P510/2
PHYSICS
Paper 2
Nov./Dec.2018
2½ hours

# UGANDA NATIONAL EXAMINATIONS BOARD
## Uganda Advanced Certificate of Education

PHYSICS

**Paper 2**

2 hours 30 minutes

## INSTRUCTIONS TO CANDIDATES:

*Answer* **five** *questions, taking at least* **one**, *from each of the sections* **A**, **B**, **C** *and* **D**, *but* **not** *more than* **one** *question should be chosen from either section* **A** *or* **B**.

*Any additional question(s) answered will* **not** *be marked.*
*Mathematical tables and squared paper will be provided.*

*Non-programmable scientific calculators may be used.*

*Assume where necessary:*

| | |
|---|---|
| *One electron volt (eV)* | $= 1.6 \times 10^{-19}$ J |
| *Acceleration due to gravity, g* | $= 9.81$ ms$^{-2}$ |
| *Electron charge, e* | $= 1.6 \times 10^{-19}$ C |
| *Electron mass* | $= 9.11 \times 10^{-31}$ kg |
| *Plank's constant, h* | $= 6.6 \times 10^{-34}$ Js |
| *Speed of light in a vacuum, c* | $= 3.0 \times 10^{8}$ ms$^{-1}$ |
| *Avogadro's number, $N_A$* | $= 6.02 \times 10^{23}$ mol$^{-1}$ |
| *Charge to mass ratio, e / m* | $= 1.8 \times 10^{11}$ Ckg$^{-1}$ |
| *The constant* $\frac{1}{4\pi\varepsilon_0}$ | $= 9.0 \times 10^{9}$ F$^{-1}$m |
| *Permeability of free space* $\mu_0$ | $= 4.0\pi \times 10^{-7}$ Hm$^{-1}$ |
| *Permittivity of free space, $\varepsilon_0$* | $= 8.85 \times 10^{-12}$ Fm$^{-1}$ |



**Turn Over**

## SECTION A

1. (a) Define the following as applied to a telescope:

   (i) Eye-ring. *(01 mark)*

   (ii) Magnifying power. *(01 mark)*

(b) What is the significance of the eye-ring of an astronomical telescope? *(01 mark)*

(c) State **two** advantages of a reflecting telescope over a refracting telescope. *(02 marks)*

(d) Figure 1 shows an optical system consisting of two thin converging lenses arranged coaxially. Lens $A$ has a focal length of 40 mm and lens $B$ has a focal length of 375 mm. An object $O$ of height 5 mm is placed 50 mm from $A$. $I_1$ is the real image of $O$ in $A$ and $I_2$ is the virtual image if $I_1$ in $B$ and is 250 mm from $B$.

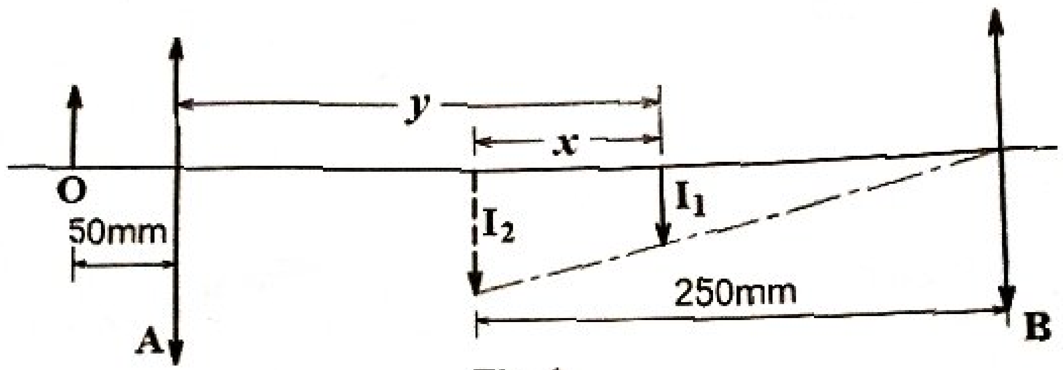


Fig. 1

(i) Determine the value of distance, $y$ of image $I_1$ from lens $A$. *(02 marks)*

(ii) Calculate the distance, $x$ between the images $I_1$ and $I_2$. *(02 marks)*

(iii) Find the linear magnification produced by the lens system. *(02 marks)*

(e) Name **one** defect of images formed by a lens and explain how the defect is minimised in practice. *(03 marks)*

(f) Explain the following;

(i) total internal reflection, *(03 marks)*

(ii) formation of mirages. *(03 marks)*

2. (a) State the **laws of refraction of light**. *(02 marks)*

(b) Derive an expression for the refractive index of a prism in terms of the refracting angle $A$, and the angle of minimum deviation $D$. *(05 marks)*

(c) A ray of light is refracted through a prism in a plane perpendicular to its edge. The angle of incidence is $30^0$ and the refractive index of the prism is 1.50. Calculate the angle of the prism such that the ray does not emerge when it strikes the second face. *(05 marks)*

(d) (i) Describe with the aid of a labelled diagram, the structure and operation of a projection lantern. *(04 marks)*

(ii) A projector produces an image of area 2 $m^2$ on a screen placed 5 m from the projection lens. If the area of the object slide is 8 $cm^2$, calculate the focal length of the projection lens. *(04 marks)*

## SECTION B

3. (a) (i) Define the following as applied to wave motion:

- Amplitude. *(01 mark)*
- Frequency. *(01 mark)*
- Wavelength. *(01 mark)*

(ii) Derive the relationship between velocity, wavelength and frequency of a wave. *(03 marks)*

(b) The displacement $y$, of a progressive wave is given as

$$y = 2\cos \pi \left(t - \frac{x}{20}\right)$$

where $x$ is the horizontal distance in metres and $t$ is the time in seconds.

Determine the:

(i) velocity of the wave. *(03 marks)*

(ii) maximum velocity of the particles of the medium. *(02 marks)*

(c) (i) What is meant by **Doppler effect**? *(01 mark)*

(ii) A source of sound moving with velocity $u$, approaches an observer moving with velocity $u_0$ in the same direction. Derive the expression for the frequency of sound heard by the observer. *(05 marks)*

**Turn Over**

(d) Two whistles are sounded simultaneously. The wave lengths of the sounds emitted are 5.5 m and 6.0 m respectively.
Find the beat frequency if the speed of sound in air is 330 $ms^{-1}$. *(03 marks)*

4. (a) What is meant by the following as applied to light waves:
   (i) Diffraction. *(01 mark)*
   (ii) Polarization. *(01 mark)*

(b) A diffraction grating of spacing $d$, is illuminated normally with light of wavelength $\lambda$.
   (i) Derive the condition for occurance of diffraction maxima. *(03 marks)*
   (ii) Describe briefly the intensity distribution on a screen placed beyond the grating. *(02 marks)*
   (iii) What is the effect on the diffraction pattern when a grating with a larger number of lines is used? *(02 marks)*

(c) Light of wavelength $5.8 \times 10^{-7}$ m is incident on a diffraction grating of 500 lines per mm. Find the:
   (i) diffraction angle for the $2^{nd}$ order image. *(03 marks)*
   (ii) maximum number of images formed. *(02 marks)*

(d) (i) Describe how polarised light can be produced by reflection. *(04 marks)*
   (ii) List any **four** uses of polarised light. *(02 marks)*

## SECTION C

5. (a) With the aid of a sketch graph, explain the hysteresis curve for ferromagnetic materials. *(07 marks)*

(b) (i) Describe with the aid of a labelled diagram, the structure and the mode of action of a moving coil galvanometer. *(06 marks)*
   (ii) Explain why eddy currents are useful in a moving coil galvanometer. *(02 marks)*

(c) A conducting disc of radius 0.05 m with its plane perpendicular to a uniform magnetic field of flux density 0.25 T, rotates at 15 revolutions per second about an axis through its centre and perpendicular to its plane.

Calculate the:

(i) magnetic flux threading the disc at any time. *(03 marks)*

(ii) e.m.f generated between the centre of the disc and any point on its rim. *(02 marks)*

6. (a) State **Faraday's law** of electromagnetic induction. *(01 mark)*

(b) With the aid of a diagram describe an experiment to illustrate **Lenz's law** of electromagnetic induction. *(05 marks)*

(c) Define **magnetic moment** of a coil. *(01 mark)*

(d) A small circular coil of 20 turns of wire lies in a uniform magnetic field of flux density $5.0 \times 10^{-2}$ T. The normal to the coil makes an angle of $30^0$ with the direction of the magnetic field. If the radius of the coil is 4 cm and the coil carries a current of 2.0 A, find the:

(i) magnetic moment of the coil. *(02 marks)*

(ii) torque on the coil. *(03 marks)*

(e) (i) State and define the unit of magnetic flux density. *(02 marks)*

(ii) Show that when the magnetic flux linking a coil changes, the total charge which passes through it depends only on the resistance of the coil and the total flux linking it. *(05 marks)*

(f) State any **two** factors which determine the efficiency of a transformer. *(01 mark)*

7. (a) (i) What is meant by **capacitive reactance**? *(01 mark)*

(ii) Define **peak value** of an alternating voltage. *(01 mark)*

(iii) Show that the r.m.s value of an alternating voltage is

$$V_{rms} = \frac{V_0}{\sqrt{2}}$$

where $V_0$ is the peak voltage. *(03 marks)*

(b) Distinguish between **mutual** and **self** induction. *(02 marks)*

(c) (i) Describe with the aid of a diagram, the structure and working of the a.c transformer. *(05 marks)*

(ii) Explain the steps taken to minimize power losses in electric power transmission. *(03 marks)*

**Turn Over**

(d) In figure **2**, $P$ is a 6 V lamp and $Q$ is a coil of negligible resistance.

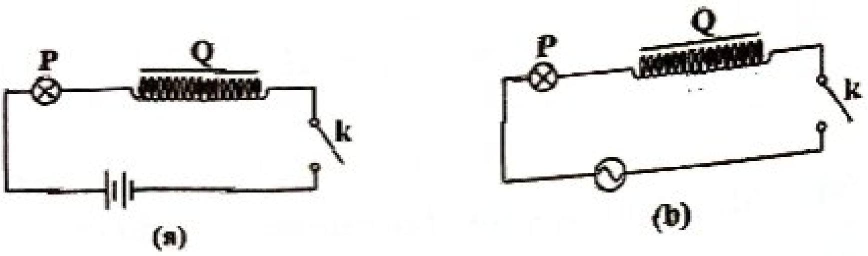


**Fig. 2**

(i) Explain which of the lamps in figure **2** will be brighter when $K$ is closed. *(02 marks)*

(ii) Explain what happens when a soft iron core is introduced in the coil in each of the circuits. *(03 marks)*

## SECTION D

**8.** (a) Define the following as applied to a battery:

(i) Electromotive force. *(01 mark)*

(ii) Internal resistance. *(01 mark)*

(b) A battery of e.m.f $E$ and internal resistance $r$, is connected across a load of resistance, $R$.

Derive an expression for the maximum power delivered to the load. *(04 marks)*

(c) Describe how the resistance of a resistor may be determined using a slide wire potentiometer. *(05 marks)*

(d) Explain why the potentiometer is more suitable for measuring small resistances than the Wheatstone bridge. *(02 marks)*

(e) In figure **3** , $AB$ is a uniform resistance wire of resistance 2.0 Ω , and length 100 cm. $E$ is a cell of e.m.f 1.5 V and $D$ is a driver cell of negligible internal resistance.
When switch $K$ is closed the balance length $AC$ is 82.5 cm.

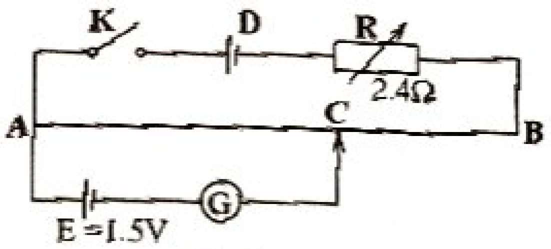


**Fig. 3**

(i) Find the e.m.f of cell $D$. *(03 marks)*

(ii) If cell $E$ and the galvanometer are replaced by a voltmeter of resistance $20.0\ \Omega$, find the reading of the voltmeter when contact $C$ is placed at the mid-point of $AB$ and the value of $R$ is $1.0\ \Omega$. *(04 marks)*

**9.** (a) (i) Define **electric field intensity** and **potential difference.** *(02 marks)*

(ii) Derive an expression for the electric potential difference between two points $a$ and $b$ in the field of a single point charge $+Q$. *(04 marks)*

(b) Describe an experiment to show that when two dissimilar dielectrics are rubbed together, they acquire equal but opposite charges. *(05 marks)*

(c) Two point charges of $+5\ \mu C$ and $-3\ \mu C$ are placed at points $A$ and $B$ as shown in figure 4.

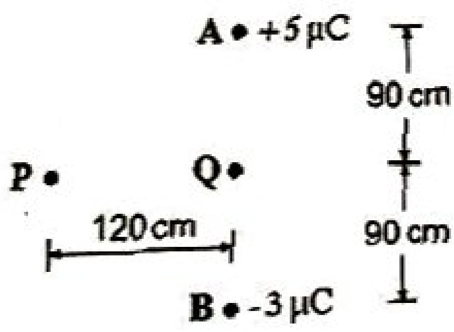


**Fig. 4**

Calculate the:

(i) electric potential at $P$. *(03 marks)*

(ii) work done in moving a charge of $-3\ \mu C$ from $P$ to $Q$. *(04 marks)*

(d) State any **two** characteristics of an equipotential. *(02 marks)*

**Turn Over**

**10.** (a) Define the following:

(i) Capacitance. (01 mark)

(ii) Relative permittivity. (01 mark)

(b) Two capacitors of capacitances $C_1$ and $C_2$ are connected in series with a battery of e.m.f $V$ as shown in figure 5.

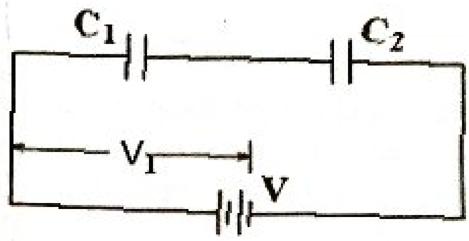


**Fig. 5**

If the p.d across the capacitor of capacitance $C_1$ is $V_1$ show that

$$\frac{1}{V_1}=\left(\frac{1}{C_1}+\frac{1}{C_2}\right)\frac{C_1}{V}.$$

(04 marks)

(c) Describe an experiment to determine the capacitance of a capacitor using a vibrating reed circuit. (04 marks)

(d) A battery of e.m.f 120 V is connected to a network of capacitors as shown in figure 6.

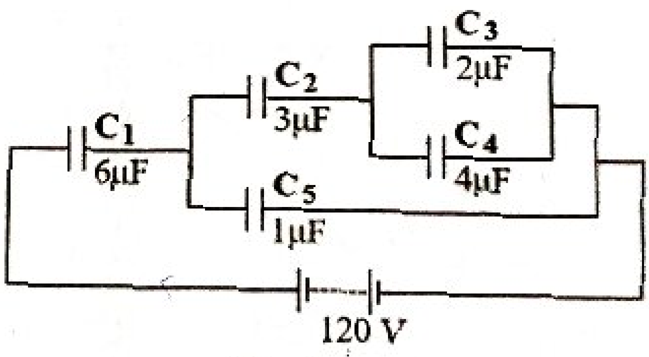


**Fig. 6**

Calculate the:

(i) charge on $C_1$. (04 marks)

(ii) energy stored in $C_5$. (03 marks)

(e) Describe how the effect of a dielectric medium on the capacitance of a capacitor may be determined. (03 marks)



**END**

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1 (a) (i) Magnifying power is the ratio of the angle subtended by the final image at the eye when using the telescope to the angle subtended by the object at the unaided eye. (2)

(ii) Eye ring of a telescope is the image of the objective formed by the eye piece

OR Position of image of objective formed by the eye piece

(b) When the image is viewed, when the eye is at the position of the eye ring, the eye has a wider field of view, and the image is brighter. It is therefore the best position for placing the eye, when viewing the image. (1)

(c) - There is no chromatic aberration (2)
- There is no spherical aberration since parabolic mirror is used in the objective.
- relatively cheaper, since only one face of the objective needs grinding.
- Has high resolving power since the objective can be made wide.
- The image is brighter.

(FIRST TWO)

(d)(i) using $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

$\Rightarrow \frac{1}{40} - \frac{1}{50} = \frac{1}{y}$ (2)

$\Leftrightarrow y = 200mm$

(ii) $\frac{1}{u} = \frac{1}{f} - \frac{1}{v}$

$= \frac{1}{375} - \frac{1}{(-250)}$

$u = \frac{375 \times 250}{375 + 250}$

$= 150mm$

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(2)

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Distance $X = V - U = 250 - 150 = 100mm$ (2)

(iii) Magnification $m = m_1 \times m_2 = \frac{200}{50} \times \frac{250}{150} = 6.7$ (2)

(e) - Chromatic aberration

Can be minimised by placing the eye very close to the lens; this ensures that the images due to the different colours subtend the same angle at the eye, hence no chromatic aberration.

or by use of achromatic doublet, the dispersion produced by one lens is reversed by the other, hence no colouration of the images.

OR

- Spherical aberration

Can be minimised by stopping down the lens this allows in only marginal or central rays hence the image is sharp.

or by grinding the lens to suitable shape e.g. a plano convex lens with the convex side facing the incident light produces minimum spherical aberration.

or - using narrow aperture lens (or reducing the aperture of the lens) only central rays

(f)(i) When a ray of light is incident from a dense to a less dense medium, there is partial reflection and partial refraction. When the angle of incidence is greater than the critical angle, all the incident light is reflected back into the dense medium. This is total internal reflection.

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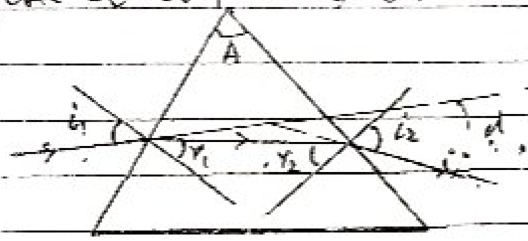
2 (a) - The incident ray, the refracted ray, and the normal at the point of incidence, all lie in the same plane.

- The ratio of the sine of angle of incidence to the sine of angle of refraction is a constant for a ray of light travelling from one medium into another (or for a given pair of media)

- constant, ~~ ~~ condition 3 terms.

(b)




Total deviation $d = (i_1 - r_1) + (i_2 - r_2)$

At minimum deviation D, the ray passes symmetrically through the prism

$\Rightarrow i_1 = i_2 = i$ and $r_1 = r_2 = r$.

$\therefore$ Total deviation

$D = (i - r) + (i - r) = 2i - 2r$

but $r_1 + r_2 = A \Rightarrow 2r = A$ $\Rightarrow r = A/2$.

$\therefore D = 2i - A \Rightarrow i = \frac{D+A}{2}$

From Snell's law, refractive index

$n = \frac{\sin i}{\sin r} \Rightarrow n = \frac{\sin \frac{D+A}{2}}{\sin A/2}$.

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(iii) On a hot day, layers of air near the ground are hotter and less dense than the layers higher up. Light from the sky propagating towards the ground ~~are~~ continuously refracted away from the normal. At some point when the angle of incidence is greater than the critical angle, total internal reflection takes place. When the eye receives this light, he views an image of the sky on the ground which gives an impression of a pool of water.

(3)

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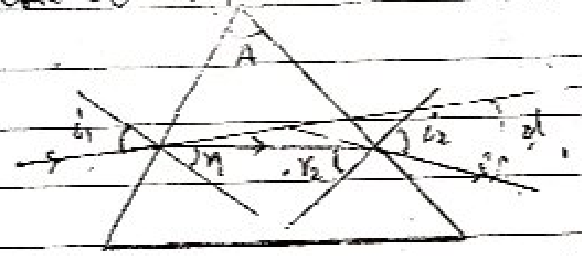
- The ratio of the sine of angle of incidence to the sine of angle of refraction is a constant for a ray of light travelling from one medium into another (or for a given pair of media)

(b) - Constant, differ Conditions & terms




Total deviation $d = (i_1 - r_1) + (i_2 - r_2)$

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but $r_1 + r_2 = A \Rightarrow 2r = A \Rightarrow r = A/2$.

$\therefore D = 2i - A \Rightarrow i = \frac{D+A}{2}$

From Snell's law, refractive index

$n = \frac{\sin i}{\sin r}$ or $n = \frac{\sin \frac{D+A}{2}}{\sin A/2}$.

(5)

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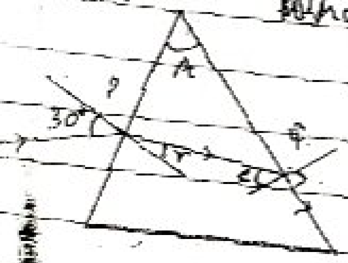



When light just emerges.

At P, $n_1 \sin i = n_2 \sin r$

$1 \sin 30° = 1.5 \sin r$

$\Rightarrow r = 19.5°$

At Q, $1.5 \sin c = 1 \sin 90°$

$\Rightarrow \sin c = \frac{1}{1.5}$ $\Rightarrow c = 41.8°$

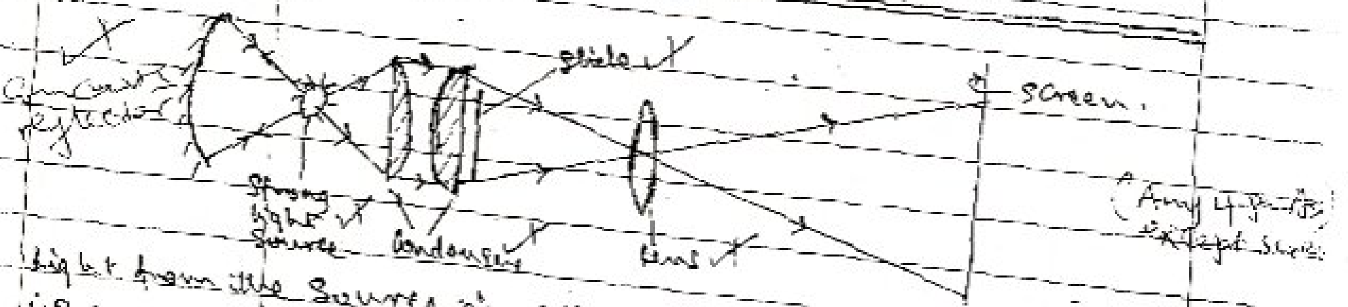
But $r + c = A$. $\Rightarrow A = (19.5 + 41.8)$

$= 61.3°$

∴ For no emergence $A > 61.3°$ or any angle in the range.

(5)

(d) (i)




(Any 4 points except screen)

Light from the source is reflected back on to the condenser which concentrates it on to the slide. The projection lens forms a magnified real image of the slide on the screen. (4)

(ii) Area magnification $= \frac{\text{Area of image}}{\text{Area of object}}$

$= \frac{20000}{8} = 2500$

Linear magnification

$m = \sqrt{2500} = 50$

From $m = \frac{v}{f} - 1$

$50 = \frac{5}{f} - 1$ $\Rightarrow 51 = \frac{5}{f}$.

$\Rightarrow f = \frac{5}{51} = 0.098 \text{ m}$

$= 9.8 \text{ cm}$ (4)

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3 (a)(i) Amplitude is the maximum displacement of a wave particle from its equilibrium position (1)

- Frequency is the number of complete waves (cycles) made in one second ✓ (1)

- Wave length is the distance between two successive wave particles that are in phase (1)

or Dist btn 2 successive troughs or crests or rare...

(ii) Consider a wave moving with speed $v$, if in time $T$ it covers a distance $\lambda$ (one wavelength) then distance = speed x time, $t$

$\Rightarrow \lambda = vT$ ✓

but $\Rightarrow T = \frac{1}{f}$ ✓

$\Rightarrow v = \lambda f$ ✓

or

Suppose the wave covers distance $\lambda$ in one cycle then speed $v = \frac{\text{dist}}{\text{time}}$

but $f = 1/T$

then $v = f\lambda$.

(b)(i) $y = 2\cos\pi\left(t - \frac{x}{20}\right)$

Comparing with $y = A\cos 2\pi\left(\frac{t}{T} - \frac{x}{\lambda}\right)$ ✓

$\Rightarrow \frac{2\pi t}{T} = \pi t$

$\Rightarrow \frac{1}{T} = \frac{1}{2} = 0.5$

$\therefore f = 0.5\,Hz$ ✓

Also $\frac{2\pi x}{\lambda} = \frac{\pi x}{20}$

$\Rightarrow \lambda = 40\,m$ ✓

$v = f\lambda$ ✓

$v = 0.5 \times 40 = 20\,ms^{-1}$ ✓

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(ii) Velocity of the particle

$\vartheta = \frac{dy}{dt} = -2\pi \sin \pi\left(t - \frac{x}{20}\right)$ ✓

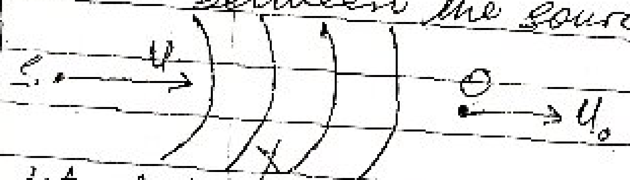
Velocity is maximum when

$\sin \pi\left(t - \frac{x}{20}\right) = 1$ ✓

$\therefore$ Maximum velocity $= |-2\pi| = 6.28\ ms^{-1}$ ✓ (2)

OR $V_{max} = \omega a$, but $\omega = \pi$, $a = 2$ $\therefore V_{max} = \pi \times 2 = 6.28\ ms^{-1}$ ✓

(c)(i) Doppler effect is the apparent change in the frequency of a wave motion due to relative motion between the source and the observer. (1)

(ii) 

Let $v$ be the velocity of sound from a source of frequency $f$. ✓

Apparent wavelength $\lambda' = \frac{v - u}{f}$ ✓

Apparent velocity $v' = v - u_0$ ✓

$\therefore$ Apparent frequency $f' = \frac{v'}{\lambda'}$ ✓ $= \frac{v - u_0}{v - u} f$ ✓ (5)

(d) For 1st sound $f_1 = \frac{v}{\lambda_1} = \frac{330}{5.5} = 60\ Hz$ ✓

For 2nd sound $f_2 = \frac{v}{\lambda_2} = \frac{330}{6} = 55\ Hz$ ✓

Beat frequency $f_b = f_1 - f_2$ ✓ $= 60 - 55$ ✓ (3)

$f_b = 5.0\ Hz$ ✓

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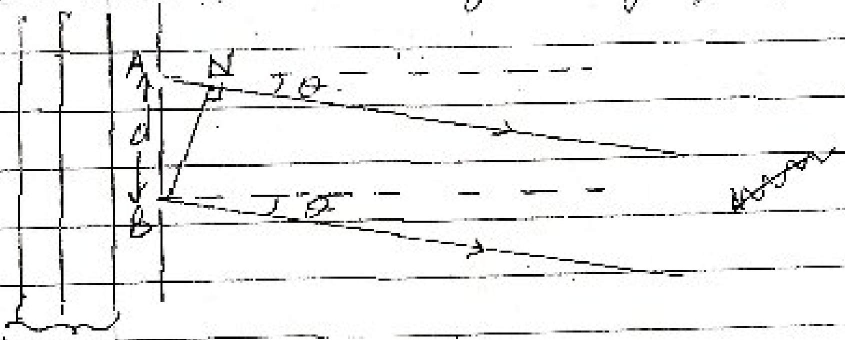
(4)(a) - Diffraction of light is the spreading of light around an obstacle in the geometrical shadow leading to interference ✓

- Polarization is the process by which vibrations of light photons are restricted in one plane perpendicular to direction of propagation of light.

(b)(i) Consider a parallel beam of monochromatic light incident on a grating of spacing d

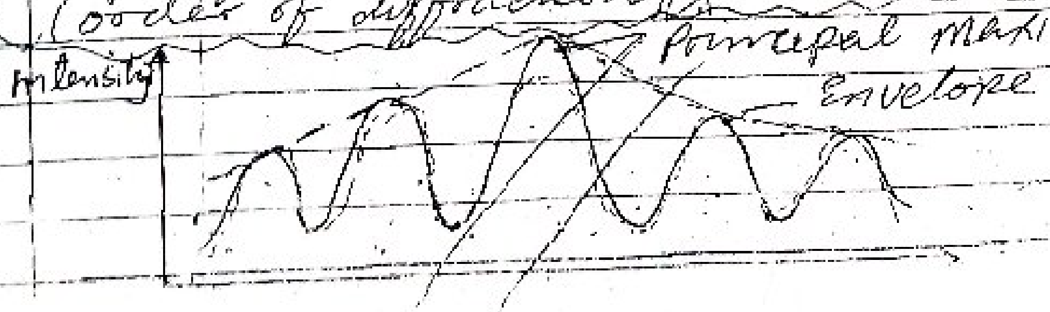



plane wave

The path difference AN between the wavelets is given by AN = d sin θ

For constructive interference, diffraction must occur so the path difference must be an integral multiple of the wavelength λ

Hence $d\sin\theta = n\lambda$ ✓✓ where θ is the angle of diffraction and n is an integer (order of diffraction).

(ii) 

(ii) Intensity

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The central principal maximum is the most intense and the intensity decreases outwards on either sides. (2)

(zero order image)

the images are sharp and almost of same intensity

(iii) When number of lines increases the diffraction maxima (images) become narrower and sharper (distinct).

(c) (i) $d = \frac{1}{N} = \frac{1}{500\times1000} = 2.0\times10^{-6}\,m$

From $d\sin\theta = n\lambda$

$\sin\theta = \frac{n\lambda}{d} = \frac{2\times5.8\times10^{-7}}{2.0\times10^{-6}} = 0.58$ (3)

$\Rightarrow \theta = 35.5^\circ$

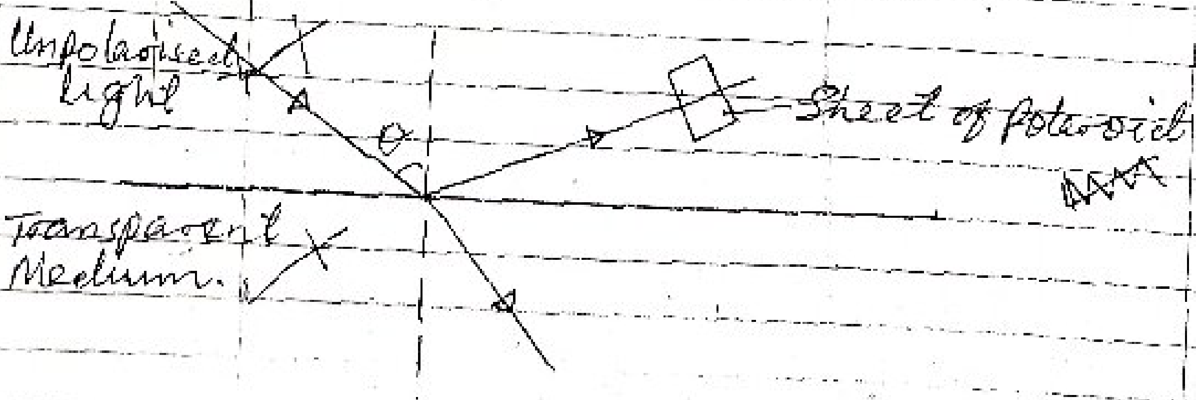
(ii) $n_{max}$ is when $\theta = 90^\circ$

$\Rightarrow d = n_{max}\lambda$

$n_{max} = \frac{d}{\lambda} = \frac{2.0\times10^{-6}}{5.8\times10^{-7}} = 3.4$

$\therefore n_{max} = 3$ (2)

(d)



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Unpolarised 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. The procedure is repeated for other angles of incidence. At a particular angle of incidence, the reflected light is extinguished at only one position (orientation) ~~of the polaroid~~. The reflected light at this position is completely plane polarised.

(ii) - Measurement of concentration of sugar in solution (saccharimetry).
- Determination of stress distribution in materials like glass, perspex and polythene. (stress analysis)
- Used in films to give the illusion of three dimensions (Holography)
- Used in liquid crystal displays.

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(ii)

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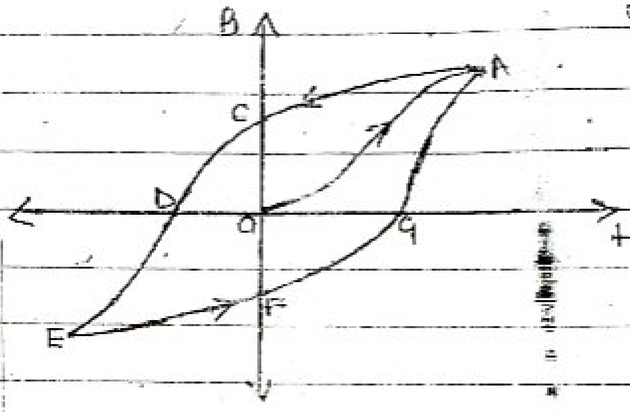
5. (a)




OA ✓
ACDE ✓
EFGA ✓
~~axes B and H ✓~~

When a magnetic field is applied to a ferromagnetic material, the magnetic domains tend to align with the applied field. The magnetic flux density increases along OA until saturation. When the magnetizing field is reduced to zero, there is residual magnetisation at C. This is due to failure of the dipoles to respond instantaneously. Energy is lost.

To bring the dipoles to their original orientation, a magnetic field OD is applied in opposite direction. As the magnetic field is increased in this reversed direction saturation is attained at E.

When the reversed magnetic field is reduced to zero, state F is attained. Reversal of dipoles requires an increase of magnetic fields in opposite direction to state G.

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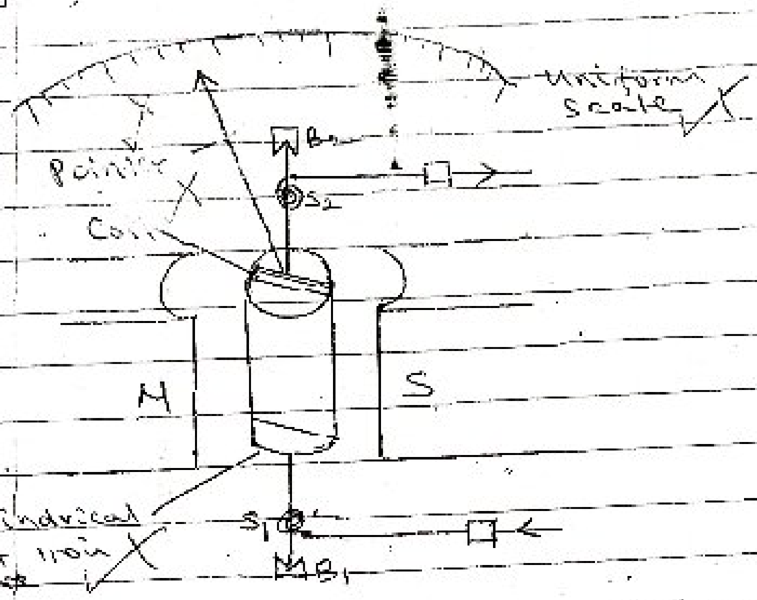
The cycle is then repeated on further increase of magnetic field.
The curve of B versus H is called a hysteresis curve.

(b) (i)




$S_1$ and $S_2$ are hair springs
N, S are concave pole pieces of a permanent magnet.
$B_1 B_2$ are jewelled bearings
Current to be measured is allowed in through hair spring $S_1$. The coil experiences a magnetic torque $T = BANI$, and the coil turns together with the pointer until it is stopped by the restoring torque of the hair spring, $T = K\theta$.

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In equilibrium, the deflecting torque on the coil is equal to the opposing torque due to the elastic force on the spring, i.e

$BANI = k\theta$

$\therefore I = \frac{k\theta}{BAN}$

Hence $I \propto \theta$ since $\frac{k}{BAN} = $ constant.

(ii) Eddy currents are induced in the core when the coil moves in the magnetic field.
In a moving coil galvanometer, the eddy currents damp the oscillation of the coil. This makes the pointer to settle at a point quickly. (dead beat)
It is desirable for quick and accuracy reading of the values.

(c) (i) Magnetic flux $\phi = BA$ but $A = \pi r^2$

$\Rightarrow \phi = B\pi r^2$

$\phi = 0.25 \times 3.14 \times (0.05)^2 = 1.96 \times 10^{-3}$

(ii) emf $E = B\pi r^2 f$

$= 0.25 \times 3.14 \times 0.05^2 \times 15$

$= 2.9 \times 10^{-2}$ V.

or $E = \phi f = 1.96 \times 10^{-3} \times 15 = 2.9 \times 10^{-2}$ V

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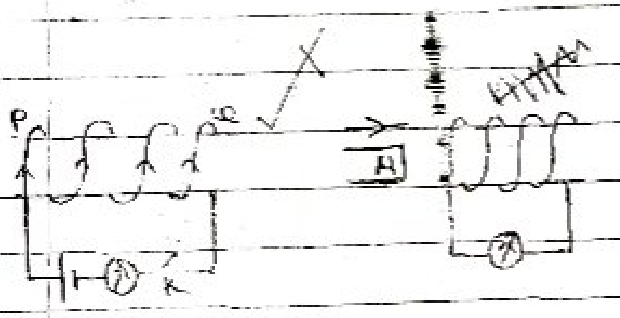
6(a) The magnitude of the emf induced in a circuit is directly proportional to the rate of change of the magnetic flux linked with the circuit.

(b)




The galvanometer is first connected in series with the battery and the coil PQ. The switch K is closed. The direction of deflection of the galvanometer for which current flows in an anticlockwise direction at the end P of the coil is noted.
The battery is then disconnected and the circuit containing the coil and the switch is made complete.
A strong permanent magnet is brought towards the coil with its north pole facing the end P of the coil. The galvanometer deflects in a direction for which the side of the coil facing the magnet is a north pole.

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When the magnet is moved away from the coil, the galvanometer deflects in opposite direction implying that the pole of the coil near the magnet is a south pole.

In the first case, the pole due to the induced current was repelling the approaching magnet while in the second case, the pole was attracting the receding magnet. The induced current therefore is in such a direction as to oppose the change causing it, which is Lenz's law. (5)

(c) Magnetic moment is the torque experienced by a coil per tesla of magnetic field acting along the plane of the coil. (1)

OR It is the product of number of turns, area and the current in the coil.

(d)(i) $M = NIA = 20\pi \times (4\times10^{-2})^2 \times 2$

$= 0.2\ Am^2$ or $NmT^{-1}$ (2)

(ii) $T = mB\sin\theta = 0.2 \times 5\times10^{-2}\sin 30$

$= 5.0\times10^{-3}\ Nm$ (2)

or $T = mB\cos 60 = 0.2\times5\times10^{-2}\cos 60 = 5\times10^{-3}\ Nm$

e(i) tesla; It is the magnetic flux density in a magnetic field, if the force on a conductor of length 1m carrying current of 1A at right angle to the magnetic field is 1N.

(ii) Consider a coil of N turns each linked by magnetic flux $\phi_1$. Suppose the magnetic flux changes to $\phi_2$. When the magnetic flux $\phi$ changes, an emf $\varepsilon$ is induced in the coil.

$$\varepsilon = -N\frac{d\phi}{dt}$$

$$I = \frac{\varepsilon}{R}, \quad R = \text{the resistance of the coil.}$$

$$\Rightarrow \varepsilon = IR$$

hence $IR = -N\frac{d\phi}{dt}$

$$I = \frac{-N}{R}\frac{d\phi}{dt}$$

but $I = \frac{dQ}{dt}$, where $Q$ is the induced charge.

$$\Rightarrow \frac{dQ}{dt} = \frac{-N}{R}\frac{d\phi}{dt}$$

$$dQ = \frac{-N}{R}d\phi$$

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The amount of charge which passes through the coil when the magnetic flux changes from $\phi_1$ to $\phi_2$ is

$$Q = \frac{-N}{R}\int_{\phi_1}^{\phi_2} d\phi = \frac{-N}{R}(\phi_2 - \phi_1)$$

$$Q = \frac{N(\phi_1 - \phi_2)}{R}$$

(5)

f) - Type of core
- Resistivity of wire used to make the primary and secondary coils / Resistance of winding
- coupling between the primary and secondary coils.
- The design of the core / eddy currents in core

(1)

20

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4(a)(i) Capacitive reactance: is the non-resistive opposition to the flow of a.c through a capacitor. ✓

(ii) Peak value of an alternating voltage: This is the maximum value of the alternating voltage. ✓

(iii) Instantaneous power $= \frac{V^2}{R}$   $V = V_0 \sin\omega t$ ✓

$$P_{inst} = \frac{V_0^2 \sin^2 \omega t}{R}$$

Average power $\langle P \rangle = \frac{V_0^2}{R} \langle \sin^2 \omega t \rangle$

but $\langle \sin^2 \omega t \rangle = \frac{1}{2}$

$$\langle P \rangle = \frac{V_0^2}{2R}$$

For steady ~~current~~ voltage, $P = \frac{V_{rms}^2}{R}$

$$\Rightarrow \frac{V_{rms}^2}{R} = \frac{V_0^2}{2R}$$

Hence $V_{rms} = \frac{V_0}{\sqrt{2}}$

(b) Mutual induction is the production of emf in a conductor caused by change in the magnetic flux linking it due to the change in current in a nearby circuit while self induction is the production of an emf in a conductor caused by change in magnetic flux linking it due to change in current in the same conductor.

(19)

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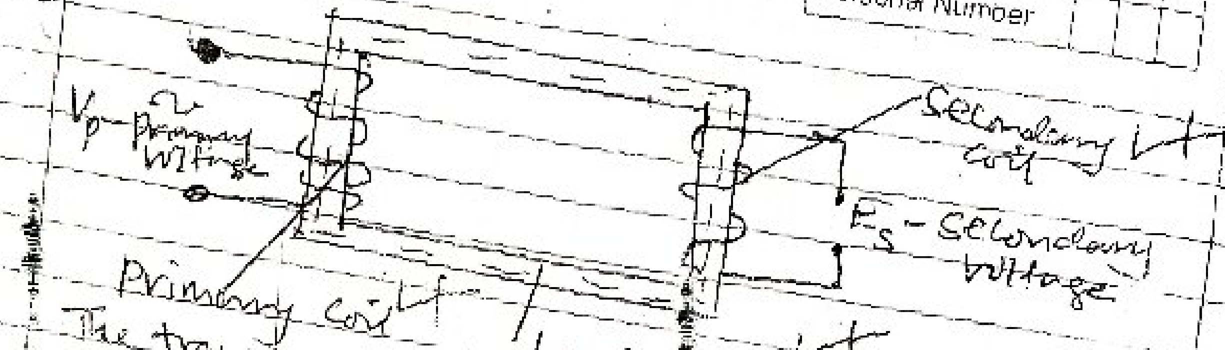
9(i)




The transformer consist of two coils of insulated wire; the primary and the secondary wound on laminated soft iron core.

When alternating voltage is connected to the primary coil, it drives alternating current to the primary coil. The alternating current produces varying magnetic flux $\Phi_p$ that links the primary coils inducing a back emf $E_b$ in the primary. The varying magnetic flux $\Phi_s$ links the secondary coils by mutual induction inducing alternating voltage $V_s$ in the secondary.

$$E_b = -N_p \frac{d\Phi_p}{dt}$$

$$\Rightarrow V_p = N_p \frac{d\Phi_p}{dt} \quad \text{——— (1)}$$

$$V_s = -N_s \frac{d\Phi_s}{dt} = N_s \frac{d\Phi_p}{dt} \quad \text{——— (2)}$$

dividing eq(1) by (2)

$$\frac{V_p}{V_s} = \frac{N_p}{N_s}$$

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$P_T = IV$ $P = I = \frac{P_T}{V}$

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Random No. $P_{loss} = I^2 R$

Personal Number $= \frac{P_T^2 R}{V^2}$

When $N_s > N_p \Rightarrow$ Step up transformer

When $N_s < N_p \Rightarrow$ Step down transformer

3

(iii) Voltage generated is step up using transformer so as to transmit at high voltage and low current.

- Using low resistance cables for transmission leading to low power loss ($P = I^2R$)

3

d(i) The bulb in (a) will be brighter. When the switch K is closed current flows in (a) and back emf is induced. This limit the brightness of the bulb. When the current reaches the steady value, the back emf is zero, the bulb light brightest and

In coil (b) the back emf is ~~steady~~ (continous) and the bulb light dimly.

(ii) When soft iron core is introduced, magnetic flux is enhanced, in (a) the back emf increases and the current decreases. The brightness of the bulb ~~decreases~~ reduces. The back emf reduces to zero when the current increases to the maximum value and the brightness increases.

In (b) ~~The magnetic flux is enhanced~~, the back emf increases, the current reduces the brightness of the bulb reduces ~~and~~ the bulb remains dim.

$\Phi_0 = B_0 A$

$B_0 = \mu_0 n I$

$\Phi = \mu_r \mu_0 n I A$

(21)

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SECTION D

8 a(i) Electromotive force of a battery: This is the energy supplied by the battery to transfer 1C of charge round a complete circuit which includes the battery. 1

OR

Emf is the ratio of the power ~~the~~ source generates to the current it delivers.

OR

Emf is the ~~maximum~~ potential ~~drop~~ difference across the terminals of the battery when it is not delivering current.

(ii) Internal resistance of a battery is the effective resistance in series with the external circuit which accounts for losses of energy inside the battery. 1

OR

Internal resistance of a battery: This is the opposition to the flow of the current within the battery due to its chemical composition.

(b) Power delivered to the load

$P = I^2R$

but $I = \frac{E}{R+r}$

$\Rightarrow P = \frac{E^2R}{(R+r)^2}$

For maximum power $\frac{dP}{dR} = 0$ 2

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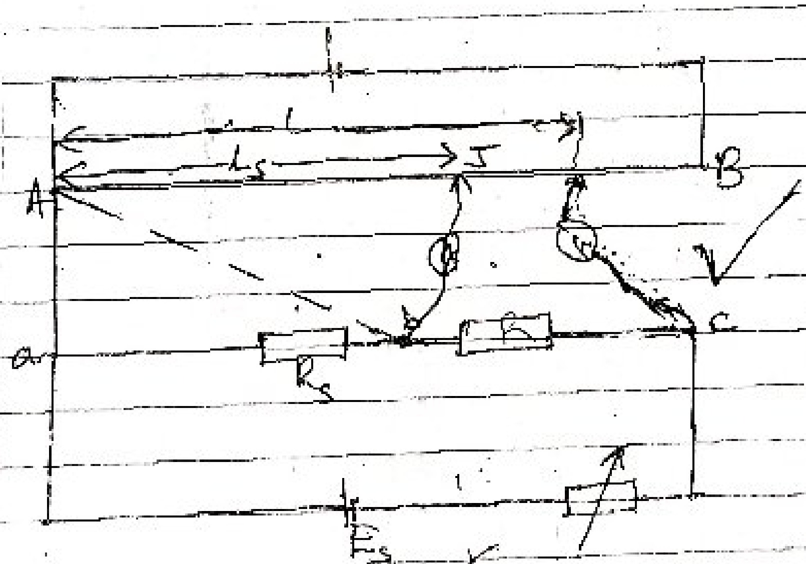
$$\frac{dP}{dR} = \frac{E^2(R+r)^2 - E^2R \cdot 2(R+r)}{(R+r)^4} = 0$$

$$\Rightarrow R = r$$

$$P_{max} = \frac{E^2R}{(2R)^2} = \frac{E^2R}{(2r)^2} = \frac{E^2}{4R} = \frac{E^2}{4r}$$

(c)




$R_s$ = standard resistance, R = unknown resistance
First the galvanometer is connected at b. The jockey is tapped at different points along the wire AB until point J is found where the galvanometer G shows no deflection. The balance length $l_s$ is measured and recorded. The galvanometer is disconnected from b and then connected ~~to~~ point c. Point b is connected to point A (dotted lines). The balance point is located on wire AB.

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The new balance $l_s$ is measured.
The unknown resistance is found from

$$R = R_s \frac{l}{l_s}$$

$1\frac{1}{2}$

(d) This is because at balance, the wires connecting the resistor into the potentiometer carry no current. There is therefore no p.d across the connecting wires and consequently their resistance doesn't ~~affe~~ affect the results as it happens in the wheatstone bridge.

2

(e)(i)

$$E_D = I(R_{AB} + R)$$
$$= I(2 + 2.4)$$
$$I = \frac{E_D}{4.4}$$

P.d across AB $= V = I R_{AB}$

$$= \frac{E_D}{4.4} \times 2 = \frac{E_D}{2.2}$$

P.d/lcm, $K = \frac{E_D}{2.2} \times \frac{1}{100} = \frac{E_D}{220}$

3

at balance p.d across AC = 1.5 V

$$K l_{AC} = 1.5$$
$$\frac{E_D}{220} \times 82.5 = 1.5$$

$$E_D = 4V$$

$I_1 \wedge \frac{1}{\ldots}$

$\frac{E_D}{4.4} \times \frac{2}{100} \times 82.5 = \ldots$

$E_D = 4V$

$6\frac{1}{2}$

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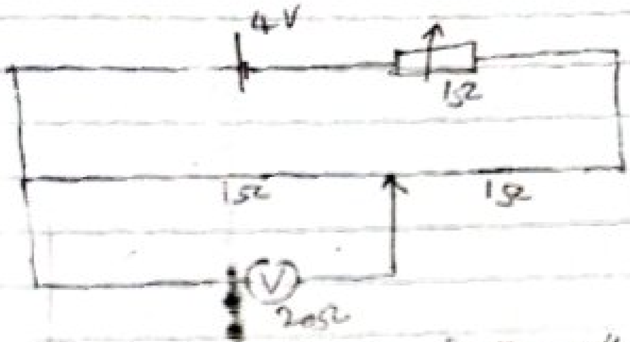
(ii)




Combined resistance in parallel

$R_c = \frac{20 \times 1}{20+1} = 0.952\Omega$

Effective resistance $R_T = 0.952 + 1 + 1$

$= 2.952\Omega$

Total current $I = \frac{V}{R} = \frac{4}{2.952}$

$I = 1.355A$

p.d across parallel combination

$V = IR$

$= 1.355 \times 0.952$

$= 1.29V$

Reading of voltmeter $= 1.29V$

OR

Combined resistance in parallel $R_c = \frac{20 \times 1}{20+1} = 0.952\Omega$

Effective resistance $R_T = 0.952 + 1 + 1 = 2.952\Omega$.

p.d across parallel combination $V_1 = \frac{R_c}{R_T} \times V$

$V_1 = \frac{0.952}{2.952} \times 4 = 1.29V$

4

(25)

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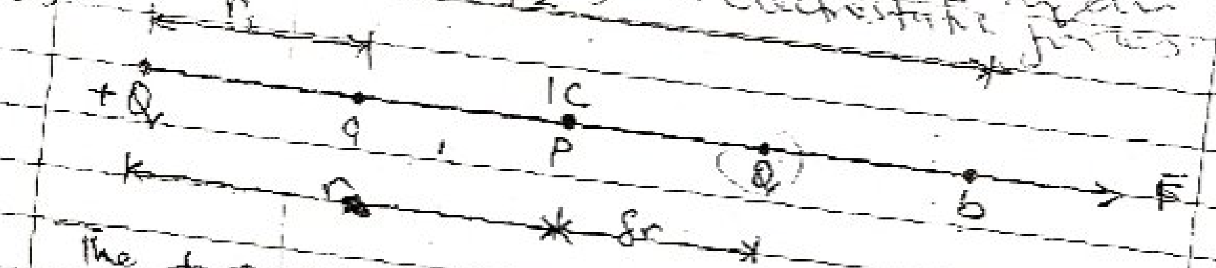
Q9(a)(i) Electric field intensity at a point is the force exerted on a positive charge of 1C placed at a point in an electric field.

The Potential difference between two points is the work done to move 1C of positive charge from one point to another in electric field against electrostatic forces.

(ii)




The force exerted on +1C charge at P

$F = \frac{Q}{4\pi\varepsilon_0 r^2}$

The work done to move +1C of charge from P to Q through a small distance $\delta r$ is

$\delta W = -F\,\delta r$

$\Rightarrow \delta W = -\frac{Q}{4\pi\varepsilon_0 r^2}\delta r$, over a small distance $\delta r$, F is assumed to remain constant

Total work done to move +1C from b to a is

$$W = \int_{r_2}^{a} \frac{Q}{4\pi\varepsilon_0 r^2}\,dr$$

$$W = \frac{Q}{4\pi\varepsilon_0}\int_{r_2}^{r_1} \frac{-1}{r^2}\,dr = \frac{Q}{4\pi\varepsilon_0}\left[\frac{+1}{r}\right]_{r_2}^{r_1}$$

$$W = \frac{Q}{4\pi\varepsilon_0}\left[\frac{1}{r_1} - \frac{1}{r_2}\right]$$

∴ P.d between a and b

$$V_{ab} = \frac{Q}{4\pi\varepsilon_0}\left[\frac{1}{r_1} - \frac{1}{r_2}\right]$$

(4)

(b) - Two [illegible] insulators are rubbed together and separated. They are then lowered one at a time [illegible] in a can placed on the cap of a neutral gold leaf electroscope.
- The leaf diverges by the same amount showing that the materials are charged.
- The two materials are then put together and then lowered into the can. No divergence is seen hence the resultant charge is zero.
- Thus the bodies acquire equal but opposite charges.

Wool is wrapped round one end of a polythene rod and several turns of thread wound over the wool. The loose end of the thread is pulled so that the wool rubs against the polythene making sure that the hands do not touch the wool. The end of the rod with wool is inserted in a metal can placed on the cap of neutral electroscope.
No divergence is observed

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When the polythene is carefully pulled out to leave the wool a divergence of the leaf of the electroscope is observed. The wool is then withdrawn and the electroscope discharged. When the polythene rod is placed inside the can, the electroscope is observed to diverge to the same extent as before. Therefore two dissimilar dielectrics have acquired equal but opposite charges. (5)

(ii) $AP = BP = \sqrt{120^2 + 90^2} = 150\text{ cm}$

Potential at P, $V = \frac{kQ}{r}$

$$V_p = k\left[\frac{Q_A}{r_1} + \frac{Q_B}{r_2}\right]$$

$$= 9\times10^9\left[\frac{5\times10^{-6}}{150\times10^{-2}} - \frac{3\times10^{-6}}{150\times10^{-2}}\right]$$

$$= \frac{9\times10^9 \times 2\times10^{-6}}{150\times10^{-2}}$$

(3)

$$= 12,000\text{V}$$

$V_L \to V_H$ (+ve)

 $V_H \to V_L$ (-ve) 

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C(ii) Potential at Q

$$V_Q = k\left[\frac{Q_A}{r_A} + \frac{Q_B}{r_B}\right]$$

$$= 9\times10^9\left[\frac{5\times10^{-6}}{90\times10^{-2}} - \frac{3\times10^{-6}}{90\times10^{-2}}\right]$$

$$= 20{,}000\,V$$

Potential difference between P and Q

$$V_{QP} = 20{,}000 - 12000$$
$$= 8{,}000\,V$$

(4)

Work done $W = Q V_{PQ}$
$$= -3\times10^{-6}\times 8000$$
$$= -0.024\,J$$

(d) - The potential is same at all points on the surface
- The work done to move a charge along the surface is zero.
- The field lines are perpendicular to the surface.

(FIRST TWO)

Total Mark

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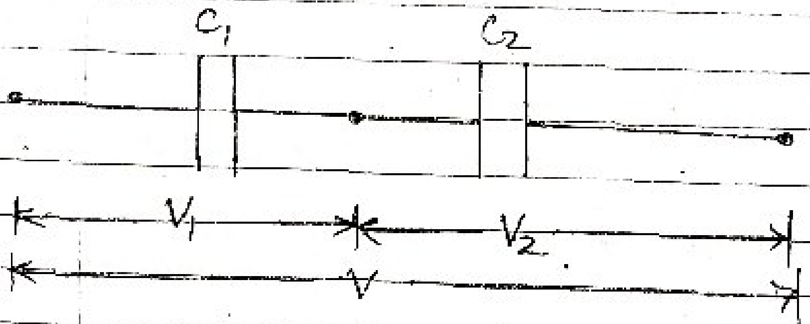
Q10(a)(i) The capacitance of a capacitor is the ratio of the magnitude of a charge on either plates of the capacitor to the potential difference between the plates ✓ (1)

~~magnitude of charge on conductor to potential of the conductor.~~

(ii) Relative permittivity of a material is the ratio of the permittivity of a material to the permittivity of free space ✓ (1)

(b)




Let the charge on each capacitor plate be $Q$ and $V_2$ = P.d across $C_2$

Total P.d $V = V_1 + V_2$ ✓

$V_1 = \frac{Q}{C_1}$ ✓ and $V_2 = \frac{Q}{C_2}$ ✓

$\Rightarrow \quad V = \frac{Q}{C_1} + \frac{Q}{C_2}$ ✓

$V = Q\left[\frac{1}{C_1} + \frac{1}{C_2}\right]$ ✓

charge on $C_1 = Q = C_1V_1$ ✓

$\Rightarrow \quad V = C_1V_1\left[\frac{1}{C_1} + \frac{1}{C_2}\right]$ ✓

Dividing through by $VV_1$ gives

(30)

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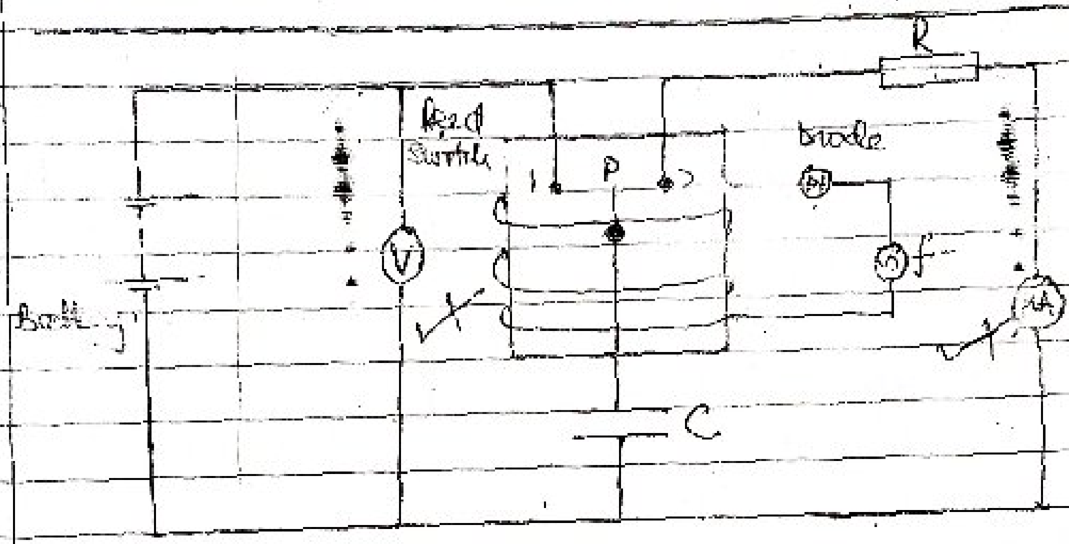
$$\frac{1}{V_1} = \frac{C_1}{V}\left[\frac{1}{C_1} + \frac{1}{C_2}\right]$$ ✓ (4)

(c)




The test capacitor capacitance C is connected to the circuit as shown above ✓ when an ac voltage of frequency f ✓ is applied to the coil, the spring steel strip P vibrates repeatedly between 1 and 2. The voltmeter reading V ✓ and the steady current I ✓ through the microammeter are read and recorded. (4)

The capacitance of the test capacitance is given by $C = \frac{I}{fV}$ ✓

d(i) Combined capacitance of $C_3$ and $C_4$ in parallel $C' = C_3 + C_4$

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$C' = 2 + 4$
$= 6\ \mu F$

Equivalent capacitance of $C_1$ and $C_2$ in series:

$C'' = \frac{C'C_2}{C'+C_2} = \frac{3 \times 6}{3+6} = 2\ \mu F$

Combined capacitance of $C''$ and $C_5$ in parallel

$C''' = 2 + 1 = 3\ \mu F$

Effective capacitance of circuit $C = \frac{C_1 C'''}{C_1 + C'''}$

$C = \frac{C_1 C'''}{C_1 + C'''} = \frac{3 \times 6}{3+6} = 2\ \mu F$ (4)

Total charge $Q = CV$
$= 120 \times 2 \times 10^{-6}$
$= 2.4 \times 10^{-4}\ C$

$\therefore$ Charge on $C_1 = 2.4 \times 10^{-4}\ C$

(ii) P.d across parallel network

$V' = \frac{Q}{C'''}$

$= \frac{2.4 \times 10^{-4}}{3 \times 10^{-6}}$

$= 80\ V$

(32)

UGANDA NATIONAL EXAMINATIONS BOARD
NOVEMBER - DECEMBER, 2017



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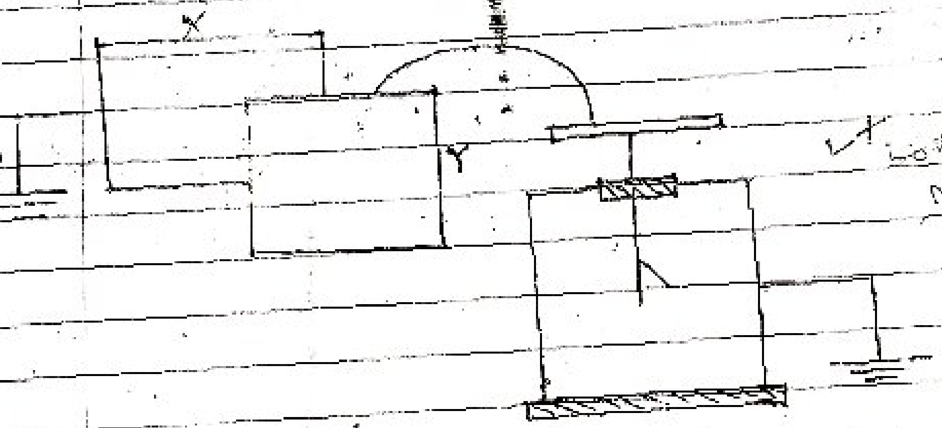
Energy stored in $C_s$

$E = \frac{1}{2}CV^2$

$= \frac{1}{2} \times 1 \times 10^{-6} \times 80^2$

$= 3.2 \times 10^{-3}$ J

(3)




Two metal plates X and Y are set close to each other but not touching, Y is given a charge Q and the divergence of the leaf of the electroscope noted.

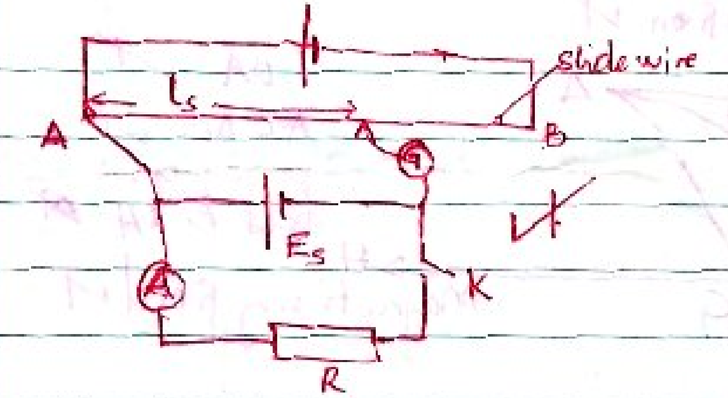
A dielectric (eg sheets of glass) is placed between X and Y keeping the separation and area of overlap constant.

The divergence of the leaf is seen to decrease. This implies the p.d between the plates has decreased.

From $C = Q/V$, the capacitance has increased.

END

Total mark




The circuit is connected as above, where $E_s$ is standard emf and R is test resistance.

With switch k open, the jockey J is tapped at different positions along the uniform wire until the galvanometer G shows no deflection. The balance length $l_s$ is recorded.

Switch K is closed and the experimenter is repeated.

The balance length $l$ together with ammeter reading $I$ are recorded. The test resistance R is now calculated from:

$$R = \frac{E_s}{l_s} \times \frac{l}{I}$$

7d(ii)

In (a) the magnetic flux increases leading to induction of back emf in the coil and the bulb goes dim. The back emf reduces to zero and the current increases making the (current) brightness increase to maximum.

In (b), the rate of change of magnetic flux linkage increases leading to increase in back emf and the bulb becomes dimmer (goes off) (current reduces.) Since the back emf persists, the bulb remains dim.

OR

Eddy currents are induced in the core which makes the core to heat up.

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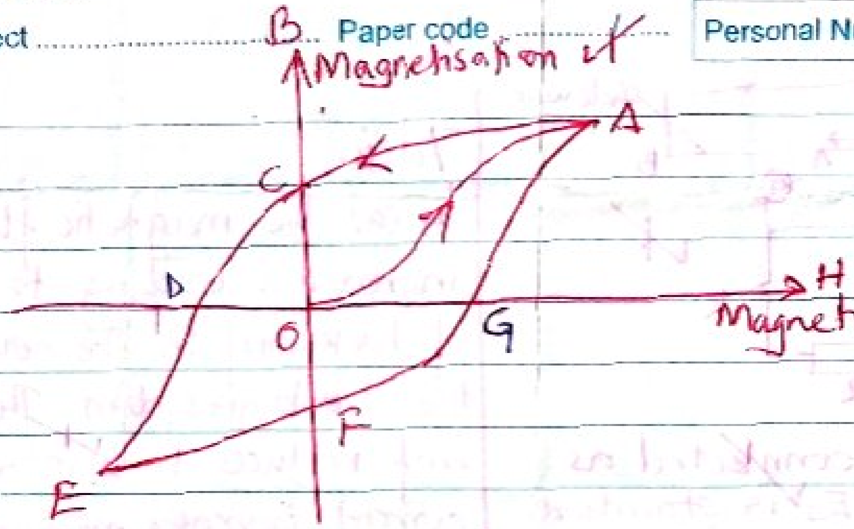
5a)




OA
ACDE
EFGA
axes B & H

When a magnetic field is applied to a ferromagnetic material, the magnetic domains tend to allign with the applied field. The magnetic flux density increases along OA until saturation. When the magnetising field is reduced to zero, there is residual magnetisation at C (some magnetisation remains at C). This is due to failure of the dipoles to respond instataneously. To bring the dipoles to their original orientation, a magnetic field (flux) is applied in opposite direction. As the magnetic field is increased in this reversed direction, saturation is attained at E.
When the field is reversed magnetisation takes places in a similiar way in the reverse direction till saturation at A.