Determine the;
- (i) mode of vibration of the air column in the tube. [3]
- (ii) end error. [2]

[Uganda Martyrs S.S.S. Namugongo]

SECTION C:

7. (a) Define electromagnetic induction. [1]
- (b) With the aid of a diagram describe how a simple d.c motor works. [6]
- (c) A motor with 600 turns coil of area 0.4m² and resistance of 50Ω rotates in a radial magnetic field of flux density 2×10^{-4} T. The motor draws a current of 0.8A when connected to 240V supply. Find the;
- (i) angular speed of the coil. [4]
- (ii) efficiency of the motor. [3]
- (d) Derive an expression for the charge Q which flows through a coil of resistance R when the magnetic flux linking the coil changes from ϕ_0 to ϕ_f . [6]

[Namilyango College]

8. (a) (i) Distinguish between mutual and self-induction. [2]
 (ii) Define self inductance. [1]
 (b) (i) Describe the construction and operation of the a.c. transformer. [6]
 (ii) Explain why increase in the secondary current leads to an increase in the primary current. [4]
 (c) A transformer designed to step down voltage to 12V is 90% efficient. It has 3000 turns in the primary and 150 turns in the secondary. Find amplitude of primary current when the load connected to the secondary takes power of 30W. [4]
 (d) Give **three** advantages of a.c. over d.c. in power production and transmission. [3]

[Uganda Martyrs S.S.S. Namugongo]

9. (a) Define the terms;
 (i) Impedance. [1]
 (ii) Reactance. [1]
 (b) A coil of wire of inductance $0.04\text{VA}^{-1}\text{s}$ is connected to sinusoidal current, $I = 5\sin 120\pi t$.
 (i) Find the instantaneous back e.m.f. in the coil. [3]
 (ii) Find the r.m.s. value of the voltage. [2]
 (c) (i) Derive the expression for resonant frequency when an inductor of inductance L , a capacitor of capacitance C and the resistor of resistance R are connected in series to an ac source of variable frequency. [4]
 (ii) Varying current I flows in a solenoid of length x , N turns and cross section area A . Show that back emf induced in the solenoid is $E = -L \frac{dI}{dt}$, where $L = \frac{\mu N^2 A}{x}$. [3]
 (d) A coil of zero resistance and self inductance 5.0H is connected to a 1000Ω resistor and an oscillator whose output voltage is 400V (r.m.s) at a frequency of 63.7Hz . Find,
 (i) r.m.s value of the current flowing through the circuit. [3]
 (ii) p.d across the coil [3]

[Mt. St. Mary's College Namagunga]

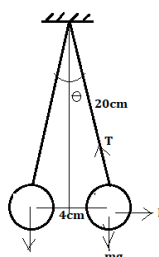
10. (a) (i) Define the root mean square value of an alternating current. [1]
 (ii) Derive the relationship between the root mean square value and the peak value of an alternating current. [5]
 (b) A 600Ω resistor, a $5\mu\text{F}$ capacitor and a 0.8H inductor are connected in series to an alternating voltage supply of $V = 340\sin 50\pi t$.
 (i) Determine the root mean square value of the alternating current flowing through the circuit. [5]
 (ii) Sketch on the same axes the variation of impedance, capacitive reactance and inductive reactance with frequency of the alternating voltage. [2]
 (c) (i) Describe the action of a hot wire meter. [5]

- (ii) Mention **two** advantages of a hot wire meter over the moving coil meter in measurement of current. [2]

[Seeta High School, Main Campus]

SECTION D

11. (a) Define the terms:
- (i) Electric field intensity at a point in an electric field. [1]
 - (ii) Electric field potential at a point in an electric field. [1]
- (b) Two small identical charged spheres of mass 8g each carrying similar charges each are hung from the same point on insulating threads of length 20cm each. When the spheres settle they are 4cm from each other.

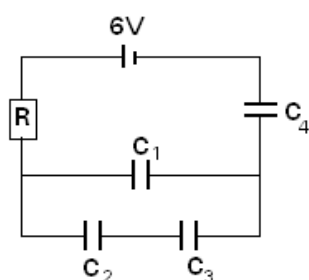


- Find magnitude of charge on each sphere. [4]
- (c) (i) Derive the relationship between electric field intensity and potential gradient. [3]
- (ii) Explain the properties of an equipotential surface. [3]
- (iii) Sketch graphs to show the variation of electric field potential and electric field intensity with distance from the centre of near a positively charged metal sphere. [4]
- (d) Describe how static electricity can be applied in reducing smoke coming out of a chimney. [4]

[St. Henry's Kitovu]

12. (a) (i) Define the capacitance of a capacitor. [1]
- (ii) Distinguish between dielectric and dielectric constant. [2]
- (b) Show that the capacitance of a parallel plate capacitor is given by,

$$C = \frac{\epsilon A}{d}$$
[4]
- (c) Describe how a ballistic galvanometer is used to compare capacitances of two capacitors. [4]
- (d) In the circuit shown below, each capacitor has capacitance $800\mu\text{F}$ and resistance of resistor R is 5Ω .



- (i) Explain why p.d across R is zero. [2]
- (ii) Find Pd across C_3 . [4]

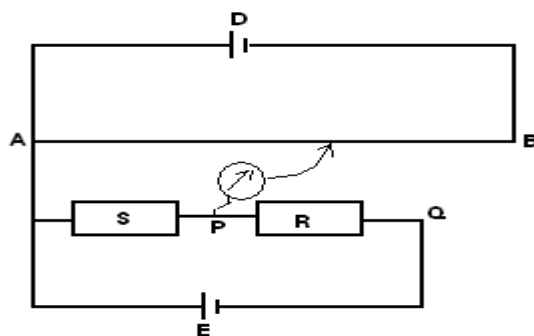
- (iii) Find energy stored in C_4 [3]

[Uganda Martyrs S.S.S. Namugongo]

13. (a) Define the terms
- (i) Define the Farad. [1]
 - (ii) Dielectric strength. [1]
- (b) With aid of an appropriate circuit diagram, describe how the ballistic galvanometer is used to determine dielectric constant of a dielectric. [5]
- (c) Derive the expression for effective capacitance of two capacitors in series. [5]
- (d) Two parallel plate air capacitors of equal dimensions and capacitance $600\mu\text{F}$ are connected in parallel. They are charged to 25 volts and then disconnected from the battery. A dielectric of constant 1.2 is inserted between the plates of one of the capacitors. Calculate the:
- (i) the p.d. across the capacitors. [4]
 - (ii) final energy in the system of capacitors. [4]

[Namilyango College]

14. (a) (i) State Ohm's law. [1]
- (ii) Distinguish between Ohmic and non-Ohmic conductors. [2]
 - (iii) State **one** example of each type of conductor in a(ii) and sketch their I-V curves. [2]
- (b) Explain the following observations.
- (i) Temperature of a wire increases when current flows in the wire. [2]
 - (ii) The resistance of a wire increases when temperature increases. [2]
- (c) Describe how you would use a meter bridge to measure the temperature coefficient of resistance of wire. [5]
- (d)



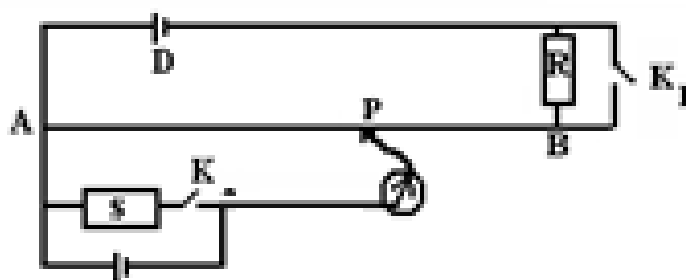
In the circuit shown above D is a driver cell of negligible internal resistance and e.m.f. 3V. AB is a uniform slide wire of resistance 20Ω . S is a standard resistor of 5Ω . E is a cell of e.m.f. 2.5V. R is an unknown resistor. When the galvanometer is connected at P the

balance length is 20 cm. When the galvanometer is connected at Q length is 80cm.

- (i) Find resistance of R. [3]
- (ii) Find internal resistance of cell E. [3]

[Seeta High School, Main Campus]

15. (a) (i) Distinguish between potential difference and e.m.f. [2]
- (ii) Explain why terminal p.d across a cell is not always equal to the e.m.f? [3]
- (b) Show that maximum power is produced in a circuit when its load resistance is equal to internal resistance of the battery to which it is connected. [4]
- (c) Describe how you would use a potentiometer to calibrate a voltmeter. [5]
- (d) In the circuit shown, D is a driver cell of negligible internal resistance. AB is a uniform slide wire of resistance 20Ω . S is a standard resistor of 5Ω . E is a cell of e.m.f. 1.5V. R is a resistor of 10Ω .



When both switches are open balance length is 20 cm. When only K_2 is closed the balance length is 15 cm.

- (i) Calculate the internal resistance of E. [3]
- (ii) Calculate the balance length when both K_1 and K_2 are closed. [3]

[Mt. St. Mary's College Namagunga]

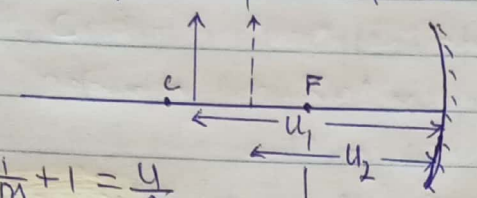
END

S6 Physics Seminar Sept. 2022

Physics Paper two (P510/2)

- 1(a) (i) It is the point on the principal axis where rays of light originally parallel and close to the principal axis appear to diverge from after reflection.
 (ii) It is the reflecting surface of the mirror or width of the reflecting surface.

(b)



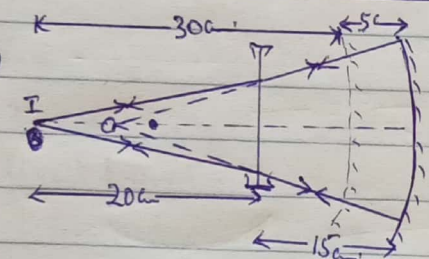
$m_1 = 2$
 $m_2 = 2.5$
 $u_1 - u_2 = 6 \text{ cm}$

From $\frac{1}{m} + 1 = \frac{u}{f}$

$\frac{u_1}{f} = \frac{1}{2} + 1 = \frac{3}{2} \quad \text{--- (1)}$
 $\frac{u_2}{f} = \frac{2}{5} + 1 = \frac{7}{5} \quad \text{--- (2)}$

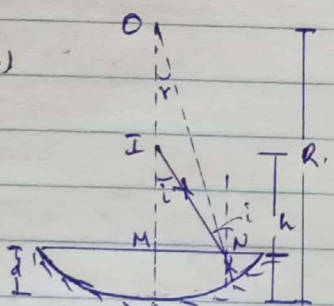
$\therefore \frac{u_1 - u_2}{f} = \frac{3}{2} - \frac{7}{5} = \frac{15 - 14}{10}$
 $\Rightarrow \frac{6}{f} = \frac{1}{10} \quad \therefore f = 60 \text{ cm}$

(c) (i)



(ii) Action of the lens.
 $u = -(30 - 15) = -15 \text{ cm}$
 $v = 20 \text{ cm}$
 $f = \frac{uv}{u+v} = \frac{-15 \times 20}{-15 + 20} = -60 \text{ cm}$

(d) (i)



Consider a ray of light from I incident on the liquid surface at N, it is refracted along parallel to ON. Refractive index n is

$n = \frac{\sin i}{\sin r}$, But $\sin i = \frac{MN}{IN}$, $\sin r = \frac{MN}{ON}$
 $\Rightarrow \frac{\sin i}{\sin r} = \frac{MN}{IN} \times \frac{ON}{MN} = \frac{ON}{IN}$

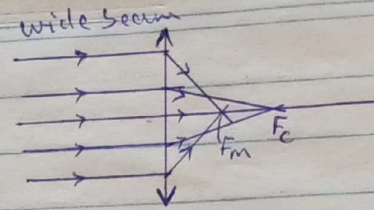
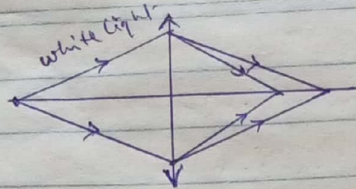
Since N is very close to M, $ON \approx OM$ and $IN \approx IM$.

$\therefore \frac{\sin i}{\sin r} \approx \frac{OM}{ON} = \frac{R-d}{h}$. Since the liquid is very small, $d \approx 0$.
 $\therefore n = \frac{R}{h}$

(ii) $R = 15 \text{ cm}$, $d = 3 \text{ cm}$, $h + d = 12.6 \text{ cm}$.

$\therefore$ using $n = \frac{R-d}{h} = \frac{15-3}{12.6-3} = 1.25$

2(a) (i)



In chromatic aberration a white beam of light incident on a lens, is dispersed to form images corresponding to different colours at different points. The image viewed is blurred with coloured edges.

In spherical aberration a wide beam of light incident on the lens is refracted such that the marginal rays are focused closer to the lens and the central rays farther away. The image viewed is blurred without colours.

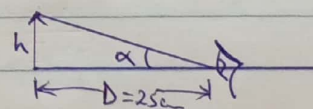
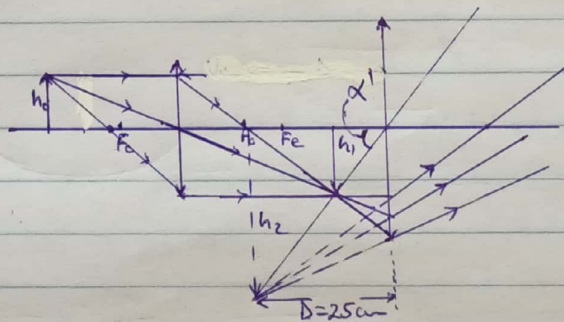
(ii) Microscopes

- Have objective of short focal length and eye piece of long focal length
- used for viewing near objects.

Telescopes

- Have objective of long focal length and eye-piece of short focal length.
- used for viewing distant objects.

(b) (i)



(ii) Angular magnification $M = \frac{\alpha'}{\alpha}$.

From above diagrams, for small angles α, α' measured in radians,

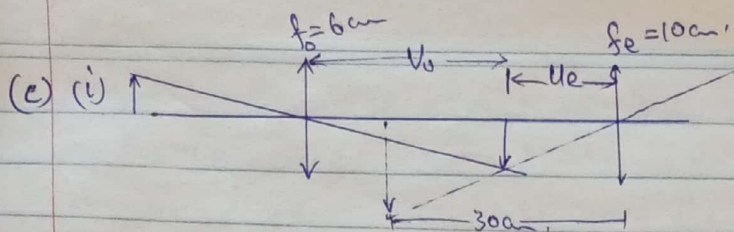
$$\alpha \approx \tan \alpha = \frac{h}{D} \quad \alpha' \approx \tan \alpha' = \frac{h_2}{D}$$

$$\therefore M = \frac{h_2}{D} \div \frac{h}{D} = \frac{h_2}{h} = \frac{h_2}{h_1} \times \frac{h_1}{h}$$

$$\text{But } \frac{h_2}{h_1} = \frac{v_e}{f_e} - 1 = -\frac{D}{f_e} - 1 \quad \text{and} \quad \frac{h_1}{h} = \frac{u_o}{f_o} - 1$$

$$\therefore M = -\left(\frac{D}{f_e} + 1\right)\left(\frac{u_o}{f_o} - 1\right)$$

(iii)



Action of the objective.

$$u = 8 \text{ cm}, f = 6 \text{ cm}$$

using $\frac{1}{v_o} = \frac{1}{u_o} + \frac{1}{f_o} = \frac{1}{8} + \frac{1}{6}$

$$= \frac{5}{24}$$

$$v_o = 24 \text{ cm}$$

Action of the eye piece.

$$u_e = \frac{v_o f_e}{v_o - f_e} = \frac{-30 \times 10}{-30 - 10}$$

$$= 7.5 \text{ cm}$$

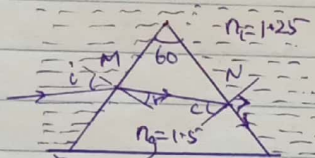
$$\therefore \text{Separation of the lenses} = v_o + u_e = 24 + 7.5 = 31.5 \text{ cm}$$

(ii) linear magnification

$$M = m_1 \times m_2 = \frac{v_1}{u_1} \times \frac{v_2}{u_2} = \frac{24}{8} \times \frac{30}{7.5} = 12$$

- 3(a) - The incident ray, the refracted ray and the normal at the point of incidence all lie in the same plane.
 - The ratio of the sine of angle of incidence to the sine of angle of refraction is a constant for a ray of light moving from one medium into another.

(b) (i)



At N, $n_g \sin C = n_e \sin 90^\circ$

$$\Rightarrow \sin C = \frac{n_e}{n_g} = \frac{1.25}{1.5}$$

$$\therefore C = 56.4^\circ$$

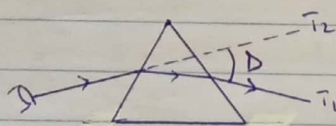
At M, $n_e \sin i = n_g \sin r$

but $r = 60 - 56.4 = 3.6^\circ$

$$\therefore \sin i = \frac{1.5 \sin 3.6}{1.25}$$

$$\Rightarrow i = 4.3^\circ$$

(ii)



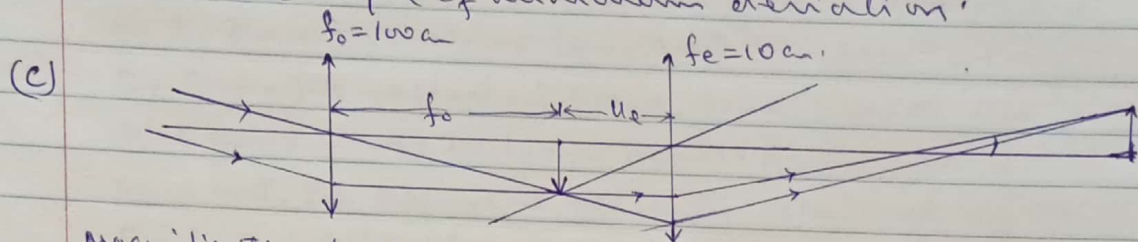
using a spectrometer.

The telescope is adjusted to focus parallel light, the collimator is adjusted

to produce parallel light, and the table is levelled.

The prism is then placed on the table with its refracting edge facing away from the collimator. The telescope is turned to the opposite side of the prism to receive the refracted light. The table and telescope are now turned in one direction until light just begins to

move in opposite direction. The angular position T_1 of the telescope on the scale is noted. The prism is removed from the table and the telescope turned to receive light directly from the collimator. The angular position T_2 of the telescope is noted. The angle, D , between the two positions is measured, and is the angle of minimum deviation.



Magnification by the objective

$$M_1 = \frac{v_o}{f_o} - 1 = \frac{100}{100} - 1 = 0$$

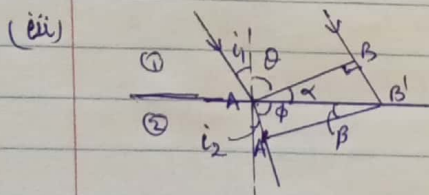
Magnification by the eye piece

$$M_2 = \frac{v_e}{f_e} - 1 = \frac{20}{10} - 1 = 1$$

Total magnification $M = M_1 \times M_2 = 0 \times 1 = 0$

4 (a) (i) It is a section through an advancing wave on which all particles are vibrating in phase.

(ii) It states that every point on a wave front acts as a source of secondary wavelets that move in the forward direction with the velocity of the wave and the new wave front is the envelope which just touches the surfaces of the wavelets.



Consider wave front AB , when side A has just reached the boundary with medium ②.

$$i_1 + \theta = 90 \Rightarrow i_1 = 90 - \theta \therefore \alpha = i_1$$

$$\& \alpha + \theta = 90 \Rightarrow \alpha = 90 - \theta$$

$$\text{also } i_2 + \phi = 90 \Rightarrow i_2 = 90 - \phi \text{ and } \beta + \phi = 90 \Rightarrow \beta = 90 - \phi \therefore \beta = i_2$$

Now C_1 and C_2 are the velocities of light in media ① and ② respectively. Suppose B takes time t to move to B' , and A takes time t to move to A' , Then

$$BB' = C_1 t \text{ and } AA' = C_2 t. \text{ From the diagram } \sin \alpha = \frac{BB'}{AB'}$$

$$\text{and } \sin \beta = \frac{AA'}{AB'}, \text{ therefore, } \frac{\sin i_1}{\sin i_2} = \frac{\sin \alpha}{\sin \beta} = \frac{BB'}{AB'} \times \frac{AB'}{AA'}$$

$$\Rightarrow \frac{\sin i_1}{\sin i_2} = \frac{BB'}{AA'} = \frac{C_1 t}{C_2 t} = \frac{C_1}{C_2}$$

(b) (i) Doppler effect is the apparent change in frequency of a wave due to relative motion between the source and the observer.

(ii) Microwaves from the speed gun are directed on to an approaching car, and is reflected by the car. The reflected wave mixes with the out going waves to form beats. As the wave goes out, the apparent velocity received by the car is $C+u_0$. When reflected the apparent wave length is $\frac{C-u_0}{f}$. Therefore apparent frequency of the reflected wave $f' = \frac{C+u_0}{C-u_0} \cdot f$. Beat frequency therefore is $\frac{C+u_0}{C-u_0} f - f = \frac{2u_0 f}{C-u_0}$. Therefore Beat frequency $f_b \approx \frac{2u_0 f}{C} \Rightarrow u_0 = \frac{C f_b}{2f}$. The speed gun counts the beats and calculates the velocity u_0 of the vehicle.

(c) (i) Let the velocity of the car be u_0 , then wavelength $\lambda = \frac{V-u_0}{f}$ of the approaching car $\lambda = \frac{V-u_0}{f}$, apparent frequency $f' = \frac{V}{V-u_0} \cdot f = 600$
 $\therefore f = \frac{600(320-u_0)}{320}$

apparent wave length from the receding car $\lambda'' = \frac{V+u_0}{f}$, and apparent frequency $f'' = \frac{V}{V+u_0} \cdot f = 560$
 $\Rightarrow f = \frac{(320+u_0)}{320} \times 560$

$$\therefore \frac{(320+u_0)}{320} \times 560 = \frac{(320-u_0)}{320} \times 600$$

$$= 320+u_0 = (320-u_0) \times \frac{600}{560} = 320 \times 1.07 - 1.07 u_0$$

$$\Rightarrow (1+1.07)u_0 = 320(1.07-1)$$

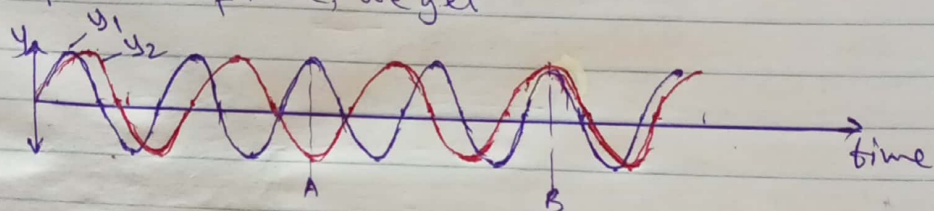
$$\Rightarrow u_0 = \frac{320 \times 0.07}{2.07} = 10.8 \text{ m/s.}$$

$$(ii) u_0 = \frac{C f_b}{2f} = \frac{3 \times 10^8 \times 0.6}{2 \times 10 \times 10^6} = 9 \text{ m/s.}$$

5(a) (i) When two waves superpose, the resultant displacement at any point is the sum of the displacements due to the individual waves at that point.

(ii) Beats is a note whose intensity rises and falls periodically, formed by superposition of two notes of slightly different frequencies but similar amplitudes sounded together.

(b) (i) Let the progressive waves be $y_1 = a \sin 2\pi \left(f_1 t - \frac{x}{\lambda_1} \right)$ and $y_2 = a \sin 2\pi \left(f_2 t - \frac{x}{\lambda_2} \right)$. If $f_1 > f_2$ then $T_2 > T_1$. When plotted as function of time, we get



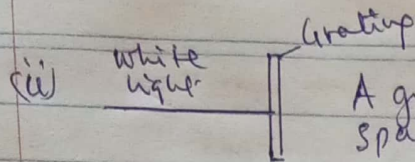
When the waves are sounded together they superpose. At instants like A, the waves meet completely out of phase, cancellation takes place and no sound is heard. At instants like B, the waves arrive in phase and reinforcement takes place. A loud sound is heard. Since the waves are not coherent, the positions of reinforcement and cancellation keep changing. Hence a periodic rise and fall in intensity.

$$(ii) y = 4 \sin 2\pi \left(\frac{t}{0.1} - \frac{x}{2} \right) \Rightarrow f = \frac{1}{0.1} = 10 \text{ Hz}$$

$$\text{C.F. } y = 4 \sin 2\pi \left(ft - \frac{x}{\lambda} \right) \quad \lambda = 2 \text{ m.}$$

$$\therefore v = f\lambda = 2 \times 10 = 20 \text{ m/s.}$$

(c) (i) In division of wavefront, wave energy from the same wave front is divided to take different paths and then meet again as if from different sources. While in division of amplitude, the wave energy is divided by partial reflection and partial refraction to travel different paths and meet again.



A grating consists of many clear spaces close to each other. When

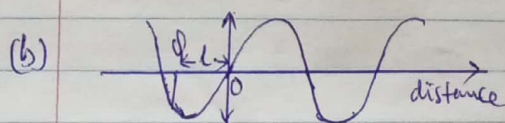
white light is incident on the grating, it diffracts through the spaces and get dispersed. The diffraction patterns due to different wave lengths from the same slit superpose, and also superpose with those from other slits. The resultant pattern has sharp and brightly coloured bands. The colours range from violet near the point of incidence of the white light, to red farther out side.

(iii) using $y_m = \frac{m\lambda D}{a}$ $\Rightarrow \lambda = \frac{a y_m}{m D}$
 $\therefore \lambda = \frac{0.18 \times 10^{-6} \times 8.1 \times 10^{-3}}{3 \times 0.5} = 9.72 \times 10^{-7} \text{ m}$

(d) As white light from the sun travels through the sky and air in the atmosphere, it is scattered by the water droplets. Short wave length light is scattered more than long wave length light. At sun set, the light travels a very long path to reach the earth. It therefore reaches the earth when nearly all the short wavelength light has been scattered. The light received is therefore predominantly red, making the sun appear red.

6(a) (i) Frequency is the number of cycles made by a wave per second or number of waves produced by the source per second.

(ii) A phase is a stage in a cycle of vibration that a particle in a wave undergoes.



Consider a wave travelling from left to right.

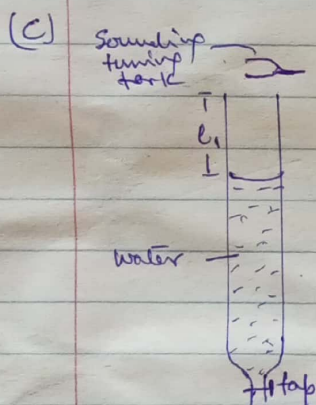
Suppose the displacement function for a particle at 0 is $y = a \sin 2\pi ft$.

The vibration of the particle at Q , distance l to the left of O lags on that at O by a time $(-\frac{l}{\lambda}T)$. Its time of vibration therefore is

$$t - (-\frac{l}{\lambda}T) \text{ and its displacement function is } y = a \sin 2\pi f(t - (-\frac{l}{\lambda}T)) = a \sin(2\pi ft + 2\pi f \frac{l}{\lambda}T)$$

$$y = a \sin \frac{2\pi}{\lambda}(ft + l) = a \sin \frac{2\pi}{\lambda}(vt + l)$$

- (ii) When the wave is reflected, they superpose to form stationary waves, whose characteristics are:
- They have nodes and antinodes.
 - amplitude of the wave varies with position along the profile.
 - The energy of the wave does not flow along the profile.
 - All particles between adjacent nodes in the wave vibrate in phase.



A long glass tube is filled with water and a sounding tuning fork held above its open end. The top is opened and water is allowed out until a loud sound is heard. The top is closed and the length l_1 of the air column in the tube is

measured. The tuning fork is again sounded and held above the glass. Water is allowed out until a loud sound is heard again. The top is closed and the length l_2 of the air column is measured, and recorded together with the frequency f of the tuning fork. Velocity, v , of sound is then calculated from $v = 2f(l_2 - l_1)$.

(d) (i) using $f_n = \frac{nv}{4l}$, $1564 = \frac{n \times 340}{4 \times 0.29}$

$$\Rightarrow n = \frac{1564 \times 4 \times 0.29}{340} = 5.3$$

$$\therefore n = 7$$

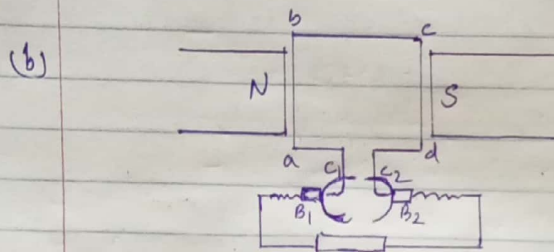
(ii) When $n=7$,

$$1564 = \frac{7 \times 340}{4 \times (0.29 + e)}$$

$$\Rightarrow 0.29 + e = \frac{7 \times 340}{4 \times 1564} = 0.38$$

$$\therefore e = 0.38 - 0.29 = 0.09 \text{ m.}$$

7 (a) Electromagnetic induction is the production of emf in a circuit (or conductor) due to change in magnetic flux linkage with the circuit (or conductor).



abcd - coil
NS - pole pieces of permanent magnet.
 c_1, c_2 - commutators
 B_1, B_2 - Carbon brushes.

The set up is as above. The coil is rotated with uniform angular velocity, and the resulting current tapped out through the carbon brushes B_1, B_2 .

When side ab is moving up and cd down, emf is induced in the coil in the direction abcd. In the vertical position, the induced emf is zero. As ab begins to move down and cd up, current reverses in the coil, but at this same time, the commutator halves change contacts with carbon brushes C_1 to B_2 and C_2 to B_1 . Current supplied to the load therefore continues to flow in the same direction.

(c) (i) $E_b = V - Ir$ also $E_b = \omega N B A$.

$$\therefore \omega N B A = V - Ir$$

$$\Rightarrow \omega = \frac{V - Ir}{N B A} = \frac{240 - (0.8 \times 50)}{600 \times 2 \times 10^{-4} \times 0.4}$$

$$= 416.7 \text{ rad s}^{-1}$$

(ii) Efficiency $\eta = \frac{E_b}{V} \times 100 = \frac{(240 - (0.8 \times 50)) \times 100}{240}$
 $= 83.3\%$

(d) When magnetic flux linking the coil changes, emf is induced in it. Induced emf

$$E = - \frac{d\Phi}{dt}, \text{ Induced current } I = \frac{E}{R} = - \frac{1}{R} \frac{d\Phi}{dt}$$

But $I = \frac{dQ}{dt} \therefore \frac{dQ}{dt} = - \frac{1}{R} \frac{d\Phi}{dt}$

$$\Rightarrow dQ = - \frac{1}{R} d\Phi$$

If the magnetic flux linkage changes from Φ_0 to Φ_f then total charge induced

$$Q = \int_{\Phi_0}^{\Phi_f} - \frac{1}{R} d\Phi = - \frac{1}{R} [\Phi]_{\Phi_0}^{\Phi_f} = - \left(\frac{\Phi_f - \Phi_0}{R} \right)$$

$$= \frac{\Phi_0 - \Phi_f}{R}$$

8(a) (i) Mutual induction is the production of emf in a circuit due to change of current in a nearby circuit while Self induction is the production of emf in a circuit due to change of current in the same circuit.

- Mutual induction requires two circuits while Self induction requires only one circuit.

(ii) Self inductance is the ratio of back emf induced to the rate of change of current in the same circuit.

(b) (i) A transformer consists of a primary and secondary coils wound on a soft iron ring. The primary is connected to an alternating voltage supply, while the secondary is connected to an external load.

When a.c. flows in the primary coil, it establishes changing magnetic field

which links the primary coil. A back emf is thus induced in the primary. For finite current in the primary, the back emf equals the supply voltage $V_p = -N_p A \frac{dB}{dt}$ — (1)

The changing magnetic field in the primary also links the secondary coil, inducing emf in it. The induced emf,

$$V_s = -N_s A \frac{dB}{dt} \quad \text{--- (2)}$$

$$\frac{(2)}{(1)} \quad \frac{V_s}{V_p} = \frac{N_s}{N_p}$$

When $N_s > N_p$, $V_s > V_p$ it is a step up transformer

When $N_s < N_p$, $V_s < V_p$ it is a step down transformer.

- (ii) When N_s increases, the magnetic flux due to it also increases. Since this flux acts in opposition to that due to primary current, the flux linkage, and rate of change of flux linkage with the primary reduces leading to a reduction in back emf in the primary. When the back emf reduces, the primary current increases.

$$(c) \quad V_p = \frac{N_p V_s}{N_s} = \frac{3000}{150} \times 12 = 240 \text{ V}$$

$$\text{Now } \frac{I_s V_s}{I_p V_p} = 0.9 \Rightarrow \frac{30}{I_p \times 240} = 0.9$$

$$\therefore I_p = \frac{30}{240 \times 0.9} = 1.39 \text{ A}$$

$$\therefore I_0 = \sqrt{2} \times I_{rms} = \sqrt{2} \times 1.39 = 1.96 \text{ A}$$

- (d)
- It is cheaper to produce a.c. in large amounts compared to d.c.
 - a.c. can be transmitted long distances with minimum loss of power compared to d.c.
 - It is easier to produce a.c. than d.c. even on small scale.

9(a) (i) Impedance is the total opposition to flow of alternating current in a circuit containing both resistive and reactive components.

(ii) Reactance is the non-resistive opposition to flow of alternating current in a circuit containing a capacitor or inductor or both.

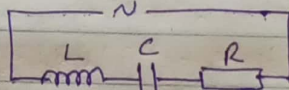
(b) (i) Back emf induced

$$\begin{aligned} \bar{E} &= -L \frac{dI}{dt} = -0.04 \times \frac{d(58 \sin 120\pi t)}{dt} \\ &= -0.04 \times 120\pi \times 58 \cos 120\pi t \\ &= \underline{\underline{-75.36 \cos 120\pi t}} \end{aligned}$$

(ii) $E_0 = 75.36$

$$\therefore E_{rms} = \frac{75.36}{\sqrt{2}} = \underline{\underline{53.3 A}}$$

(c) (i)



Consider the circuit above connected across a voltage source of $V = V_0 \sin \omega t = V_0 \sin 2\pi f t$.

$$X_L = 2\pi f L \text{ while } X_C = \frac{1}{2\pi f C}$$

Resonance in the circuit occurs when $X_L = X_C$.

$$\Rightarrow 2\pi f L = \frac{1}{2\pi f C} \quad (\Rightarrow) 4\pi^2 f^2 LC = 1$$

$$\Rightarrow f^2 = \frac{1}{4\pi^2 LC} \quad \therefore f = \underline{\underline{\frac{1}{2\pi\sqrt{LC}}}}$$

(d) When current flows in the solenoid, magnetic flux density at the centre of the coil

$$B = \mu_0 \frac{N}{x} I$$

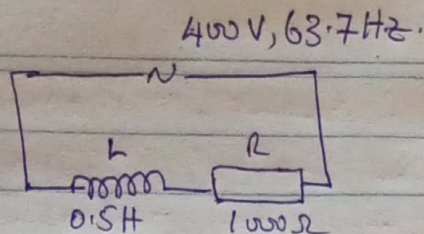
Magnetic flux linkage with the coil

$$\Phi = NBA = N \cdot \mu_0 \frac{N}{x} I \cdot A$$

Back emf induced in the coil

$$\begin{aligned} \bar{E} &= -\frac{d\Phi}{dt} = -\frac{d}{dt} \left(\mu_0 \frac{N^2}{x} A I \right) = -\mu_0 \frac{N^2}{x} A \frac{dI}{dt} \\ &= \underline{\underline{-L \frac{dI}{dt}}} \end{aligned}$$

(d) (i)



$$X_L = 2\pi fL = 2\pi \times 63.7 \times 0.5 = 200 \Omega$$

$$Z = \sqrt{X_L^2 + R^2} = \sqrt{200^2 + 1000^2} = 1019.8 \Omega$$

$$\text{Current supplied } I = \frac{V}{Z} = \frac{400}{1019.8} = 0.3922 \text{ A}$$

$$I_{\text{rms}} = 0.3922 \text{ A}$$

(ii) p.d. across the coil $V_L = IX_L$

$$= 0.3922 \times 200 = 78.44 \text{ V}$$

10 (a) (i) Root mean square value of an alternating current is the value of steady current which dissipates heat in a given resistor at the same rate as the alternating current.

(ii) $I = I_0 \sin \omega t$

Consider current of $I = I_0 \sin \omega t$ flowing through the resistor of R . Instantaneous power dissipated

$$P_{\text{inst}} = I^2 R = (I_0 \sin \omega t)^2 R$$

$$\langle P \rangle = \langle (I_0 \sin \omega t)^2 R \rangle = I_0^2 R \langle \sin^2 \omega t \rangle$$

$$\text{But } \langle \sin^2 \omega t \rangle = \frac{1}{2}$$

$$\therefore \langle P \rangle = \frac{I_0^2 R}{2}$$

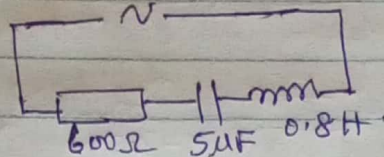
If I_{rms} is the value of steady current which dissipates heat in the resistor as the alternating current then

$$I_{\text{rms}}^2 R = \frac{I_0^2 R}{2} \quad (\Rightarrow) \quad I_{\text{rms}}^2 = \frac{I_0^2}{2}$$

$$\therefore I_{\text{rms}} = \frac{I_0}{\sqrt{2}}$$

$$V = 340 \sin 50\pi t$$

(b) (i)



$$2\pi f = 50\pi$$

$$\Rightarrow f = 25 \text{ Hz}$$

$$X_C = \frac{1}{2\pi f C} = \frac{10^6}{2\pi \times 25 \times 5} = 1273.9 \Omega$$

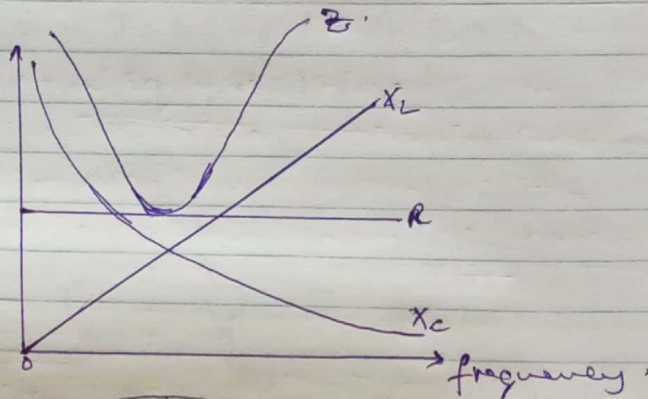
$$X_L = 2\pi f L = 2\pi \times 25 \times 0.8 = 125.6 \Omega$$

$$Z = \sqrt{(1273.9 - 125.6)^2 + 600^2} = 1295.6 \Omega$$

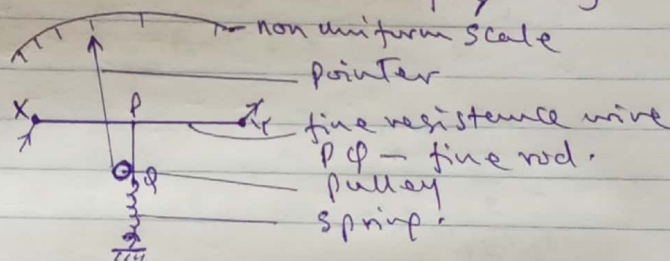
$$I_{\text{rms}} = \frac{V_0}{\sqrt{2} Z} = \frac{340}{\sqrt{2} \times 1295.6}$$

$$= 0.186 \text{ A}$$

(ii)



(c) (i)



Current to be measured is passed through the fine resistance wire XY. The wire heats up, expands and sags. The sag is taken up by the fine rod PQ which is pulled down by the spring. As PQ moves down it rotates the pulley which turns the pointer over the scale. The deflection of the pointer is proportional to the sag, which is proportional to the rate at which heat is dissipated in XY. Hence the deflection θ is proportional to the square of the average current.

$$\theta \propto I_{\text{rms}}^2$$

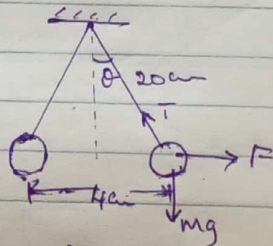
(ii) - The Hot wire ammeter can measure both a.c. and d.c. while moving coil ammeter cannot measure a.c.

- Moving coil ammeter is more prone to getting blown by high currents compared to hot wire ammeter.

11 (a) (i) Electric field intensity at a point in an electric field is the force experienced by 1C of positive charge placed at the point.

(ii) Electric field potential at a point is the work done to bring 1C of positive charge from infinity to that point.

(b)



In equilibrium
vertically
 $T \cos \theta = mg$ — (1)
Horizontally
 $T \sin \theta = F$ — (2)

$$\Rightarrow \textcircled{2} / \textcircled{1} \quad \tan \theta = \frac{F}{mg} \quad \text{But } F = \frac{K q^2}{x^2}$$

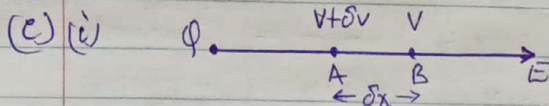
$$\therefore \tan \theta = \frac{K q^2}{mg x^2} \Rightarrow q^2 = \frac{mg x^2 \tan \theta}{K}$$

$$q^2 = \frac{8 \times 10^{-3} \times 9.81 \times (4 \times 10^{-2})^2 \times \frac{2}{\sqrt{20^2 - 2^2}}}{K}$$

$$= \frac{8 \times 9.81 \times 16 \times 0.1 \times 10^{-7}}{K}$$

$$q = \sqrt{1.256 \times 10^{-5}} = \sqrt{12.56 \times 10^{-6}}$$

$$= \underline{\underline{3.54 \times 10^{-3} \text{ C}}}$$



Consider two points A and B, a small distance δx apart in ~~and~~ ^{any} electric field such that the potential at B is V and, $V + \delta V$ at A. If the electric field intensity is almost constant at the two points, the work done to transfer 1C of charge from B to A is $= Fx - \delta x = Ex - \delta x$.

But the work done $= V + \delta V - V = \delta V$

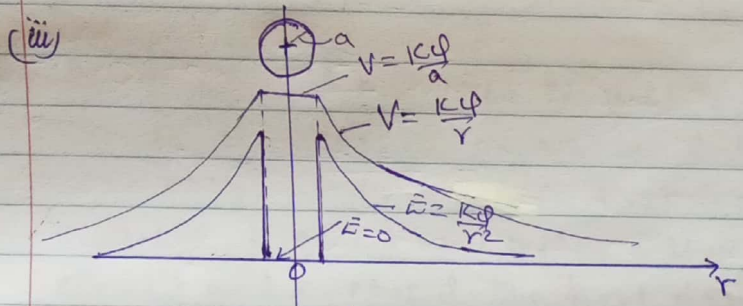
$\therefore \delta V = -E \delta x$

$\therefore E = -\frac{\delta V}{\delta x}$

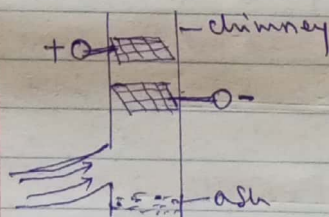
The electric field intensity is equal to potential gradient.

(ii) An equipotential surface is one on which the electric potential at all points is the same. This means the potential difference between any two points is zero. Work done to transfer charge of q from one point to another on the surface $W = Vq = 0 \times q = 0$.

Work done to transfer charge from one point to another $W = F \times \delta x = E \cos \theta \times \delta x$, where $E \cos \theta$ is the component of electric field intensity along the surface. From above $W = 0 \Rightarrow E \cos \theta = 0$. This implies that $\theta = 90^\circ$. Hence electric field intensity is perpendicular to the surface.



(d)

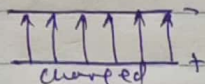


The chimney is fitted with layers of wire mesh, one is maintained at negative potential, and the other positive. Smoke from combustion passes through the negatively charged mesh picking negative charge from it. They are attracted and get attached to the positively charged mesh. The wire mesh is periodically shaken to remove ash particles that fall to the bottom of the chimney.

12(a) (i) Capacitance of a Capacitor is the ratio of the magnitude of charge on either plate of the capacitor to the p.d. between the plates.

(ii) A dielectric is an electrical insulator while dielectric constant is the ratio of capacitance of a capacitor with a dielectric between the plates to capacitance of the same capacitor with vacuum between the plates.

(b)



Consider a capacitor of plate separation d and area A . The electric field intensity between the plates $\vec{E} = \frac{\sigma}{\epsilon_0} = \frac{Q}{\epsilon_0 A}$.

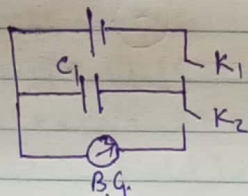
But electric field intensity $\vec{E} = \frac{V}{d}$.

$$\therefore \frac{V}{d} = \frac{Q}{\epsilon_0 A} \Rightarrow \frac{\epsilon_0 A}{d} = \frac{Q}{V}$$

Also $\frac{Q}{V} = C$ Capacitance of the capacitor

$$\therefore C = \frac{\epsilon_0 A}{d}$$

(c)

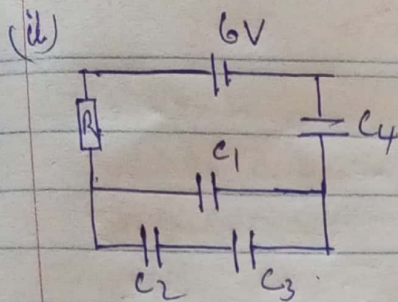


The circuit is connected as above. Let C_1 be capacitance of the first capacitor connected.

Switch K_1 is closed and after a short time K_1 is opened and K_2 closed. The first deflection θ_1 of the B.G. is noted. K_2 is opened and the capacitor is replaced by another, let its capacitance be C_2 . K_1 is closed and after a short time it is opened and K_2 is closed. The first deflection θ_2 of the B.G. The ratio of capacitances

$$\frac{C_1}{C_2} = \frac{\theta_1}{\theta_2}$$

(d) (i) When the circuit is connected current flows for a short time then it stops when the capacitor are full. $\Rightarrow I = 0$. p.d. across the resistor $V = IR = 0$.



Capacitance in series

$$C_A = \frac{800 \times 800}{1600} = 400 \mu F$$

Capacitance in parallel

$$C_B = 800 + 400 = 1200 \mu F$$

Total capacitance

$$C_C = \frac{800 \times 1200}{2000} = 480 \mu F$$

Charge stored in the network

$$Q = 480 \times 6 = 2880 \mu C$$

Pot. across C_B

$$= \frac{2880 \times 10^{-6}}{1200 \times 10^{-6}} = 2.4 V$$

Charge in ~~the~~ C_A

$$= 400 \times 2.4 = 960 \mu C$$

$\therefore$ Pot. across C_3

$$= \frac{960 \times 10^{-6}}{800 \times 10^{-6}}$$

$$= 1.2 V$$

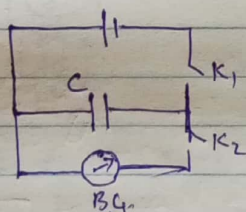
(iii) Energy stored in C_4

$$E = \frac{Q^2}{2C} = \frac{(2880 \times 10^{-6})^2}{2 \times 800 \times 10^{-6}} = 1.8 \times 10^{-6} J$$

13 a) (i) one farad is the capacitance of a capacitor across which is a pot. of 1V when it carries charge of 1C.

(ii) dielectric strength is the minimum electric field intensity required to cause dielectric break down in a material.

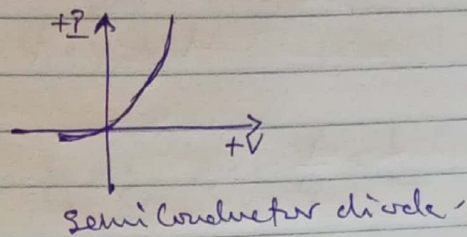
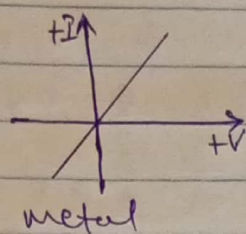
(b)



The circuit is connected as above. C is a capacitor with air between the plates. switch K_1 is closed and after a short time

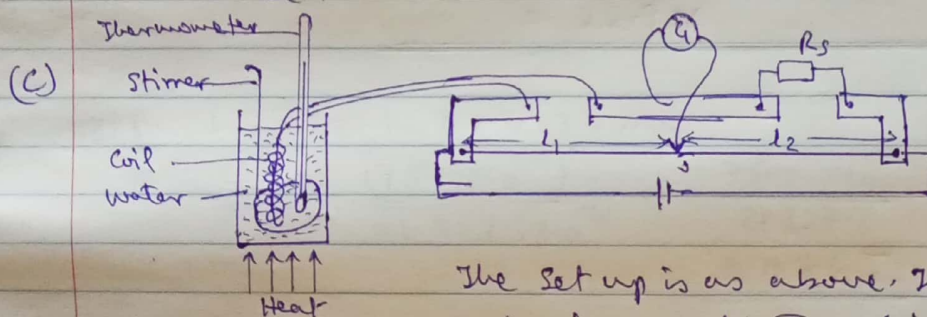
it is opened and K_2 is closed. The first deflection, θ_1 , is noted, and K_2 is opened. The test dielectric is now inserted in the capacitor and the experiment is repeated. The first deflection, θ_2 is noted. The dielectric constant ϵ_r is now calculated from $\epsilon_r = \frac{\theta_2}{\theta_1}$.

- (iii) Metals are examples of ohmic conductors while a semi-conductor or junction diode is a non ohmic conductor.



- (b) (i) When current flows through a wire, the conduction electrons collide with the metal atoms losing some of their kinetic energy to the atoms. The atoms thus vibrate with increased amplitude, which manifests as increase in temperature.

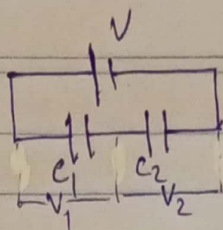
- (ii) When the temperature of a conductor increases, the atoms of the conductor vibrate with larger amplitudes, thus reducing the mean free path for conduction electrons. Fewer electrons are thus able to flow per second implying increase in resistance.



The Set up is as above. The test wire is wound into a coil and connected on the left hand gap of the bridge, while R_s is standard resistance.

The water bath is heated gently while stirring continuously. At some thermometer reading θ , the balance point is determined, where G , shows no deflection. The balance lengths l_1 and l_2 are measured and recorded together with θ . The experiment is repeated for other values of θ and the results recorded in a table including

(c)



The circuit is connected as above, charge on the two capacitors are equal

let it be Q . The p.d.s $V_1 + V_2 = V$.

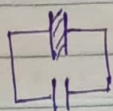
But $V_1 = \frac{Q}{C_1}$ and $V_2 = \frac{Q}{C_2}$

$$\therefore V = \frac{Q}{C_1} + \frac{Q}{C_2} \Rightarrow \frac{V}{Q} = \frac{1}{C_1} + \frac{1}{C_2} \quad \text{But } \frac{V}{Q} = \frac{1}{C}$$

where C is the effective capacitance

$$\therefore \frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$$

(d) (i)



$$C_0 = 600 \mu F$$

$$\epsilon_r C_0 = 1.2 \times 600 \mu F$$

$$\text{Total capacitance initially } C_1 = \frac{(600 \times 10^{-6})^2}{2 \times 600 \times 10^{-6}}$$

$$= 300 \mu F$$

$$\text{Charge stored } Q = CV = 300 \times 25 = 7500 \mu C$$

When the dielectric is inserted, Total

$$\text{Capacitance } C_T = \frac{1.2 \times (600 \times 10^{-6})^2}{2 \times 600 \times 10^{-6}} = 327.3 \mu F$$

$$\text{P.d. across the network} = \frac{Q}{C_T} = \frac{7500 \times 10^{-6}}{327.3 \times 10^{-6}}$$

$$= 22.9 V$$

(ii) Final energy in the network

$$E = \frac{Q^2}{2C} = \frac{(7500 \times 10^{-6})^2}{2 \times 327.3 \times 10^{-6}} = \frac{7500^2 \times 10^{-6}}{2 \times 327.3} = 0.086 J$$

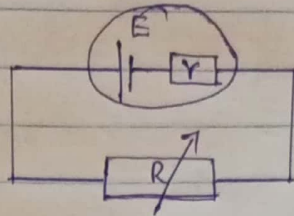
14(a)

(i) The current through a homogeneous conductor is directly proportional to the p.d. between its ends provided the temperature and other conditions remain constant.

(ii) Ohmic conductors are those in which the current flowing through is directly proportional to the p.d. across its ends, while non ohmic ones current is not directly proportional to the p.d. across its ends.

the external load and the internal resistance. Hence emf is always greater than terminal p.d.

(b)



Consider the circuit above. Current supplied to the circuit $I = \frac{E}{(R+r)}$

$\therefore$ Power delivered to the load

$$P = I^2 R = \left(\frac{E}{R+r} \right)^2 R = E^2 \frac{R}{(R+r)^2}$$

$$\frac{dP}{dR} = E^2 \left[\frac{(R+r)^2 - R \cdot 2(R+r)}{(R+r)^4} \right] = E^2 \left[\frac{(R+r-2R)(R+r)}{(R+r)^4} \right]$$

$$= E^2 \left(\frac{r-R}{(R+r)^3} \right) \quad \text{when } \frac{dP}{dR} = 0, \quad R=r,$$

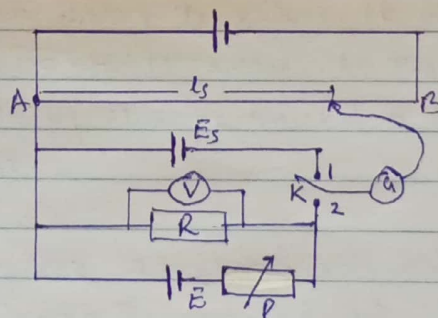
$$\frac{d^2P}{dR^2} = E^2 \left(\frac{-1(R+r)^3 - (r-R) \cdot 3(R+r)^2}{(R+r)^6} \right)$$

$$= E^2 \left(\frac{-R-r-3r+3R}{(R+r)^6} \right) = E^2 \left(\frac{2R-4r}{(R+r)^6} \right)$$

$$\text{When } R=r, \quad \frac{d^2P}{dR^2} = E^2 \left(\frac{2r-4r}{(2r)^6} \right) \text{ which is -ve}$$

Hence P is max. when $R=r$.

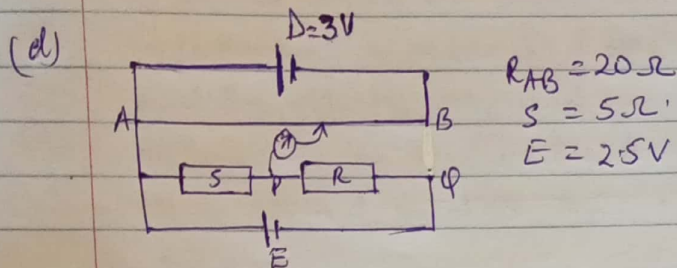
(c)



V is Voltmeter to be calibrated.

The circuit is connected as above. E_s is standard emf. Switch K is connected to position 1 and the balance point determined where the galvanometer

values of $R_0 = \frac{l_1}{l_2} \times R_5$. A graph of R_0 against θ is plotted, and the slope, S , determined and recorded together with the intercept R_0 on the R_0 axis. The temperature coefficient of resistance α is calculated from $\alpha = \frac{S}{R_0}$.



$$(i) \frac{R_2}{R_1} = \frac{l_2}{l_1} \Rightarrow \frac{R}{5} = \frac{60}{20}$$

$$\Rightarrow R = 15 \Omega$$

$$(ii) I_d = \frac{3}{20}$$

$$\therefore \text{with } G \text{ connected at } P$$

$$I_t \times 5 = \frac{3}{20} \times \frac{20}{100} \times 20$$

$$\frac{2.5}{(5+15+r)} \times 5 = 0.6$$

$$\Rightarrow 20+r = \frac{2.5 \times 5}{0.6}$$

$$\therefore r = \frac{2.5 \times 5}{0.6} - 20$$

$$= 0.83 \Omega$$

15(a) potential difference between ~~across~~ a conductor is the work done to move 1C of charge across the conductor while ~~emf~~ is the work done to convey 1C of charge round a circuit containing the source.

(ii) In practice, electric cells have internal resistance. Terminal p.d. is the work done to pass charge of 1C through the external load connected to the cell while ~~emf~~ includes work done to pass 1C of charge through

Shows no deflection. The balance length l_0 is determined. Switch K is now connected to position 2 and the rheostat P adjusted to give a large value. The balance point is determined and the balance length l , measured and recorded together with the ammeter reading V_r . The experiment is repeated for other settings of P and the results recorded in a table including values of $V_a = \frac{E_s}{l_0} \times l$. A graph of V_a against V_r is plotted, and it constitutes the calibration graph.

$$(d) \quad (i) \quad r = R \left(\frac{l_0}{l} - 1 \right) = 5 \left(\frac{20}{15} - 1 \right) \\ = 1.67 \, \Omega$$

(ii) At balance when K_1 is open,

$$I_d = \frac{E_D}{20+10} = \frac{E_D}{30}$$

At balance with K_2 open.

$$1.5 = \frac{E_D}{30} \times \frac{20}{100} \times 20$$

$$\Rightarrow E_D = \frac{1.5 \times 30}{4} = 11.25 \, V$$

When both K_1 and K_2 are closed,

$$I_d' = \frac{E_D}{20} = \frac{11.25}{20} = 0.5625 \, A$$

$$I_t = \frac{1.5}{5+1.67} = 0.225 \, A$$

$\therefore$ At balance,

$$I_t \times 5 = I_d' \times \frac{20}{100} \times l$$

$$0.225 \times 5 = 0.5625 \times \frac{20}{100} \times l$$

$$l = \frac{0.225 \times 5 \times 5}{0.5625} = 10 \, \text{cm}$$

UACE PHYSICS SEMINAR SLATED FOR 23RD
SEPTEMBER 2023 AT
UGANDA MARTYRS' S.S.S NAMUGONGO

Physics Paper one (P510/1)

SECTION A

1. (a) (i) Define momentum of a body and state its standard units.
(ii) State the law of conservation of linear momentum.
- (b) Two bodies A and B of masses 2.0kg and 3.0kg respectively, moving at right angles to each other with respective velocities of 4.0ms^{-1} and 2.0ms^{-1} are involved in a perfectly inelastic collision. Find
- (i) Their velocity after collision.
(ii) The loss in kinetic energy of the bodies.
- (c) A man who can swim at 5ms^{-1} in still water wishes to cross from one point of a river bank to another directly opposite him. If the river is 400m wide and flows at a speed of 4ms^{-1} , find
- (i) The direction in which the man should swim
(ii) The time he will take to cross the river.
- (d) Ship A is 10km south of ship B and is moving northwards at 100kmh^{-1} . Ship B is moving eastwards at 120kmh^{-1} . Find;
- (i) The shortest distance between the two ships.
(ii) The time it takes to reach the point of shortest distance.

[NDEJJE S.S]

2. (a) (i) State Kepler's laws of planetary motion.
(ii) State Newton's law of Universal gravitation.
- (b) (i) Sketch a graph showing the variation of acceleration due to gravity with distance from the centre of the earth.
(ii) Derive an expression for the acceleration due to gravity g , inside the earth at a distance r , from the earth's surface given that the earth has a uniform density ρ .
- (c) The orbital radius of Mars about the Sun is 1.53 times that of the earth about the sun. How many days does Mars take to move once round the Sun?

-
- (d) (i) Define a parking orbit.
(ii) State any two uses of artificial satellites.
- (e) A satellite of mass 100kg is in a circular orbit at a height of $3.59 \times 10^7\text{m}$ above the earth's surface.
(i) Find the mechanical energy of the satellite.
(ii) Explain what would happen if the satellite encountered resistance to its forward motion.

[STANDARD HIGH SCHOOL, ZZANA]

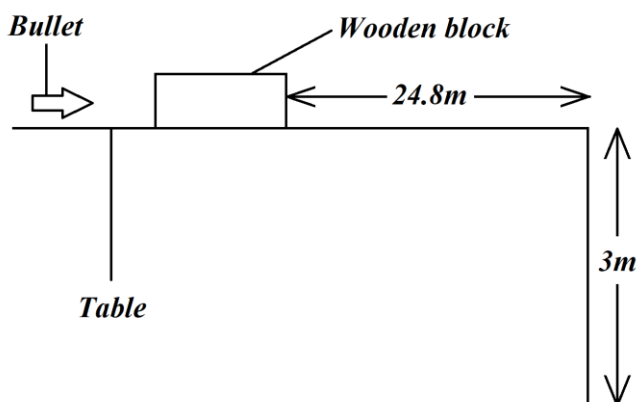
3. (a) (i) Define *angular velocity* and *centripetal acceleration*.
(ii) Derive the expression for the centripetal acceleration of a body moving with angular velocity ω in a circular path of radius R.
- (b) The period of a conical pendulum is 2.0 s. If the string makes an angle of 60° to the vertical at the point of suspension, calculate the:
(i) Vertical height of the point of suspension above the circle.
(ii) Length of the string,
(iii) Velocity of the mass attached to the string.
- (c) (i) Define simple harmonic motion.
(ii) Show that a small mass, m attached to the free end of a helical spring of force constant K, suspended vertically executes simple harmonic motion when displaced through a small vertical distance x, and then released.
(iii) Explain briefly how you can use the experimental arrangement in (ii) above to determine acceleration due to gravity.
- (d) A particle of mass 0.1kg is executing simple harmonic motion of amplitude $3.6 \times 10^{-2}\text{m}$ between two points A and B about point O as the centre of oscillation. The maximum restoring force on the particle has a magnitude 3.52 N.

Calculate;

- (i) The period of the motion
(ii) The kinetic energy of the particle when it is at a distance $4.5 \times 10^{-2}\text{m}$ from A.
(iii) The total energy of the particle

[SEETA HIGH SCHOOL, GREEN CAMPUS]

4. (a) (i) Define Friction
(ii) State the laws of solid friction
(iii) Use the molecular theory to explain the laws mentioned in (ii) above.
- (b) Describe an experiment to measure the coefficient of dynamic friction between a wooden block and a plane surface.
- (c) A block of wood of mass 950g rests on a horizontal table of height 3.0m at a distance of 24.8m from the edge of the table. A bullet of mass 50g moving with a horizontal velocity of 750ms^{-1} hits and gets imbedded in the block as shown in the diagram below.



If the coefficient of dynamic friction between the block and the table is 0.3, find

- (i) the velocity of the block and bullet just after collision.
(ii) the horizontal distance from the table to the point where the block hits the ground.

[BUDDO S.S]

5. (a) (i) Define **Young's modulus**.
(ii) State Hooke's law.
- (b) (i) Show that when a wire is stretched, the energy E stored per unit volume is given by $E = \frac{1}{2} \text{Stress} \times \text{Strain}$.
(ii) A copper wire of length 1.000 m is joined at one end to a steel wire of same length and diameter to form a composite wire of length 2.000 m. The composite wire is subjected to a tensile stress until its length becomes

2.002 m. Calculate the tensile stress applied to the wire.

[Young's moduli for copper and steel are 1.2×10^{11} Pa and 2.0×10^{11} Pa respectively]

- (c) (i) Describe an experiment to determine Young's modulus for a wire.
- (ii) State any two precautions taken in c (i) above to ensure accurate results.
- (d) (i) Distinguish between **ductile** and **brittle** materials.
- (ii) State the circumstance under which a brittle material can be used during construction.

[JINJA PROGRESSIVE ACADEMY]

- 6. (a) Define surface tension and derive its dimensions.
- (b) (i) Calculate the amount of energy liberated when 1000 droplets of water, each of diameter 1.0×10^{-6} m coalesce to form a bigger drop.
- (ii) Derive an expression for the pressure difference between the inside and outside of a soap bubble in air given that the radius of the bubble is r and surface tension of soap solution is γ
- (iii) Two soap bubbles of diameters d_1 and d_2 respectively are attached to each other to form an interface of radius r , if $d_1 < d_2$, derive the expression for r in terms of d_1 and d_2 .
- (c) (i) Distinguish between streamline flow and turbulent flow of a liquid.
- (ii) Describe an experiment to demonstrate streamline and turbulent flows.

[CRANE HIGH SCHOOL, ENTEBBE]

SECTION B

- 7. (a) (i) Define thermal conductivity.
- (ii) Describe an experiment to determine thermal conductivity of a copper.
- (b) The external wall of a brick house is of area 16m^2 and thickness 0.3m . The indoor and outdoor temperatures are 20°C and 0°C respectively. Find;
 - (i) The rate at which heat is lost through the wall.
 - (ii) The amount of heat lost in one hour when the internal surface of the wall is covered with expanded polystyrene tiles of thickness 20mm .

(iii) The temperature of the brick-tile interface.

(Thermal conductivity of, brick = $0.5 \text{ W m}^{-1} \text{ K}^{-1}$, polystyrene = $0.03 \text{ W m}^{-1} \text{ K}^{-1}$)

- (c) (i) Define a thermometric property.
(ii) State four examples of thermometric properties.
- (d) The electrical resistance in ohms of a certain thermometer varies with temperature T kelvin according to the approximate law $R = R_0 [1 + 5 \times 10^{-3}(T - T_0)]$. The resistance is 101.6 ohms at the triple point of water and 165.5 ohms at 600.5K. What is the temperature when the resistance is 123.4 ohms?

[GAYAZA HIGH SCHOOL]

8. (a) (i) What is meant by a **black body**?
(ii) State Stefan's law of black body radiation.
(iii) Draw a graph of relative intensity against wavelength for a black body at three different temperatures and use it to explain why the centre of a furnace appears white.
- (b) A 150W electric light bulb has a filament which is 0.8m long and diameter $6.0 \times 10^{-5} \text{ m}$. Estimate the working temperature of this filament if its total emissivity is 0.7.
- (c) With aid of a labeled diagram, describe how a total radiation pyrometer is used to measure the temperature of a furnace.

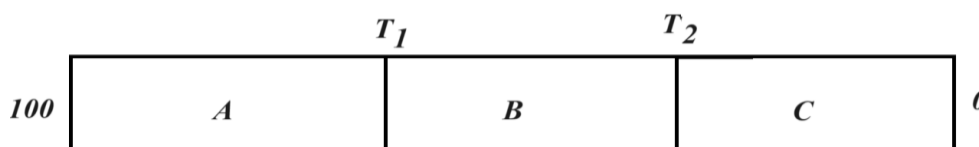
[Mt. St. MARY'S COLLEGE, NAMAGUNGA]

9. (a) (i) What is the difference between an isothermal and an adiabatic change?
(ii) What are the conditions for a reversible adiabatic change to be achieved?
- (b) (i) State any three differences between real and ideal gases.
(ii) Draw sketches showing the P-V isothermals for a real gas above and below the critical temperature. Mark on the curve, the liquid, saturated vapour and gaseous states.
- (c) One mole of a gas occupies $2.24 \times 10^{-2} \text{ m}^3$ at a pressure of $1.01 \times 10^5 \text{ Nm}^{-2}$ and temperature 0°C . If the molar heat capacity at constant pressure is $28.5 \text{ J mol}^{-1} \text{ K}^{-1}$, calculate the molar heat capacity at constant volume.
- (d) 20g of the gas in (c) initially at 27°C is heated at constant pressure of $1.0 \times 10^5 \text{ Nm}^{-2}$ and its volume increased from 0.250 m^3 to 0.375 m^3 . Calculate,
(i) The external work done.

- (ii) The increase in internal energy
[Relative molecular mass of the gas =2]

[KYAMBOGO COLLEGE SCHOOL]

10. (a) (i) Define cooling correction.
(ii) State Newton's law of cooling.
- (b) (i) Using a well labelled diagram, describe an experiment to determine the specific latent heat of vaporization of water by the method of mixtures.
(ii) State two advantages of the electrical method over the method of mixtures in determining the specific latent heat of vaporization of a liquid.
- (c) Three metallic conductors A, B and C of equal lengths and cross section area are joined to form an insulated composite rod as show in the figure below.



The exposed end of A and C are maintained at 100°C and 0°C respectively. If the ratio of the thermal conductivities of A, B and C is 1.5:2:2.5 respectively,

- (i) Find the steady temperatures of the interfaces T_1 and T_2 .
(ii) Draw a sketch graph of temperature against length of the composite rod
- (d) Explain why;
- (i) One feels cool after sweating.
(ii) Greenhouse effect causes global warming.

[GREENHILL ACADEMY]

SECTION C

11. (a) (i) State the laws of photoelectric emission.
(ii) Define; **work function** and **threshold frequency**
- (b) With use of a labeled diagram, describe Millikan's experiment to verify Einstein's equation of photoelectric emission.
- (c) Electrons are accelerated through a high potential difference and enter mid-way between two parallel plates with a velocity parallel to the plates. The plates are

15.0cm long and separated by 12.0mm. The electrons are deflected through 2.0cm on a screen placed 12.5cm beyond the plates when a potential difference of 960V is connected across the plates. Find;

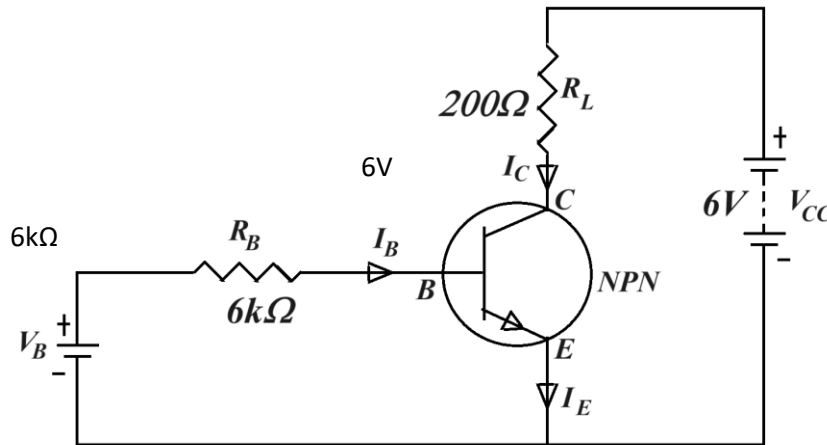
- (i) the velocity of the electrons as they emerge from the region between the plates.
 - (ii) the voltage used to accelerate the electrons before they enter the region between the plates.
- (d) In Millikan's oil drop experiment an oil drop of radius $6.2 \times 10^{-6}\text{m}$ and density 880kgm^{-3} was observed to fall through a distance of $6.25 \times 10^{-1}\text{cms}^{-1}$, when no potential difference was put across the plates. When a potential difference of 690V was applied between the plates, the same drop was seen to rise steadily at a speed of $7.25 \times 10^{-2}\text{cms}^{-1}$. If the distance between the plates is 1.5cm and the coefficient of viscosity of air is $1.8 \times 10^{-7}\text{Ns}^{-1}\text{kg}^2$, find the charge on the oil drop.

[NAALYA S.S, BWEYOGERERE CAMPUS]

12. (a) (i) Define mass defect of a nucleus.
- (ii) Explain the observations of Rutherford's scattering of alpha particles by a gold foil.
- (iii) Calculate the closest distance of approach when a 5.0MeV proton approaches a gold nucleus. (Atomic number of gold = 79)
- (b) (i) Given that the radius of a hydrogen atom having an electron of mass **m** and charge **q** orbiting its nucleus is **r**. Derive the expression for the total energy of the electron. (Angular momentum of the electron $= \frac{nh}{2\pi}$)
- (ii) Draw an energy level diagram for hydrogen to indicate emission of ultraviolet, visible and infra-red spectral lines.
- (iii) A hydrogen atom is in an excited state of energy -10.6eV. It absorbs a photon of wavelength $1.2 \times 10^{-7}\text{m}$ and is excited to a higher energy level. When it falls back to its ground state, a photon of wavelength $0.9 \times 10^{-7}\text{m}$ is emitted. Find the energy of the ground state.

[NAMILYANGO COLLEGE]

13. (a) (i) Distinguish between an **intrinsic** and **extrinsic** semiconductor.
- (ii) What is meant by a p-n junction?
- (iii) Sketch the I_C - V_{CE} characteristic of a transistor in a common emitter connection for two different I_B current.
- (b) The figure below shows a circuit incorporating an n-p-n transistor whose current amplification factor h_{fe} is 50.



With an input voltage V_B of 1.5V, find the;

- (i) Base current I_B
- (ii) Emitter Current I_E
- (iii) Output Voltage V_O
- (c) (i) With use of a labelled diagram, describe the use of the main feature of a cathode ray oscilloscope (C.R.O)
- (ii) State any two uses of a C.R.O.
- (d) With the time base switched off, an alternating voltage with root-mean-square value 2.82 V is connected across the Y-plates of a C.R.O. If a vertical trace of length 4.0 cm is formed on the screen, find the value at which the gain control of the C.R.O is set.

[KAKUNGULU MEMORIAL]

-
14. (a) When fast moving electrons strike a metal target in an X-ray tube, two types of X-ray spectra are produced.
- (i) Draw a sketch graph of intensity against wavelength of the X-rays.
 - (ii) Account for the occurrence of the two types of spectra.
- (b) (i) State Bragg's law of X-ray diffraction.
- (ii) Derive Bragg's equation.
- (c) (i) State the energy changes that take place in an X-ray tube during the production of X-rays.
- (ii) A beam of X-rays of wavelength $2.0 \times 10^{-10} \text{m}$ is incident on a set of cubic planes in a potassium Chloride crystal. First order diffraction maxima are observed at a glancing angle of 18.5° . Find the density of Potassium Chloride if its molecular weight is 74.55.
- (Avogadro's number $N_A = 6.02 \times 10^{23}$)
- (iii) Briefly explain any application of X-rays.

[NABISUNSA GIRLS SCHOOL]

15. (a) Define binding energy of a nuclide
- (b) (i) Sketch a graph showing how binding energy per nucleon varies with mass number.
- (ii) Describe the main features of the graph in b (i) above.
- (c) Distinguish between **nuclear fission** and **nuclear fusion** and account for energy released.
- (d) With the aid of a labelled diagram, describe the working of an ionization chamber.
- (e) (i) What is meant by **half-life** and **decay constant** as applied to radioactivity?
- (ii) A Geiger Muller (GM) tube placed **20cm** from a **2.0g** of Randon $^{222}_{86}\text{Rn}$ gives a count rate of **85** counts per second. If the entrance window of the GM tube has an area of **10cm²**, calculate the half-life of Randon.

[UGANDA MARTYRS' S.S. NAMUGONGO]

Physics Paper Two (P510/2)

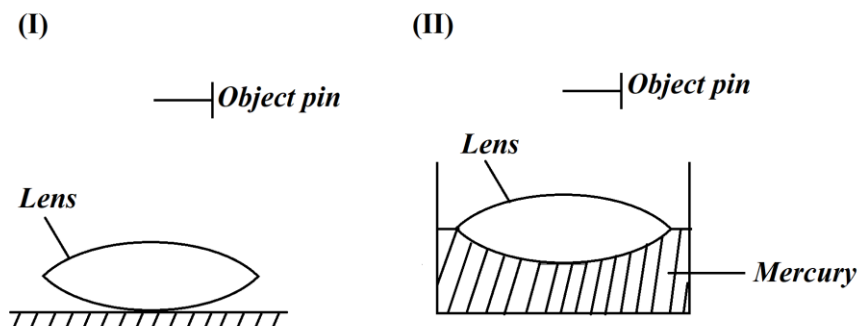
SECTION A

1. (a) (i) What is meant by **refraction** of light? (1)
- (ii) Describe an experiment to determine the refractive index of a liquid using an air cell. (5)
- (b) (i) Explain why water in a glass, viewed from above, appears shallower than it actually is. (3)
- (ii) A pin is mounted horizontally in a retort stand above a concave mirror, smeared with water. When the pin is adjusted vertically, it is found to coincide with its image at a height, h_w , above the water. When the experiment is repeated with another liquid, coincidence is achieved at a height of, h_l . If the refractive index of water is n_w , show that the refractive index of the liquid, n_l , is given by, $n_l = \frac{h_w n_w}{h_l}$. (4)
- (c) A convex lens of focal length 12cm is arranged coaxially with a convex mirror of focal length 20cm, placed 8cm apart. An object is placed 40cm in front of the lens on the side remote from the mirror.
- (i) Find the position of the final image. (5)
- (ii) Using a point object, draw a sketch ray diagram to show the image formation. (2)

[St. HENRY'S COLLEGE, KITOVU]

2. (a) Define **magnifying power** and **exit pupil** as applied in optical instruments. (2)
- (b) (i) Draw a sketch ray diagram to show how a Galilean telescope forms the final image at the near point. (2)
- (ii) Derive the expression for the magnifying power in this setting. (3)
- (iii) Compare the magnifying power of the instrument with that of an astronomical telescope, with identical focal lengths when they form the final image at the near point. (2)
- (c) Describe an experiment to determine the refractive index of the material of a prism of known refracting angle, using an optical spectrometer. (5)

(d)



A pin is arranged with a convex lens and plane mirror as in diagram above. The pin coincides with its image at a height of 16cm, above the mirror. When the lens is placed on mercury in a dish and again arranged with the pin as shown above, the pin coincides with its image at a height of 12cm above the mercury.

- (i) Find the radius of curvature of the lens. (3)
- (ii) Suppose the apparatus is again arranged as in figure (I) above, with liquid of refractive index 1.4 between the mirror and the lens, find the height at which the pin coincides with its image. (5)

[WAMPEEWO NTAKE]

SECTION B

3. (a) Define **frequency** and **amplitude** of a wave. (2)
- (b) (i) What is a stationary wave? (1)
- (ii) Show that when two progressive waves of equal wavelengths, equal frequencies and amplitude travelling in opposite directions superpose, they form a stationary wave. (4)
- (c) (i) What is meant by **pitch** and **quality** of a sound note. (2)
- (ii) Explain why a note produced by a closed pipe sounds different from when it is produced by an open pipe. (3)
- (iii) Describe an experiment to demonstrate that a stretched wire plucked in the middle vibrates in more than one mode simultaneously. (5)

-
- (d) An open pipe of length 130cm producing its fundamental note, resonates with a closed pipe three times as wide, producing its fundamental note. If the frequency is 120Hz, find the;
- (i) end correction. (4)
- (ii) length of the closed pipe. (3)

[UGANDA MARTYRS' S.S. NAMUGONGO]

4. (a) (i) What is **Doppler effect**? (1)
- (ii) An ambulance sounding a siren at a frequency, f , passes a stationary observer with a velocity of u , towards a tall wall. If the velocity of sound in air at the time is, c , derive the expression for the frequency of beats heard by the observer. (3)
- (i) Describe how the velocity of a star may be determined using Doppler effect. (3)
- (b) A motorist moving at a velocity of 60kmh^{-1} hears a siren at a frequency of 540Hz, from a police car pursuing him. If the car is moving at a velocity of 90kmh^{-1} , and the velocity of sound in air at the time 330ms^{-1} , find the
- (i) frequency of the siren. (3)
- (ii) frequency received by the motorist after the police car mistakenly passed him. (3)
- (c) (i) Define **beats**, in reference to sound notes. (1)
- (ii) Explain how beats are used to determine the frequency of a given note. (3)
- (d) Describe an experiment to demonstrate that sound waves undergo interference. (5)

[SEETA HIGH SCHOOL, MAIN CAMPUS]

5. (a) What are **coherent sources** of waves? (1)
- (b) Explain how coherent sources are obtained;
- (i) using a bi-prism (2)
- (ii) using Lloyd's mirror (2)

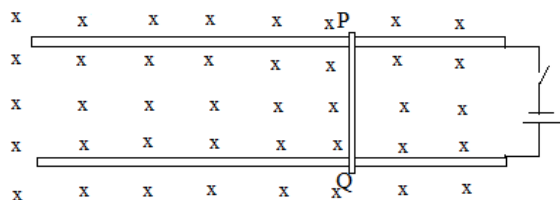
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- (c) (i) Two coherent sources of waves a distance, d , apart produce light of wavelength, λ , which interfere on a screen, a distance, D , from the source forming an interference pattern. Show that the width, y , of each fringe is given by $y = \frac{\lambda D}{d}$. (4)
- (ii) In an experiment to demonstrate interference by Young's double slit method, the slit separation was 0.3mm and the screen was 1.8m away from the slits. The distance between the 2nd bright fringe and the 5th dark fringe was measured and found to be 9.3mm. Determine the wavelength of the light used. (4)
- (d) (i) Two glass slides in contact at one end are separated by a sheet of paper 15cm from the line of contact, to form an air wedge. When the air wedge is illuminated almost normally by light of wavelength 600nm, interference fringes of separation 1.8mm are formed. Find the thickness of the paper. (4)
- (ii) Explain why the fringe along the line of contact of the slides in d(i) above is dark, yet the geometrical path difference is zero. (2)
- (e) (i) Describe how plane polarized light can be produced by double refraction. (4)
- (ii) Describe how polarized light is used in determining the concentration of sugar in a solution. (3)

[KING'S COLLEGE, BUDDO]

SECTION C

6. (a) (i) Define **one tesla**. (1)
- (ii) Write the expression for the force acting on a straight conductor of length, l , carrying current of, I , at an angle, θ , to a magnetic field of flux density, B . (1)
- (iii) From the expression in a(i) above, deduce the expression for the force acting on one free electron in the conductor. (3)

(b) (i)



The figure above shows a metal rod PQ of mass $24.1 \times 10^{-3} \text{g}$ lying on two smooth horizontal rails connected in series with a battery of emf 1.5V and a resistor of 18Ω . The rails are parallel and placed 20.4cm apart, in a uniform magnetic field of flux density $5.6 \times 10^{-2} \text{T}$. Find the velocity of the rod 3 seconds after switch K is closed. (5)

(ii) An aeroplane of wing span 40cm is flying in a straight horizontal coast westwards at a speed of 300kmh^{-1} . If the angle of dip at the location is 67° , and the horizontal component of the earth's field intensity is 12.7Am^{-1} , Calculate the emf induced between the wing tips. (2)

(c) (i) Define magnetic meridian and magnetic variance. (2)

(ii) Describe an experiment to determine the horizontal component of the earth's magnetic flux density using a tangent galvanometer and a graphical analysis. (6)

[St. MARY'S COLLEGE, KISUBI]

7. (a) Define the terms **reactance** and **impedance** as applied to alternating current. (2)

(b) An alternating current of $I = I_0 \sin \omega t$ through a circuit containing a capacitor of capacitance, C.

(i) Derive the expression for the reactance of the capacitor. (3)

(ii) Compare the values of, V, and, I, at $t=0$, $t=\frac{\pi}{2\omega}$, and $t=\frac{\pi}{\omega}$, hence deduce the phase relationship between V and I. (2)

(c) Explain why a capacitor appears to conduct alternating current. (3)

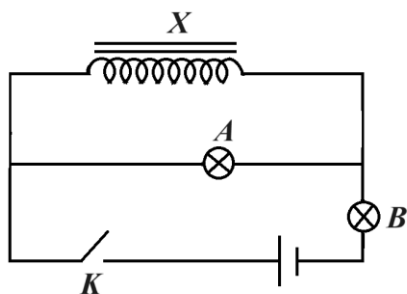
(d) A capacitor of $16 \mu\text{F}$, a coil of inductance 0.5H and a resistor of 74Ω are connected across an a.c source of $V = 30 \sin 120\pi t$. Find the;

(i) average p.d across the capacitor. (4)

- (ii) power dissipated in the circuit. (3)
- (e) Describe how the attraction type of moving iron ammeter works. (5)

[UGANDA MARTYRS S.S, NAMUGONGO]

8. (a) State the laws of **electromagnetic induction**. (2)
- (b) (i) Derive the expression for the charge, Q , induced in a coil of N turns when the magnetic flux through it changes. (4)
- (ii) Describe how the magnetic flux density between pole pieces of a permanent magnet can be determined using a ballistic galvanometer of unknown charge sensitivity. (5)
- (c) A copper disc of radius 8cm is placed in a uniform magnetic field of flux density 0.5T, with its plane perpendicular to the magnetic field. The disc is rotated about an axis through its centre at 2500revolutions per minute. If the centre of the disc is connected to the rim through a resistor of 3Ω and an ammeter, find the ammeter reading. (4)
- (d)



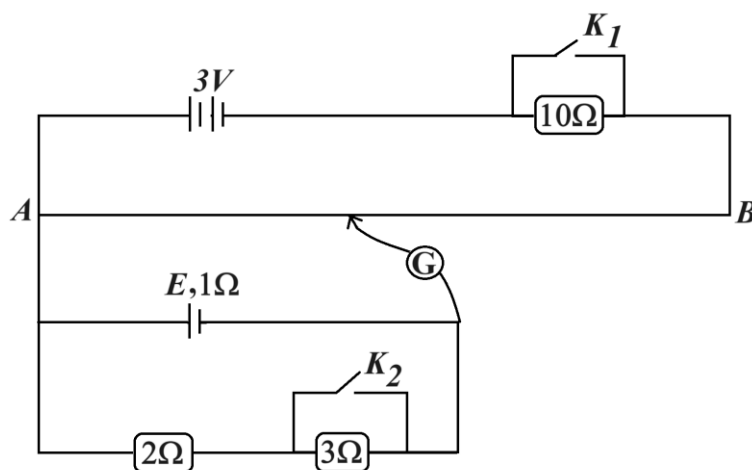
Two identical bulbs A and B are connected to an inductor X, of large inductance as in circuit above across a strong voltage source. Explain what is observed when;

- (i) switch K is first closed (4)
- (ii) switch K is opened. (2)

[St. JOSEPH'S S.S, NAGALAMA]

SECTION D

9. (a) Define the following as applied to current electricity:
- (i) Electromotive force (1)
 - (ii) Internal resistance. (1)
- (b) Explain the factors determining resistance of a conductor. (6)
- (c) (i) Describe an experiment to determine the *emf* of a thermocouple using a potentiometer. (4)
- (ii) Explain any special modification made to achieve the experiment in c(i) above. (3)
- (d)



In figure above, AB is a uniform wire of length 100cm and resistance 30Ω . The driver battery has emf of 3V and negligible internal resistance. Battery E has internal resistance of 1Ω .

With both switches K_1 and K_2 open, the balance length is 92.6cm, when both switches are closed, the balance length is 55.6cm. Find the;

- (i) emf of battery E. (5)
- (ii) balance length when K_1 is open and K_2 is closed. (2)

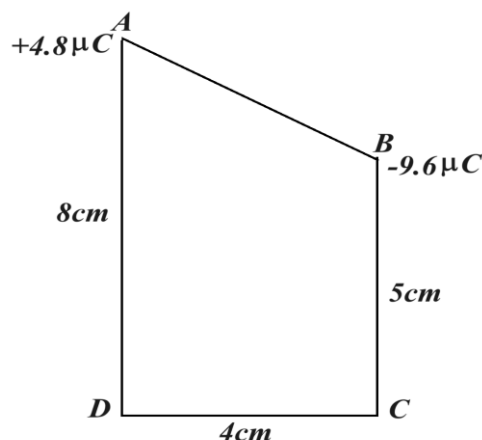
[SEROMA CHRISTIAN HIGH SCHOOL]

10. (a) (i) Define electrical resistivity of a material. (1)
- (ii) Describe an experiment to determine the electrical resistivity of a material using a potentiometer. (6)

- (iii) The conductivity of nichrome at room temperature is $9.1 \times 10^5 \Omega^{-1}\text{m}^{-1}$. Find the resistance of a nichrome wire 20cm long and diameter 0.05mm. (3)
- (b) (i) Define **voltage** across a conductor. (1)
- (ii) Derive the expression for electrical energy dissipated in a conductor of resistance, R , when a current of, I , flows through it for, t , seconds. (3)
- (iii) Explain why a wire heats up when current flows through it. (3)
- (c) A resistance wire wound into a coil, is connected on the left hand gap of a metre bridge, and a standard resistor of 8.0Ω on the right hand gap. The coil is immersed in a water bath which is heated gently while stirring continuously.
- When the temperature of the bath is 20°C , the balance point is 42.5cm from the left hand end of the slide wire. When the temperature is 80°C , the balance point is 55.4cm. Find the temperature coefficient of the material of the coil. (5)

[KIBULI S.S]

11. (a) Define electric **field intensity** and **electric potential difference** between two points in an electric field. (2)
- (b) (i) Describe an experiment to show that the surface of a charged, pear shaped conductor is equipotential. (3)
- (ii) Explain why the electric field intensity from the surface in b(i) above must be perpendicular to the surface. (3)
- (c)

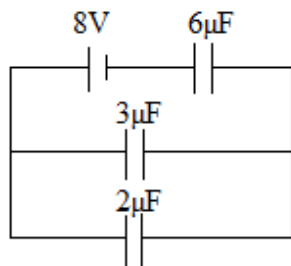


- Charges of $+4.8\mu\text{C}$, $-9.6\mu\text{C}$ and $-6.4\mu\text{C}$ are placed at the vertices A, B and C, of a trapezium in air, as in figure above. Find the;
- (i) Electric field intensity at point D. (4)

- (ii) Energy required to transfer the $+4.8\mu\text{C}$ charge from A to D. (4)
- (d) Describe how a large potential is built in a Van de Graff generator. (6)

[JINJA COLLEGE]

12. (a) Define;
- (i) capacitance of a conductor. (1)
- (ii) dielectric constant of a material. (1)
- (b) (i) Describe an experiment to determine the relative permittivity of a material, using a vibrating reed switch circuit. (4)
- (ii) Explain the theory of the experiment in b(i) above. (3)
- (c) (i) Two identical capacitors are connected in series across a d.c voltage source of, V , and a dielectric of relative permittivity, ϵ_r , is inserted in one of the capacitors. When they are fully charged, the capacitors are each isolated and then connected in parallel. Show that the final p.d, V' , across the network becomes, (3)
- $$V' = \frac{2\epsilon_r V}{(\epsilon_r + 1)^2}.$$
- (ii) Explain why the capacitance of two identical capacitors reduces to half when connected in series and doubles when connected in parallel. (4)
- (d) The total electric flux due to a charged spherical conductor of diameter 80cm is $8.14 \times 10^7 \text{ Nm}^2 \text{ C}^{-1}$. Find the total charge on the conductor. (3)
- (e)



Three capacitors of $6\mu\text{F}$, $3\mu\text{F}$ and $2\mu\text{F}$ are connected across a voltage source of 8V as above. Find the;

- (ii) energy stored in the network. (4)
- (iii) p.d across the $3\mu\text{F}$ capacitor. (3)

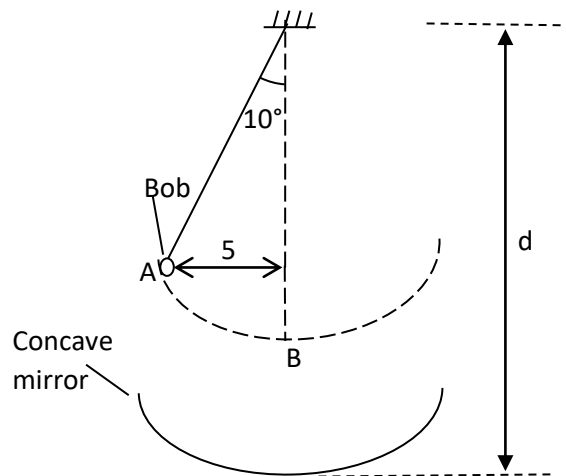
[St. JOSEPH'S GIRLS S.S, NSAMBYA]

A' LEVEL PHYSICS

P510/2 REVISION QUESTIONS

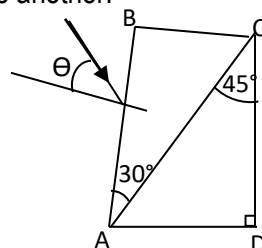
LIGHT

1. a) Define the terms principal focus and Centre of curvature as applied to concave mirror. (2marks)
- b) Explain why a paraboloidal mirror is used in search lights instead of a concave mirror. (3marks)
- c)(i) Derive the expression relating the radius of curvature of a convex lens to the object and image distances. (4marks)
- (ii) Sketch a graph of image distance against object distance for a concave mirror and use it to describe the image formed by the mirror as the object distance varies from a large to very small values. (3marks)



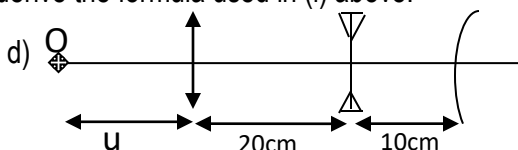
The diagram above shows a swing pendulum swinging above a concave mirror of radius of curvature 20 cm. B is along the principal axis of the mirror. A real image of the bob of the pendulum at B is 30 cm from the mirror. Find the

- (i) height d. (4marks)
 - (ii) position of the image of bob at B if a small quantity of liquid of refractive index 1.33 is dropped on the reflecting surface of the mirror. (4marks)
2. a) State the laws of refraction (2 marks)
 - b) Explain why stars twinkle at night whereas planets don't twinkle. (3marks)
 - c) The diagram below shows two prisms ABC of refractive index 1.54 and ACD of refractive index 1.64 placed against one another.



- Find the value of angle θ for which the ray will just emerge through side CD. (5marks)
- d) (i) Sketch a graph of deviation, d , against angle of incidence, i for a ray of light through a glass prism. (2marks)
- (ii) Give the interpretation of the minimum value of your graph? (2mark)
- e)(i) Describe an experiment to determine refractive index of a glass prism of known refracting angle. (4marks)
- (ii) State two uses of prisms. (2marks)

3. a) Define the terms magnifying power and visual angle as applied to optical instruments. (2 marks)
- b) (i) With the help of the diagram, discuss the problem terrestrial telescopes try to solve compared to astronomical telescopes. (4 marks)
- (ii) State two disadvantages of terrestrial telescopes compared to astronomical telescopes. (2marks)
- c) A compound microscope objective has a focal length of 4.0 cm while the eye piece has focal length, f_e . A small object is placed 5.0 cm from the objective. The final virtual image is formed in the plane of the object and is 30 cm from the eyepiece.
- (i) Why is the object viewed with the eye very close to the eyepiece? (1mark)
- (ii) Find the focal length, f_e of the eye piece. (4marks)
- (iii) Find the angular magnification when the objective is replaced with another convex lens of focal length 4.05 cm. (5marks)
- (iv) Sketch a ray diagram to show formation of final image in (iii) above. (2marks)
4. a) Explain why a convex lens converges parallel beam of light incident on it whereas concave lens diverges it. (4 marks)
- b) Explain two defects of the lenses and state how to minimize them. (4 marks)
- c) (i) Describe an experiment to determine the focal length of a lens in an inaccessible tube. (5marks)
- (ii) derive the formula used in (i) above. (3marks)



In the diagram above, a convex lens of focal length 10 cm, concave lens of focal length 15 cm and convex mirror of focal length 10 cm are arranged coaxially as shown. If a point object O coincide with its image at O, find the distance, U . Illustrate with a ray diagram. (5marks)

WAVES

5. (a) state two differences between sound and light waves [02]
- (b) Define the following:
- (i) Beats [01]
- (ii) Resonance [01]
- (c) (i) describe an experiment to determine frequency of a tuning fork using a resonance tube in a region of known speed of sound in air. [04]

(ii) State one hazard of resonance [01]

(d) (i) define Doppler effect [01]

(ii) a car travelling at 10ms^{-1} sounds its horn which has a frequency of 500 Hz, and this is heard in another car which is travelling behind the first car, in the same direction, with a velocity of 20ms^{-1} . The sound can also be heard in the second car by reflection from a bridge ahead. Calculate the frequency of frequency of beats that will be heard by the driver of the second car. (speed of sound in air $=340\text{ms}^{-1}$) [04]

(iii) explain how to measure the speed of a star that is moving towards the earth. [03]

(e) (i) define reverberation [01]

(ii) explain why reverberations are not heard in small rooms. [02]

6. (a) state huygen's principle [01]

(b) monochromatic light propagating in air is incident obliquely onto a plane boundary with a material of refractive index, n .

(i) use huygen's principle to show that the speed, v , of the light in the material is given by

$$v = \frac{c}{n}$$

where c is speed of light in air [05]

(ii) if the wave length of the light is 600nm in air, what will it be in a material of refractive index 1.51? [03]

(c) what is a diffraction grating ? [01]

(d) state three differences between the spectra produced by a prism and that by a diffraction grating. [03]

(e) (i) what is meant by interference of waves?[01]

(ii) State the conditions necessary for interference fringes to be observed. [02]

7. (a) Distinguish between the terms nodes and antinodes with reference to stationary waves. (2)

(b) A steel wire of length 40.0 cm and diameter 0.0250 cm vibrates transversely in unison with a tube, closed at one end and of length 56.4 cm and end correction 3.6 cm, when each is sounding its fundamental note. The air temperature is 27°C . Find the tension in the wire. (Assume that the velocity of sound in air at 0°C is 331ms^{-1} and density of steel is 7800kgm^{-3} .) (4)

(c) With the aid of a sonometer, describe an experiment to show how the frequency of a vibrating string is affected by changes of length. (5).

d) (i) Define the term Doppler Effect (1)

(ii) An observer moving at a speed of 10 ms^{-1} between two sources of sound A and B hears beats at 5 s^{-1} . If the frequency of waves produced by source A is 515 Hz and the observer is moving towards A, find the frequency of sound produced by B. (speed of sound in air is 340 ms^{-1}) (5)

(iii) Explain how Doppler Effect can be used to determine plasma temperature (3)

8. a) What is meant by **diffraction** and **polarization** of light waves? (2)

b) A Transmission diffraction grating of spacing ***d*** is illuminated normally with light of wavelength λ .

i) Derive the condition for occurrence of diffraction maxima. (3)

ii) Describe briefly the intensity distribution on a screen placed beyond the grating. (2)

iii) What is the effect on the diffraction pattern, of using a grating with a larger number of lines? (2)

c) Light of wave length $5.8 \times 10^{-7} \text{ m}$ is incident on a diffraction grating with 500 lines per mm. Find the;

i) diffraction angle for the 2nd order image. (3)

ii) maximum number of images possible. (2)

d. i) Describe how polarized light can be produced by reflection. (4)

ii) List **two** uses of polarized light. (2)

9.(a)(i) State the conditions which must be satisfied in order to observe an interference pattern due to two wave motions. (1)

(ii) Account briefly, for the interference pattern produced by transparent thin film. (4).

(iii) A liquid film of uniform thickness is just thick enough to cause maximum reflection of light of wavelength 560nm at normal incidence. The refractive index of the liquid is 1.40. Find the thickness of the film. (3).

(b) A diffraction grating spectrometer is set up to measure the wavelength of monochromatic light.

- (i) Draw a labeled diagram to show the essential features of the spectrometer. (3)
- (ii) State the initial adjustments that have to be carried out before the spectrometer can be used. (3).
- (c) A light source emits two wavelengths 450nm and 600nm. The light is incident normally on a diffraction grating of 500lines per mm.

Find,

- (i) the angular separation of these lines in the second order spectrum.(4)
- (ii) the respective orders for the two wavelengths to overlap.

10. (a) (i) With aids of suitable sketch diagrams, distinguish between free and damped oscillation (3mks)

(ii) State one application of damping (1mk)

(b)(i) Define a wave and wave front (2mks)

(ii) What is meant by beats in sound? (2mks)

(iii) State one use of beats (1mk)

(c) (i) what is meant by Doppler effect? (1mk)

(ii) A police car traveling at 108km/hr is chasing a lorry which is traveling at 72km/hr. Both are about to pass a stationary bystander and the police car siren emits a sound of frequency 400Hz. Calculate the apparent frequency of the note from the siren as observed by the lorry driver. (3mks)

(d) (i) Define resonance (1mk)

(ii) State one and one hazard of resonance (2mks)

(iii) A cylindrical pipe of length 29cm is closed at one end. The air in the pipe resonates with a tuning fork of frequency 860Hz sounded near the open end of the tube. Determine the mode of vibration and find the end correction. (4mks).

11. (a) (i) what is meant by coherent sources of (1mk)

(ii) Distinguish between interference and diffraction of light (2mks)

(b) With the aid of suitable sketches, explain the following;

(i) Division of wave front (2mks)

(ii) Division of amplitude (2mks)

(c) In young's two slits experiment;

(i) State the conditions necessary for an interference fringes to be visible and explain why these conditions are necessary. (3mks)

(ii) Monochromatic light of wavelength $5 \times 10^{-7} \text{m}$ is incident on two slits of separation $4 \times 10^{-4} \text{m}$. Calculate the fringe separation on a screen placed 1.5m from the slit. (3mks)

(d) Two microscope slides 7.5cm long are separated at one end by a thin piece of thread and are just touching at the other end. The slides are illuminated normally with monochromatic light. A series of dark and bright bands are formed at a distance x cm from each other.

(i) With help of a labeled diagram, explain how the bands formed. (4mks)

(ii) If $x = 0.27 \text{ cm}$ how many bright bands are seen when viewed in the reflected light. (3mks)

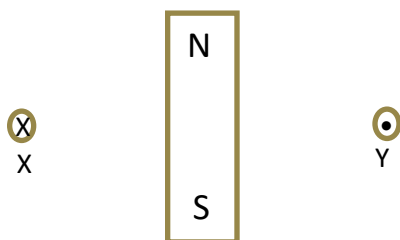
MAGNETISM

12. (a) Define the following terms

(i) Magnetic flux density [1]

(ii) Direction of magnetic line of force [1]

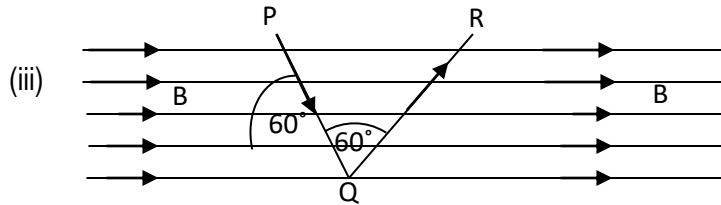
(b)



In the figure above, parallel electric currents flow near an isolated bar magnet. With the aid of a well sketched magnetic field pattern, explain the effects of the bar magnet on the wires x and Y, [4]

(c) (i) Define the term magnetic moment [1]

(ii) With the aid of a well labeled, describe the structure of a ballistic galvanometer [4]



The figure shows two straight conductors PQ and QR joined at Q , carrying a current of 2.0A and subjected to a uniform magnetic field of flux density 0.02T whose direction lies in the plane PQR at 60° to PQ . Both PQ and QR are 6.0cm long. The angle PQR is 60° . Calculate the forces on PQ and QR . What movement do the two forces together try to produce? [4]

(d) With the aid of a labeled diagram, describe the absolute measurement of current [5]

13. (a) (i) Define self-induction and state one of its applications [2]

(ii) Explain why when a current is switched off in some circuits, a spark is seen across the gap. [3]

(b) With the aid of a well labeled diagram describe how an a.c. generator works, and state how you can modify it into a d.c. motor [7]

(c) (i) Explain the term back emf in a dc motor [2]

(ii) Show how back emf in a motor is related to the efficiency of the motor [3]

(d) The current in a coil falls at 2.0As^{-1} and consequently induces an emf of 4.0mV in a second coil close to it. What induced voltage would occur in the first coil due to a 4.0As^{-1} fall of current in the second coil [3]

14. (a) Distinguish between electrical resistance and reactance [2]

(b) With the aid of a diagram describe how a thermocouple meter works. [4]

(c) An alternating current I flows through a coil of inductance L . The instantaneous value of current is $I = I_0 \sin 2\pi ft$, where I_0 is the amplitude and f is the frequency.

(i) Derive the expression for the voltage V across the coil. [4]

(ii) State the phase of V relative to that of I [1]

(iii) If the coil is a pure inductor, explain why it is non-dissipative. [3]

(d) Define root mean square value of alternating current [1]

(e) A sinusoidal voltage of rms 20V is applied across a $70\mu\text{F}$ capacitor. If the frequency of the a.c. supply is 50Hz , calculate

(i) The rms value of the current through the capacitor [3]

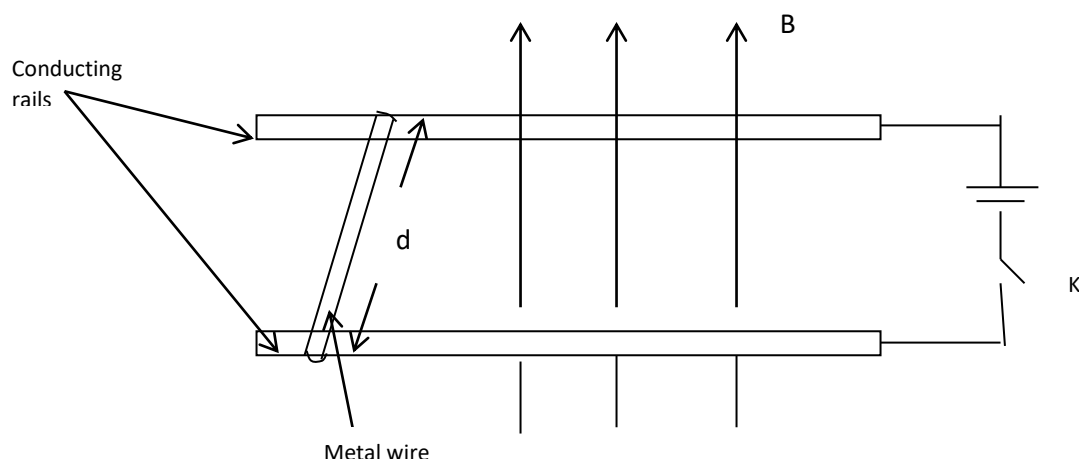
(ii) The maximum charge on the capacitor [2]

15.(a) State expressions for the force on

- (i) a straight conductor of length l , carrying current, I , at right angles to a uniform magnetic field of flux density, B . (1)
- (ii) a particle of charge, q , moving with velocity, v , at an angle θ to a uniform magnetic field of flux density, B . (1).

(b)(i) define a tesla (1)

- (ii) In the figure below, a metal wire of mass $24.1 \times 10^{-3} \text{g}$ can slide without friction on two horizontal parallel conducting rails separated by a distance $d = 2.56 \text{cm}$. A vertical magnetic field of flux density $B = 5.62 \times 10^{-2} \text{T}$ is applied in the direction shown. At time $t = 0$, switch K is closed. If a constant current of 9.13mA flows, find the velocity of the rod after $61.1 \times 10^{-2} \text{s}$. (6)



(c)(i) With the aid of a labeled diagram, describe the structure and operation of a moving coil galvanometer. (5).

- (ii) Explain why the coil should have a radial magnetic field and explain how this is achieved (3).

(iii) A standard capacitor of $1.0 \mu\text{F}$ is charged to a p.d. of 12V and then discharged through a ballistic galvanometer. The first deflection of the reflected light spot is 40mm on a screen 1.0m away. Find the ballistic sensitivity of the galvanometer. (3)

16. a)(i) Define amplitude and root mean square value of an alternating current. (2).

(ii) An electric kettle draws 1.5kW from 250V(rms) mains supply. Find the amplitude of the current drawn by the kettle, if the voltage is sinusoidal. (2).

b) A sinusoidally alternating voltage of 20V(rms) and frequency 60Hz is applied to a capacitor of capacitance $10\mu\text{F}$.

(i) Find the rms current which flows. (2)

(iii) Explain why a.c apparently flows through a capacitor but d.c does not? (3)

(c) With the aid of a labeled diagram, describe the structure and action of a hot-wire ammeter. (5)

(d) Draw a circuit diagram of a bridge full-wave rectifier and explain how it works. (3).

(e) (i) distinguish between reactance and impedance [01]

(ii) a coil of 1 H is connected in series with a resistor of 100Ω . A voltage of 5vr.m.s, 50Hz , is connected across the combination . calculate the power absorbed in the circuit. [02]

(f) Explain why an ordinary voltmeter cannot measure alternating voltage. [02]

17. (a) State the laws of electromagnetic induction. (2)

(b) What are:

(i) Self-induction? (1)

(ii) Mutual induction? (1).

(c) (i)Describe the construction and operation of an ac transformer. (5)

(ii) An ac transformer operates on 240V. If the transformer is 90% efficient, calculate the current in the primary coil when a 36W lamp is connected across the secondary. (4)

d) (i) What is back emf? (2)

(ii) Give two applications of back emf (1)

(iii)Describe a simple experiment to demonstrate the damping effect of eddy currents.

(4).

18. a) (i)Define the term magnetic field line (1)

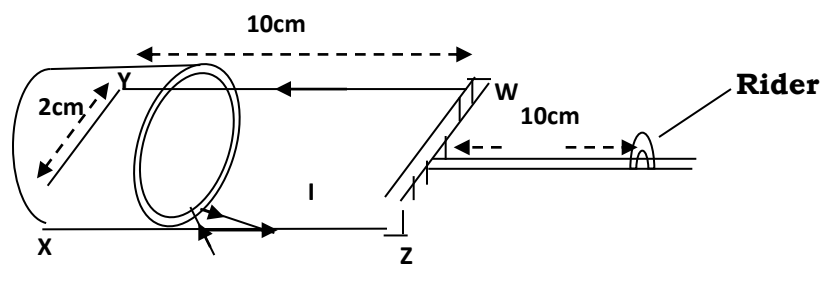
(ii) Sketch the resultant magnetic field pattern of a current carrying straight wire at right angle to a uniform magnetic field and use it to explain neutral point (3)

b) (i) Explain how hall voltage is produced across the face of a metal strip carrying a current I at right angle to uniform magnetic field of flux density B . (3)

(ii) Show that hall voltage, $V_h = \frac{BI}{net}$, where n is number of charge carriers per unit volume, t is thickness of the strip. (3)

c) A copper wire has 1.0×10^{29} free electrons per cubic metre, across – sections area of 2.0mm^2 and carried a current of 5.0A . Calculate the force acting on each electron if the wire is now placed in a magnetic field of flux density 0.15T which is perpendicular to the wire. (4)

d) (i)



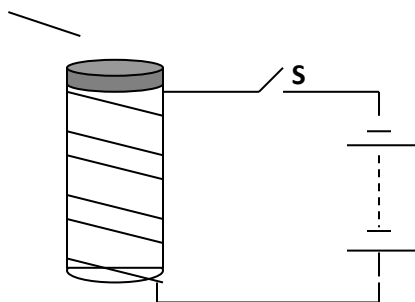
A rectangular wire WXYZ is balanced horizontally so that the length XY is at the center of a solenoid of 800 turns per metre. A current I is passed through XY and 2.5 A through the solenoid, a rider of mass $2.5 \times 10^{-2}\text{ kg}$ has to be placed at a distance of 7.0 cm from WZ to restore balance. Find the value of I . (4)

(ii) State two advantages of using a current balance to measure current over an ammeter.

(2)

19. a) The figure below shows an Aluminium ring resting on a solenoid

Aluminum ring



(i) On closing switch S the ring jumps up. Explain this behaviour. (3)

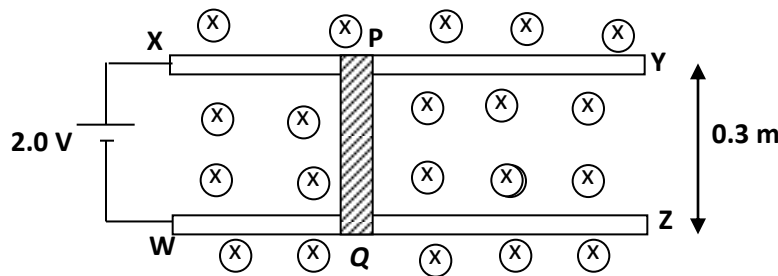
(ii) What would happen to the ring if a high alternating current was instead passed through the solenoid?
(3)

b) A circular coil of 50 turns of mean radius 50 cm is arranged so that its plane is perpendicular to the magnetic meridian. The coil connected to a ballistic galvanometer of sensitivity $5.7 \times 10^4 \text{ rad C}^{-1}$. The total resistance of the coil and galvanometer is 100Ω . The coil is then rotated through 180° about the vertical axis, the B.G deflects through 0.8 radians. Calculate the horizontal component of the earth's magnetic flux density.
(5)

c(i) What is back emf in a motor (2)

(ii) Explain the importance of back emf in the operation of a motor. (2)

d) XY and WZ are conducting coils in figure below along which is a conducting rod PQ of length 0.3 m which can slide without friction across a uniform magnetic field of 0.6 T. The conductor PQ moves to the right with a constant velocity of 10 ms^{-1} . Assume that the resistance of the conducting loop XPQW stays at 4Ω .



(i) Indicate and describe the forces acting on the conductor PQ. (2)

(ii) The magnitude and direction of the emf induced in loop XPQW. (2)

(iii) Calculate the current flowing through PQ (2)

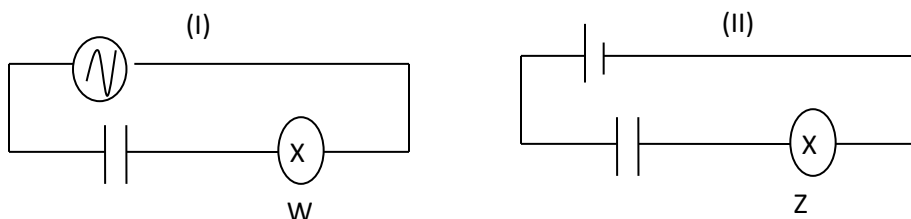
(iv) Find the efficiency of the circuit (2)

20. a) i) Define the **root mean square** (r.m.s) value of an alternating current. (1)

ii) A sinusoidal alternating current $I = 3\sin(120\pi t)$ amperes flows through a resistor of resistance 2.5Ω .

Find the mean power dissipated in the resistor. (3)

b) The circuit below shows two circuits. Circuit (I) shows a capacitor connected in series with a bulb W and ac source. Circuit (II) shows a capacitor identical to one in circuit (I) connected in series with dc source and bulb Z. Bulbs W and Z are identical. Explain what happens to bulbs W and Z (4)



c) In an experiment to measure the reactance of a capacitor, the rms current is measured to be 10mA. The peak to peak voltage is measured to be 16V. If the frequency is 10Hz, find the capacitance of the capacitor. (3)

d) With the aid of a diagram, describe how a repulsion type of meter works. (5)

e) Distinguish between self induction and mutual induction (2)

f) Explain why a spark is observed when a switch is opened. (2)

ELECTRICITY

21. (i) Define the terms resistivity and temperature coefficient of resistance (2marks)

(ii) explain why temperature coefficient for metals is positive and negative for semi-conductors (4marks)

b) A piece of aluminum of length 1.0 m and diameter 1.00mm, at a temperature of 20°C is placed in the left hand gap of a metre bridge. The slide contact is at 40 cm from the left hand side of the metre bridge. If the temperature of aluminum is raised to 70°C , how may the balance be restored by

(i) adjusting the slide contact (4marks)

(ii) by keeping the contact at 40 cm from left hand side. (4marks)

(resistivity of aluminum wire $= 7.85 \times 10^{-6} \Omega\text{m}$, temperature coefficient of resistance $= 4 \times 10^{-3} \text{K}^{-1}$)

c) Describe an experiment to show the variation of resistance with temperature. (6marks)

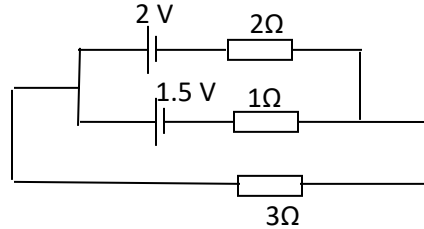
22. a) Define emf and internal resistance of the cell. (2 marks)

b) Explain the effect in current when cells are connected in series and parallel.(3marks)

c) An accumulator of emf **3.0 V** and of negligible internal resistance is joined in series with a resistance of **6 Ω** and unknown resistance **R**. The readings of a voltmeter successively across the **500 Ω** resistance and **R** are $\frac{3}{5}$ V and $\frac{6}{5}$ V respectively. Calculate the value of **R** and the resistance of the voltmeter. (6marks)

d) Describe the connections and values of resistors used in the construction of the voltmeter and ammeter. (4marks)

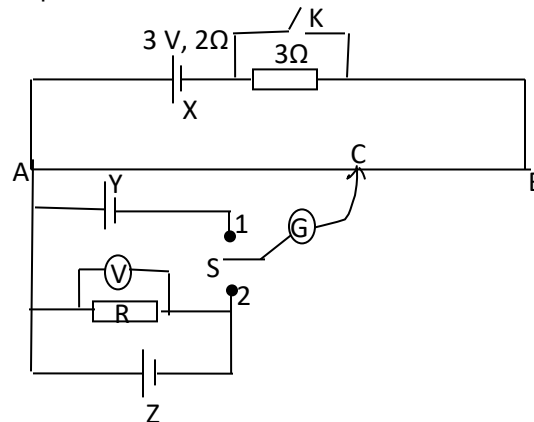
e) In the circuit shown find the power developed in the **3 Ω** resistor (6marks)



23. a) Explain the principle of operation of a potentiometer (4marks)

b) Describe an experimenter to measure internal resistance using a potentiometer (5marks)

c)



In the circuit above, AB is a slide wire of length 1.00m and resistance 10 Ω . The driver cell X has emf 3.0V and internal resistance 2 Ω . Y is a standard cell of emf 1.05 V.

(i) Find the balance length when K is open and S connected to position 1. (2marks)

(ii) When K is closed and S connected to position 2, the voltmeter reading is 1.30V and the balance length is 50 cm from end A. find the percentage error in the voltmeter reading. (3marks)

(iii) When R is replaced with 8 Ω resistor while S is at position 2 and K closed, the balance length is 54.4 cm from end A. Find emf and internal resistance of cell Z. (5marks)

d) State the advantages of using a potentiometer to measure p.d compared to a voltmeter.

24. a) (i) State Ohm's law (1mark)

(ii) Describe an experiment to verify ohm's law (4marks)

b) what meant by a passive resistor and explain why a loudspeaker is not a passive resistor. (3mark)

c) Explain why loading resistors on dynamo or battery should have a high resistance. (2marks)

d) show that for a battery of emf E and internal resistance r when connected to a variable resistor R , the maximum power delivered to R occurs when $R = r$ (4marks)

e) An electric heating coil is connected in series with a resistance of $X\Omega$ across the 240 V mains, the coil being immersed in a 1 kg of water at 20°C . The temperature of water rises to boiling point in 10 minutes. When a second heating experiment is made with the resistance X short – circuited, the time required to develop the same quantity of heat is reduced to 6 minutes. Calculate the value of X . (6marks)

25. . (a) (i) Define the capacitance of a conductor. (1mk)

(ii) Explain the energy changes that take place in a Van de Graaff generator. (3mks)

(b) A light metal disc of area A is suspended by a spring so that its plane is horizontal. The disc is placed immediately above a similar disc which is earthed and the distance between them is d m. the suspended disc is connected to a potential V and this causes the separation d to decrease by x .

(i) Show that $V^2 = \frac{2kx(d-x)^2}{A\epsilon_0}$ where k is the force per unit extension of the spring. (4mks)

(ii) Explain why the separation decreases. (3mks)

(c) Two capacitors each of capacitance $10\mu\text{F}$ are connected in parallel across a source of 100V supply.

(i) Calculate the energy stored in the capacitors (4mks)

(ii) Calculate the energy transferred by the source of e.m.f (2mks)

(iii) Account for the energy difference in (i) and (ii) above (2mks)

26.(a)(i) State coulomb law of electrostatics. (1mk)

(ii) Explain how a body gets charged by rubbing (3mks)

(b)With a suitable diagram explain electrostatics shielding (3mks)

(c) Given a charged pear shaped conductor, describe an experiment to show that;

(i) There is high concentration of charge at sharp point (3mks)

(ii) The surface of the conductor is equipotential surface (2mks)

(d) Two point charges repel each other with a force of $2.0 \times 10^{-4}\text{N}$. When the charges are moved 6 mm further apart, the repulsive force reduces to $8 \times 10^{-6}\text{N}$.

(i) how far apart were the charges were originally? (5marks)

(ii) If the two charges were identical, find the magnitude of each of the charges. (2 marks)

(iii) explain how the presence of a neutral conductor near a positively charged sphere may reduce its potential (3marks)

27. (a)(i) Define *electric potential energy* of a charge. (1)

(ii) Derive an expression for the electric potential energy of two point charges of Q_1 and Q_2 a distance x apart, in air. (4)

(b)



Three charges of $-5 \times 10^{-9}\text{C}$, $+7 \times 10^{-9}\text{C}$ and $+6 \times 10^{-9}\text{C}$ are placed at the vertices A, B and D respectively of a rectangle, in air. The rectangle is of sides $3\text{cm} \times 5\text{cm}$ as in the figure above. Calculate the electric field intensity at C. (7)

(c)(i) What is an equi-potential surface? (1)

(ii) Show that the electric field intensity is always perpendicular to the equi-potential surface. (2)

(d) Describe an experiment to show that charge resides only on the outside surface of a charged hollow conductor. (5)

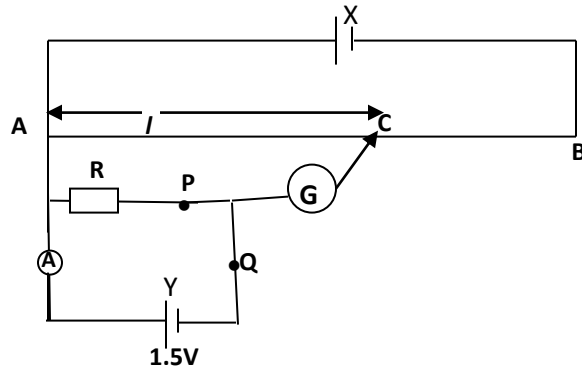
28. a) Distinguish between the terms temperature coefficient of resistance and resistivity of a material [2]

b) Explain the factors affecting resistance of a material of a metal wire [6]

c) Describe an experiment to determine the temperature coefficient of resistance of a metal wire.

[6]

d) A potentiometer is connected to a resistor, R , an ammeter, A , and a source Y of emf 1.5 V and internal resistance, r , as shown in the diagram below. The potentiometer wire has resistance of $5\ \Omega$ and cell X has negligible internal resistance and an emf of 2 V .



When a resistor of resistance R_s is connected at P , the balance length l is 70 cm and the ammeter reads 0.266 A . When R_s is now connected at Q , the balance length l changes to 60 cm . Find the values of r , R , and R_s . [6]

29. (a) Derive an expression for the current density in a metal having n free electrons per m^3 drifting with a velocity v under an application of a p.d. (4).

(b)(i) State ohm's law (1)

(ii) Define internal resistance of a cell (1)

(iii) Sketch a graph of current against p.d. for a tungsten filament bulb and explain its features (3)

(c) Derive the formula for the effective resistance of three resistors in parallel.(4)

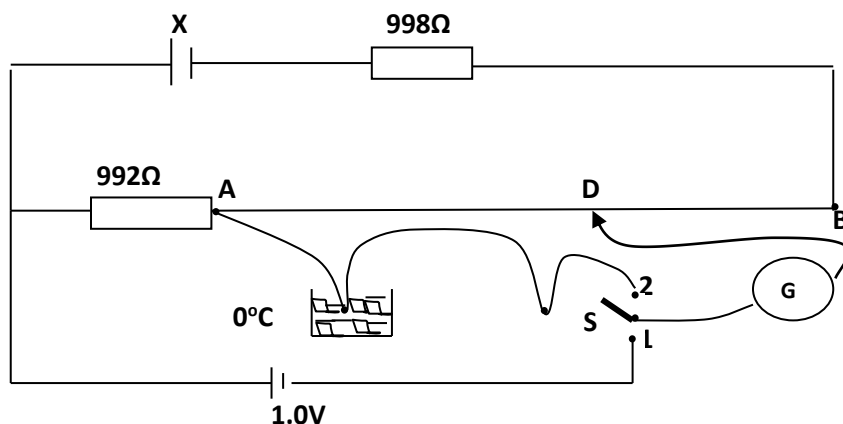
(d) In the circuit below, X is an accumulator of negligible internal resistance; AB is a uniform wire of length 1.0 m , diameter $3.57 \times 10^{-4}\text{ m}$, and electrical resistivity $1.0 \times 10^{-6}\ \Omega\text{ m}$, G is a galvanometer connected to a

contact, S is D. When switch S is thrown into position 1, G shows no deflection when AD= 80.0cm. When switch S is thrown into position 2, G shows no deflection when AD=40.0cm. Find,

(i) the resistance of AB. (3)

(ii) the emf of the thermocouple. (2).

(iii) the emf of cell, X. (2)



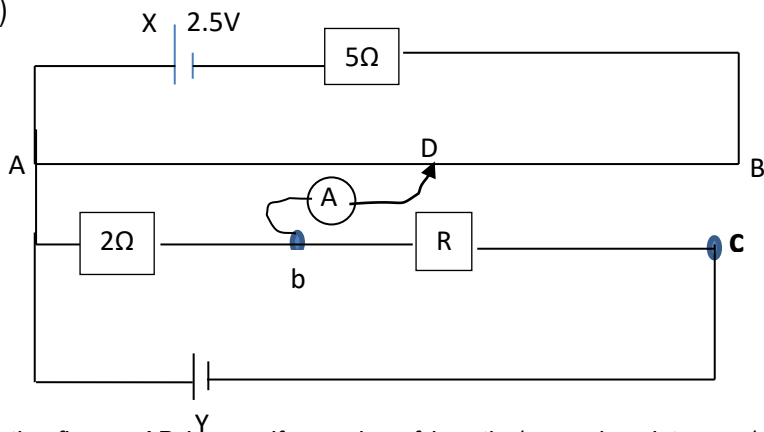
30.(a) (i) Define the terms electromotive force and internal resistance of a cell [02]

(ii) Explain why the terminal p.d is usually less than the e.m.f of a cell. [02]

(b) (i) Briefly describe how a slide wire potentiometer works [03]

(ii) explain one advantage of using a potentiometer over a moving coil galvanometer [02]

(c)



In the figure, AB is a uniform wire of length 1m and resistance 10Ω. X is a driver cell of emf 2.5V and negligible internal resistance. When the galvanometer G is connected in turn to points b and c, the balance lengths are 0.640m and 0.900m respectively. Calculate the

(i) Current flowing through the resistor R [03]

(ii) Emf of cell Y given that the cell has negligible internal resistance [03]

(d) (i) Define temperature coefficient of resistance [01]

(ii) Give one example of a material with negative temperature coefficient [01]

(iii) The resistance of a coil at 30°C is 48.4Ω . When connected to a 220V supply, a steady temperature is soon attained with a current of 3.91 A flowing through it. Calculate the value of the steady temperature if the coefficient of resistance of the material of the coil is $2.1 \times 10^{-4}\text{K}^{-1}$ [03]

31. (a) (i) Define electrostatic potential at a point. [01]

(ii) Derive an expression for the electric potential at a point a distance r from a charge Q coulombs [04]

(iii) Two identical spheres P and R separated by 1m are charged with $12\mu\text{C}$ and $9\mu\text{C}$ respectively. A third identical uncharged sphere C is first touched with P and then with R afterwards, and moved away. What is the electrostatic force between P and R? [05]

(b) With the aid of a labeled diagram describe the assembly of a van-der Graaff generator and explain its mode of action [05]

(c) What is meant by action at points? [03]

(d) Give two characteristics of equi-potential surfaces [02]

32.(a) Define capacitance of an isolated conductor [01]

(b) Describe an experiment to investigate how a capacitance of a capacitor varies with area of overlap of a parallel plate capacitor. [04]

(c) (i) explain why the capacitance of a capacitor changes when a dielectric material is placed between its plates [05]

(ii) Explain what would happen if a conductor instead of a dielectric material was placed between the plates of a capacitor [02]

(d) Derive an expression for capacitance C of a parallel plate capacitor in terms of the area, A , separation of plates, d , and permittivity of free space, ϵ_0 [03]

(e) A potential difference of 600V is established between the top cap and the case of a calibrated electroscope by means of a battery which is then removed, leaving the electroscope isolated. When a

parallel plate capacitor with air dielectric is connected across the electroscope, the potential difference is found to drop to 400V. If the capacitance of the parallel plate capacitor is 10pF, calculate

(i) the capacitance of the electroscope. [02]

(ii) the change in electrical energy which results from sharing of the charge [03]

33. (a) (i) define the term relative permittivity of an insulator. [01]

(ii) Describe with a diagram, how to determine the relative permittivity of an insulator. [04]

(iii) Describe what happens to the p.d across a charged capacitor when an insulator is placed between its plates. [03]

(b) (i) define a farad [01]

(ii) Show that capacitance of a parallel plate capacitor is

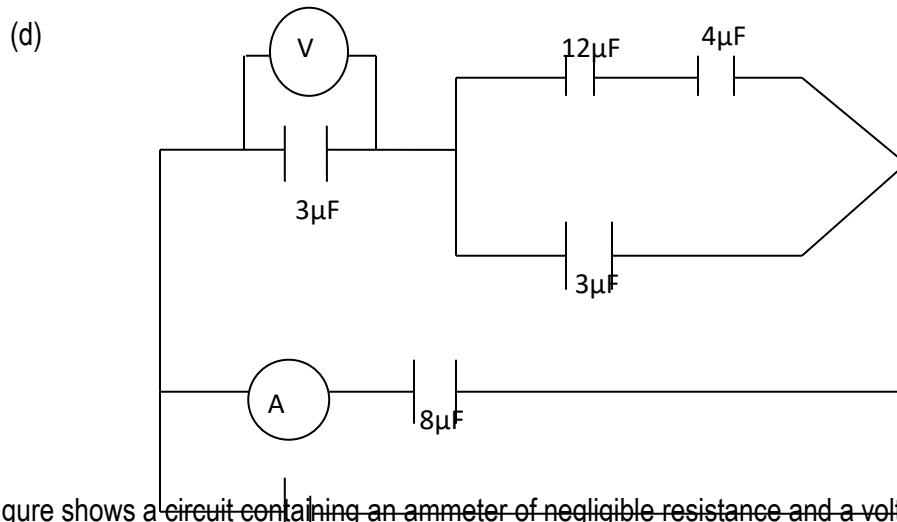
$$C = \frac{\epsilon_0 A}{d}$$

Where ϵ_0 is permittivity of free space

A is area of each plate

d is separation of the plate.

(c) Obtain an expression for the energy stored in a charged parallel plate capacitor.



The figure shows a circuit containing an ammeter of negligible resistance and a voltmeter.

(i) Explain what is observed on an ammeter [01]

(ii) Find the voltmeter reading [03]

END

Where necessary, use the following constants:

$$\text{Permittivity of free space, } \epsilon_0 = 8.85 \times 10^{-12} \text{ Fm}^{-1}$$

$$\text{The constant } \frac{1}{4\pi\epsilon_0} = 9.0 \times 10^9 \text{ F}^{-1}\text{m}$$

1. (a) (i) State the laws of refraction of light. (2 marks)

(ii) With the aid of ray a diagram, explain why a pond appears to be shallow when viewed directly from above. (3 marks)

(b) Draw a well-labelled diagram of the telescope part of the spectrometer and describe how it can be adjusted. (4 marks)

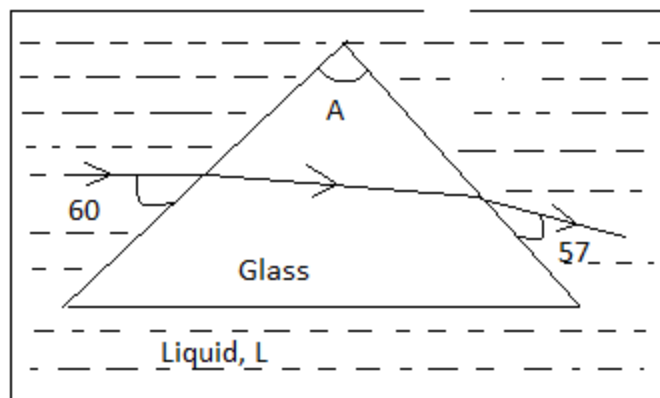


Fig.1

In Fig. 1, a ray of light passing through a liquid of refractive index $\frac{4}{3}$ is incident on a prism of refractive index $\frac{3}{2}$. Find the refracting angle, A, of the prism. (4 marks)

(d) Describe an application of a convex mirror. (2 marks)

(e) A window of area 1.44m^2 is 100cm in front of a curved mirror. If an image of area 36cm^2 forms on a screen in front of the mirror, find the:

(i) Magnification of the image. (2 marks)

(ii) Focal length of the mirror. (3 marks)

2. (a) Define principal focus of a diverging lens. (1 mark)

(b) Explain the effect of a convex lens on a parallel beam of light. (3marks)

(c) (i) Draw a ray diagram to show how a bi-convex lens forms an image of an object placed perpendicular to its principle axis and between the focal plane and the pole. (2 marks)

(ii) Describe how the set-up in 2 (b) (i) above can be used. (2 marks)

(d) A lens is fixed in a tube opened at both ends. Describe an experiment to measure the focal length of the lens. (6 marks)

(e) A plano-concave glass lens of refractive index $3/2$ and surface radius 12 cm filled with a liquid, L, is placed on a plane mirror facing up as shown in figure 2. A horizontal pin, viewed from above the combination coincides with its image at 72cm from the mirror.



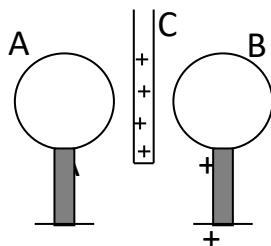
Fig. 2

Find the refractive index of liquid L.

(6 marks)

3. (a) Explain how objects get charged by rubbing. (3 marks)

(b) The diagram shows two metallic spheres A and B placed apart and each supported on an insulating stand. A positively charged plate C is placed mid-way between them but without touching them.



B is momentarily earthed in the presence of C. Finally C is withdrawn.

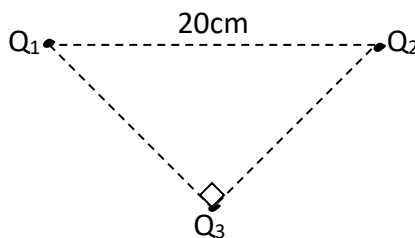
(i) Draw the spheres at the end of the operation and show the charge distribution over them. (2 marks)

(ii) On the same diagram sketch the electric field pattern in the region of the spheres. (2 marks)

(iii) Explain the change in p.d between the spheres as the spheres are moved further apart. (2 marks)

(c) (i) Describe an experiment to investigate the distribution of charge over a conductor. (5 marks)

(d) In the figure below $Q_1 = -2\mu\text{C}$, $Q_2 = +2\mu\text{C}$ and $Q_3 = +3\mu\text{C}$



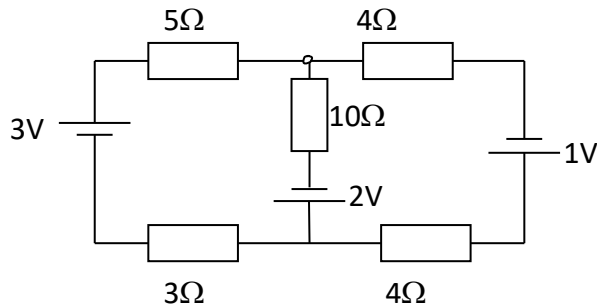
Find the resultant electric field intensity at point P, midway between Q_1 and Q_2 , due to the charges. (6 marks)

4. (a) (i) State Kirchhoff's circuit laws.

(2 marks)

(ii) In the circuit shown below find the current through the $10\ \Omega$ resistor.

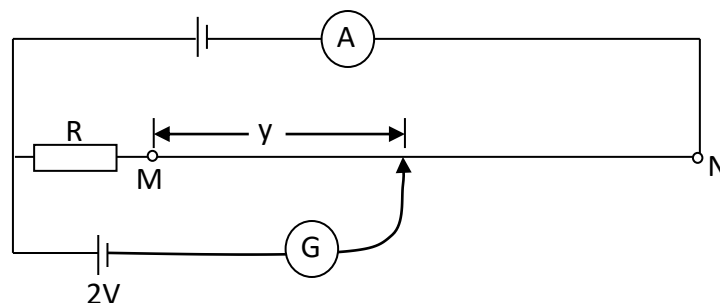
(4 marks)



(b) (i) Explain the principle of a slide wire potentiometer. (4 marks)

(ii) State one advantage of using a potentiometer over a moving-coil voltmeter. (1 mark)

(c) In a potentiometer experiment the following circuit was set up.



The ammeter, A, reads 0.1 A and the balance length, y , found for the 2V cell is 30 cm. MN is a uniform wire of length 100 cm.

When the 2V cell is replaced with another cell, X, the balance length becomes 50 cm and when the two cells are connected in series the combination gives a balance length of 90 cm.

Determine the

(i) resistance per cm of MN. (5 marks)

(ii) value of resistance R (2 marks)

(iii) emf of cell X. (2 marks)

5. (a) (i) Define **capacitance**. (1 mark)

(ii) Distinguish between **dielectric constant** and **dielectric strength** of a substance (2 marks)

(iii) Describe an experiment to determine the dielectric constant of a substance by the vibrating-reed switch method. (6 marks)

(b) Derive an expression for the energy stored in a capacitor. (6 marks)

(c) The following operations were carried out on two parallel-plate capacitors A and B, each of capacitance $6\mu\text{F}$, having air as the dielectric.

I: Each was separately charged to a p.d of 120 V and then isolated

II: A substance of dielectric constant 3 was inserted in between the plates of B to completely fill the space.

III: The capacitors were finally connected in parallel, similar charged plates being connected together.

Find the final p.d across the combination. (5 marks)

INSTRUCTIONS TO CANDIDATES

Attempt **FIVE** questions only

Assume where necessary:

$$\text{Acceleration due to gravity, } g = 9.81 \text{ ms}^{-2}$$

$$\text{Speed of light in vacuum, } c = 3.0 \times 10^8 \text{ ms}^{-1}$$

$$\text{Electron charge, } e = 1.6 \times 10^{-19} \text{ C}$$

$$\text{Electron mass, } m_e = 9.11 \times 10^{-31} \text{ kg}$$

$$\text{Permeability of free space, } \mu_0 = 4.0 \pi \times 10^{-7} \text{ Hm}^{-1}$$

$$\text{Permittivity of free space, } \epsilon_0 = 8.85 \times 10^{-12} \text{ Fm}^{-1}$$

$$\text{The constant } \frac{1}{4\pi\epsilon_0} = 9.0 \times 10^9 \text{ F}^{-1}$$

1. (a) What is meant by

(i) **principal focus** of a concave lens. (1)

(ii) **conjugate points** with respect to a lens. (1)

(b) Two thin lenses of respective focal lengths f_1 and f_2 are arranged coaxially in contact. Derive an expression for the focal length of the combination. (5)

(c) Describe an experiment to determine the focal length of a concave lens using a convex lens. (6)

(d) (i) Write down an expression relating the focal length of a lens to the refractive index of its material and the radii of curvature of its surfaces. (1)

(ii) In an experiment to determine the refractive index of a liquid L, a little of liquid L was poured on a horizontal plane mirror facing up and a lens was placed on top. A pin viewed from above coincided with its own image at a height of 27.5 cm above the mirror.

When the procedure was repeated after replacing L with water of refractive index 1.34 the pin's coincided with its image occurred at a height of 24.6 cm. Finally, when only the lens was on the mirror, coincidence occurred at a height of 17.0 cm.

Find the refractive index of liquid L. (6)

2. (a) (i) What is meant by **refractive index** of a medium? (1)

(ii) Show that when the bottom of a pond is observed from above, the refractive index, n , of the liquid in the pond is given by (5)

$$n = \frac{\text{real depth}}{\text{apparent depth}}$$

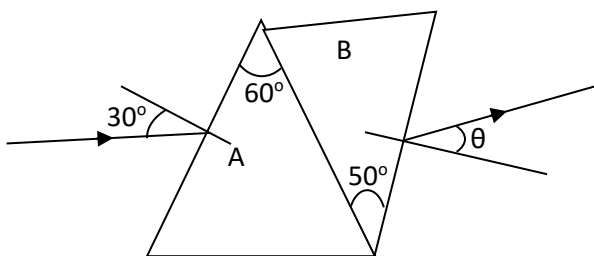
(iii) Describe an experiment that employs the principle in (ii) to determine the refractive index of the material of a glass block. (4)

(b) (i) Sketch a ray diagram to illustrate the deviation of a ray by a prism. (1)

(ii) Sketch a graph to show how the deviation varies with the angle of incidence. (1)

(iii) If a graph in (ii) is obtained for a prism of refracting angle θ , describe how it can be used to determine the refractive index of the material of the prism. (2)

(c) In the figure below a ray of light from air enters prism A, of refracting angle 60° , at an angle of incidence of 30° . The ray emerges into an adjoining prism, B, of refracting angle 50° . It finally emerges out of B at an angle θ , as shown.



Given that the refractive index of the material of A is 1.51 and that of B is 1.62, determine the emergent angle θ . (6)

3. (a) (i) State the principle employed in the optical lever mirror galvanometer so as to achieve the purpose. (1)

(ii) With the aid of a diagram describe how the instrument in (i) above works
(5)

(b) Sketch a ray diagram to show how a concave mirror forms a real

(i) diminished image of a real object (1)

(ii) magnified image of a real object (1)

(c) By referring to a convex spherical mirror, derive the mirror formula. (5)

(d) A concave mirror forms, on a screen, a real image half the linear dimensions of the object. The object and the screen are then shifted until the image is three times the size of the object. If the shift of the object is 25 cm, determine

(i) the focal length of the mirror (5)

(ii) the shift of the screen (2)

4. (a) What is meant by the terms

(i) **current sensitivity** of a galvanometer (1)

(ii) **magnetic moment** of a coil? (1)

(b) Account for the force on a current-carrying conductor perpendicular to a magnetic field. (3)

(c) (i) Show that the torque on a coil carrying a current, I in a uniform magnetic field of flux density, B , is independent of the shape but dependent on its area, A , number of turns, N and angle α between the normal to the plane of the coil and B . (4)(ii) Sketch a graph showing the variation of the torque with the

angle α . (1)

(d) With the aid of a labelled diagram, describe an experiment to investigate the type of majority charge carriers in a semi-conductor using the Hall effect. (4)

(e) A current of 8.0A is passed along the length of a 2mm x 2mm square cross-sectional wire placed perpendicular to a uniform magnetic field of flux density 1.6×10^{-2} T. Calculate:

(i) the force on each electron. (3)

(ii) the hall voltage between opposite faces (3)

(Take the number of electrons per unit volume of the wire = $1.0 \times 10^{22} \text{ m}^{-3}$)

5. (a) Explain the following

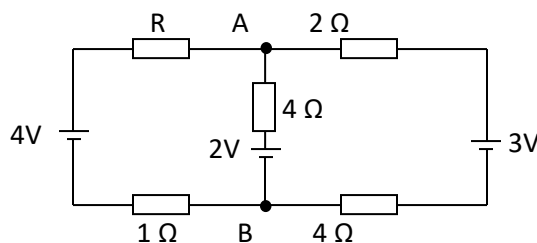
(i) The terminal potential difference in a circuit decreases when the current increases. (3)

(ii) The heating effect of a current is independent of the direction of current. (2)

(b) (i) Derive an expression for the balance conditions of a Wheatstone bridge. (4)

(ii) Describe an experiment to determine the resistivity of the material of a wire. (6)

(c) In the circuit shown below, the p.d between points A and B is 2.8 V



Determine the value of the resistance R. (5)

6. (a) (i) What is meant by the **dielectric strength** of a substance? (1)

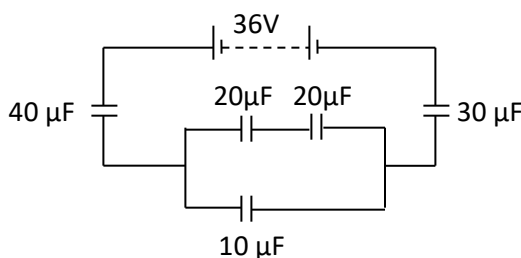
(ii) Using the same axes sketch graphs to show how p.d across a capacitor and charging current vary with time. (2)

(iii) An insulated metal slice is inserted in the space between the plates of an isolated charged capacitor. Explain what happens to the potential difference between the plates. (2)

(b) Describe an experiment, using a vibrating-reed switch arrangement, to compare capacitances of two capacitors. (5)

(c) Derive an expression for the energy stored in a capacitor of capacitance C charged to potential difference V . (5)

(d) In the figure below calculate the energy stored in the $30\mu\text{F}$ capacitor. (5)



7. (a) (i) What is meant by **electrostatic induction**? (1)

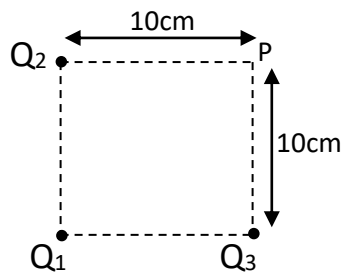
(ii) State two advantages of charging by induction over charging by contact. (2)

(b) Explain why the leaf divergence of a charged gold-leaf electroscope gradually decreases as a neutral conductor approaches the cap of the electroscope. (4)

(c) (i) State Coulomb's law of electrostatics (1)

(ii) Derive an expression for the electric potential at a point, z metres from a point charge, Q , in a medium of permittivity ϵ . (5)

(d) In the figure below, Q_1 , Q_2 and Q_3 are point charges lying on a straight line AB, where $Q_1 = +4.0\mu\text{C}$ and $Q_2 = -3.0\mu\text{C}$ and $Q_3 = +3.0\mu\text{C}$.



Find: (i) the electric force acting on Q_1 (4)

(ii) the work done in moving a charge of $2\mu\text{C}$ from infinity to the centre of square. (3)

INSTRUCTIONS TO CANDIDATES

Attempt **FIVE** questions only

Assume where necessary:

$$\text{Acceleration due to gravity, } g = 9.81 \text{ ms}^{-2}$$

$$\text{Speed of light in vacuum, } c = 3.0 \times 10^8 \text{ ms}^{-1}$$

$$\text{Electron charge, } e = 1.6 \times 10^{-19} \text{ C}$$

$$\text{Electron mass, } m_e = 9.11 \times 10^{-31} \text{ kg}$$

$$\text{Permeability of free space, } \mu_0 = 4.0 \pi \times 10^{-7} \text{ Hm}^{-1}$$

$$\text{Permittivity of free space, } \epsilon_0 = 8.85 \times 10^{-12} \text{ Fm}^{-1}$$

$$\text{The constant } \frac{1}{4\pi\epsilon_0} = 9.0 \times 10^9 \text{ F}^{-1}$$

1. (a) (i) Distinguish between **angle of incidence** and **glancing angle** for a ray that is incident on a surface. (2)

(ii) A ray is incident on a plane mirror. The ray is kept fixed in direction while the mirror is rotated through an angle α . Derive the relationship between the rotation of the reflected ray and the angle α . (3)

(iii) Explain the action of a device that applies the principle in (a)(ii) above. (5)

(b) Opio, whose height is 172 cm, plans to fix a plane mirror on a vertical wall in his room so that he sees the image of the whole of himself.

If his eyes are 12 cm below the highest point of his head, find

(i) how high above the floor the lowest edge of the mirror should be. (3)

(ii) the minimum height of the mirror. (2)

(c) You are provided with a small plane mirror, a metre rule, an optical pin and a convex mirror. Describe an experiment to determine the focal length of the convex mirror using the given apparatus. (5)

2. (a) (i) State the conditions for total internal reflection. (2)

(ii) Draw a labeled diagram of a named device to show (without description) an application of total internal reflection. (2)

(b) Explain how a fish in a pond is able to enjoy a 180° field of view. (3)

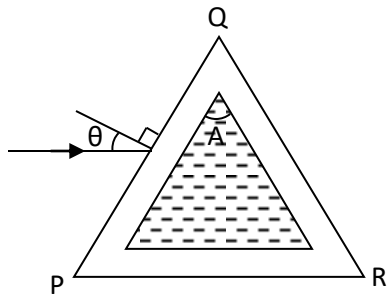
(c) Show that when a ray of light passes through different media separated by plane boundaries

$$n \sin i = \text{constant}$$

where n is the absolute refractive index of a medium and i is the angle made by the ray with the normal in the medium. (4)

(d) Describe an experiment to measure the refractive index of glass of rectangular shape by the apparent depth method. (4)

(e) The figure below shows a liquid of refractive index 1.33 enclosed by glass of uniform thickness.



A ray of light, incident on face PQ at an angle of incidence, θ , emerges through face QR. As the angle θ is reduced, suddenly the emergent ray disappears when $\theta = 16^\circ$.

Find the angle A. (5)

3. (a) What is meant by

(i) focal length of a diverging lens. (1)

(ii) conjugate points for a lens. (1)

(b) Draw a ray diagram to show how a converging lens forms a real image of a virtual object. (2)

(c) Two lenses of respective focal lengths f_1 and f_2 are placed coaxially in contact.

Derive an expression for the focal length of the combination. (5)

(d) Describe an experiment to determine the refractive index of a liquid using a plane mirror and a converging lens. (5)

(e) A lens L_1 forms a real image, at A, of a distant object.



When another lens, L_2 , is placed between L_1 and point A, at a distance of 10 cm from L_1 , the image shifts by 4 cm towards L_1 . When L_2 is placed 5 cm from L_1 , the image shifts further by 3.5 cm towards L_1 . Find the focal length of each lens. (6)

4. (a) (i) What is meant by **electrostatic induction**? (1)

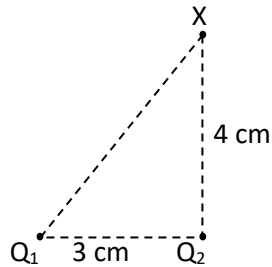
(ii) State the advantages of charging by induction. (2)

(b) Explain why a neutral conductor is attracted by charged body nearby. (3)

(c) Describe an experiment to investigate the charge distribution over a conductor, showing how the conclusion is arrived at. (4)

(d) (i) Derive an expression for the electric potential at a distance d from a point charge Q in a medium of permittivity ϵ . (4)

(e) In the figure below, Q_1 and Q_2 are point charges of $3.0 \mu\text{C}$ and $-2.0 \mu\text{C}$ respectively.



Find

(i) the electric potential energy of Q_2 . (2)

(ii) the magnitude of the electric intensity at point X

(4)

5. (a) (i) Define **capacitance**. (1)

(ii) What is meant by **dielectric strength**? (1)

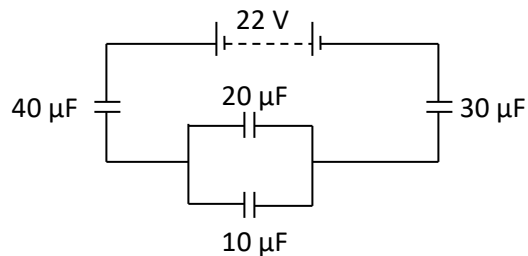
(iii) Explain the action of a dielectric. (4)

(b) Describe an experiment to show the relationship between capacitor charge and potential difference. (5)

(c) Derive an expression for the energy stored in a capacitor of capacitance, C , charged to a voltage V . (5)

(d) In the figure below calculate the energy stored in the system.

(4)

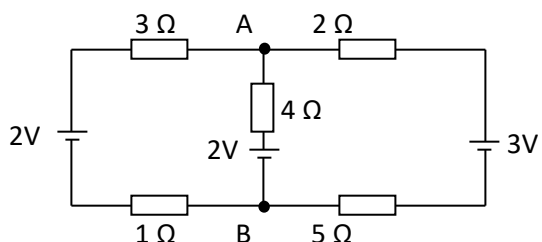


6. (a) (i) What is meant by **potential difference**? (1)

(ii) Define a **volt**. (1)

(b) Explain why the terminal p.d across a source decreases when a bigger current is drawn from the source. (3)

(c)



In the circuit shown above, find

(i) the current flowing in the 4-ohm resistor. (4)

(ii) the p.d between points A and B. (2)

(d) Describe an experiment to measure the internal resistance of a cell. (5)

(e) When a battery of emf 3 V is connected in series with a cell C, the combination gives a balance length of 90.0 cm. When cell C is reversed, the balance length falls to 18.0 cm. What is the emf of cell C? (4)

Assume where necessary:

Acceleration due to gravity, $g = 9.8 \text{ m s}^{-2}$

Speed of light in vacuum, $c = 3.0 \times 10^8 \text{ m s}^{-1}$

Electron charge, $e = 1.6 \times 10^{-19} \text{ C}$

Electron mass $m_e = 9.11 \times 10^{-31} \text{ kg}$

Permeability of free space, $\mu_0 = 4.0\pi \times 10^{-7} \text{ H m}^{-1}$

Permittivity of free space $\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$

1.

$4\pi\epsilon_0$

The constant $\epsilon_0 = 9.0 \times 10^9 \text{ F}^{-1} \text{ m}$

Specific heat capacity of water, $c = 4.2 \times 10^3 \text{ J kg}^{-1} \text{ K}^{-1}$

Avogadro's number, $N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$

SECTION A

1. (a) (i) Write down an expression for the deviation of a ray of light passing through a prism of small angle A whose material is of refractive index n when the angle of incidence is small. (1)

(ii) Find the relation between the focal length f of a lens whose material is of refractive index n and whose surfaces have radii of curvature r_1 and r_2 . (5)

(b) In an experiment to determine the refractive index of paraffin a converging lens was placed on a horizontal plane mirror facing up. A pin viewed from above coincided with its image at a height of 15 cm above the mirror.

When water of refractive index $4/3$ was interposed between the lens and the mirror the

pin coincided with its image at a height of 18.7 cm while when paraffin was used instead of water coincidence occurred 20.0 cm above the mirror.

Find the refractive index of paraffin. (6)

(c) (i) In an arrangement of a lens, what are conjugate points? (1)

(ii) Establish the conditions for the minimum distance between the object and the screen for the formation of a real image by a lens. (3)

(iii) In an experiment a lens produced a sharp image of an object of magnification 3 on a screen. When the lens was shifted, along its axis, by a distance of 30 cm towards the screen, leaving the object and screen fixed, another sharp image was formed on the screen. Find the focal length of the lens. (4)

2. (a) Define refraction.

(1)

(b) (i) With the aid of suitable ray diagrams, explain the terms **critical angle** and **total internal reflection**.

(4)

(ii) Monochromatic light is incident at an angle of 45° on a glass prism of refracting angle 70° in air. The emergent light grazes the other refracting surface of the prism. Find the refractive index of the glass.

(6)

(c) (i) With the aid of a labelled diagram describe the structure and action of prism binoculars.

(4)

(ii) Explain why prisms rather than plane mirrors are used in binoculars. (2)

(iii) In a pair of prism binoculars the optical path from the objective to the eyepiece is 50.0 cm. Find the magnifying power in normal adjustment if the eyepiece has a focal length of 2.5 cm.

(3)

SECTION B

3. (a) (i) Define the terms **frequency** and **amplitude** as applied to waves. (2)

(ii) State the differences between progressive and stationary waves. (2)

(b) The displacement, y , in metres of a wave travelling in the x -direction is given at time, t , by:

$$y = a \sin 2\pi \left(\frac{t}{0.2} - \frac{x}{1.5} \right)$$

Find the speed of the wave.

(4)

(c) Describe with the aid of a diagram how you can determine the velocity of sound in air by a method which uses interference of sound.

(6)

(d) A vertical glass tube, open at the top is filled with water. A tuning fork vibrating at 512 Hz is held above the tube and the water is allowed to flow out slowly. The first resonance occurs when the water level is 15.1 cm from the top while the second resonance occurs when the level is 46.9 cm from the top. Find

(i) the speed of sound in the air column

(4)

(ii) the end correction

(2)

4. (a) State Huygen's principle.

(1)

(b) Monochromatic light propagating in air is incident obliquely onto a plane boundary with a medium of refractive index n

(i) Use Huygen's principle to show that the speed, v , of the light in the medium is given

by
$$v = \frac{c}{n}$$

where c is the speed of light in air

(6)

(ii) If the wavelength of the light is 600 nm in air, what will it be in a medium of refractive index 1.50?

(4)

(c) (i) What is meant by **interference of waves**?

(1)

(ii) State the conditions necessary for interference fringes to be observed. (2)

(iii) Explain the term **path difference** with reference to interference of two wave motions (3)

(d) Two glass slides in contact at one end are separated by a wire of diameter 0.04 mm at the other end to form a wedge. Fringes are observed when light of wavelength 5.0×10^{-7} m is incident normal to the slides. Find the number of fringes which can be observed. (3)

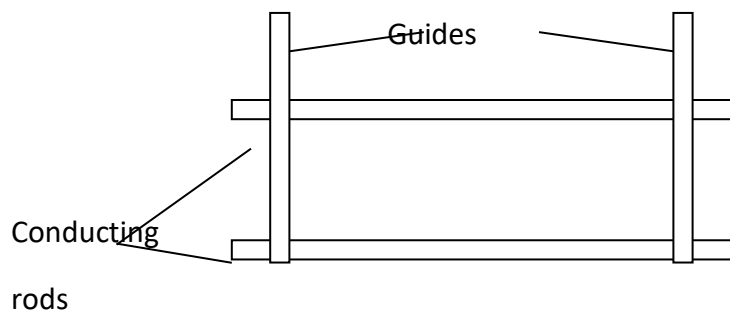
SECTION C

5. (a) (i) Define the AMPERE.

(2)

(ii) Describe the measurement of current using a current balance. Write down all the precautions necessary for accurate results. (8)

(b) The figure below shows two identical straight conductors each 10 cm long and mass 2.0 g arranged in air such that they are horizontal, parallel and one directly above the other. The upper is fixed and the lower is free to move in conducting guides 9.8 cm apart. If the earth's magnetic field is negligible, calculate the approximate current through the guides that will maintain the conductors 4.0 cm apart. (5)



(c) A small magnet suspended so as to rotate freely about a vertical axis is situated at the centre of a long horizontal solenoid of 1000 turns per metre, the axis of which lies at right angles to the magnetic meridian.

Calculate the current required in the solenoid to cause the magnet to deflect through 40° about a vertical axis, given the flux density and angle of inclination at the location of the solenoid are $3.6 \times 10^{-6} \text{ T}$ and 60° respectively. (5)

6. (a) (i) Define **magnetic flux** and give its SI unit. (2)

(ii) State the laws of electromagnetic induction. (2)

(iii) A square coil of side 10 cm has 100 turns. The coil is arranged to rotate at $3000 \text{ rev. min}^{-1}$ about a vertical axis perpendicular to the horizontal uniform magnetic field of flux density 0.8 T. The axis of rotation passes through the mid-points of a pair of opposite sides of the coil. Calculate the emf induced in the coil when the plane of the coil makes an angle of 30° with the field. (4)

(b) (i) With the aid of a labelled diagram, describe how a simple d.c motor works. (4)

(ii) State the power losses in a d.c motor and how they are minimised in practice. (3)

(c) A d.c motor has an armature resistance of 1.0 ohm and is connected to a 240-V supply. The armature current taken by the motor is 20A. Calculate

(i) the emf generated by the armature (2)

(ii) the power supplied to the armature (1)

(iii) the mechanical power developed by the motor (1)

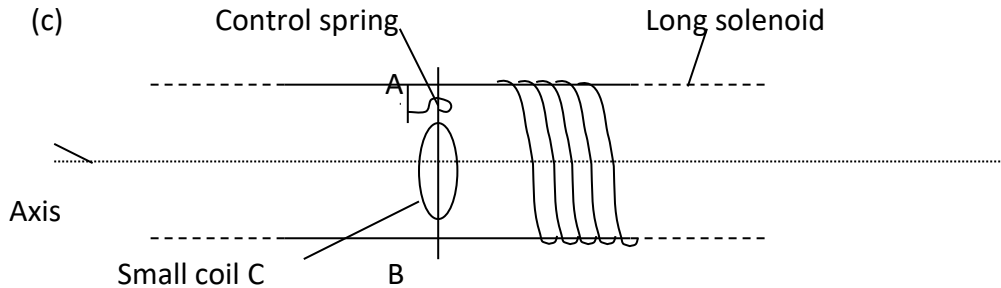
(iv) the efficiency of the motor (1)

7. (a) (i) Explain why a current-carrying conductor placed in a magnetic field experiences a force. (2)

(ii) Write down the expression for the force on a straight wire of length l carrying a current I at an angle θ to the magnetic field of flux density B . (1)

(iii) A rectangular coil of N turns and area A is suspended in a uniform magnetic field of flux density B . Initially the plane of the coil is parallel to the magnetic field. Derive the expression for the initial torque on the coil when a current I flows through the coil. (4)

- (b) (i) Draw a labelled diagram of a moving-coil galvanometer and explain how it works. (6)
- (ii) What factors determine the sensitivity of a moving-coil galvanometer? (2)



A small coil C of 20 turns and mean radius 2.5 cm is mounted at the centre of a long solenoid of 1000 turns per metre. The coil can turn about an axis AB which is perpendicular to the axis of the solenoid and fixed to a control spring. With no current flowing in it, the coil rests with its axis perpendicular to that of the solenoid. When a current of 3.0 A is flowing through the solenoid and 2.0 A in the coil, the coil rests with its plane making an angle of $\frac{1}{4}\pi$ radians to the axis of the solenoid. Find the constant of the control spring. (5)

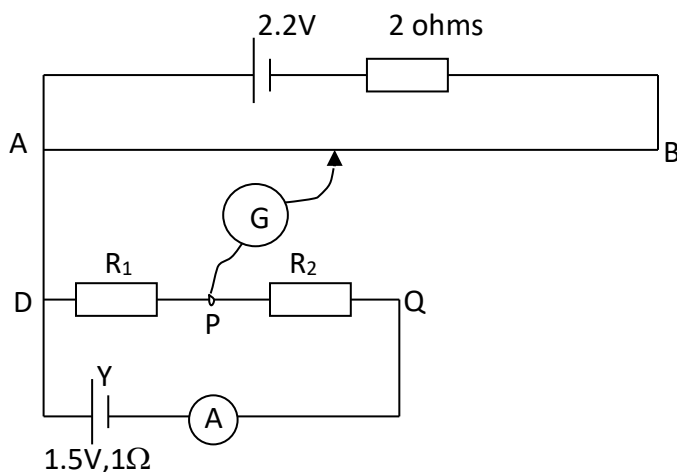
SECTION D

8. (a) (i) Using a diagram, explain the principle of a potentiometer. (3)
- (ii) What is meant by a balance point? (1)
- (b) A potentiometer circuit was connected to compare two resistances. State the likely causes of the following problems:
- (i) No deflection at all on the galvanometer whatever the position of the slider. (2)
- (ii) The galvanometer deflected but no balance point could be found on the potentiometer wire. State all the likely causes of the problem. (3)
- (c) In the circuit below, X is an accumulator of emf 2.2 V and negligible internal resistance, connected in series with a 2-ohm resistance and a uniform wire AB of length 100 cm. A dry cell Y, of emf 1.5 V and internal resistance 1 ohm is connected in series with two resistors R_1 and R_2 .

The balance length along AB from A is 30 cm when the galvanometer G is connected between point P and a point on AB. The balance length becomes 70 cm when G is connected from Q instead of P.

The ammeter A reads 0.1 A. Find

- (i) The current flowing through AB (3)
- (ii) The resistances R_1 and R_2 (4)
- (iii) the resistance per cm of AB (2)
- (iv) Suppose now R_1 is disconnected from end D, what does the balance length become? (2)



9. (a) Explain the following

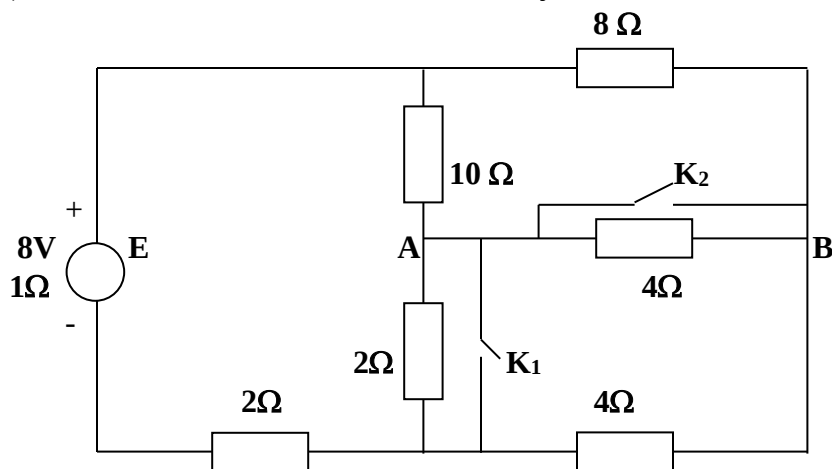
- (i) The temperature of a conductor rises when a current flows through it. (2)
- (ii) The heating effect is independent of the direction of current. (1)

(b) What is meant by the efficiency of a circuit? (1)

(c) A circuit in which the source has emf of 6V and internal resistance 1 ohm is operated at an efficiency of 80%. Calculate

- (i) the load resistance, assumed passive. (3)
- (ii) the power output (3)

(d) In the circuit shown below, E is a battery of emf 8V and internal resistance of 1.0 ohm



(i) With only switch K_1 closed, find the p.d between junctions A and B. (5)

(ii) If only K_2 is now closed what is the p.d across the 10-ohm resistor? (5)

10. (a) Define

(i) Capacitance (1)

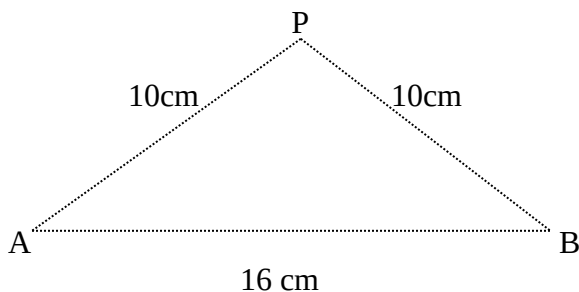
(ii) Dielectric material (1)

(b) (i) Describe an experiment to determine the dielectric constant of an insulator using the vibrating-reed switch set-up. (5)

(ii) A capacitor, formed of two large parallel metal plates held in air, is charged to a p.d of 100 V. When the capacitor is discharged through a ballistic galvanometer, the first throw is 0.5 radians.

A substance of dielectric constant 3 is packed in between the plates to occupy half the overlapping area. If the capacitor is now charged to a p.d of 120 V and discharged through the same ballistic galvanometer, what will be the first throw? (5)

(c)



A and B are point charges of $+2 \mu\text{C}$ and $-1 \mu\text{C}$ separated by a distance of 16 cm as shown. Find

(i) the electric field intensity at point P. (5)

(ii) the magnitude and direction of the force that will act on a point charge of $-0.5 \mu\text{C}$ placed midway between A and B. (3)

E N D

Where necessary, use the following constants:

$$\text{Acceleration due to gravity, } g = 9.81 \text{ m s}^{-2}$$

$$\text{Permeability of free space, } \mu_0 = 4\pi \times 10^{-7} \text{ H m}^{-1}$$

$$\text{Permittivity of free space, } \epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$$

$$\text{Speed of light in a vacuum, } c = 3.0 \times 10^8 \text{ m s}^{-1}$$

$$\text{Electronic charge, } e = 1.6 \times 10^{-19} \text{ C}$$

$$\text{The constant } \frac{1}{4\pi\epsilon_0} = 9.0 \times 10^9 \text{ F}^{-1}\text{m}$$

1. (a) For a converging mirror define the terms

(i) radius of curvature (1)

(ii) principal focus (1)

(b) With the aid of a ray diagram derive the mirror formula for a convex mirror.
(6)

(c) (i) With the aid of a ray diagram, describe the structure and action of a reflecting telescope in normal adjustment. (5)

(ii) State two advantages of a reflecting telescope over a refracting one.
(2)

(d) An astronomical telescope with an objective of focal length 84.0 cm and an eyepiece of focal length 8.0 cm. The eyepiece is shifted until the final image is formed at a distance of 64.0 cm from the objective.

Find the distance between the two lenses. (5)

2. (a) (i) Distinguish between **free** and **damped** oscillations. (2)

(ii) What is a **wave**? (1)

(b) A mechanical wave in a certain medium is represented by the equation

$$y = 0.3\sin 2\pi(35t - 0.4x)$$

where all distances are in metres.

(i) State what each of the symbols x and y represents. (2)

(ii) Find the velocity of the wave (3)

(c) (i) What is meant by **resonance** in waves? (1)

(ii) Describe an experiment to determine the velocity of sound in air using the resonance method. (6)

(d) (i) What is a **harmonic** in sound. (1)

(ii) A string of length 0.50 m and mass 5.0 g is stretched between two fixed points. If the tension in the string is 100 N, find the frequency of the second harmonic.

$$(\text{Velocity of sound along the string} = \sqrt{\left(\frac{\text{Tension}}{\text{Mass per unit length}}\right)}) \quad (4)$$

3. (a) What is meant by the terms:

(i) Magnetic meridian (1)

(ii) Magnetic declination (1)

(b) Explain what happens to the angle of dip as one moves along the same longitude from the Equator to the North pole. (2)

(c) (i) Write down an expression for the magnetic flux density at the centre of a narrow circular coil of radius r having N turns when a current I is flowing in it. (1)

(ii) Describe an experiment to determine horizontal component of the Earth's magnetic flux density at a certain location. (5)

(d) A circular coil of 4 turns and diameter 14.0 cm carries a current of 0.35A. It is placed at the equator with its plane along the magnetic meridian. Calculate the

direction and magnitude of the resultant magnetic flux density at the position if the earth's magnetic flux density at the location is $1.8 \times 10^{-5} \text{ T}$. (4)

(e) (i) What is meant by the term **magnetic moment** of a coil? (1)

(ii) Explain why a moving coil galvanometer must have the following:

A radial magnetic field,

Fine hair springs,

Large number of turns

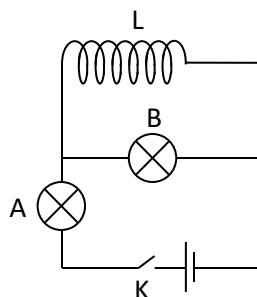
A conducting former. (5)

4. (a) What is meant by

(i) self induction (1)

(ii) eddy current (1)

(b) The diagram shows an iron-cored coil, L, of many turns and negligible resistance with identical bulbs, A and B, connected in a circuit.



(i) When switch K is closed, at first both bulbs A and B light up, but soon B dims out while A becomes brighter. Explain these observations. (3)

(ii) If now K is opened, state and explain what is observed. (3)

(c) (i) Explain the origin of the back emf in a motor. (2)

(ii) A motor, whose armature resistance is 2Ω , is operated on 240V mains supply. If it runs at $3000 \text{ rev min}^{-1}$ when drawing a current of 5 A, at what speed will it run when drawing a current of 15 A? (3)

(d) (i) With the aid of a labeled diagram, describe the mode of action of a simple d.c generator. (5)

(ii) Sketch the output against time of a simple d.c generator. (1)

(iii) State two factors that determine the polarity of the output of a d.c generator. (1)

5. (a) For a source of electricity, what is meant by

(i) electromotive force (1)

(ii) internal resistance? (1)

(b) (i) State the factors which determine the resistance of a wire of a given material. (2)

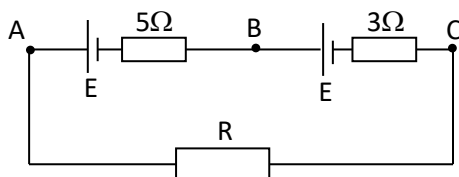
(ii) Explain why the resistance of a metal increases when the temperature of the metal is increased. (2)

(iii) Derive an expression for the equivalent resistance of three resistances, R_1 , R_2 and R_3 connected in series. (3)

(c) You are provided with about 1 m of a bare constantan wire, an ammeter, a voltmeter, crocodile clips and some connecting wires.

Describe an experiment you would perform, using all but only the items provided, to determine the internal resistance of a cell. Give a diagram of your setup. (5)

(d) In the circuit shown below, each source has an emf of 2V and negligible internal resistance.



When a voltmeter is connected between A and B, it reads 0V.

Find

(i) the value of the resistance R . (4)

(ii) the reading of the voltmeter when connected between B and C. (2)

INSTRUCTIONS TO CANDIDATES

Answer **FIVE** questions, including **ONE** from each of sections **A&B** and at least **ONE** but not more than **TWO** from each of the sections **C** and **D**.

Assume where necessary:

Acceleration due to gravity, g	=	9.81 ms^{-2}
Speed of light in vacuum, c	=	$3.0 \times 10^8 \text{ ms}^{-1}$
Electron charge, e	=	$1.6 \times 10^{-19} \text{ C}$
Electron mass, m_e	=	$9.11 \times 10^{-31} \text{ kg}$
Permeability of free space, μ_0	=	$4\pi \times 10^{-7} \text{ Hm}^{-1}$
Permittivity of free space, ϵ_0	=	$8.85 \times 10^{-12} \text{ Fm}^{-1}$
The constant $\frac{1}{4\pi\epsilon_0}$	=	$9.0 \times 10^9 \text{ F}^{-1}$
One electron-volt (eV)	=	$1.6 \times 10^{-19} \text{ J}$
Avogadro's number, N_A	=	$6.02 \times 10^{23} \text{ mol}^{-1}$

SECTION A

1. (a) (i) Explain the difference between the terms **magnifying power** and **magnification** as applied to optical instruments. (3)

(ii) State what is meant by **normal adjustment** in the case of an astronomical telescope. (1)

(iii) With the aid of a ray diagram, explain how the two lenses of a telescope form, at infinity, a magnified virtual image of a real distant object. (4)

(b) A telescope has an objective of focal length 80cm and an eyepiece of focal length 2.0cm. It is focused on the moon, whose diameter subtends an angle of 8.0×10^{-3} rad at the objective. The eyepiece is adjusted so as to project a sharp image of the moon onto a screen placed 20cm from the eyepiece lens. Calculate:

(i) the diameter of the intermediate image formed by the objective lens.

(3)

(ii) the diameter of the image on the screen.

(3)

(iii) the separation of the lenses.

(2)

(c) Explain, with the aid of a diagram, the formation of the **eye-ring** in a telescope and state why it is the best position for the eye of the observer. (4)

2. (a) (i) What is meant by **refraction of light**?

(1)

(ii) Explain why a pond of clear water appears shallower, than it actually is, to an observer.

(3)

(iii) Describe an experiment to determine the refractive index of a liquid using the air-cell method.

(6)

(b) A lens forms a sharp image of height h_1 on a fixed screen. As the lens is moved towards the screen another sharp image of height h_2 , of the same object, is formed on the screen. If the object position remained the same in both cases, obtain an expression for the height of the object.

(4)

(c) A converging lens of focal length 30 cm is placed between an object and a diverging lens of focal length 5 cm. If the object is 6 metres from the converging lens and 6.20 metres from the diverging lens, determine

(i) the position and nature of the image formed.

(4)

(ii) the magnification of the image.

(2)

SECTION B

3. (a) Distinguish between progressive and stationary waves. (4)

(b) A string under tension has a number of natural frequencies. Briefly describe an experiment to show that such a string vibrates freely only at its natural frequencies.

(5)

(c) A uniform wire of length 1.00m and mass 2.0×10^{-2} kg is stretched between two fixed points. The tension in the wire is 200N. The wire is plucked in the middle and released.

Calculate the:

(i) speed of the transverse waves. (2)

(ii) frequency of the fundamental note. (3)

(d) (i) Explain how beats are formed. (3)

(ii) Derive an expression for the beat frequency. (3)

4. (a) (i) What is meant by interference of waves? (2)

(ii) State the conditions necessary for the observation of interference pattern. (2)

(iii) Describe how interference can be used to test for the flatness of a surface. (3)

(b) Describe with the aid of a labeled diagram, how the wavelength of monochromatic light is measured using Young's double-slit method. (5)

(c) Two microscope slides are in contact at one end and are separated by a thin piece of paper at the other end. Monochromatic light is directed normally on the wedge.

(i) What type of fringes will be observed? (2)

(ii) Explain what will be observed if a liquid is introduced between the slides. (2)

(d) When monochromatic light of wavelength 5.0×10^{-7} m is incident normally on a transmission grating, the second order diffraction line is observed at an angle of 27° . How many lines per centimeter does the grating have? (4)

SECTION C

5. (a) (i) Define the unit of magnetic flux density. (1)

(ii) A rectangular coil of length ***l*** and breadth ***b*** has ***N*** turns and carries a current ***I***. It is placed with its plane vertical in a horizontal magnetic field of flux density ***B***.

Derive an expression for the torque exerted on the coil when the normal to its plane makes an angle θ with the magnetic field. (5)

(b) Explain the origin of the force on a current-carrying conductor placed in a magnetic field. (3)

(c) (i) Define the term angle of Dip as applied to the earth's magnetism. (1)

(ii) A circular coil of 4 turns and diameter 11.0 cm carries a current of 0.35A. It is placed with its plane in the magnetic meridian. Calculate the direction and magnitude of the resultant magnetic flux density at a position where the horizontal component of the earth's magnetic flux density is 1.8×10^{-6} T. (5)

(d) Explain why a moving coil galvanometer must have the following:- A radial magnetic field, fine hair springs, large number of turns and a conducting former. (5)

6. (a) Explain the meaning of the terms

(i) **self induction** (1)

(ii) **mutual induction.** (1)

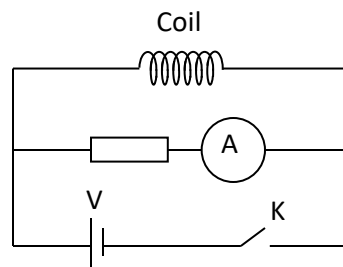
(b) (i) State the laws of electromagnetic induction. (2)

(ii) By using a suitable illustration with a North Pole, explain how Lenz's law serves as a good example of the principle of conservation of energy. (4)

(c) (i) Explain the main energy losses in a transformer and how they can be minimized. (4)

(ii) An a.c. transformer operates on a 240 V mains. The voltage across the secondary is 20 V. If the transformer is 80% efficient, calculate the current in the primary coil when a resistor of 40Ω is connected across the secondary. (3)

(d)



An iron-cored coil is connected as shown in the circuit above. Explain what happens to the reading of the Ammeter, A, when the switch k is

(i) first closed. (3)

(ii) opened. (2)

7. (a) Define the following terms as applied to voltage in alternating current circuits.

(i) **Root-mean-square value.** (1)

(ii) **Peak value.** (1)

(b) Derive the relationship between the root mean square value and the peak value of the alternating current. (4)

(c) With the aid of a labeled diagram, describe the mode of operation of a repulsion type moving iron ammeter. (5)

(d) A source of alternating current voltage of **frequency f** is connected across the ends of a pure inductor of **self inductance L** . Derive an expression for the inductive reactance of the circuit and explain the phase difference between the voltage and the current that flows. (5)

(e) A pure inductor of inductance 2H , is connected in series with a resistor of $500\ \Omega$ across a source of e.m.f $240\text{ V}_{(\text{r.m.s})}$, alternating at a frequency of 50 Hz . Calculate the potential difference across the resistor. (4)

SECTION D

8. (a) Explain why the terminal p.d falls as the current drawn from a source increases. (3)

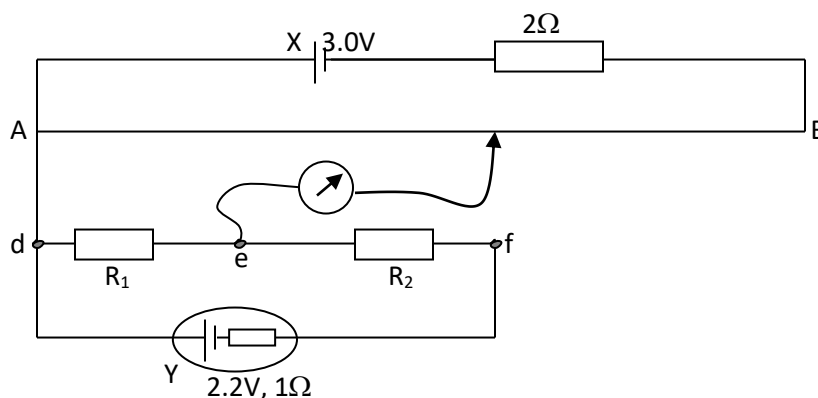
(b) A d.c source of emf 12 V and negligible internal resistance is connected in series with two resistors of $400\ \Omega$ and $R\text{ ohms}$, respectively. When a voltmeter is connected across the $400\ \Omega$ resistor, it reads 4 V while it reads 6 V when connected across the resistor of $R\text{ ohms}$. Find the:

(i) resistance of the voltmeter (6)

(ii) value of R (1)

(c) Describe how you would use a slide wire potentiometer to measure the internal resistance of a dry cell. (5)

(d) In the circuit diagram shown below, AB is a slide wire of length 1.0 m and resistance $10\ \Omega$. X is a driver cell of emf 3.0 V and negligible internal resistance. Y is a cell of emf 2.2 V and internal resistance $1.0\ \Omega$



When the centre-zero galvanometer is connected in turns to points **e** and **f**, the balance lengths obtained are 45.0 cm and 80.0 cm respectively.

Calculate the:

(i) current flowing through R_1 . (3)

(ii) resistances of R_1 and R_2 . (2)

9. (a) Define

(i) capacitance (1)

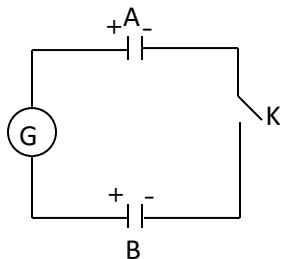
(ii) dielectric strength (1)

(b) Explain the action of a dielectric in a capacitor. (4)

(c) Describe an experiment to show that capacitance is affected by the thickness of the dielectric. (4)

(d) Derive an expression for the energy stored in a capacitor of capacitance C charge to a p.d V . (5)

(e) In the circuit shown below switch K is open, capacitors A and B have respective capacitances of $10\mu\text{F}$ and $15\mu\text{F}$ and are charged to p.ds of 25 V and 20 V respectively.



A ballistic galvanometer G , with sensitivity of 2 divisions per μC joins the positive plates of the capacitors. If K is now closed, what will be the throw on G ? (5)

10. (a) (i) State Coulomb's law of electrostatics. (1)

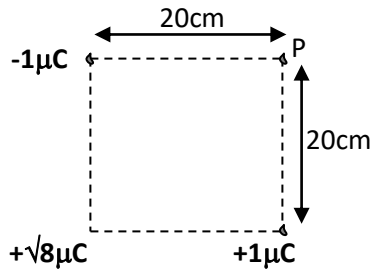
(ii) Define the terms **electric field intensity** and **electric potential at a point**. (2)

(b) (i) Sketch graphs of the variation of electric potential and electric field intensity with distance from the centre of a charged conducting sphere. (2)

(ii) Describe how a conducting body may be positively charged but remains at zero potential. (3)

(iii) Explain how the presence of a neutral conductor near a charged conducting sphere may reduce the potential of the sphere. (3)

(d) Charges of $-1\mu\text{C}$, $+8\mu\text{C}$ and $+1\mu\text{C}$ are placed at the corners of a square of side 20 cm as shown below



Calculate the:

(i) electric potential at P (4)

(ii) electric field intensity at P (5)

Assume where necessary:

$$\text{Acceleration due to gravity, } g = 9.81 \text{ ms}^{-2}$$

$$\text{Speed of light in vacuum, } c = 3.0 \times 10^8 \text{ ms}^{-1}$$

$$\text{Electron charge, } e = 1.6 \times 10^{-19} \text{ C}$$

$$\text{Electron mass, } m_e = 9.11 \times 10^{-31} \text{ kg}$$

$$\text{Permeability of free space, } \mu_0 = 4.0 \pi \times 10^{-7} \text{ Hm}^{-1}$$

$$\text{Permittivity of free space, } \epsilon_0 = 8.85 \times 10^{-12} \text{ Fm}^{-1}$$

$$\text{The constant } \frac{1}{4\pi\epsilon_0} = 9.0 \times 10^9 \text{ F}^{-1}$$

SECTION A

1. (a) (i) Define **absolute refractive index** of a material. (1)

(ii) Explain, with the aid of a diagram, why a thick plane mirror forms multiple images. (4)

(b) Describe how the refractive index of a liquid can be determined using a concave mirror. (6)

(c) (i) A parallel-sided glass block of thickness h and refractive index n is placed over a mark scribbled on a sheet of paper. Write an expression for the apparent displacement of a mark when viewed directly from above. (1)

(ii) A coin is placed at the bottom of a beaker. Water of refractive index 1.33 is poured in the beaker to a height of 15 cm. Above the water surface there is a layer of another liquid L, of thickness 8 cm. An observer from above sees the coin displaced 6.0 cm from the bottom. Calculate the refractive index of the liquid. (3)

(d) (i) For a ray of light passing through a prism perpendicular to the refracting edge of the prism, what are the conditions for minimum deviation? (1)

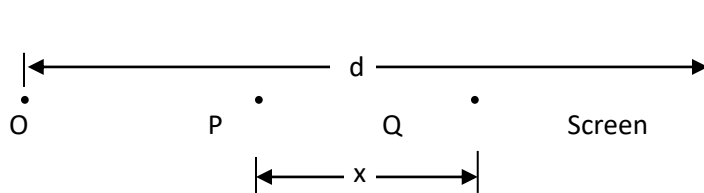
(ii) In part (i), if the refracting angle of the prism is θ , the minimum deviation is γ , and the refractive index of the material of the prism is n , derive an expression relating n , θ and γ . (4)

2. (a) What is meant by the following?

(i) **Conjugate points** with respect to a lens. (1)

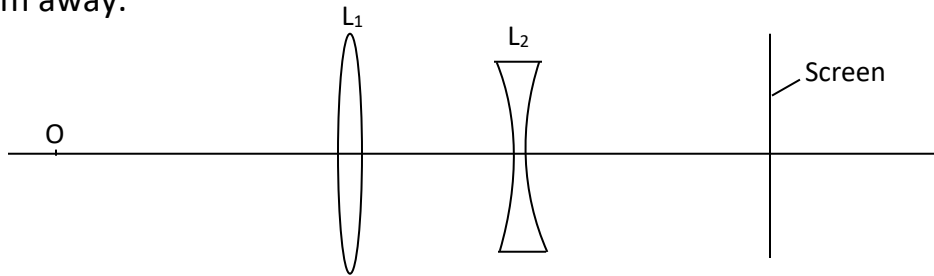
(ii) **A real image** (1)

(iii) In the diagram below the image of the object is formed on the screen, which is d cm from the object O, when a convex lens is placed either at P or Q.



If P and Q are x cm apart, find an expression for the focal length of the lens in terms of d and x . (3)

(b) A convex lens, L_1 , and a concave lens, L_2 , of focal lengths 20 and 10 cm respectively are mounted coaxially apart with the convex lens facing an object, O, 40 cm away.



The arrangement casts a sharp image of O onto a screen which is 30 cm from L_2 .

(i) Calculate the distance between the two lenses. (5)

(ii) If now the screen is withdrawn and L_2 is shifted until the final image is virtual and 30 cm from L_2 , find the new distance between L_1 and L_2 . (3)

(c) (i) Draw a labelled diagram to show how two converging lenses can be used to make a compound microscope in normal adjustment. (2)

(ii) An object of size 2.0 mm is placed 2.5 cm in front of the objective of a compound microscope. The focal length of the objective is 2.2 cm while that of the eyepiece is 5.0 cm. The microscope forms a virtual image of the object at the near point (25 cm) from the eye.

Find the size of the final image. (5)

SECTION B

3. (a) (i) What is meant by the **direction of a magnetic field**? (1)

(ii) State the laws of electromagnetic induction. (2)

(iii) A square coil of side 10 cm has 100 turns. The coil is arranged to rotate at $3000 \text{ rev. min}^{-1}$ about a vertical axis perpendicular to the horizontal uniform magnetic field of flux density 0.8 T. The axis of rotation passes through the mid-points of a pair of opposite sides of the coil. Calculate the emf induced in the coil when the plane of the coil makes an angle of 60° with the field. (4)

(b) (i) With the aid of a labelled diagram, describe how a simple d.c motor works. (5)

(ii) Explain how a back emf comes about in a motor (3)

(c) A d.c motor has an armature resistance of 1.0 ohm and is connected to a 240-V supply. The armature current taken by the motor is 20A. Calculate

(i) the emf generated by the armature (2)

(ii) the power supplied to the armature (1)

(iii) the mechanical power developed by the motor (1)

(iv) the efficiency of the motor (1)

4. (a) What is meant by the following?

(i) Self-induction (1)

(ii) Eddy current (1)

(b) (i) State and explain the features of a ballistic galvanometer. (4)

(ii) A coil, connected to a closed circuit, is placed in a magnetic field. Show that when the flux linkage of the coil changes, the charge that circulates in the circuit is independent of the time taken. (4)

(c) Describe an experiment to calibrate a ballistic galvanometer. (4)

(d) A capacitor of capacitance $10\mu\text{F}$ is charged to a p.d of 5V and then discharged through a ballistic galvanometer which gives a throw of 24 divisions. The capacitor is disconnected and the ballistic galvanometer is connected across a coil of 20 turns wound tightly round the middle of a solenoid of 1000 turns per

metre and diameter 4.0 cm. When the current in the solenoid is reversed, the galvanometer deflects through 10 divisions. If the total resistance of the galvanometer circuit is $12\ \Omega$, find the current in the coil. (6)

5. (a) (i) Give two advantages of alternating current over direct current in power transmission. (2)

(ii) Explain the fact that an alternating current continues to pass through a capacitor whereas direct current cannot. (4)

(b) A sinusoidal voltage, $V = V_0 \sin 2\pi ft$, is connected across a capacitor of capacitance C . Derive an expression for the reactance of the capacitor. (4)

(c) With the aid of a labelled diagram describe the structure and action of a hot-wire ammeter. (6)

(d) Power of 60 kW produced at 120 V is to be transmitted over a distance of 2 km through cables of resistance $0.2\ \Omega\ \text{m}^{-1}$. Determine the voltage at the output of an ideal transformer needed to transmit the power so that only 6% of it is lost. (4)

SECTION C

6. (a) Define the terms

(i) Dielectric constant (1)

(ii) Equipotential (1)

(b) (i) State the characteristics of an equipotential. (2)

(ii) Explain the occurrence of corona discharge (3)

(c) Describe, with the aid of a diagram, how a high voltage can be generated using a Van de Graaf generator. (6)

(d) An air capacitor of capacitance $600\ \mu\text{F}$ is charged to $150\ \text{V}$ and then connected across an uncharged capacitor of capacitance $900\ \mu\text{F}$.

(i) Find the energy stored in the $900\ \mu\text{F}$ capacitor (4)

(ii) With the two capacitors still connected, a dielectric of dielectric constant 1.5 is inserted between the plates of the $600\ \mu\text{F}$ capacitor. Find the new p.d. across the two capacitors. (3)

7. (a) A battery of emf E volts and internal resistance $5\ \Omega$ is connected in series with a resistor of variable resistance R .

Find the condition for the maximum power dissipated in the variable resistance. (3)

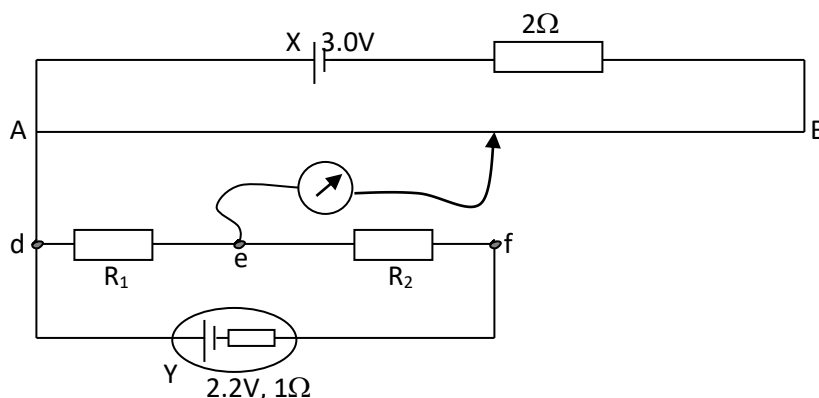
(b) A d.c source of emf $22\ \text{V}$ and negligible internal resistance is connected in series with two resistors of 500 and R ohms, respectively. When a voltmeter is connected across the $500\ \Omega$ resistor, it reads $10\ \text{V}$ while it reads $8\ \text{V}$ when connected across the resistor of R ohms. Find the:

(i) resistance of the voltmeter (6)

(ii) value of R (1)

(c) Describe how you would use a slide wire potentiometer to measure the internal resistance of a dry cell. (5)

(d) In the circuit diagram shown below, AB is a slide wire of length $1.0\ \text{m}$ and resistance $10\ \Omega$. X is a driver cell of emf $3.0\ \text{V}$ and negligible internal resistance. Y is a cell of emf $2.2\ \text{V}$ and internal resistance $1.0\ \Omega$



When the centre-zero galvanometer is connected in turns to points **e** and **f**, the balance lengths obtained are 45.0 cm and 80.0 cm respectively.

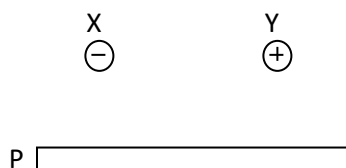
Calculate the:

(i) current flowing through R_1 . (3)

(ii) resistances of R_1 and R_2 . (2)

8. (a) (i) Explain why a neutral conductor may be attracted to a charged body. (3)

(ii) X and Y are small neighbouring balls charged as shown in the figure below and brought near a positively charged plate P.

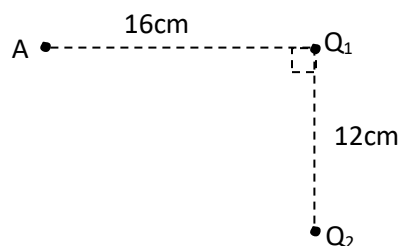


Sketch the electric field pattern in the region of the three bodies and indicate the neutral point(s). (3)

(b) Describe an experiment to investigate the charge distribution over the surface of a charged conductor. (5)

(c) Derive an expression for the electric potential at a point which is a distance r from an isolated point charge Q in a medium of permittivity ϵ . (5)

(d) In the figure A is a point 16 cm from a point charge Q_1 .



Another point charge Q_2 is located 12 cm from Q_1 as shown. If $Q_1 = 4 \mu\text{C}$ and $Q_2 = 6 \mu\text{C}$, find the work done in moving a charge of $2 \mu\text{C}$ from point A to a point midway between A and Q_2 . (4)

Assume where necessary:

Acceleration due to gravity, g	=	9.81 ms^{-2}
Speed of light in vacuum, c	=	$3.0 \times 10^8 \text{ ms}^{-1}$
Electron charge, e	=	$1.6 \times 10^{-19} \text{ C}$
Electron mass, m_e	=	$9.11 \times 10^{-31} \text{ kg}$
Permeability of free space, μ_0	=	$4\pi \times 10^{-7} \text{ Hm}^{-1}$
Permittivity of free space, ϵ_0	=	$8.85 \times 10^{-12} \text{ Fm}^{-1}$
The constant $\frac{1}{4\pi\epsilon_0}$	=	$9.0 \times 10^9 \text{ F}^{-1}$
One electron-volt (eV)	=	$1.6 \times 10^{-19} \text{ J}$
Avogadro's number, N_A	=	$6.02 \times 10^{23} \text{ mol}^{-1}$

SECTION A

1. (a) (i) State the laws of reflection of light. (2)

(ii) With the aid of a ray diagram show that the image formed by a plane mirror is the same size as the object. (4)

(b) Derive the mirror formula for a spherical mirror. (5)

(c) Describe an experiment to determine the focal length of a convex mirror using a plane mirror. (5)

(d) A convex lens of focal length 10 cm is placed coaxially 8 cm in front of a convex mirror. An object placed 23 cm from the mirror coincides with its own image. Find the focal length of the convex mirror. (4)

2. (a) (i) What is meant by the term **visual angle**. (1)

(ii) Explain how a lens corrects shortsightedness. (3)

(iii) State two ways of minimizing spherical aberration in a telescope (2)

- (b) (i) What is meant by the term **eye-ring** as applied to a telescope is. (1)
- (ii) Derive an expression for the angular magnification of a telescope in normal adjustment. (4)
- (iii) Show that the angular magnification is equal to the ratio of the objective diameter to eye-ring diameter. (3)
- (c) A telescope, with an objective of focal length 72 cm and an eyepiece of focal length 3 cm, forms an image of the moon on a screen placed 18 cm from the eyepiece.
- (i) Sketch a ray diagram to show how the image is formed. (2)
- (ii) Find the separation of the lenses? (4)

SECTION B

3. (a) What is meant by the term **stationary wave**? (1)
- (b) The displacement, y in metres, in a progressive wave is given by

$$y = 0.2 \sin 2\pi(12t - 5x).$$
- Find: (i) the wavelength (2)
(ii) the speed of the wave (2)
- (c) If the progressive wave in (b) is reflected back along the same path, show that the resultant is a stationary wave and find the amplitude at an antinode of the stationary wave. (5)
- (d) (i) In sound, what is meant by the terms **harmonic** and **beats**? (2)
- (ii) State two uses of beats. (2)
- (e) A source that produces sound is receding from a stationary observer towards a vertical wall with a speed of 4 ms^{-1} . The observer hears beats of frequency 5 Hz.
- (i) Explain why the observer hears the beats. (3)
- (ii) Find the frequency of the source of sound, if the velocity of sound is 340 ms^{-1} . (3)
4. (a) Use Huygen's principle to show that the angle of incidence is equal to the angle of reflection for light falling on a plane reflecting surface. (5)
- (b) (i) Draw a ray diagram showing the path of light rays through the experimental arrangement for the determination of the wavelength of light using a single slit and biprism. (2)

(ii) In a single slit and biprism experiment a prism of refracting angle 1.5° and refractive index 1.5 is used. The slit and the screen are 5 cm and 1 m respectively from the biprism. If light of wavelength 5.80×10^{-7} m is used, find the width of the fringes. (5)

(iii) State one advantage of the biprism method over Young's double slit method. (1)

(c) Distinguish between **continuous** and **line emission** spectra. (3)

(d) Monochromatic light of wavelength 600 nm is incident normally on a plane diffraction grating which has 500 lines per mm. Calculate the:

(i) number of diffraction maxima observed. (2)

(ii) angular position of the first diffraction maximum. (2)

SECTION C

5. (a) What is meant by the terms:

(i) Magnetic meridian (1)

(ii) Magnetic declination (1)

(b) Explain what happens to the angle of dip as one moves along the same longitude from the Equator to the North pole. (2)

(c) (i) Write down an expression for the magnetic flux density at the centre of a narrow circular coil of radius r having N turns when a current I is flowing in it. (1)

(ii) Describe an experiment to determine horizontal component of the Earth's magnetic flux density at a certain location. (5)

(d) A circular coil of 4 turns and diameter 14.0 cm carries a current of 0.35 A. It is placed at the equator with its plane along the magnetic meridian. Calculate the direction and magnitude of the resultant magnetic flux density at the position if the earth's magnetic flux density at the location is 1.8×10^{-5} T. (4)

(e) (i) What is meant by the term **magnetic moment** of a coil? (1)

(ii) Explain why a moving coil galvanometer must have the following:

A radial magnetic field,

Fine hair springs,

Large number of turns

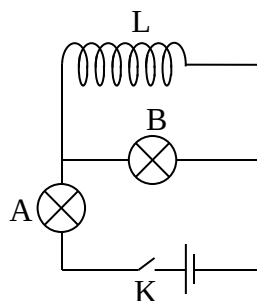
A conducting former. (5)

6. (a) What is meant by

(i) self induction (1)

(ii) eddy current (1)

(b) The diagram shows an iron-cored coil, L, of many turns and negligible resistance with identical bulbs, A and B, connected in a circuit.



(i) When switch K is closed, at first both bulbs A and B light up, but soon B dims out while A becomes brighter. Explain these observations. (3)

(ii) If now K is opened, state and explain what is observed. (3)

(c) (i) Explain the origin of the back emf in a motor. (2)

(ii) A motor, whose armature resistance is 2Ω , is operated on 240V mains supply. If it runs at $3000 \text{ rev min}^{-1}$ when drawing a current of 5 A, at what speed will it run when drawing a current of 15 A? (3)

(d) (i) With the aid of a labeled diagram, describe the mode of action of a simple d.c generator. (5)

(ii) Sketch the output of a simple d.c generator (1)

(iii) State two factors that determine the polarity of the output of a d.c generator. (1)

7. (a) As far as alternating current is concerned, what is meant by

(i) root-mean-square value of current (1)

(ii) peak value of current (1)

(b) (i) Derive an expression for the root-mean square value of a sinusoidal current. (4)

(ii) With the aid of a labeled diagram, describe the structure and action of a hot-wire meter. (6)

(c) A sinusoidal voltage, represented by $V = V_0 \sin \omega t$ (where t is time), is connected across a capacitor of capacitance C.

(i) Explain why an alternating current apparently flows through a capacitor whereas a direct current does not. (4)

(ii) Derive an expression for the current. (2)

(iii) If the capacitance is $100\ \mu\text{F}$ and the frequency is $50\ \text{Hz}$, what is the reactance of the circuit? (2)

SECTION D

8. (a) (i) For a source of electricity, what is meant by **emf** and **internal resistance**? (2)

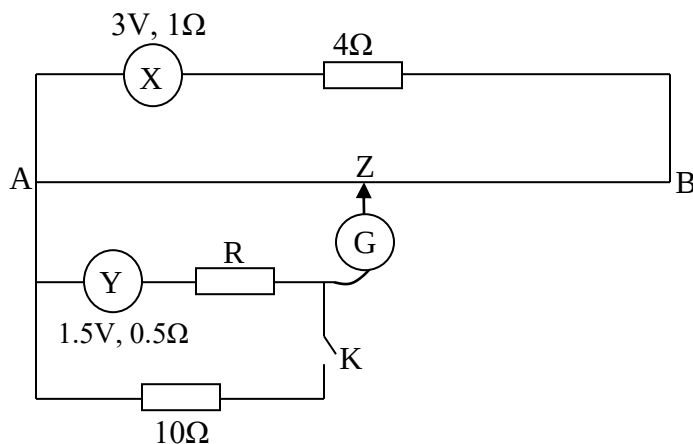
(ii) Define **electrical resistivity** and state its units (2)

(iii) Explain why the resistance of a metal increases when the temperature of the metal is increased. (2)

(b) You are provided with about $1\ \text{m}$ of a bare constantan wire, an ammeter, a voltmeter, crocodile clips and some connecting wires.

Describe an experiment you would perform, using all but only the items provided, to determine the internal resistance of a cell. Give a diagram of your setup. (5)

(c) In the potentiometer circuit shown below X is source of emf 3V and internal resistance $1\ \Omega$ while Y is a cell of emf $1.5\ \text{V}$ and internal resistance $0.5\ \Omega$. AB is a uniform wire of length $80\ \text{cm}$.



When the switch, K, is open the balance length AZ is $48.0\ \text{cm}$ and when K is closed the balance length becomes $32.0\ \text{cm}$. Determine

(i) the resistance of wire AB (4)

(ii) the power generated by the source X (2)

(iii) the value of the resistance R (3)

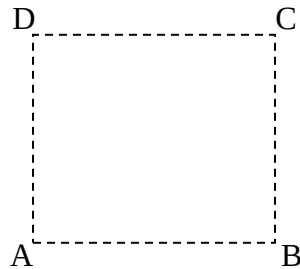
9. (a) (i) Explain why two insulators of different materials acquire equal opposite charges when rubbed together. (3)

(ii) Sketch a graph to show how the electric potential varies with distance from the centre of a charged sphere. (1)

(b) (i) With the aid of a labeled diagram describe how a high voltage is generated using a Van de Graaf generator. (6)

(ii) What factors do affect the highest voltage this machine can develop? (2)

(c) Three point charges of $+6\mu\text{C}$, $-2\mu\text{C}$ and $+4\mu\text{C}$ are placed respectively at corners A, B and C of a square of side 10 cm.



(i) Find the magnitude and direction of the electric intensity at the centre of the square. (5)

(ii) If the charge at B is to be moved to the centre, how much work is done? (3)

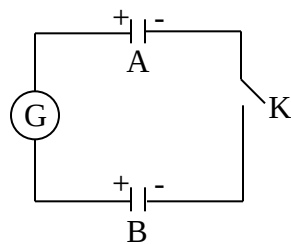
10. (a) (i) What is meant by the terms **dielectric constant** and **dielectric strength** of a substance. (2)

(ii) State two uses of a dielectric in a capacitor. (2)

(iii) With the aid of a circuit diagram describe an experiment to measure the capacitance of a capacitor using an uncalibrated ballistic galvanometer. (6)

(b) Derive an expression for the energy stored in a capacitor of capacitance C charged to a p.d V . (5)

(e) In the circuit shown below switch K is open, capacitors A and B have respective capacitances of $10\mu\text{F}$ and $15\mu\text{F}$ and are charged to p.ds of 25 V and 20 V respectively.



A ballistic galvanometer G, with sensitivity of 2 divisions per μC joins the positive plates of the capacitors. If K is now closed, what will be the throw on G? (5)

Assume where necessary:

Acceleration due to gravity, g	=	9.81 ms^{-2}
Speed of light in vacuum, c	=	$3.0 \times 10^8 \text{ ms}^{-1}$
Electron charge, e	=	$1.6 \times 10^{-19} \text{ C}$
Electron mass, m_e	=	$9.11 \times 10^{-31} \text{ kg}$
Permeability of free space, μ_0	=	$4\pi \times 10^{-7} \text{ Hm}^{-1}$
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The constant $\frac{1}{4\pi\epsilon_0}$	=	$9.0 \times 10^9 \text{ F}^{-1}$
One electron-volt (eV)	=	$1.6 \times 10^{-19} \text{ J}$
Avogadro's number, N_A	=	$6.02 \times 10^{23} \text{ mol}^{-1}$

SECTION A

1. (a) (i) State the laws of reflection of light. (2)

(ii) With the aid of a ray diagram show that the image formed by a plane mirror is the same size as the object. (4)

(b) Derive the mirror formula for a concave spherical mirror. (5)

(c) Describe an experiment to determine the focal length of a convex mirror using a plane mirror. (5)

(d) A concave lens is placed coaxially in front of a concave mirror of focal length 12 cm. An object, placed 34 cm from the mirror, coincides with its own image when the lens is 14 cm from the mirror.

Find the focal length of the lens. (4)

2. (a) In light what is meant by

(i) Refraction (1)

(ii) Critical angle (1)

(b) Explain why a pond of clear water looks shallower than it actually is. (3)

(c) A lens is set up and produces an image of luminous point source on a screen 25 cm away. Then a parallel glass slab of thickness 6 cm and refractive index 1.6 is placed between the lens and the screen. If the aperture of the lens is small

(i) sketch a ray diagram to show how the image is formed on the screen in the latter arrangement. (3)

(ii) find by how much the screen must be shifted from its original position so as to cast a clear image. (4)

(d)(i) With the aid of a ray diagram explain how a Galilean telescope forms an image at the near point. (4)

(ii) Derive an expression for the angular magnification of the arrangement described in (d)(i) (4)

SECTION B

3. (a) What is meant by

(i) **wavelength** of a wave. (1)

(ii) **pitch** of a musical note (1)

(b) (i) A source of sound of frequency f , is moving with velocity u_s away from an observer who is moving with velocity u_o in the same direction. If the velocity of sound is V , derive an expression for the frequency of sound heard by the observer. (5)

(ii) Explain what happens to the pitch of the sound heard by the observer in (b)(i) above when the observer moves faster than the source. (2)

(c) (i) A star which emits light of wavelength λ is approaching the earth with velocity v . If the velocity of light is c , write down an expression for the shift in the wavelength of the emitted light. (1)

(ii) Describe how the speed of a star may be measured using the Doppler effect. (4)

(d) Two open pipes of lengths 78 cm and 80 cm are found to give a beat frequency of 5 Hz when each is sounding in its fundamental note. If the end errors are 1.7 cm and 1.5 cm respectively, calculate the

(i) velocity of sound in air (4)

(ii) frequency of each note. (2)

4. (a) (i) What evidence does suggest that light is a transverse wave while sound is a longitudinal one? (1)

(ii) What is meant by **division of wavefronts** as applied to interference of waves? (2)

(b) Two slits X and Y are separated by a distance s and illuminated with light of wavelength λ . Derive the expression for the separation between successive fringes on a screen placed a distance D from the slit. (5)

(c) A source of light, a slit, S, and a double slit (A and B) are arranged as shown below



(i) Describe what is observed on the screen through the microscope when a white source of light is used. (2)

(ii) Explain what is observed when slit S is gradually widened. (3)

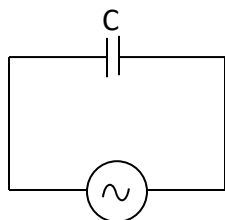
(iii) How would you use the set up above to measure the wavelength of red light? (4)

(d) In Young's double-slit experiment, the 8th bright fringe is formed 6mm away from the centre of the fringe system when the wavelength of light used is 6.3×10^{-7} m. Calculate the distance of the screen from the slits if the separation of the two slits is 0.7 mm. (3)

SECTION C

5. (a) Define the term **impedance** of an a.c circuit. (1)

(b) In the diagram below, a capacitor is connected across an a.c voltage supply.



(i) Using the same axes, sketch graphs to show the variation of **V_C and I** with time. (2)

(ii) Explain why current apparently flows through the capacitor. (4)

(c) Describe with the aid of a labeled diagram, the structure and action of a **hot wire ammeter**. (5)

(d) A $250\mu\text{F}$ capacitor is connected in series with a non-inductive resistor of $20\ \Omega$ across a source of p.d **$V = 300\sqrt{2} \sin 320t$**

(i) the root mean square (r.m.s) values of the current in the circuit and the p.d across the capacitor. (5)

(ii) the mean rate at which energy is supplied by the source. (1)

(iii) the phase angle between the current and the applied voltage. (2)

6. (a) (i) Explain why a current-carrying conductor placed in a magnetic field experiences a force. (2)

(ii) Write down the expression for the force on a straight wire of length l carrying a current I at an angle θ to the magnetic field of flux density B . (1)

(iii) A rectangular coil of N turns and area A is suspended in a uniform magnetic field of flux density B . Initially the plane of the coil is parallel to the magnetic field. Derive the expression for the initial torque on the coil when a current I flows through the coil. (3)

(b) (i) Draw a labelled diagram of a moving-coil galvanometer and explain how it works. (6)

(ii) What factors determine the sensitivity of a moving-coil galvanometer? (2)

(c) A small circular coil of 10 turns and mean radius 2.5 cm is mounted at the centre of a long solenoid of 1000 turns per metre with its axis at right angles to the axis of the solenoid. If the current in the solenoid is 2.0 A, calculate the initial torque on the circular coil when the current of 1.0 A passes through it. (5)

7. (a) Define the following

(i) magnetic meridian (1)

(ii) magnetic declination (1)

(iii) neutral point in a magnetic field (1)

(b) (i) Sketch the field pattern in a region where a bar magnet is placed east-west in the earth's magnetic field. (3)

(ii) Write down an expression for the flux density at the centre of a narrow circular coil of N turns, radius r carrying a current I . (1)

(c) Describe how you would compare magnetic intensities of two fields using a deflection magnetometer, explaining its principle (6)

(d) A narrow circular coil of 10 turns and diameter 20.0 cm is arranged with its plane in the magnetic meridian. A magnetic compass is placed in a

horizontal plane at the centre of the coil. When a current of 7.0 A is passed through the coil, the compass deflects through an angle of 49° . When the current is reversed, the deflection in the opposite direction is 47° .

(i) Give a possible reason why the magnitudes of the deflections are different when the current is reversed. (1)

(ii) Calculate the horizontal component of the earth's magnetic flux density (4)

(iii) What would be the compass deflection if the plane of the coil is perpendicular to the magnetic meridian (1)

(iv) Give the relationship between the angle of deflection and the radius of the coil. (1)

SECTION D

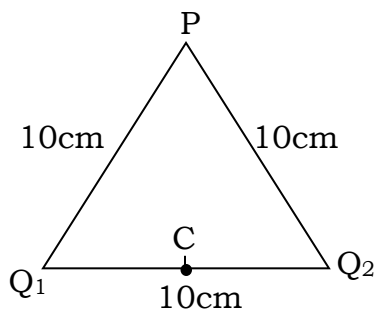
8. (a) (i) Explain why a charged body attracts a neutral conductor. (3)

(ii) Explain the occurrence of corona discharge. (3)

(b) Describe an experiment to investigate the charge distribution over a conductor, showing how the conclusion is arrived at. (4)

(c) (i) Derive an expression for the electric potential at a point a distance d from a point charge Q in a medium of permittivity ϵ . (5)

(ii) The diagram below shows two point charges Q_1 and Q_2 of $+6\mu\text{C}$ and $+4\mu\text{C}$ respectively



Find the work done in moving a charge of $-4\mu\text{C}$ from point P to point C midway between Q_1 and Q_2 and interpret the answer you have obtained.

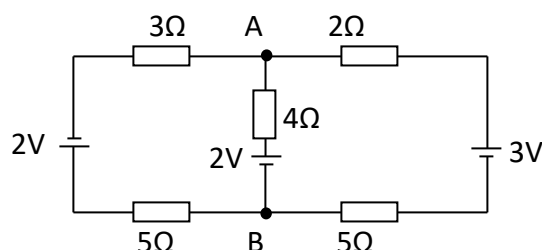
(5)

9. (a) (i) What is meant by **potential difference**? (1)

(ii) Define a **volt**. (1)

(b) Explain why the terminal p.d across a source decreases as a bigger current is drawn from the source. (3)

(c)



In the circuit shown above, find

(i) the current flowing in the 4-ohm resistor. (4)

(ii) the p.d between points A and B. (2)

(d) Describe an experiment to measure the internal resistance of a cell. (5)

(e) When a battery of emf 2 V is connected in series with a cell C, the combination gives a balance length of 80.0 cm. When cell C is reversed, the balance length falls to 16.0 cm.

What is the emf of cell C? (4)

10. (a) (i) What is meant by the dielectric constant? (1)

(ii) Derive an expression for the energy stored in a capacitor, of capacitance C, charged to a voltage V. (5)

(b) Explain the action of a dielectric. (4)

(c) Describe how the unknown capacitance of a capacitor can be determined using a ballistic galvanometer. (4)

(d) A capacitor of capacitance $5\ \mu\text{F}$ is charged to a p.d. of $52\ \text{V}$ with the aid of a battery. The battery is then removed and the capacitor is connected to an uncharged capacitor of capacitance $8\ \mu\text{F}$. Calculate:

(i) the final p.d., V across the combination. (2)

(ii) the energy stored before and after connecting the two capacitors. (3)

(iii) Account for the difference in the quantities of energy calculated. (1)

Assume where necessary:

Acceleration due to gravity, g	=	$9.81\ \text{ms}^{-2}$
Speed of light in vacuum, c	=	$3.0 \times 10^8\ \text{ms}^{-1}$
Electron charge, e	=	$1.6 \times 10^{-19}\ \text{C}$
Electron mass, m_e	=	$9.11 \times 10^{-31}\ \text{kg}$
Permeability of free space, μ_0	=	$4\pi \times 10^{-7}\ \text{Hm}^{-1}$
Permittivity of free space, ϵ_0	=	$8.85 \times 10^{-12}\ \text{Fm}^{-1}$
The constant $\frac{1}{4\pi\epsilon_0}$	=	$9.0 \times 10^9\ \text{F}^{-1}$
One electron-volt (eV)	=	$1.6 \times 10^{-19}\ \text{J}$
Avogadro's number, N_A	=	$6.02 \times 10^{23}\ \text{mol}^{-1}$

SECTION A

1. (a) (i) State the laws of reflection. (2)

(ii) Give a case where spherical mirrors are more convenient to use than plane mirrors and briefly explain why they are more convenient. (2)

(iii) Explain why parabolic mirrors instead of spherical ones are employed in reflecting telescopes. (2)

(b) (i) Draw a ray diagram to show how a **diverging mirror** forms an image. (2)

(ii) Describe an experiment to determine the focal length of a diverging mirror by the use of a converging lens. (5)

(c) A concave mirror forms, on a screen, a real image of **half** the linear dimensions of the object. The object and the screen are then moved until the image is **three times** the size of the object. If the shift of the screen is 25 cm, determine

(i) the focal length of the mirror (4)

(ii) the shift of the object (3)

2. (a) (i) State the conditions for total internal reflection. (2)

(ii) Draw a labeled diagram of a named device to show (without description) an application of total internal reflection. (2)

(b) Explain how a fish in a pond is able to enjoy a 180° field of view. (3)

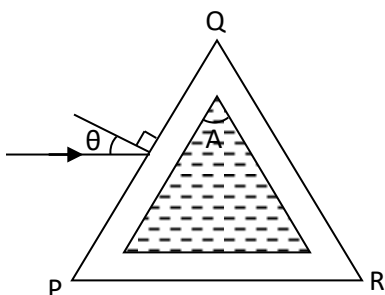
(c) Show that when a ray of light passes through different media separated by plane boundaries

$$n \sin i = \text{constant}$$

where ***n*** is the absolute refractive index of a medium and ***i*** is the angle made by the ray with the normal in the medium. (4)

(d) Describe an experiment to measure the refractive index of glass of rectangular shape, using a pin, by the apparent depth method. (4)

(e) The figure below shows a liquid of refractive index 1.33 enclosed by glass of uniform thickness. A ray of light, incident on face PQ at an angle of incidence, θ , emerges through face QR.



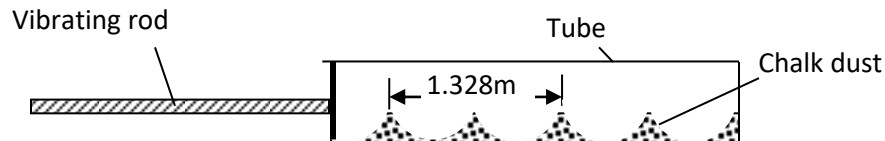
As the angle θ is reduced, suddenly the emergent ray disappears when $\theta = 16^\circ$. Find the angle A. (5)

SECTION B

3. (a) (i) State **two** characteristics of a stationary wave. (2)

(ii) What is meant by **Doppler effect**? (1)

(b) In an experiment to determine the speed of sound in air in a tube, chalk dust settled in heaps as shown in the figure below



If the frequency of the vibrating rod is 252 Hz and the distance between three consecutive heaps is 1.328 m, calculate the speed of sound in air. (3)

(c) The speed of sound in air is given by $v = \sqrt{\frac{\gamma P}{\delta}}$,

where P is the pressure, δ the density and γ the ratio of the principal heat capacities of air.

Use this expression to explain the effect of temperature on the speed of sound in air. (3)

(d) (i) A train moving with uniform velocity, v_1 , sounds a horn as it passes a stationary observer. Derive the expression for the apparent frequency of the sound detected by the observer. (3)

(ii) If the frequency of the sound detected by the observer after the train passes is 1.2 times lower than the frequency detected when the train is approaching, find the speed of the train.

[speed of sound in air = 330 ms^{-1}] (4)

(e) Describe a simple experiment to show interference of longitudinal waves. (4)

4. (a) (i) Define the term **diffraction**. (1)

(ii) What is meant by **plane polarised light**? (1)

(iii) Explain the term **path difference** with reference to interference of two wave motions (3)

(b) (i) Describe how polarized light is produced by double refraction. (5)

(ii) State **two** uses of polarized light. (2)

(iii) A parallel beam of unpolarised light incident on a transparent medium of refractive index 1.62, is reflected as plane polarized light. Calculate the angle of incidence in air and angle of refraction in the medium. (3)

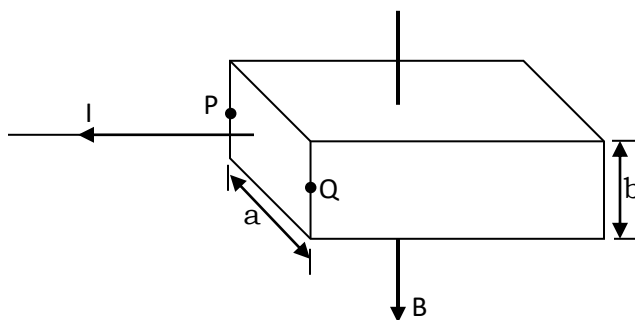
(c) (i) What is a **diffraction grating**? (1)

(ii) Sodium light of wavelengths $5.890 \times 10^{-7}\text{m}$ and $5.896 \times 10^{-7}\text{m}$ falls normally on a diffraction grating. If in the first order beam, the two sodium lines are separated by 2 minutes, find the spacing of the grating. (4)

SECTION C

5. (a) What is a **magnetic field**? (1)

(b) A magnetic field of flux density B is applied normally to a metal strip carrying current I as shown in the figure below.



(i) Account for the occurrence of a potential difference between points P and Q, indicating the polarity of this p.d. (3)

(ii) Derive an expression for the electric intensity between P and Q if the drift velocity of the conduction electrons is v . (3)

(c) (i) With the aid of a labeled diagram, describe the mode of action of a simple d.c generator. (5)

(ii) Sketch the output against time of a simple d.c generator. (1)

(iii) Explain how a back emf is developed in a motor. (3)

(d) A square coil of side 10 cm has 100 turns. The coil is arranged to rotate at $3000 \text{ rev. min}^{-1}$ about a vertical axis perpendicular to the horizontal uniform magnetic field

of flux density 0.8 T. The axis of rotation passes through the mid-points of a pair of opposite sides of the coil. Calculate the emf induced in the coil when the plane of the coil makes an angle of 60° with the field. (4)

6. (a) State the laws of electromagnetic induction. (2)

(b) A coil of area A is rotated at a frequency f in a uniform magnetic field of flux density B about an axis which is perpendicular to the field.

(i) Derive an expression for the emf generated. (3)

(ii) Deduce at least four of the factors on which the emf depends (2)

(iii) State any two factors that reduce the efficiency of an a.c. generator to less than 100% (2)

(c) A rectangular coil of 50 turns is 15.0 cm wide and 30.0 cm long. If it rotates at a uniform rate of 3000 revolutions per minute about an axis parallel to its long side and at right angles to a uniform magnetic field of flux density 0.04T, find the peak value of the emf induced in the coil. (2)

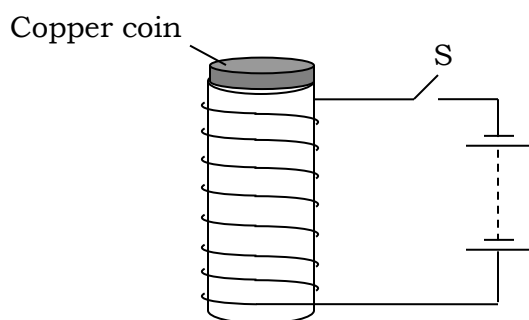
(d) (i) A metallic circular disc of diameter d is in a uniform magnetic field of flux density B and the plane of the disc is perpendicular to the field. If the disc is rotated at a frequency f , derive an expression for the emf developed between its centre and rim. (4)

(ii) Describe an experiment to measure resistance by means of a rotating disc in a magnetic field. (5)

7. (a) (i) Distinguish between **root mean square value** and **peak value** of an alternating current. (2)

(ii) What is the peak value of the voltage from a 220V a.c. mains. (2)

(b) The figure below shows a copper coin resting on a solenoid



Explain these observations:

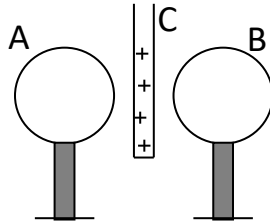
- (i) On closing switch S the coin jumps up and settles back. (3)
- (ii) When the d.c. source is replaced by a high-frequency alternating voltage and S is closed, the coin remains in position but gets heated up. (3)
- (c) (i) What is meant by the term **capacitive reactance**? (1)
- (ii) Derive an expression for the reactance of a capacitor of capacitance C when a sinusoidally varying a.c. of frequency f passes through it. (5)
- (iii) A sinusoidal alternating voltage, **$10 \sin 20\pi t$** , is applied to a coil of inductance 0.5 H. Assuming that the coil has negligible resistance, calculate the root mean square value of the current. (3)

SECTION D

8. (a) (i) State Ohm's law (1)
- (ii) Describe an experiment to verify Ohm's law. (5)
- (b) An accumulator of emf 3V and negligible internal resistance is joined in series with a resistance of 500Ω and another resistance of 300Ω . The voltmeter reads $\frac{5}{3} \text{ V}$ when connected across the 500Ω resistor. Calculate
- (i) the resistance of the voltmeter. (4)
- (ii) the reading of the voltmeter when connected across the 300Ω resistor. (3)
- (c) Define
- (i) **electrical resistivity** (1)
- (ii) **temperature coefficient of resistance** (1)
- (d) An electric element consists of 4.64 m of nichrome wire of diameter 0.5 mm, the resistivity of nichrome at 15°C being $1.12 \times 10^{-6} \Omega\text{m}$. When connected to a 240V supply, the wire dissipates 2.0 kW and the temperature of the element is 1015°C . Determine the mean temperature coefficient of resistance of nichrome between 15°C and 1015°C . (5)

9. (a) Explain how objects get charged by rubbing. (3)

(b) The diagram shows two metallic spheres A and B placed apart and each supported on an insulating stand. A positively charged plate C is placed mid-way between them but without touching them.



B is momentarily earthed in the presence of C. Finally C is withdrawn.

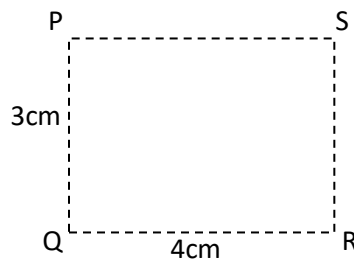
(i) Draw the spheres at the end of the operation and show the charge distribution over them. (2)

(ii) On the same diagram sketch the electric field pattern in the region of the spheres. (2)

(iii) Explain the change in p.d between the spheres as the spheres are moved further apart. (2)

(c) Describe an experiment to show that excess charge resides outside a hollow conductor. (5)

(d) Charges of $-3\mu\text{C}$, $+4\mu\text{C}$ and $+3\mu\text{C}$ are placed at the corners P, Q and R of a rectangular frame PQRS in which $PQ = 3\text{ cm}$ and $QR = 4\text{ cm}$ as shown in the figure below



If the charges are in vacuum, calculate the magnitude of the electric intensity at S due to the charges. (6)

10. (a) Define

(i) **capacitance** (1)

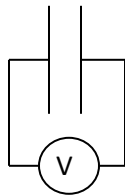
(ii) **dielectric strength**

(1)

(b) Describe an experiment to show the relationship between capacitor charge and potential difference. (5)

(c) Derive an expression for the equivalent capacitance of three capacitors connected in series. (3)

(d) Two large metal plates, placed parallel to each other and separated by dry air, form a capacitor. The arrangement is given a charge, then isolated and finally an ideal voltmeter is connected across its plates as shown.



Explain what is observed on the voltmeter reading when

(i) an insulating material is inserted in between the plates. (2)

(ii) the separation of the plates is increased. (2)

(e) When two capacitors, C_1 and C_2 are connected in series and the combination connected to a supply V the charge stored by C_1 is $8\mu\text{C}$ while the p.d. across C_1 is 4V .

When the capacitors are connected in parallel to the same supply the total charge stored by the combination is $36\mu\text{C}$. Given that $C_1 < C_2$, find

(i) the capacitances of the capacitors (4)

(ii) the p.d, V , of the supply (2)

1. (a) Distinguish between transverse and longitudinal waves. (2)

(b) The displacement Y of a wave traveling in x -direction at a time t is

$$Y = a \sin 4\pi(5t - 0.2x) \quad \text{meters.}$$

Find (i) the period of the wave. (3)

(ii) the velocity of the wave. (3)

(c) (i) What is meant by Doppler effect? (1)

(ii) A police car moving at 90 km h^{-1} , sounds a siren of 945 Hz as it approaches a stationary observer. What is the apparent frequency of the siren heard by the observer if the speed of sound in air is 335 ms^{-1} . (3)

(iii) Give one application of the Doppler Effect. (1)

(d) (i) Describe the motion of air in a tube closed at one end and vibrating in its fundamental mode. (3)

(ii) A cylindrical pipe of length 29 cm is closed at one end. The air in the pipe resonates with a tuning fork of frequency 860 Hz sounded near the open end of the tube. If the velocity of sound is 340 ms^{-1} , determine the mode of vibration and find the end correction. (4)

2. (a) What is meant by each of the following terms?

(i) Flux linkage (1)

(ii) Mutual induction (1)

(b) A coil whose terminals are joined together through a low resistance is placed in a magnetic field. The strength of the field is then changed. Show that the total charge that circulates in the circuit during the period is independent of the time taken. (4)

(c) (i) State and explain the main features of a ballistic galvanometer. (4)

(ii) Describe an experiment you could perform to calibrate a ballistic galvanometer (4)

(d) A small circular coil of 1000 turns and area 12 cm^2 having total resistance 10Ω is placed coaxially in the middle of a long solenoid of 1000 turns per metre. A ballistic galvanometer of total resistance 10Ω is connected across the terminals of the coil. When the steady current in the solenoid is switched off the ballistic galvanometer gives a maximum deflection of 20 divisions. When the galvanometer is disconnected and a capacitor of capacitance $100 \mu\text{F}$ charged to 12 V is discharged through it, the galvanometer gives a maximum deflection of 25 divisions.

(i) Describe and explain the behaviour of the pointer of the galvanometer before the steady current is switched off. (2)

(ii) Determine the steady current through the solenoid. (4)

1. (a) What is meant by the term **stationary wave**? (1)

(b) The displacement, y in metres, in a progressive wave is given by

$$y = 0.2\sin 2\pi(12t - 5x).$$

Find: (i) the wavelength (2)

(ii) the speed of the wave (2)

(c) If the progressive wave in (b) is reflected back along the same path, show that the resultant is a stationary wave and find the amplitude at an antinode of the stationary wave. (5)

(d) (i) In sound, what is meant by the terms **beats** and **Doppler effect**? (2)

(ii) State two uses of beats. (2)

(e) A source that produces sound is receding from a stationary observer towards a vertical wall with a speed of 4 ms^{-1} . The observer hears beats of frequency 5 Hz.

(i) Explain why the observer hears the beats. (3)

(ii) Find the frequency of the source of sound, if the velocity of sound is 340 ms^{-1} . (3)

2. (a) Define the term **root-mean-square** value as applied to an alternating current. (1)

(b) An alternating voltage, of r.m.s value V and frequency f , is connected across a pure capacitor of capacitance C .

Derive an expression for the current that flows. (4)

(c) (i) Explain why a moving-coil meter is not suitable for measuring alternating currents. (3)

(ii) With the aid of a labelled diagram, describe the structure and mode of operation of a moving-iron ammeter of the repulsion type. (5)

(d) A sinusoidal alternating voltage $V = 200\sin 160t$ is applied across a coil of inductance 0.5 H and resistance 60Ω . Find:-

(i) the phase difference between the current and the applied voltage. (2)

(ii) the current through the coil. (3)

(iii) the power dissipated in the coil. (2)

Where necessary use the following constants:

Permeability of free space, $\mu_0 = 4.0\pi \times 10^{-7} \text{ H m}^{-1}$

Permittivity of free space $\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$

1. (a) (i) State how **spherical** aberration and **chromatic** aberration is minimised in lens instruments. (2)

(ii) Explain why the virtual image seen in a magnifying glass is almost free of chromatic aberration when the eye is placed close to the lens. (2)

(b) State

(i) the advantages of a reflector telescope over a refractor telescope. (2)

(ii) how the resolving power of a reflector telescope can be increased. (1)

(c) (i) With the aid of a ray diagram, describe how a compound microscope may be used to form at infinity the image of an object. (4)

(ii) Derive an expression for the magnifying power of the microscope in c(i). (3)

(iii) If the final image formed coincides with the object, and is at the least distance of distinct vision (25cm) when the object is 3 cm from the objective, calculate the focal lengths of the objective and the eye lenses, given that the magnifying power of the microscope is 15. (6)

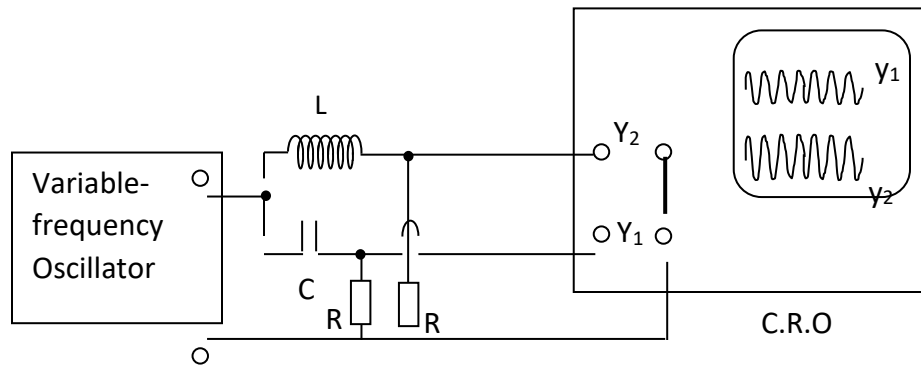
2. (a) (i) The electrical power obtained from a generator is always less than the mechanical power needed to drive the generator.

Give reasons why this is so. (2)

(ii) How are the energy losses in a generator minimised? (4)

(b) (i) A capacitor of capacitance C and an inductor of inductance L are each in turn connected across an a.c voltage of frequency f. Write down an expression for the reactance of each of the components. (1)

(ii) An oscillator of variable frequency produces a signal of constant amplitude. The output of such an oscillator is fed into a pair of identical resistors, R , as shown in the diagram.



C is a capacitor and L an inductor. The output through C is connected to the Y_1 plates while that through L is connected to the Y_2 plates of a double-beam C.R.O. y_1 and y_2 are the respective signals due to the inputs at Y_1 and Y_2 . It is observed that as the frequency of the oscillator is varied from minimum to maximum the amplitude of y_2 decreases as that of y_1 increases.

Explain these observations. (4)

(c) A sinusoidal supply of $40V_{(r.m.s)}$ and frequency 60 Hz is connected across a coil of inductance $1/\pi$ H and resistance 160Ω . Determine

(i) the impedance in the circuit (4)

(ii) the current (r.m.s) that flows (2)

(iii) the average power consumed in the circuit. (3)