

UGANDA MARTYRS SECONDARY SCHOOL
ANNUAL ‘A’-LEVEL PHYSICS SEMINAR (2019)

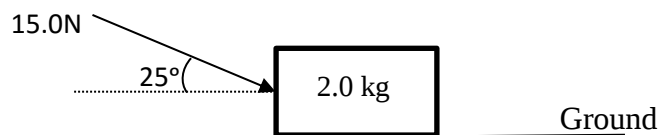
Assume where necessary;

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	=	$8.31\text{Jmol}^{-1}\text{K}^{-1}$
Density of water	=	1000 kg m^{-3}
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	=	$3.0 \times 10^8\text{ms}^{-1}$
Speed of light in air	=	340 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	=	$6.02 \times 10^{23}\text{mol}^{-1}$
Permittivity of free space ϵ_0	=	$8.85 \times 10^{-12}\text{Fm}^{-1}$
Permeability of free space μ_0	=	$4.0\pi \times 10^{-7}\text{Hm}^{-1}$
The constant $\frac{1}{4\pi\epsilon_0}$	=	$9.0 \times 10^9\text{ F}^{-1}\text{ m}$

PAPER I

SECTION A

1. a) i) State the laws of **static friction**. [3 marks]
 - ii) Describe an experiment to determine the coefficient of dynamic friction between a wooden block and a plane surface. [4 marks]
- b) A force of 15.0 N is used to push a block of mass 2.0 kg along a horizontal ground as shown in the diagram below.



If the block moves with constant velocity find;

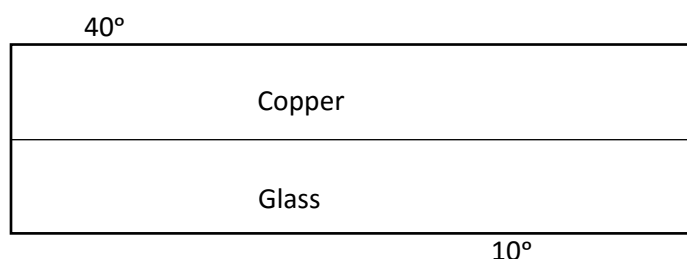
- (i) The coefficient of dynamic friction between the block and the ground. [3 marks]
 - (ii) The force applied at the same angle that will cause the 2.0 kg mass to accelerate at a rate of 2.0 ms^{-2} . [3 marks]
 - c) Define **resultant velocity**. [1mark]
 - d) A pilot who can fly at 500 kmh^{-1} wishes to fly from airport **A** to airport **B**, which is 3,000 km North-East of **A**. wind blows from west to east at 150 kmh^{-1} . Find;
 - (i) The direction in which he should fly. [3 mark]
 - (ii) The time he will take to reach airport **B**. [3 marks]
2. a) i) State **Bernoulli's principle** and give one application of this principle. [2 marks]
- ii) Derive Bernoulli's equation. [4 marks]
- b) i) Explain why water droplets are spherical. [3 marks]
- ii) Two soap bubbles of radii 2.0 cm and 4.0 cm respectively coalesce under isothermal conditions. If the surface tension of the soap solution is $2.5 \times 10^{-2} \text{ Nm}^{-1}$ and atmospheric pressure is 2.6 Pa, calculate the pressure inside the resulting soap bubble. [4 marks]
- c) i) Explain why an aero plane has to bank its wings in order to move in a circular path. [3 marks]
- ii) An aero plane has a wing area of 40 m^2 . At take-off, the speeds of air above and below the wings are 120 ms^{-1} and 100 ms^{-1} respectively. Find the lift on the aero plane, if the density of air is 1.3 kgm^{-3} [4 marks]
3. a) Define **angular momentum**. [1 mark]
- b) A car whose centre of gravity is **h** meters above the ground and its width is **2a** meters, moves round a horizontal circular track of radius **R** with velocity **V**.
- (i) Draw a sketch diagram to show the forces acting on the car. [2 marks]

- (ii) Derive an expression showing the velocity for which the car can move safely round the track without overturning [4 marks]
- (iii) Explain why the car would move at a higher velocity if the track was banked. [2 marks]
- c) A small bob of mass 0.5 kg is tied on an inextensible string of length 0.8 m. The bob is whirled in a horizontal circle of radius 0.3 m forming a conical pendulum.
- (i) Draw a diagram to show the forces acting on the bob. [2 marks]
- (ii) Calculate the frequency of motion of the bob. [3 marks]
- d) i) State **Kepler's laws** of planetary motion. [3marks]
- ii) Show that Newton's law of universal gravitation is consistent with Kepler's third law. [3marks]
4. a) i) Define **Young's modulus**. [1mark]
- ii) A wire of length **L** metres and Young's modulus **E** stretches by **e** metres when a force is suspended on it. Derive an expression for the energy stored in a unit volume of the wire in terms of **E**, **L** and **e**. [3marks]
- b) With use of a labelled diagram, describe an experiment to determine Young's modulus for wire. [5 marks]
- c) i) State the **work-energy theorem**. [1mark]
- ii) Using Newton's second law of motion prove the work-energy theorem for a body of mass **M** kg that is uniformly accelerated from velocity **U** ms⁻¹ to **V** ms⁻¹ in time **t** seconds. [4 marks]
- d) i) Distinguish between **conservative** and **non-conservative** forces. [2 marks]
- ii) A body is released from a point at a distance 9R from the centre of a planet of mass 6.0×10^{20} kg. Calculate the speed of the body when it is at a distance 3R from the planet's centre. ($R = 6.0 \times 10^6$ m). [4 marks]

SECTION B

5. a) i) What is meant by **internal energy** of a substance? [1mark]
ii) Define **specific latent heat** of a substance. [1mark]
- b) i) With use of a diagram, describe an experiment to determine the specific heat capacity of a good conducting solid by the electrical method. [6 marks]
ii) State two factors that make the value of specific heat capacity obtained in (i) above inaccurate. [2 marks]
- c) State **Newton's law of cooling**. [1 mark]
- d) An electric heater rated 500 W is used to heat a metal of mass 2.0 kg initially at room temperature of 25° C, its temperature rises steadily up to 80° C and remains constant.
(i) Explain why the temperature remains constant. [3 marks]
(ii) If the heater was used for 3 minutes and 18 seconds, estimate the specific heat capacity of the metal. [3 marks]
- e) Calculate the work done against the atmosphere when 1 kg of water turns into vapor at atmospheric pressure of 1.01×10^5 Pa. [Density of water vapor = 0.598 kgm^{-3}] [3 marks]
6. a) i) State the factors that determine the rate at which heat flows through a conductor. [2 marks]
ii) Explain the mechanism of heat transfer in metals. [3 marks]
- b) Describe an experiment to determine the thermal conductivity of a metal. [6 marks]
- c) i) What is meant by a **black body**? [1mark]
ii) How can a black body be realized in practice? [3 marks]
- d) The sun is a black body of surface temperature 6000 K. If the radius of the earth's orbit about the sun is 1.5×10^{11} m, estimate the equilibrium temperature of the earth. [5 marks]
7. a) Define molar heat capacity of a gas,
(i) **at constant pressure** C_p [1 mark]
(ii) **at constant volume** C_v [1 mark]
- b) i) Derive an expression relating C_p and C_v as defined in (a) above [4 marks]
ii) Define an **adiabatic** and an **Isothermal** change. [2 marks]

- iii) State the conditions for a *reversible adiabatic change* [2 marks]
- c) An ideal gas at 27° C and at a pressure of 1.01×10^5 Pa is compressed reversibly and isothermally until its volume is halved. It is then expanded reversibly and adiabatically to twice its original volume.
- (i) Draw a P-V diagram for the above processes. [1 mark]
- (ii) Calculate the final pressure and temperature of the gas if $\gamma=1.4$ [5 marks]
- d) i) State **Dalton's law** of partial pressures. [1 mark]
- ii) A vessel of volume 500 cm³ containing air at a pressure of 8.0×10^4 Pa is connected by a very narrow tube fitted with a tap to a vessel of volume 700 cm³ containing air at a pressure of 2.0×10^5 Pa What is the resulting pressure in the vessel when the tap is opened? [3 marks]
8. a) i) Define **thermal conductivity** of a material and state its units. [2 marks]
- ii) Explain why glass is a poor conductor of heat. [2 marks]
- b) With use of a labelled diagram describe an experiment to determine the thermal conductivity of glass [6 marks]
- c) A conduction plate of thickness 5.0 mm is made out copper and glass in a thickness ratio of 4:1 respectively, as shown in the diagram below.

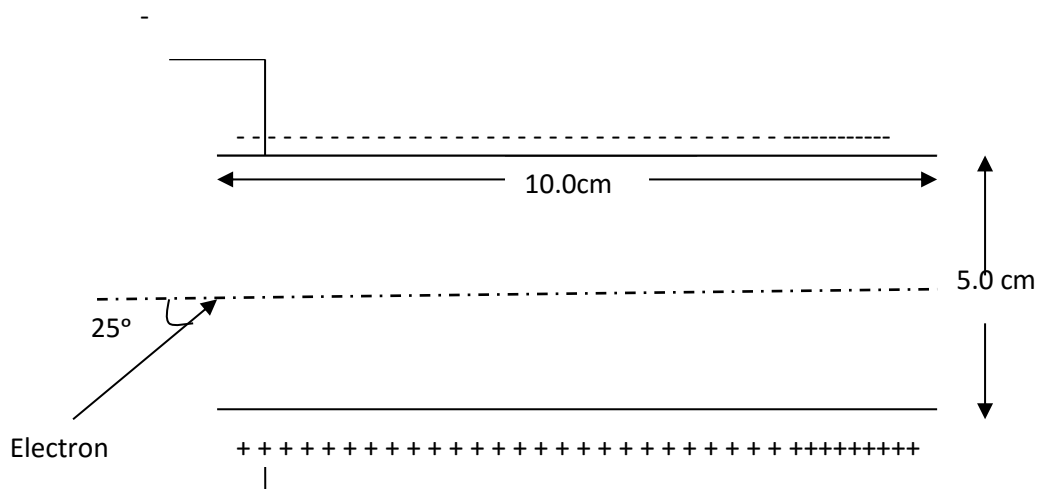


If the temperature of the outer faces of the plate are 40° C and 10° C, respectively and if the rate of heat flow through the plate is 60 W, find:

- (i) The temperature of the interface between copper and glass. [3 marks]
- (ii) The cross sectional area of the plate. [2 marks]
- [Conductivities of copper and glass are $40 \text{ Wm}^{-1}\text{K}^{-1}$ and $6 \text{ Wm}^{-1}\text{K}^{-1}$ respectively]
- d) Describe how heat transfer by **convection** takes place. [3 marks]
- e) Define and give one example of a **black body**. [2 marks]

SECTION C

9. a) i) With use of a labelled diagram describe how a **cathode ray oscilloscope (CRO)** can be used to measure dc voltage. [5 marks]
- ii) Give two reasons why a CRO is preferred to a moving coil instrument in measuring voltage. [2 marks]
- b) An electron moving with a speed of $3.0 \times 10^6 \text{ ms}^{-1}$ enters midway between two horizontal parallel plates at an angle of 25° to the horizontal as shown in the diagram below.



The plates are 10.0 cm long and 5.0 cm apart. If the voltage across the plates is 200V, Find,

- (i) The time it takes the electron to traverse the region between the plates. [2 marks]
- (ii) The velocity of the electron as it emerges from the region between the plates [4 marks]
- c) In a Millikan's oil drop experiment, a charged oil drop of radius $9.2 \times 10^{-7} \text{ m}$ and density 800 kgm^{-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 marks]
- (ii) Find the electric field intensity that can be applied vertically to move the drop with velocity 0.005 ms^{-1} upwards. [3 marks]
- [Density of air = 1.29 kgm^{-3} ; coefficient of viscosity of air = $1.8 \times 10^{-5} \text{ Nsm}^{-1}$]

10. a) State the laws of **photoelectric effect**. [4 marks]
- b) Define the following terms as used in photoelectric emission.
- (i) **Work function** [1 mark]
 - (ii) **Stopping potential**. [1 mark]
- c) A source emits monochromatic light of frequency 5.5×10^{14} Hz at a rate of 0.1W. Of the photons given out, 15% fall on the cathode 98% of incident photons emit electrons. Calculate the:
- (i) Energy of each photon [2 marks]
 - (ii) Number of photons leaving the source per second [2 marks]
 - (iii) The photocurrent that results. [3 marks]
- d) Potassium $^{44}_{19}\text{K}$ has a half-life of 20 minutes and decays to form $^{14}_{20}\text{Ca}$, a stable isotope of calcium. Given a sample of 10 mg of Potassium, calculate;
- (i) The activity of the sample after one hour. [3 marks]
 - (ii) The ratio of Potassium atoms to calcium atoms after one hour. [4 marks]
11. 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. [2 marks]
 - (ii) Account for the occurrence of the two types of spectra. [4 marks]
- b) i) State **Bragg's law** of X-ray diffraction. [1 mark]
- ii) Derive Bragg's equation. [4 marks]
- c) i) State the energy changes that take place in an X-ray tube during the production of X-rays. [2 marks]
- ii) A beam of X-rays of wavelength 2.0×10^{-10} 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 $N_A = 6.02 \times 10^{23}$) [4 marks]
- iii) Briefly explain any application of X-rays. [3 marks]

12. a) Define the following terms as used for a radioactive substance.

(i) **Isotopes** [1 mark]

(ii) **Mass number** [1 mark]

(iii) **Activity** [1 mark]

b) With the aid of a labelled diagram, explain how a *Geiger Muller tube* is used to detect radioactive substances. [6 marks]

c) A radio isotope ${}^{60}_{27}\text{Co}$ decays to ${}^{60}\text{Ni}$ by emission of a beta particle and two gamma photons. The half-life of ${}^{60}_{27}\text{Co}$ is 5.27 years.

(i) Calculate the maximum energy in MeV of the gamma radiation given off per disintegration. [4 marks]

(ii) Find the power of the radiation emitted by 5g of ${}^{60}_{27}\text{Co}$.

[Mass of ${}^{60}_{27}\text{Co}$ = 59.9338μ, mass of ${}^{60}\text{Ni}$ = 59.9308μ, mass of ${}^0_{-1}\text{e}$ = 0.0005μ]

(1μ = 931Mev) [5 marks]

d) State any two applications of radioisotopes. [2 marks]

PAPER II

SECTION A

1. a) (i) Describe how the focal length of a diverging lens may be determined. (5 marks)

(ii) A cylindrical tube of length 6cm has a concave lens of focal length 18cm, fixed on one end, and a convex lens on the other. When the tube is used to focus a distant object, the image is formed on a screen placed 36cm from the tube. Find the possible values of the focal length of the convex lens. (5 marks)

b) (i) Define **magnifying power** of an optical instrument and **exit pupil**. (2 marks)

(ii) Derive the expression for the magnifying power of telescope with the final image at the near point. (4 marks)

c) A compound microscope has an objective of focal length 1.5cm and the eye piece of focal length 5.0cm. If in normal setting the object is 2.0cm in front of the objective lens, find the:

(i) The separation between the lenses. (3 marks)

(ii) Magnifying power.

(2 marks)

2. a) (i) Define the term ***deviation of light***. (1 mark)
- (ii) Derive the expression for the deviation produced by a small angle prism when light is incident on it at a small angle of incidence. (4 marks)
- b) When light is incident on a prism of refractive index 1.52, at an angle of incidence 36° , it emerges making angle 54.3° with the normal on the opposite face. Find the angle of minimum deviation of the prism. (4 marks)
- c) (i) Describe an experiment to determine the *refractive index* of a liquid using an air cell. (5 marks)
- (ii) Describe briefly the theory used in the experiment in c(i) above. (3 marks)
- d) Explain why we are able to see the sun rise in the morning. (3 marks)

SECTION B

3. a) (i) State two characteristics of waves. (1mark)
- (ii) Explain why sound is louder at night than during day. (2 marks)
- b) (i) State the *principle of superposition* of waves. (1mark)
- (ii) Derive the equation of a stationary wave. (2 marks)
- c) (i) Define the term fundamental frequency as applied to waves. (2 marks)
- (ii) Describe an experiment to show the dependence of frequency of a vibrating string on its wavelength. (5 marks)
- (iii) A wire of length 100cm is under tension of 2N, and produces a note of 100 cycles per second when plucked in the middle. Calculate the frequency of the first overtone. (2 marks)
- d) (i) Define the term ***Doppler Effect***. (1 mark)
- (ii) A man riding a bicycle towards a wall at a velocity of 4m/s blows a whistle which makes 600 cycles per second. If the velocity of sound in the air at that time was 320ms^{-1} . Calculate the frequency of beats heard by the man. (4 marks)
4. a) (i) What is meant by ***coherent sources*** of waves? (1 mark)
- (ii) Distinguish between ***interference*** and ***diffraction*** of light. (2 marks)
- b) With the aid of suitable sketches, explain the following:
- (i) Division of wave front (2 marks)
- (ii) Division of amplitude (2 marks)

- 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. (2 marks)
 - (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. (3 marks)
- 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. (4 marks)
 - (ii) If $x = 0.27 \text{ cm}$ how many bright bands are seen when viewed in the reflected light. (3 marks)

SECTION C

5. a) State the **laws of electromagnetic induction**. (2 marks)
- b) (i) Show that the magnitude of *e.m.f* induced across the ends of a rod of length L, perpendicular to a magnetic field of flux density B moving at a velocity u, in a direction inclined at an angle θ to the magnetic field is , $E = BLu \sin \theta$.
- (ii) At a certain place on the earth, when a horizontal metal rod of length 15m facing east-west is moved northwards at a speed of 200 ms^{-1} , emf of 1.2mV develops between its ends. When the rod is moved at the same speed vertically upwards , emf of 6mV develops between its tips. Find magnetic flux density of the earth at that place. (4 marks)
- c) (i) Write the expression for the magnetic flux density along the axis of a solenoid of n turns per meter, carrying current I. (1 mark)
- (ii) Describe the direct method of determining resistance. (5 marks)
- (iii) Why is the method above called direct method? (1 mark)
- d) A coil of 30 turns' each of radius 4cm is wound tightly around the middle of a solenoid of 150 turns per meter so that the axes of the coils coincide. The solenoid carries current I and the coil is connected to a ballistic galvanometer of sensitivity

$2.4\mu\text{Crad}^{-1}$ and resistance 4Ω . When current in the solenoid is reversed, the ballistic galvanometer deflects through 2.5rad . Find current that was flowing in the solenoid.

(4 marks)

6. a) (i) Define **one ampere**. (1 mark)
- (ii) Describe how the magnetic flux density at the center of a coil may be determined using a current balance. (5 marks)
- b) (i) A rectangular coil of N turns measuring a cm by b cm is placed in a magnetic field of flux density, B . If a current of, I flows through the coil, derive the expression for the magnetic torque experienced by the coil when the normal to the coil makes angle θ with the magnetic field. (5 marks)
- (ii) List the uses of two devices that depend on magnetic torque of a current carrying coil. (2 marks)
- c) A circular coil of 25 turns each of radius 12cm lies on a table. The earth's magnetic field intensity at the location of the coil is 52.7Am^{-1} , while the angle of the dip is 73.0° . Find the:
- (i) Magnetic flux linking the coil. (4 marks)
- (ii) Torque on the coil when a current of 1.5A is passed through it. (3 marks)
7. a) Define the following as applied to alternating current:
- (i) **Root mean square value**. (1 mark)
- (ii) **Reactance**. (1mark)
- b) (i) With the aid of a diagram, describe how a rectifier meter works in the measurement of a.c current. (4 marks)
- (ii) State **two** advantages of the moving iron meter over a moving coil one in measuring a.c. (2 marks)
- c) A capacitor of capacitance C is connected across a source of current of $I = I_0 \sin\omega t$.
- (i) Derive the expression for the reactance of the capacitor. (4 marks)
- (ii) Sketch using the same axes, graphs to show the variation of voltage, V , across a capacitor and current, I , flowing in the circuit, and comment on the graph. (3 marks)

- (iii) Explain the phase relationship between, V, and, I, as identified in (ii) above. (2 marks)

d) A circuit consists of a capacitor of capacitance, $5.0\mu\text{F}$ and a resistor of resistance 2000Ω connected in series. An alternating emf of 12V and frequency 60Hz is applied across the combination. Find the;

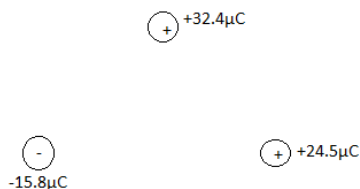
- (i) current supplied (2 marks)
(ii) Voltage across the capacitor. (2 marks)
(iii) average power supplied. (1 mark)

SECTION D

8. a) What is meant by an:

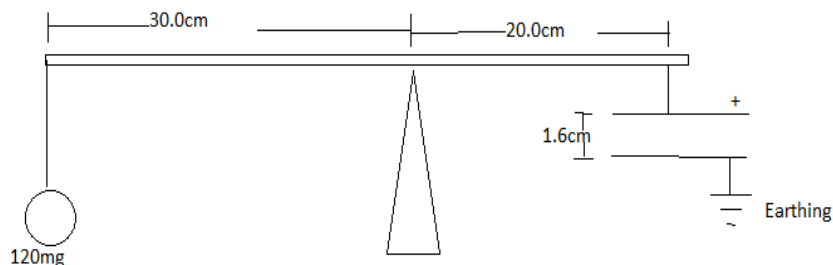
- (i) **Electric field?** (1 mark)
(ii) **Electric field line?** (1 mark)

b) Sketch the electric field pattern due to the charge distribution below:



c) (i) Derive the relationship between **electric field intensity** and **electric potential**. (3 marks)

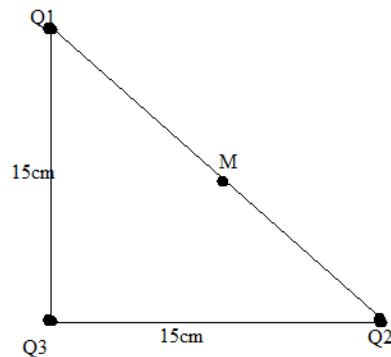
(ii) A neutral polythene ball of mass 120mg is hanged at one end of a light uniform wooden beam at 30.0cm mark from the knife edge, while a charged parallel plate capacitor is at 20.0cm from the knife edge as shown in figure below:



Given that the charge on the capacitor is $0.24\mu\text{C}$ and the plate separation is 1.6cm, determine the p.d across the plates of the capacitor. (4 marks)

- e) (i) A pin is placed on the cap of a positively charged gold leaf electroscope with its sharp end off the cap. Explain what is observed? (3 marks)
- (ii) Describe an experiment to show that the surface of pear shaped conductor is an equipotential. (3 marks)

(e)



Charges Q_1 , Q_2 , and Q_3 of magnitudes $+2\mu\text{C}$, $-3\mu\text{C}$ and $+5\mu\text{C}$ are situated at the corners of a triangle respectively as in figure above. Find the work done to move charge Q_3 to point M, mid-way between Q_1 and Q_2 . (4 marks)

9. a) Define **relative permittivity** and **dielectric strength**. (2 marks)
- b) Describe how you can determine relative permittivity of a material using a circuit with vibrating reed switch. (4 marks)
- c) Two identical capacitors of capacitance C are connected in a series across a voltage source of V . A dielectric of relative permittivity ϵ_r is inserted in one of the capacitors, and then they are charged fully. The voltage source is now removed and is replaced with an empty identical capacitor with air between its plates. Show that the p.d across the new capacitor will be $V' = \frac{\epsilon_r V}{(2\epsilon_r + 1)}$ (4 marks)

(d)

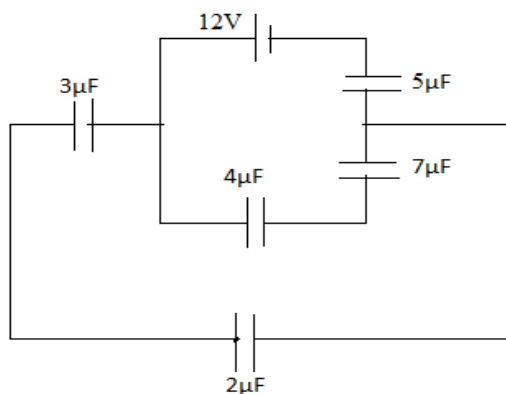
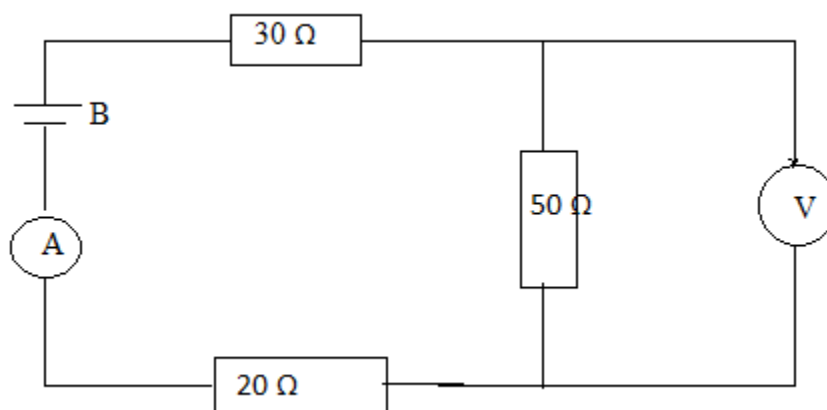


Figure 5 shows a network of capacitors connected to a d.c supply of emf 12V

Calculate the

- (i) energy stored in the network (4 marks)
- (ii) pd across the $5\mu\text{F}$ capacitor. (4 marks)
- e) State **two** uses of capacitors in an electrical circuit. (2 marks)

10. a) Define **terminal p.d** and **one volt**. (2 marks)
- b) Derive the condition for maximum power dissipated in a variable resistor of resistance, R , connected to a battery of emf E and internal resistance, r . (4 marks)
- c)



In figure above, B is a battery of four cells each of emf 10V and internal resistance 15Ω . A is an ammeter of resistance 1Ω and V is a voltmeter of resistance 140Ω .

Calculate:

- (i) Power dissipated in the battery. (4 marks)
- (ii) reading of the voltmeter. (4 marks)

PHYSICS PRACTICAL (P510/3)

1.

x(m)	t(s)
0.900	19.04
0.800	21.49
0.700	24.11
0.600	27.96
0.500	33.63
0.400	42.24

where t = time for 20 oscillations.

a) Copy the table include values of $\frac{1}{x^2}$ and T^2 (where T = time for one oscillation).

b) Plot a graph of T^2 against $\frac{1}{x^2}$.

c) Determine the slope S of the graph.

d) Calculate the value of moment of inertia I of the meter rule from the expression:

$$I = \frac{SMg}{4\pi^2 l}$$

where $\pi = 3.14$, $g=9.81 \text{ ms}^{-2}$, $M=120.50\text{g}$ and $l = 50.0\text{cm}$.

2.

$i(^{\circ})$	$r(^{\circ})$	$l(\text{cm})$
10	6	6.5
20	13	6.7
30	19	6.9
40	25	7.2
50	31	7.6
60	35	7.9

$w = 6.50 \text{ cm}$.

a) Copy the table include values of $l \sin i$ and $w \tan r$.

b) Plot a graph of $l \sin i$ against $w \tan r$.

c) Determine the slope n of the graph.

3.

$x(m)$	$l(m)$
0.200	0.470
0.300	0.442
0.400	0.425
0.500	0.405
0.600	0.392
0.700	0.370

a) Copy the table include values of $\frac{1}{l}$.

b) Plot a graph of $\frac{1}{l}$ against x .

c) Determine the slope S of the graph.

d) Read and record the intercept C on the $\frac{1}{l}$ - axis.

e) Calculate the value of the resistivity ρ of the wire from the expression:

$$\rho = \frac{\pi S R d^2}{4C}$$

where $\pi = 3.14$, $d = 0.38 \text{ mm}$, $R = 10 \Omega$.