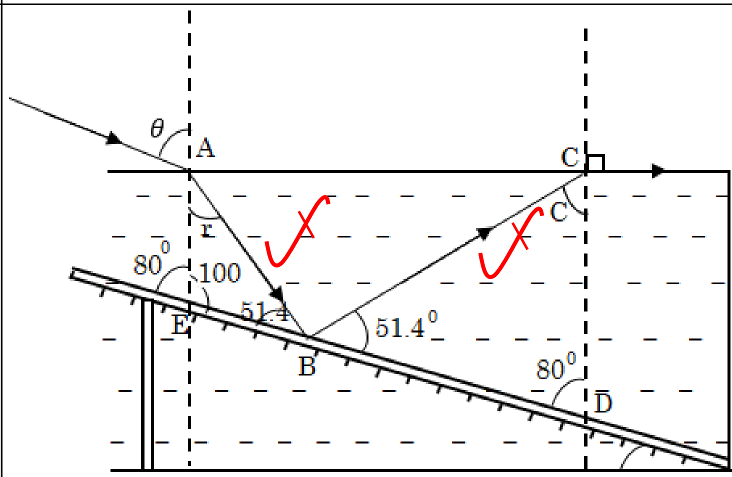
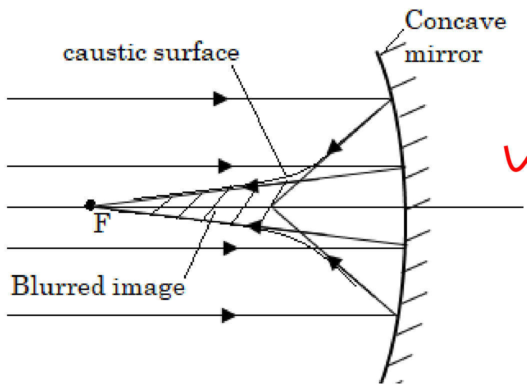
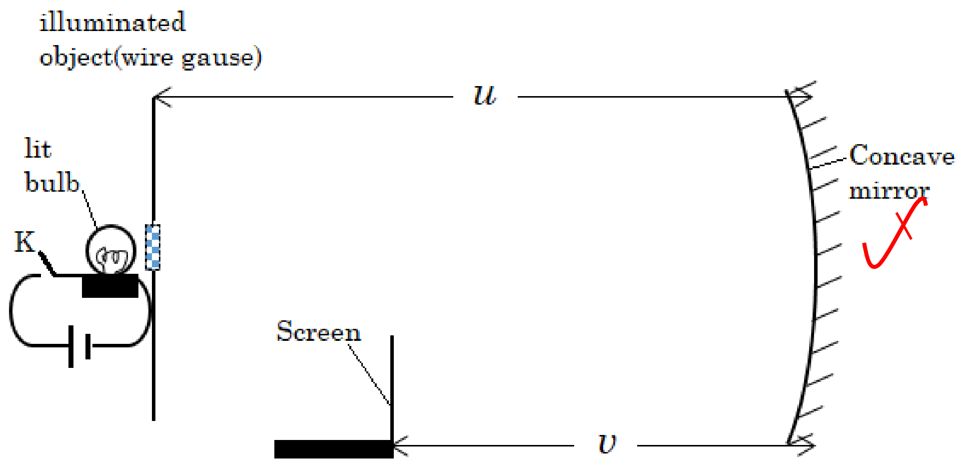
MATIGO EXAMINATIONS BOARD

P510/2
PHYSICS
MARKING GUIDE 2023
PAPER 2

Qn	Answer	Marks
1(a)(i)	Real depth is the actual distance of an object beneath the surface of the medium.	**01**
(ii)	Apparent depth is the depth of an object in a denser medium as seen from the rarer medium. Note: A rarer medium is a medium in which the speed of light is more.	**01**
(b)	 *Snell's law at point C: Critical angle,* $C = sin^{-1}\left(\frac{1}{n}\right)$ $= sin^{-1}\left(\frac{1}{4/3}\right)$ $C = 48.6°$ From the geometry of triangle CBD, it gives the glancing angle at B to be: $g = 180 - (80 + 48.6) = 51.4°$ Also from triangle ABE, angle of refraction, $r = 180 - (100 + 51.4)$ $r = 28.6°$ *Applying Snell's law at A:* $nsini = constant$ $\sin\theta = \frac{4}{3} sin\ 28.6°$ $\therefore\ \theta = sin^{-1}\left[\frac{4}{3} sin 28.6\right]$ $= 39.7°$	**05**

<table>
<tr>
<td>(c)(i)</td>
<td>When a wide beam of light is incident on the concave mirror of large aperture; marginal rays and central rays do not pass through a single focus after reflection. They instead form a caustic curve with its apex at the principal focus as shown below:


The distortion causes blurring of images due to overlap of the coloured edges.</td>
<td>03</td>
</tr>
<tr>
<td>(ii)</td>
<td>It can be minimized by:

Using parabolic mirrors. These mirrors focus the parallel beam to the principal axis at its focus no matter how wide the beam is.
Reducing the aperture of the spherical mirror using a disc which can cut off marginal rays. However this makes the image less bright and some details may be left out.
</td>
<td>02</td>
</tr>
<tr>
<td>(d)</td>
<td>

An illuminated object is placed in front of a concave mirror a known distance, u from it slightly greater than its approximate focal length.
The position of the screen is adjusted to focus the image on the screen.
The image distance, v is measured using a metre rule & recorded.
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- The experiment is repeated for different values of , u and corresponding values of v determined. The results are tabulated including values of $\frac{1}{u}$ and $\frac{1}{v}$.
- A graph of $\frac{1}{v}$ against $\frac{1}{u}$ is plotted and the intercepts C_1 and C_2 on $\frac{1}{v}$ *axis* and $\frac{1}{u}$ *axis* determined respectively.
- Focal length, f is obtained from $f = \frac{1}{2}\left(\frac{1}{C_1} + \frac{1}{C_2}\right)$

NOTE: Accept pin — no parallax method and other methods involving graphical analysis

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<td>05</td>
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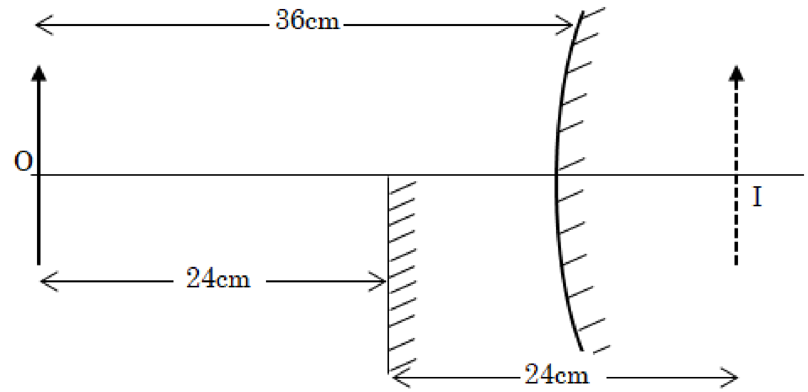
<tr>
<td>(d)(ii)</td>
<td>



Object distance , $u = 36cm$

Image distance, $v = -(36 - 24) = -12cm$

Action of the convex mirror;

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

$$\frac{1}{f} = \frac{1}{36} - \frac{1}{12}$$

$$= \frac{1-3}{36}$$

$$= \frac{-2}{36}$$

$\therefore$ *Focal length of the convex mirror*, $f = -18cm$, *hence*

radius of curvature, $r = 2f = 2 \times -18$

$-36cm$

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<td>03</td>
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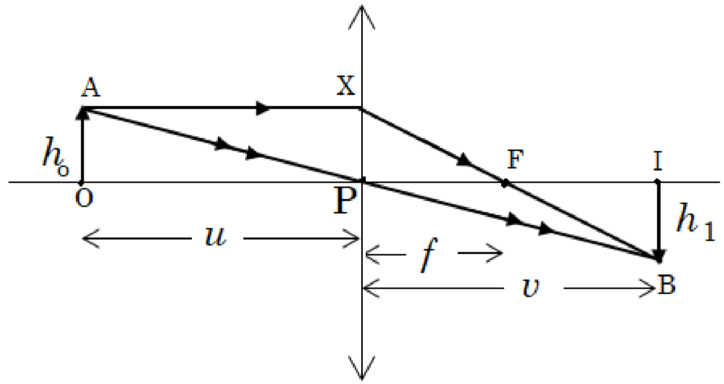
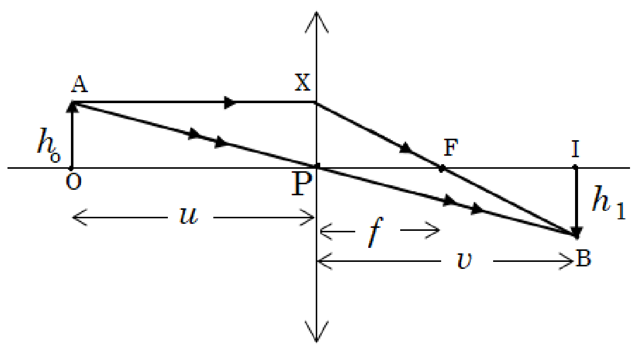
<table>
<tr><td>2(a)(i)</td><td>Focal plane: This is a vertical plane perpendicular to the principal axis of the lens containing the principal focus. ✓</td><td>01</td></tr>
<tr><td>(ii)</td><td>


✓

- Consider triangles FBI and FPX which are similar;
$$\frac{PX}{PF}=\frac{IB}{IF} \Rightarrow \frac{PX}{IB}=\frac{PF}{IF} \Rightarrow \frac{h_0}{h_1}=\frac{f}{v-f} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (i)$$ ✓
- Also triangles AOP and PIB are similar
$$\frac{AO}{OP}=\frac{IB}{IP} \Rightarrow \frac{AO}{IB}=\frac{OP}{IP} \Rightarrow \frac{h_0}{h_1}=\frac{u}{v} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (ii)$$ ✓
- Equating (i) to (ii)
$$\frac{f}{v-f}=\frac{u}{v} \Rightarrow fv=uv-uf \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (iii)$$ ✓
- Divide throughout equation (iii) by uvf, we obtain:
$$\frac{1}{f}=\frac{1}{u}+\frac{1}{v}$$ ✓
</td><td>05</td></tr>
<tr><td>(iii)</td><td>
To show that: $m=\frac{v}{u}$for a converging lens.



✓
</td><td></td></tr>
</table>

- Triangles AOP and PIB are similar

$$\frac{AO}{BI} = \frac{OP}{PI} \Rightarrow \Rightarrow \frac{h_0}{h_1} = \frac{u}{v} \Rightarrow \frac{h_1}{h_0} = \frac{v}{u}, but\ m = \frac{h_1}{h_0}$$

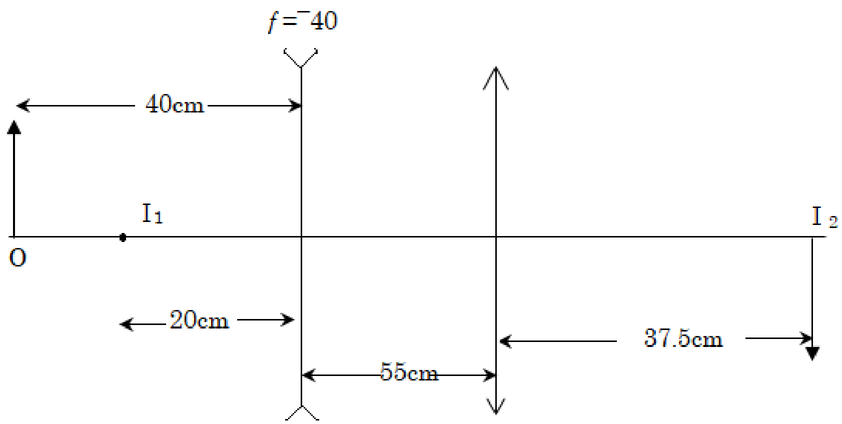
Hence magnification,

$$m = \frac{v}{u}$$

$$m = \frac{image\ distance\ from\ the\ lens}{object\ distance\ from\ the\ lens}$$

03

(b)



Action of the concave lens.

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v} \Rightarrow \frac{1}{v} = \frac{1}{-40} - \frac{1}{40} \Rightarrow v = -20cm$$

Action of the convex lens.

$u = (20 + 55) = 75cm\ , v = 37.5cm, \frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

$$= \frac{1}{75} + \frac{1}{37.5}$$

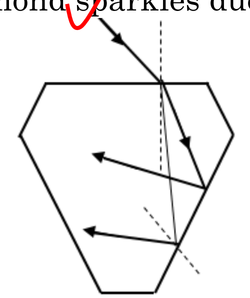
$$\Rightarrow f = 25cm.$$

Focal length of the converging lens is 25cm.

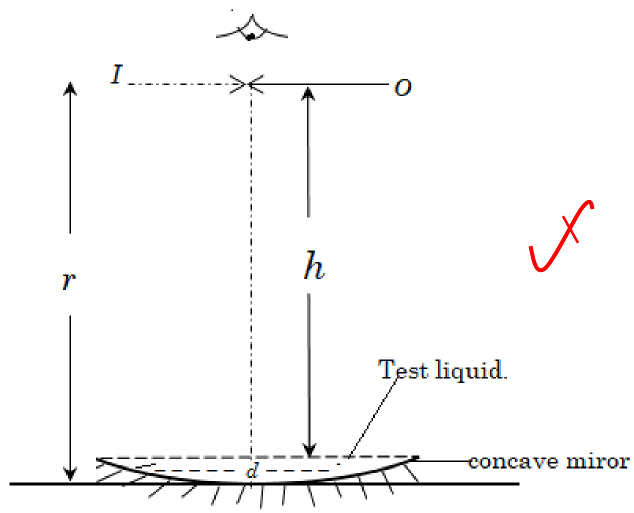
04

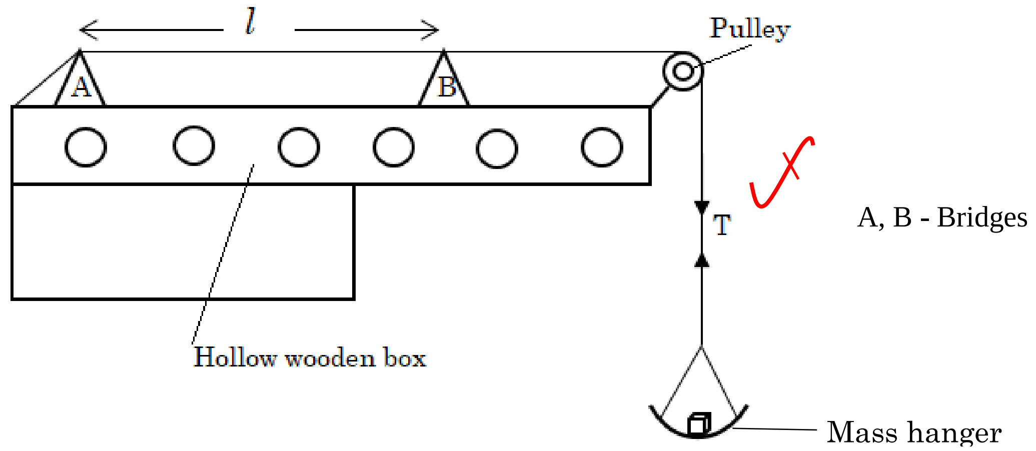
(c)

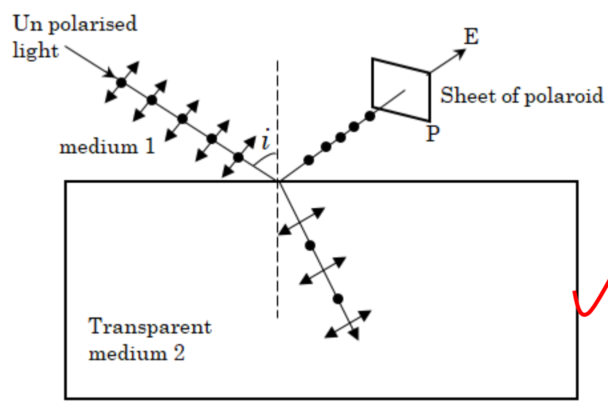
Due to high refractive index, the critical angle of substances like diamond is very small, $C = sin^{-1}\left(\frac{1}{n}\right)$, so most of the light incident on diamond is totally internally reflected repeatedly and diamond sparkles due to multiple total internal reflection at various facets within the diamond before it comes out.

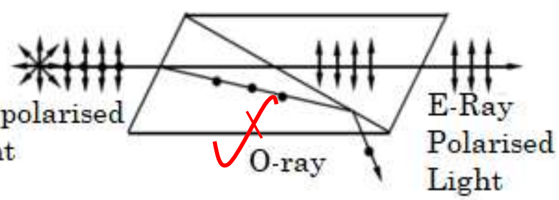


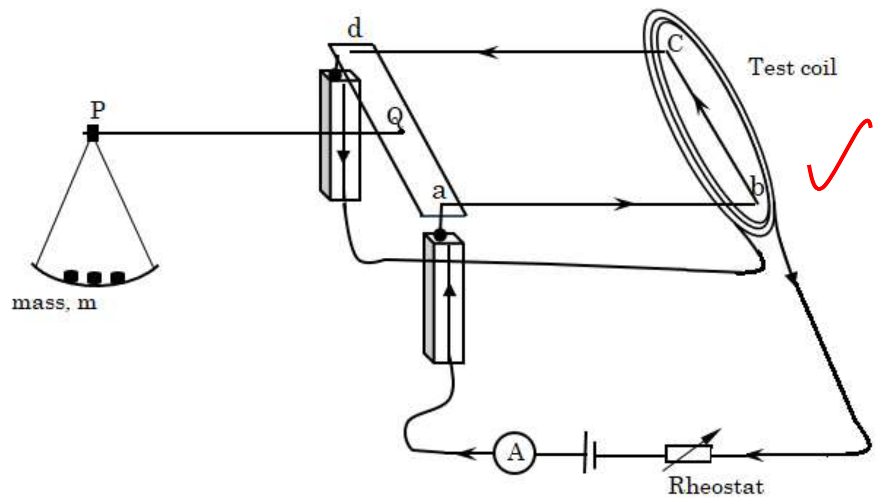
03

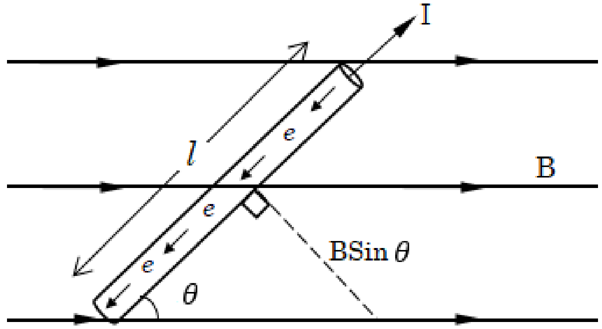
(d)	 • A concave mirror is placed on an optical bench with its reflecting surface acting upwards. • A pin is clamped horizontally on a retort stand with its tip along the principal axis. • The position of the pin is adjusted until it coincides with its image without parallax between them. • The height, r of the pin above the pole of the mirror is measured using a metre rule.. • A small quantity of the test liquid is poured into the mirror. The position of the pin is again adjusted until it coincides with it image without parallax between them. • The height, h of the pin above the liquid is measured using a metre rule.. • Refractive index of the liquid is obtained from $n = \frac{r}{h},$ or $n = \frac{r-d}{h}$, where d is the depth of the liquid.	**05**
3(a)(i)	Beat period: This is the time interval between two successive beats. Or the time interval between two intense sounds heard.	**01**
(ii)	Beat frequency; $f_b = f_1 - f_2$ where $f = \frac{v}{\lambda}$ $$f_b = v\left(\frac{1}{\lambda_1} - \frac{1}{\lambda_2}\right), where\ f_b = \frac{n}{t} = \frac{7}{4}$$ $$\therefore velocity\ of\ sound, v = f_b(\lambda_1 - \lambda_2)$$ $$= \frac{7}{4}(2.02 - 2.0)$$ $$= 0.035ms^{-1}$$	**03**
(b)(i)	Laws of vibration of a fixed string. • **Law of length:** The fundamental frequency of a stretched string is inversely proportional to its vibrating length, if tension and mass per unit length are kept constant. i.e $f \propto \frac{1}{l}$	

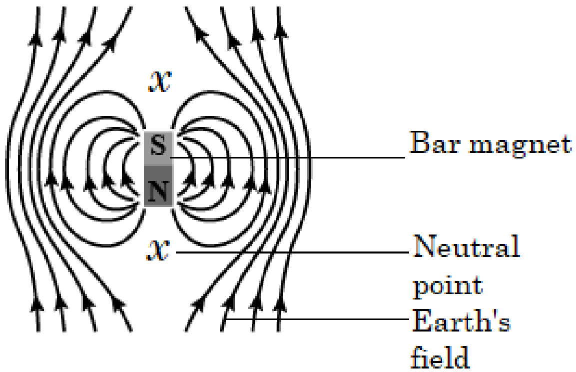
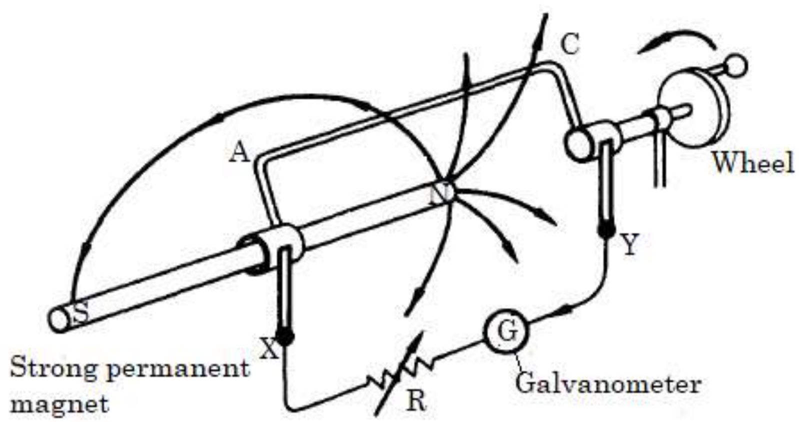
	• **Law of tension:** The fundamental frequency of vibration of a fixed string is directly proportional to the square root of tension in the string. $f \propto \sqrt{T}$. If the length and mass per unit length are kept constant. • **Law of mass or linear density:** The fundamental frequency of vibration of the string is inversely proportional to the square root of its mass per unit length, if tension and length are kept constant. $f \propto \sqrt{\frac{1}{\mu}}$	03
(ii)	 • The setup is put as shown above. • The wire under tension is made by putting weights on the mass hanger. • The wire is then plucked in the middle. Different tuning forks of different frequencies are then brought near the wire in turn, one at a time to find out the one that resonates with it. • The frequency f_1 of the resonating tuning fork is noted. • Keeping l and T constant. The procedure is repeated with the string plucked at a distance of $\frac{1}{4}l$ and $\frac{1}{8}l$ from bridge A. • It is found that in each case, the frequency of the resonating tuning fork will be different. • Hence the wire under tension vibrates with more than one frequency.	05
(c)(i)	Stationary waves are formed when two progressive waves of same frequency and amplitude moving in opposite direction superpose, At points where the waves meet in phase reinforcement/ constructive interference occurs forming regions of maximum displacement called antinodes are formed and At points where waves meet out of phase, cancellation occurs leading to region of zero displacement called nodes are these antinodes and anti-constitutes a stationary wave.	03
(ii)	Frequency, $f = nf_0$ where f_0 is the fundamental frequency. $$f_0 = \frac{v}{4l}, for\ closed\ pipes$$ $$\therefore f = \frac{nv}{4l}$$	

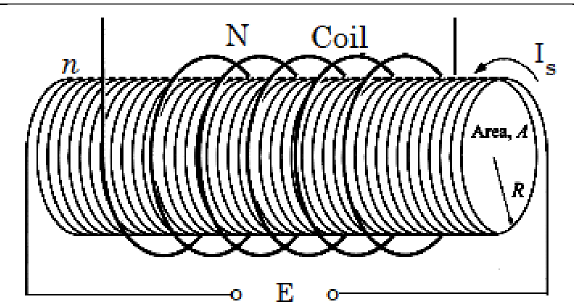
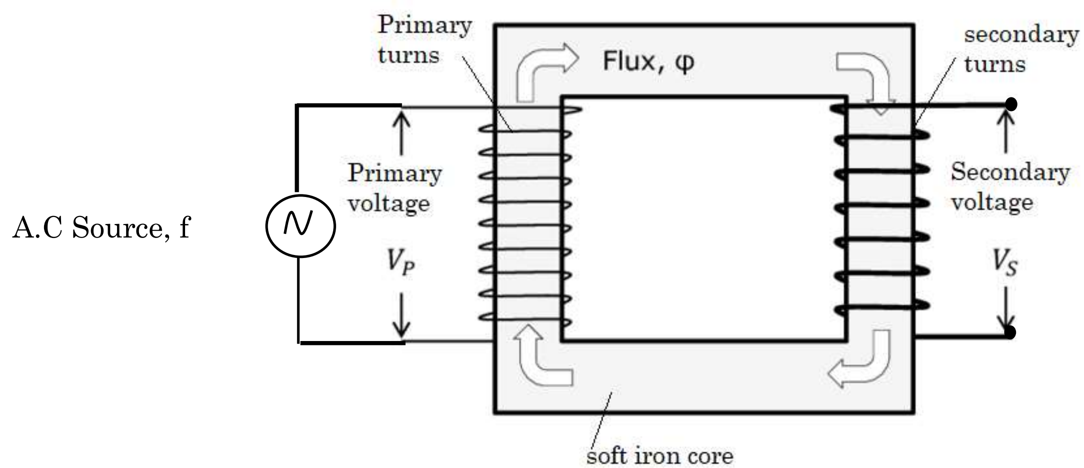
	$$760 = \frac{n300}{4 \times 0.4} \Rightarrow n = 4.053.$$ $But\ closed\ pipes\ have\ only\ odd\ harmonics.\ n = 1,3,5 \ldots\ Hence\ n = 5;$ $the\ mode\ of\ vibration\ is\ 5^{th} harmonics.\ To\ cater\ for\ end\ correction,\ c\ then$ $$f = \frac{nv}{4(l+c)}$$ $$760 = \frac{5 \times 300}{4(0.4 + C)} \Rightarrow C = \frac{5 \times 300}{4 \times 760} - 0.4$$ $$= 0.0934m$$ $$= 9.34cm$$	**05**
4(a)(i)	Coherent sources are sources which emit a wave with the same frequency, wave length and constant phase difference.	**01**
(ii)	Methods of producing coherent sources are: 1. Division of wave front where a wave front is divided into two or more parts with the help of mirrors, lenses and prisms. 2. The common methods are: young's double slit arrangement, Fresnel bi-prism etc. 3. Division of amplitude where the amplitude of the incoming beam is divided into two or more parts by partial reflection or refraction. 4. These divided parts travel different paths and reunite later to produce interference e.g. Newton's rings, Michelson's inter ferometer etc.	**04**
(b)(i)	Polarized light is one whose vibrations of the electric vector are restricted to only one plane. It is naturally coherent. Un polarized light is one whose vibrations are in all directions or planes. It is incoherent in nature.	**02**
(ii)	How plane polarized light is produced. 	**04**

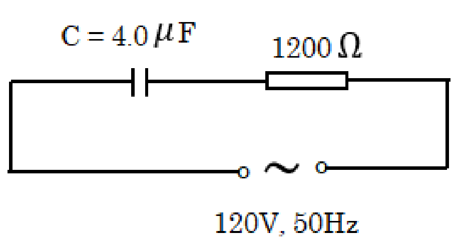
	• A fine beam of un polarized light is made incident on a transparent medium at an angle i. • The light is partially reflected and the other partially transmitted (refracted) into medium 2. • The reflected light is viewed through a sheet of Polaroid while turning the Polaroid sheet about an axis perpendicular to its plane. • The procedure is repeated for other increasing angles of incidence and at a particular angle of incidence called the polarizing angle, i_p, the reflected light gets cut off from the observer at E, for all positions of rotation of polaroid P except only two positions of P. • The two rays are now perpendicular to each other. • The reflected light at this position is completely plane polarized and light is received at E, at only the plane polarization of P.	
OR	 • A narrow beam of monochromatic light is made incident on a nicol prism and viewed from the opposite side as shown above. • The angle of incidence is gradually increased (or changed) and at each angle the Polaroid is rotated about an axis through it plane. • At one point the light gets cut off from the observer, At this point, the emergent light is plane polarized.	
(iii)	• It is used in measurement of concentration of sugar. • Used in stress analysis. • Used in sun glasses to reduce the glare. • Used in liquid crystal display (LCD).	*Any two* **01**
(c)(i)	When two coherent waves from meet they superpose. The interference pattern produced depends on the path difference. If the path difference is a whole number, multiples of full wavelength of wave, reinforcement takes place resulting into a region of maximum intensity. If the path difference in an odd number, multiple of half-wavelength, cancellation takes place resulting into regions of minimum intensity.	**03**

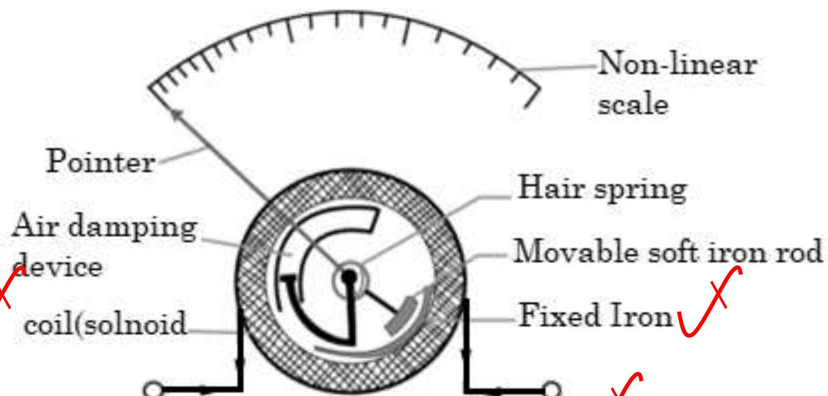
	If these permanent alternative regions of bright and dark fringes formed are called interference pattern. Thus interference has occurred.	
(c)(ii)	Fringe spacing; $y = \frac{\lambda D}{a}$ where $y = \frac{2.0 \times 10^{-3}}{20}$ $\therefore$ wave length, $\lambda = \frac{ya}{D}$ $= \frac{(1.4\times10^{-3})\times(2.0\times10^{-3})}{(20\times10^{-2})\times20}$ $\lambda = 7 \times 10^{-7} m$	**03**
(iii)	The fringe width in the interference fringe pattern obtained will decrease since $y \propto D$ and wavelength of light will increase i.e $\lambda \propto \frac{1}{D}$	**02**
5(a)(i)	An ampere is the steady current which when flowing in each of two infinitely long thin parallel wires, placed 1m apart in a vacuum produced between them a force of $2.0 \times 10^{-7} Nm^{-1}$ of each other's length.	**01**
(ii)	 • The set – up is as shown above with insulator and on the pivot. Length $\overline{PQ} = ab$ and the arm bc of the conducting frames is placed the plane of the coil. • With mass, m fixed, the current in the conducting frame is varied by adjusting the rheostat until the frame balances horizontally. • The ammeter reading I and mass m on the scale pan recorded. The length l of the arm bc is also measured.	

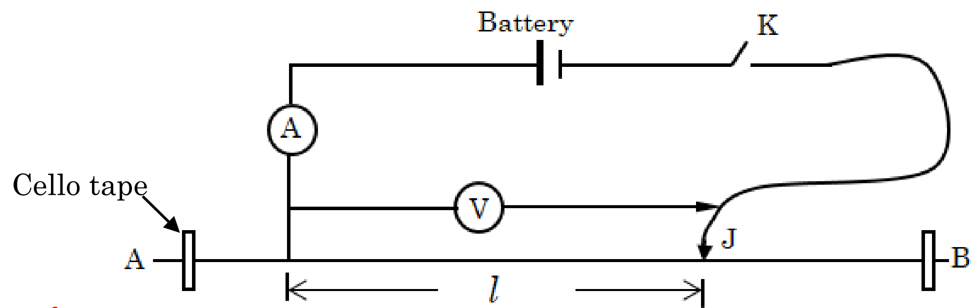
	• Magnetic flux density at the centre of the coil is obtained from. $B = \frac{mg}{Il}$ *where g is the acceleration due to gravity.*	**05**
(b)(i)	Consider a conductor carrying current, I at an angle θ to the magnetic field as shown below.  Component B normal to the conductor is $Bsin\theta$. If the conductor contains n charged particles per unit volume, each of charge, e moving with an average drift velocity, v. the time taken to move a length, l of the conductor is $t = \frac{l}{v}$. Total charge passing through the conductor, ne but current $I = \frac{q}{t} = \frac{ne}{t} = \frac{ne}{l/v} = \frac{nev}{l}$ Now from $F = BILsin\theta$ $= B\left(\frac{nev}{l}\right) lsin\,\theta$ $= nBevsin\theta.\ for\ n = 1\ and\ conductor\ is\ perpendicular\ to\ the\ field\ F = Bev$	
OR	From $f = BIlSin\,\theta\ where\ I = \frac{q}{t} = \frac{ne}{t}$ $= B\frac{ne}{t} lSin\theta\ where\ \frac{l}{t} = v$ $= nBevSin\theta\ but\ for\ n = 1\ and\ \theta = 90°, then:$ $F = Bev$	
(ii)	$A = (1.0 \times 10^{-2})(0.2 \times 10^{-2}) = 2.0 \times 10^{-5} m^2$, I = 50A, n = $6.0 \times 10^{28} m^{-1}$, $B = 1.5T$ $Hall\ voltage, V_H = \frac{BI}{net} = \frac{1.5 \times 50}{(6.0 \times 10^{28}) \times (1.6 \times 10^{-19}) \times (1.0 \times 10^{-2})}$ $= 7.8 \times 10^{-7} V$	**04**
(c)(i)	Magnetic torque is the product of magnitude of one of the forces constituting a couple and the perpendicular distance between the line of action of the two forces, i.e $T = \|F\| \times d$	**01**
(ii)	The devices are: • Moving coil galvanometer • d.c motor	**02**

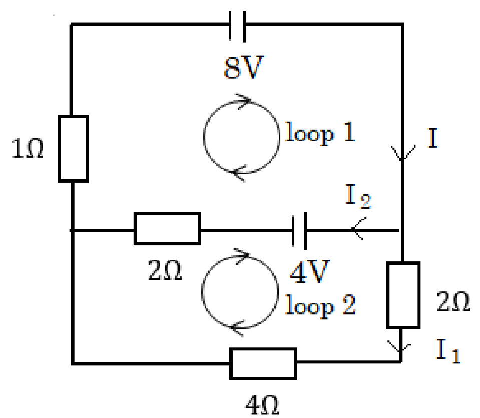
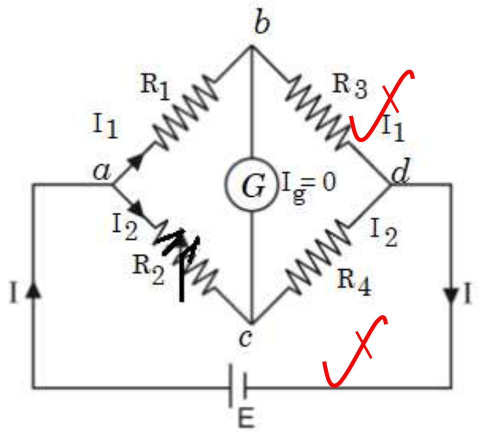
(d)(i)	• Have two poles, the north and south. • Unlike poles of a magnet attract, the like poles repel each other. • The magnetic effect is greatest at the poles of the magnet. • When the magnet is suspended and allowed to rest, it rests with its north pointing in the north south direction.	02
(ii)	The field pattern is as shown below.  -Direction of fields -Position of neutral point -Pattern	02
6(a)(i)	The magnitude of the induced emf is directly proportional to the rate of change of magnetic flux linked with the coil. The direction of the induced emf is such as to oppose the change causing it.	02
(ii)	 *AC − metal frame(copper rod) X and Y are curbon brushes* • The set –up is as above. The metal frame is rotated by means of the wheel. • For a given galvanometer deflection, θ the speed of rotation is maintained and the time for 20 revolutions is recorded.	

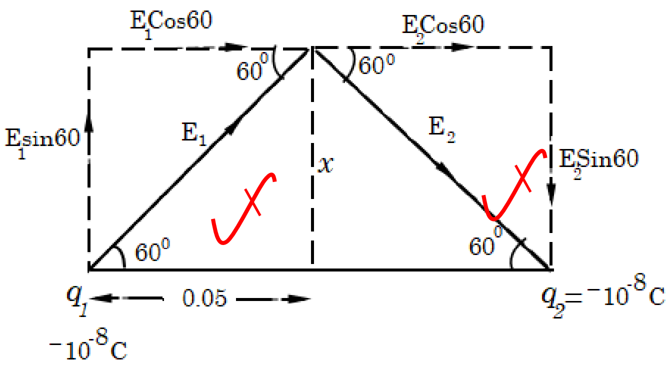
	• The experiment is repeated for other values of the deflection θ and values recorded in a table including values of frequency, $f = \frac{20}{t}$ • A graph of θ against, f is plotted and a straight line through the origin is obtained, this implies that $\theta \propto f$ but $\theta \propto I \propto E$ $$And\ f = \frac{d\varphi}{dt} \therefore E \propto \frac{d\varphi}{dt}$$	**05**
(b)	 Magnetic flux density at the centre of the solenoid, $B = \mu_0 nI$ Magnetic flux linkage with the coil, $\varphi = NBA = N\mu_0 nIA$ $= N\mu_0 nA(5\sqrt{2}Sin100\pi t)$ $Induced\ emf, \varepsilon = \frac{-d\varphi}{dt}$ $= 5\sqrt{2}N\mu_0 nA\frac{d}{dt}(sin100\pi t)$ $= 5\sqrt{2} \times 100 \times (4\pi \times 10^{-7}) \times 250 \times \pi(5 \times 10^{-2})^2 \times 100\pi(cos100\pi t)$ $= 6.17 \times 10^{-5}cos100\pi t$	**04**
(c)(i)	Mutual induction is the production of emf in a circuit due to change of current in a nearby circuit. Self induction is the production of emf in a circuit due to change of current in the same coil.	**02**
(ii)	When R is varied, current in A varies and magnetic flux in A linking B varies, An emf is induced in B and since B is a closed circuit, induced current flows in it and the bulb lights.	**02**
(d)	**Action of an a.c transformer.** 	

	The primary coil is connected to an alternating current supply source. When current flows, it establishes a changing magnetic field in the core which links the primary inducing a back emf in the primary. Since the primary is without resisstance to have finite current , the back emf is equal to the supply voltage, $$V_p = -\frac{N_p AdB}{dt} \ldots\ldots\ldots\ldots\ldots..(i)$$ The same changing magnetic field also links the secondary coil inducing emf in it. Induced emf. $$V_s = -\frac{N_s AdB}{dt} \ldots\ldots\ldots\ldots\ldots..(ii)$$ $$(i)/(ii)\ gives\ \frac{V_s}{V_p} = \frac{N_s}{N_p}$$ When $N_s > N_p and V_s > V_p -\ \ it\ is\ a\ step\ up\ transformer$ When $N_s < N_p and V_s < V_p -\ \ it\ is\ a\ step\ down\ transformer$	**05**
7(a)(i)	Root mean square value of a.c is the value of steady current which dissipate heat in a given resistor at the same rate as the alternating current.	**01**
(ii)	Peal value of a.c is the maximum value of the alternating current.	**01**
(b)	• The action of a moving coil galvanometer depends on *the torque exerted* on the coil in the magnetic field, so to measure alternating current, the torque will urge the coil in a *clockwise* and *anticlockwise* direction at the *frequency of* the alternating current, so that the resultant deflection of the pointer is zero hence no current reading is taken from it. • The hot wire meter however depends on the *heat generated* in the wire (resistance) hence can measure both a.c.	**03**
(c)(i)	Resonant frequency is the frequency at which maximum energy out put is achieved. Or Is the frequency at which the effective opposition to the flow of a.c is minimum and current flowing is maximum Or Is the frequency at which $X_L = X_C$ and the circuit behaves like a pure resistor.	**01**
(c)(ii)	 $$Reactance, X_C = \frac{1}{2\pi f C}$$ $$X_C = \frac{1}{2\pi \times 50 \times (4 \times 10^{-6})}$$ $$= 795.8\Omega$$ $$Impedance, Z = \sqrt{X_C^2 + R^2}$$ $$= \sqrt{795.8^2 + 120^2}$$ $$= 1440\Omega$$	

	$Current\ supplied.\ I = \frac{V}{Z} = \frac{120}{1440} = 0.083A$	03
(ii)	$V_C = IX_C$ $= 0.083 \times 795.8$ $= 66.1V$	$01\frac{1}{2}$
(iii)	Average power supplied $\langle P \rangle = I_{rms}^2 R$ $= \frac{1}{2} I_0^2 R$ $= 0.083^2 \times 1200$ $8.3W$	$01\frac{1}{2}$
d(i)	• In the 1st quarter cycle, when voltage is increasing, the capacitor charges and energy is transferred from the source and stored in the electric field within the capacitor plates. • In the 2nd quarter cycle, when the voltage is decreasing, the capacitor discharges and energy is returned to the source. • In the 3rd quarter cycle, energy is again transferred from the source to the capacitor as capacitor charge in opposite direction. • In the 4th quarter cycle,energy is returned to the source during discharge, so in a full cycle energy stored in the capacitor is zero, hence it is a wattless device.	04
(ii)	 Any two parts labelled well each a half (only if diagram is • Current to be measued is passed through the coil via terminals as shown above. • In whatever direction of current, the soft iron rods become magnetized in the same sense and therefore repel. • The movable iron rod is pushed away and the pointer attached to it is moved/deflects over the scale. • The pointer deflects until it is stopped by the restoring torque due to the hair spring. • Thus the force of repulsion between the rods is proportional to the square of the average current.	04

	• Hence defelection, θ is proportional to the square of the average current i.e $\theta \propto \langle I^2 \rangle$, hence non - linear scale.	
8(a)	Emf is the total work done to move 1C of charge around a complete circuit in which the cell is connected. Internal resistance is the opposition to the flow of current within the cell due to its chemical composition.	**02**
(b)	 V- Voltmeter A- Ammeter K- Switch J - Jockey • A sample of the material of the wire has its diameter measured at three different positions and the average diameter, d is obatined, Cross sectional area A is calculated as $A = \frac{\pi d^2}{4}$ • The length AB of the test wire is mounted on a meter rule as shown in the figure above. • Th circuit is set up as shown above, starting with a measured length, l of wire AB, switch k is closed. • The ammeter and voltmeter reading I and V respectively noted. • The experiment is repeated using increasing measured lengths, l of the specimen wire. • The results are then tabulated in a suitable table of results including values of $l$and $\frac{\text{V}}{\text{I}}$ • Agrapgh of $\frac{\text{V}}{\text{I}}$against l is plotted. The slope, S of the graph is determined. • Resistivity of the wire, $\rho = \frac{S\pi d^2}{4}$ is calculated	**05**
(c)(i)	Law 1: the algebric sum of currents at a junction in a circuit is zero i.e $\sum \text{I} = 0$ Law 2: in any closed loop in a circuit, the algebric sum of emf is equal to the algebric sum of the potential drops $\sum E = \sum IR$	**02**

(ii)	 $I = I_1 + I_2$ $\Rightarrow I_2 = I - I_1 \ldots\ldots\ldots\ldots\ldots (i)$ $Consider\ loop 1:$ $(8-4) = 2I_2 + I \times 1$ $\therefore 4 = 2I_2 + I$ $4 = 3I - 2I_1 \ldots\ldots\ldots\ldots\ldots (ii)$ $Loop\ 2: \ 4 = 6I_1 - 2I_2$ $4 = 8I_1 - 2I \ldots\ldots\ldots\ldots\ldots (iii)$ $from\ (ii) and\ (iii)$ $3I - 2I_1 = 8I_1 - 2I \quad \therefore I = 2I_1$ $from\ (ii)\ 4 = 3I - 2I_1$ $I = 2A$	03
	$P = I^2R\ but\ I = 1A$ $P = I^2 \times 4$ $= 4W$	02
(d)(i)	 $When\ R_2\ is\ adjusted\ so\ that\ the\ galvanometer\ G\ show\ no\ deflection\ \Rightarrow i.e\ I_g =$ $0\ potential\ at\ b =$ $potential\ at\ C. same\ current\ I_1 flow\ through\ R_1\ and\ R_3\ at\ balance,$ $and\ same\ current\ I_2\ passes\ through\ R_2 \& R_4$ $\Rightarrow p.d\ across\ ab = p.d\ across\ ac$ $I_1R_1 = I_2R_2 \ldots\ldots\ldots\ldots (i)$ $Also \Rightarrow p.d\ across\ bd = p.d\ across\ cd$ $I_1R_3 = I_2R_4 \ldots\ldots\ldots\ldots (ii)$ $Divide\ (i) by\ (ii) we\ get;$ $\frac{R_1}{R_3} = \frac{R_2}{R_4}\ Balance\ condition$ Correctly drawn Circuit diagram	04
(ii)	eter bridge is unsuitable for measurement of too high resistances because the metre deflections will be too small due to low current similarly, for very low resistances, the resistance will be comparable to the contact, resistance and that of wire causing end error measurements.	03
9(a)(i)	Coulomb's law states that "force between two point charges is directly proportional to the product of the magnitudes of the charges and inversely proportinal to the square of their mean distance apart"	01
(ii)	$x = \sqrt{0.1^2 - 0.05^2}$ $= \sqrt{0.0075} m$ $Electric\ field\ intensity$	



$$E = \frac{KQ}{r^2}$$

$$E_1 = \frac{9 \times 10^9 \times 10^{-8}}{0.1^2}$$

$$= 9{,}000NC^{-1}$$

$$E_2 = \frac{9 \times 10^9 \times 10^{-8}}{0.1^2}$$

$$= 9{,}000NC^{-1}$$

$$\overrightarrow{E_X} = E_1 Cos\ 60 + E_1 Cos\ 60$$
$$= (9{,}000 + 9{,}000)\cos 60$$
$$= 9{,}000NC^{-1}\ to\ the\ right$$
$$\uparrow E_Y = E_1 Sin\ 60 - E_1 Sin\ 60$$
$$= (9{,}000 - 9{,}000)\ \mathrm{Sin}\ 60$$
$$= 0NC^{-1}$$

NB: Students must define any symbol used.

−Directions of E_1 and E_2 @ $\frac{1}{2}$

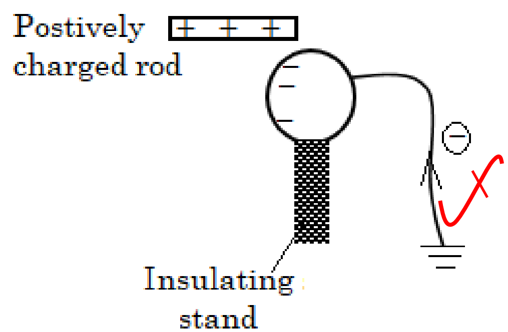
−General formula @ $\frac{1}{2}$

−Substitution of E_1 and E_2 @ $\frac{1}{2}$

−Answers of E_2 and E_2 @ $\frac{1}{2}$

$\therefore$ *Resultant electric field intensity* $E = \overrightarrow{E_X} = 9{,}000\ NC^{-1}$ *to the right*

(b)(i)



NB: Take the alternative of

A positively charged body brought close to a neutral conductor on insulating stand

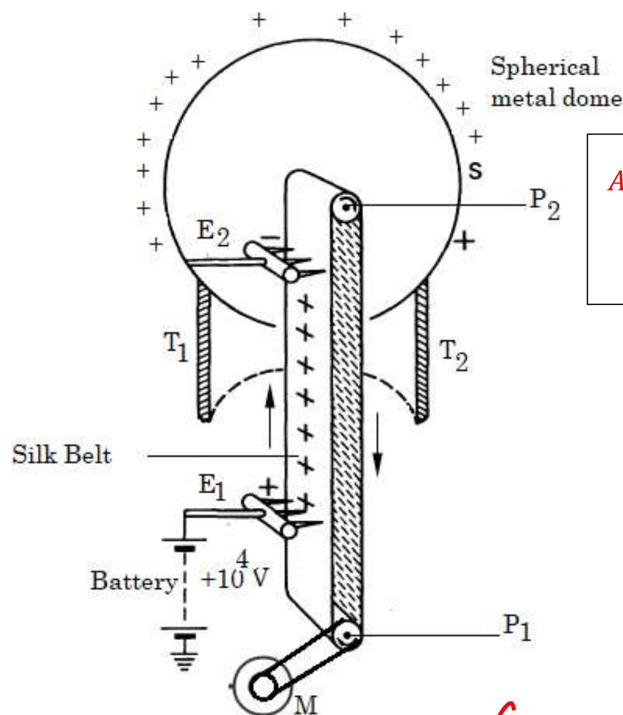
- The conductor is placed on an insulating stand and connected to the ground.
- A positively charged body is brought close to it.
- Negative charges are attracted from the ground to the near side of the conductor.
- The earthing is removed and the charging material also removed.
- Negative charges now distribute it self all over the conductor.

03

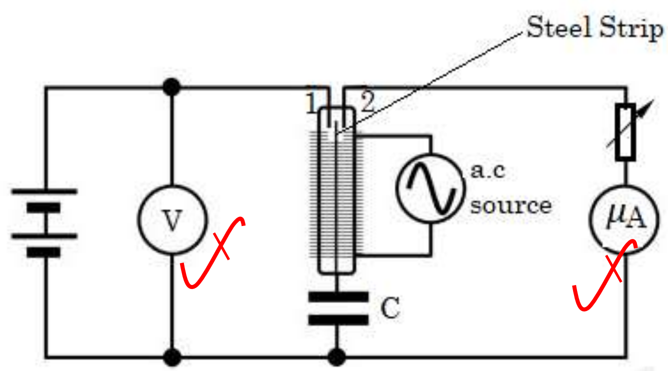
(ii)

- When a conductor (neutral) is placed near a negatively charged material, it induces positive charge on the near side of the conductor and negative charges to the far end.
- The potential of at a point negatively charged material is the sum of potential due to its charge and the neigbouring charges.

03

	• Since the resultant potential due to the induced charge is positive and the potential at a point in negatively charged material of A is negative, then the negative potential on the surface of negatively charged material is reduced.	
(c)(i)	Electrostatic shielding is the process of creating an electrically neutral space in the neigbourhood of an electric field./a charged body. This is achived by surrounding a charged body with an earthed hollow coductor. (faraday cage). OR is a process of generating an electricall neutral space in the neighbourhood of a charged body in order to protect it from effects of external field or prevventing the neig hbourhood from effect of charged body. This is done by enveloping the body in an insulated hollow conductor (faraday cage) or enclosing charged body in an earthed faraday cage respectively.	**02**
(ii)	**The Van de graff generator.**  *Any two major parts labelled @ $\frac{1}{2}$ marks* *Ensure its a working diagram.* $E_1, E_2 - Electrodes$ $P_1, P_2 - Pulleys$ $m - motor$ $T_1, T_1 - insulating\ stands$ • The electrode E_1 is highly charged to a potential of about $+10^4 V$ relative to the earth by the battery. • High charge density at E_2 creates a high electric field intensity at E_1 which ionises the air around it. positive charges are repelled onto the belt. which is driven by the motor carries the charge into the sphere.	**06**

	• On approaching $E_2$the ions (positive) induce negative charge onto the spikes of $E_2$and positive charges on to the sphere to which the blunt end, of $E_2$is connected. • The electric field intensity around E_2ionises air around $E_2$and negative ions are repelled onto the belt neautralising positive charge there before the belt goes over the pulley P_2 • The process is repeated several times persecond, building a large amount of charge onto the sphere to about $10^6 V$	
10(a)	Dielectric field strength is the maximum electric field intensity that the insulator can with stand without dielectric breakdown. OR Dielectric field strength is the maximum potential gradient a dielectric material can with stand before it starts conduct	**01**
(b)(i)	When the sheet of a dielectric is inserted between capacitor plates initially charged; the molecules of the dielectric get polarised. The surface adjacent to the plates develop a charge opposite to that on the near plate. Since charges with in the dielectric are bound charges, they donot neutralise. An eleectric field is set up in the dielectric which opposes the one due to the applied p.d across the plates. The resultant electric field intensity, thus reduces. Since $E = \frac{V}{d}$ the $p.d, V$ between the plates also decreases	**04**
(ii)	$Initial\ charge, Q = cv$ $= 100C \ldots\ldots\ldots\ldots(i)$ $when\ the\ dielectric\ is\ inserted\ , the\ charge\ is\ conserved$ $Q = \ \varepsilon_r C \times 50 \ldots\ldots\ldots\ldots\ldots(ii)$ $Equating\ (i) to\ (ii)$ $50\varepsilon_r C = 100C$ $Dielectric\ constant, \varepsilon_r = 2\ but\ \varepsilon_r = \frac{\varepsilon}{\varepsilon_0}$ $\therefore\ permitivity\ of\ the\ sheet\ , \varepsilon = 2 \times 8.85 \times 10^{-12}$ $= 1.77 \times 10^{-11} F^{-1} m$	**04**
(c)	Suppose the charge in the plate is q and total p.d across the plates is V. if a small charge,q is transferred from one plate to another. The small work done increasing charge by δq is $\delta w = (V + \delta V)\delta q$ $= V\delta q + \delta v\delta q\ but\ \delta v\ , \delta q\ being\ very\ small;\ \delta v\delta q \approx 0$ $\delta w = V\delta q\ but$ $V = \frac{q}{C}$ $\delta w = \frac{q}{C}\delta q$	**04**

	Total work done in accumulating charge from 0 *to maximum charge Q is W* $W = \int_0^W dw = \int_0^Q \frac{q}{C}dq = \frac{1}{C}\int_0^Q q\,dq$ $W = \frac{1}{C}\left[\frac{1}{2}q^2\right]_0^Q$ $= \frac{1}{2}\frac{Q^2}{C}\, but\; Q^2 = C^2V^2$ $W = \frac{1}{2}CV^2,$ $Hence\; eneergy\; stored, E = \frac{1}{2}CV^2 \;\; or\; E = \frac{1}{2}\frac{Q^2}{C} \;\; or\;\; E = \frac{1}{2}QV$	
(d)(i)	• It must be an insulator with polarisable molecules • It must have a high dielectric strength. • It must be thin to provide a smaller seperation distance so as to increase capacitance.	**01**
(ii)	Types: e.g dielectric material include • Solids : eg ceramics, paper, mica, glass etc • Liquids: e.g. transformer oil, distilled water etc • Glases: e.g. nitrogen, dry air, helium etc • Vacuum.	**02**
(e)	 • The circuit is set up as shown above. The vibrating read circuit is connected to an a,c supply of known frequency. f • The reed switch is activated and the metal strip vibrates between contact 1 and 2 • The test capacitor, of capacitance C charges when the strip is at contact 1 and discharges when the strip is in contact with 2. • The average value of ammeter reading I and the voltmeter reading V are noted and recorded, together with the frequency, f.	**05**

	• Capacitance, C of the test capacitor is obtained from. $$C = \frac{I}{Vf}$$	

END

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