B·C

JINJA JOINT EXAMINATIONS BOARD

P510/2 PHYSICS PAPER 2

PROPOSED U.A.C.E. JJEB MARKING GUIDE - 2019

SECTION A

Half tick(½ Mark)
Full Tick (1 mark)

1. (a) (i) The incident ray, the normal and the refracted ray at the point of incidence, all lie in one plane.

The ratio of the sine of the angle of incidence to the sine of the angle of refraction equals a constant for a given pair of optical media.

[02]

(ii) Using $n \sin i = a\ constant\ at\ Q$

$1.52 \sin c = \sin 90°$

$c = sin^1 \left(\frac{1}{1.52}\right)$

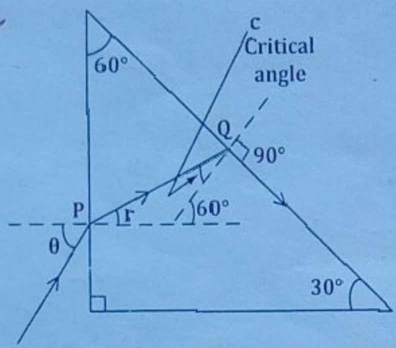
$\therefore c = 41.1°$

$\therefore r = 60° - 41.1°$

$r = 18.9°$

At P, $\sin \theta = 1.52 \sin 18.9°$

$\therefore \theta = 29.5°$ (with unit)



[03]

(b) (i) Reflection is the bouncing back of light rays into the same medium after striking a reflecting surface or boundary between two media. [01]

accept change in direction to same medium.

(ii) $\angle ODC = 35°$

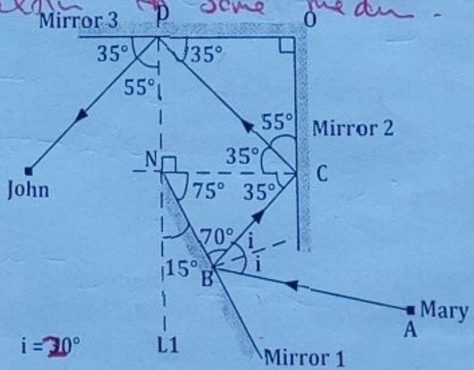
$\angle DCO = 55°$

$\angle CNB = 75°$

$\angle NCD = 35°$

$\angle CBN = 70°$

$\therefore \angle i = 30°$



[03]

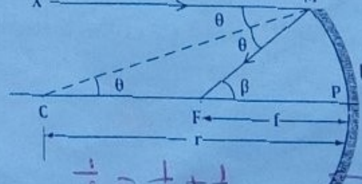
(c) (i) Consider incident ray XM parallel to the principal axis CP.

$\angle XMC = \angle MCF = \theta = \angle CMF$

Let $\angle MFP = \beta$

$\Rightarrow 2\theta = \beta$ .... (i)

For mirror of small aperture,



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

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

$M = \frac{v}{f}$

M is very close to P

$\therefore$ MP is normal to CP.

For small angles θ and β in radians

$\Rightarrow \tan\theta \approx \theta = \frac{MP}{CP}$

$\tan\beta \approx \beta = \frac{MP}{FP}$ .... (ii)

From (i) and (ii) $\quad 2\frac{MP}{CP} = \frac{MP}{FP}$

But $\quad CP = r \qquad \frac{2}{r} = \frac{1}{f}$

$\quad FP = f \qquad \therefore r = 2f$

04

[03]

(ii) using $1 + \frac{1}{m_1} = \frac{u_1}{f}$ .... (i)

$1 - \frac{1}{m_2} = \frac{u_2}{f}$ .... (ii) since m_2 is negative

Equation (i) – (ii)

$\Rightarrow \frac{1}{m_1} + \frac{1}{m_2} = \frac{u_1 - u_2}{f}$

But, $|m_1| = |m_2| = m$ and $u_1 - u_2 = d$

$\Rightarrow \quad \frac{2}{m} = \frac{d}{f}$

$\therefore d = \frac{2f}{m}$

[03]

(d) A star is considered as ***a point source*** emitting *a fine beam of light ray*. As the light from the star travels *through different layers of air* at different *temperatures in the earth's atmosphere*, before reaching the Earth's surface, *Each colour* is *continuously refracted to and away from the observer's eye*. This causes the *on and off fluctuation of the intensity of light entering the observer's eye* known as *twinkling*.

[03]

2. (a) (i) **Optical centre** is the point at the centre of the lens surfaces lying along the principal axis where all incident rays onto the lens and passing through it go un deviated after refraction.

[01]

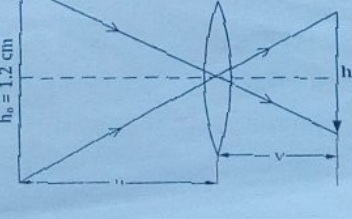
(ii) **Focal plane** is a vertical plane or *plane normal to the principal axis* of the lens and passing through its principal focus, where images of finite distant objects are formed.

[01]

(b) (i) NB wild daisy is a flower.

f = 15.0cm

u = 90.0cm



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

$\Rightarrow \quad \frac{1}{v} = \frac{1}{15} - \frac{1}{90} = \frac{5}{90}$

$\Rightarrow \quad v = 18.0 \text{ cm}$ [03]

(ii) $m = \frac{h_1}{h_0} = \frac{v}{u}$

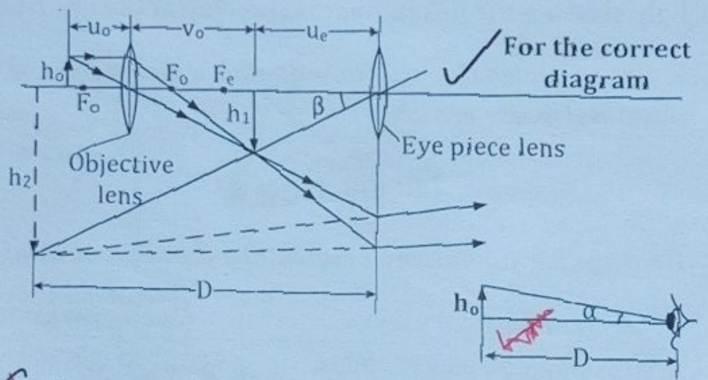
$\Rightarrow \quad h_1 = \frac{18}{90} \times 1.2 \quad = 0.24cm$ [02]

$\therefore$ Diameter of the image of the daisy = 0.24cm
or the radius of the image is 0.12 cm.

(c) (i) Light rays from a finite object placed just beyond the principal focus, F_0 of the objective lens L_0, are refracted by L_0 to form a real finite inverted intermediate image I_1 inside the focal plane of the eye piece lens. The eye piece is then moved slowly to and from the objective lens until a sharp, magnified inverted virtual image, I_2 is formed at a distance of 25cm from the eye piece lens, L_e.

05

(ii)



$M = \frac{\beta}{\alpha}$ For α and β being small angles in radians

$\alpha \approx \tan\alpha = \frac{h_0}{D}$, and $\beta \approx \tan\beta = \frac{h_2}{D}$

$\therefore M = \frac{h_2}{D} \times \frac{D}{h_0} = \frac{h_2}{h_0} \qquad = \frac{h_2}{h_1} \times \frac{h_1}{h_0}$

$= m_e \times m_0$

$= \left(\frac{v_e}{f_e} - 1\right)\left(\frac{v_0}{f_0} - 1\right)$ But, $v_e = -D$

$\therefore M = -\left(\frac{D}{f_e} + 1\right)\left(\frac{v_0}{f_0} - 1\right)$

[03]

(d) (i)

Compound microscope	Astronomical telescope
- Is used for observing nearby objects	- Is used for observing distant objects ~~at infinity~~.
- Has objective lens of a shorter focal length than its corresponding eye – piece focal length i.e. $f_o < f_e$	- Has objective lens of a longer focal length than its corresponding eye –piece focal length i.e. $f_o > f_e$
- Forms the final image at the near point when in normal adjustment.	- Forms the final image at infinity when in normal adjustment.
- Has a relatively greater resolving power than of Astronomical telescope.	- Has a relatively smaller resolving power than of a compound microscope.

Any three correct responses @ pair 1mark. [03]

(ii) Images viewed via the eye ring are ***very bright*** and ***distinct*** because all the light passing the instrument is received at the eye ring.

It also provides ***the instrument with a wider field of view*** when objects are observed at the eye ring. [02]

SECTION B

3. (a) (i) ***Distinguishing between Mechanical and Electromagnetic waves.***

Mechanical waves	Electromagnetic waves
Are propagated as a result of vibrations of the particles of a given material medium.	Are propagated by the vibrations of electric and magnetic fields.
Travel at relatively low speeds.	Travel at relatively higher speeds.
They require material medium for their propagation to occur.	Can be propagated even in the absence of a material medium.

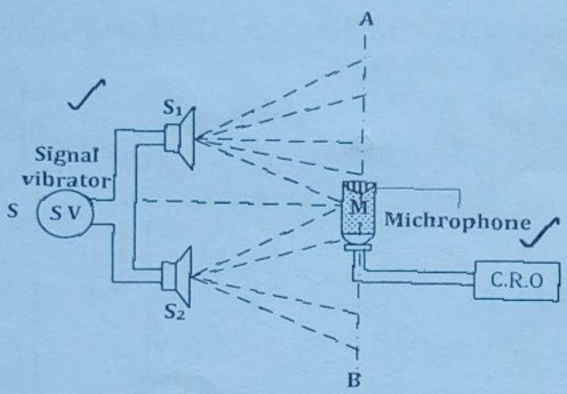
Any two correct responses @ pair 1mark. [02]

(ii) ***Distinguishing between sound waves and Light waves.***

Sound waves	Light waves
- Are longitudinal waves in nature.	- Are transverse waves in nature
- Require a material medium for their propagation to occur.	- Can be propagated through a region without any medium.
- They can not be polarized.	- They undergo polarization.
- They can not travel through a vacuum.	- They travel through a vacuum.
- They travel at a relatively low speed through air.	- They are propated at a very high speed through air.

Any two correct responses @ pair 1mark. **[02]**

(b)



Two loud speakers S_1 and S_2 are connected to one signal vibrator S and their planes made to coincide a long a straight line.

A microphone, M, is connected to the y – plates of a C.R.O with its time base switched off.

The signal vibrator is switched on and the microphone ~~is~~ moves up and down along a line perpendicular line **AB** to that from the midpoint of S_1 and S_2.

The length L of the vertical line trace on the screen of the C.R.O is noted for each position of the microphone.

Its observed that there is a systematic ***rise and fall*** in the length L of the line trace.

The positions of increase in length correspond to regions of constructive interference where the two wave trains from the coherent sources are in phase, while the positions of decrease in length L of the line trace correspond to positions of destructive interference where the two wave trains from the coherent sources are completely out of phase.

The alternate increase and decrease in the length of the line trace shows an interference pattern. **[05]**

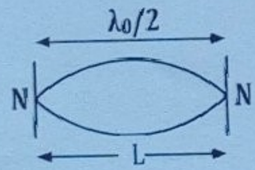
(c) (i) *The frequency of vibration of a string of an instrument is inversely proportional to the length of the string provided tension in the string and the mass per unit length, are all kept constant.*

The frequency of vibration of the string is directly proportional to the square root of the tension in the string provided length and mass per unit length are kept constant.

The frequency of vibration of a string is inversely proportional to the square root of the mass per unit length, provided, length of the string and the tension in it are kept constant. **[03]**

(ii) $d = 0.30mm = 3.0 \times 10^{-4}m$ $\quad \rho = 780kgm^{-3}$

$T = 100N, \quad f_0 = 842\ H_z$



Using $v = f\lambda = \sqrt{\frac{T}{\mu}}$

$\Rightarrow \quad f_0 = \frac{1}{\lambda}\sqrt{\frac{T}{\mu}} = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$ $\qquad$ but $\lambda_0 = 2L$

$\therefore L = \frac{1}{2f_0}\sqrt{\frac{T}{\mu}}$ $\quad$ where $\mu = \frac{m}{L} = \frac{A\,L\,\rho}{L} = \frac{\pi d^2 \rho}{4}$

$\therefore L = \frac{1}{2f_0}\sqrt{\frac{4T}{\pi d^2 \rho}}$

$\frac{1}{2 \times 842}\sqrt{\frac{4 \times 100}{\pi\,(3.0 \times 10^{-4})^2 \times 780}}$

$L = 7.997 \times 10^{-1}m$

$L = 0.800\ m$ **[04]**

(d) (i) **Doppler effect** is the apparent change in the frequency of sound waves received by the observer, due to relative motion between the source of sound waves and the observer. **[01]**

(ii) $f = 600H_z$ $\quad U_s = 4.0ms^{-1}$ $\quad U_0 = 0.5ms^{-1}$ $\quad V = 340ms^{-1}$

$$f^1 = \left(\frac{V + u_0}{V - u_s}\right) f$$

$$= \left(\frac{340 + 0.5}{340 - 4.0}\right) \times 600$$

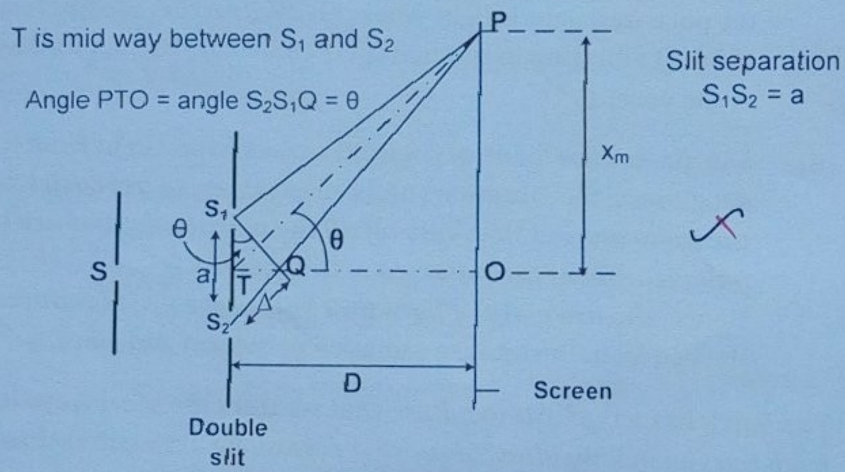
$$f^1 = 608.04H_z \approx 608\ H_z$$ **[03]**

4. (a) (i) **Interference** is the super position of two wave trains originating from at least two coherent sources resulting to the formation of permanent regions of bright and dark bands. **[01]**

(ii) ***Conditions for interference by division of wave front.***

- Sources must be coherent.
- Distance between the slits should be very small.
- Width of the slits should be very small i.e use narrow slits.
- Screen for observing interference fringes should be relatively far from the slits.
- Amplitudes of the waves must be same or comparable. **[03]**

(b) (i) The derivation of fringe separation, y



Suppose P is the position of the mth bright fringe, then

$S_2P - S_1P = m\lambda$ ....(i)

The path difference between the waves arriving at P from S_1 and S_2 is

$\Delta = S_2Q = (S_2P - S_1P)$ ....(ii)

For small value of angle θ in radians, $\sin\theta \approx \tan\theta = \frac{x_m}{D}$

$S_2Q \approx a\sin\theta = a\tan\theta = \frac{a\,x_m}{D}$

Hence , $S_2Q = \frac{a\,x_m}{D}$

From (i) , (ii) and (iii) , the m[th] bright fringe is obtained from,

$m\lambda = \frac{a\,x_m}{D}$ implying $x_m = \frac{m\lambda D}{a}$

For the (m – 1)[th] **bright fringe,** $x_{m-1} = \frac{(m-1)\lambda D}{a}$

$\therefore$ Fringe width(separation), $y = (x_m - x_{m-1}) = \frac{\lambda D}{a}$

Thus Fringe width(separation), $y = \frac{\lambda D}{a}$ **[04]**

(ii) $a = 0.127mm$ $D = 3.30m$ $\lambda = 6.34 \times 10^{-7}m$

Using, $x_m = \frac{mD\lambda}{a}$ for m = 5 and m = 3

$$(x_5 - x_3) = \frac{5D\lambda}{a} - \frac{3D\lambda}{a} = \frac{2D\lambda}{a}$$

$$= \frac{2 \times 3.30 \times 6.34 \times 10^{-7}}{0.127 \times 10^{-3}}$$

$\therefore (x_5 - x_3) = \mathbf{3.29 \times 10^{-2}\,m}$ **[03]**

(c) (i) Plane polarized light is light whose electric vector vibrates in only one plane perpendicular to that of propagation of the wave,

While

Un-polarized light is light whose electric vectors are not restricted to any plane of vibration in relation (perpendicular) to the direction of propagation of the wave. **[02]**

(ii) Sun glasses are made of polaroid's which when light from the sun falls on the sunglasses, the vibrations of the electric vector ***get restricted to the plane of the polaroid*** and thus ***cuts off all the vibrations that are not in the plane of polarization of the polaroid of the glasses.***

Hence, ***the intensity of light that enters the eye is reduced*** thus protecting the eye from the intense radiation of the sun and glare. **[03]**

(d) The Earth has a *thick* **atmosphere that** ***scatters*** *the short wave length radiation* from the sun mainly ***blue colour*** that eventually illuminates the entire sky.

The ***moon*** on the other hand ***has no atmosphere*** and hence has no particles in the atmosphere that cause the scattering of short wave length, leaving the sky appearing black or dark. **[04]**

SECTION C

5. (a) (i) **A tesla** – *Is the magnetic flux density that causes a straight conductor of length 1m to experience a magnetic force of 1N when it carries a current of 1A in a normal to the magnetic field.* **[01]**

(ii) **A weber** - Is the magnetic flux threading normally an area of 1m² placed normal to a uniform magnetic field of flux density one tesla. **[01]**

(b) (i) B at P due to wire W, $B_w = \frac{\mu_0 I_w}{2\pi\,(d + 0.03)}$

B at P due to wire, X $B_X = \frac{\mu_0 I_X}{2\pi d}$

Resultant, $B_P = B_X - B_w$ or $B_P = B_w - B_X$

Since $B_P = 0 \Rightarrow B_X - B_w = 0$

$\therefore \quad B_X = B_w$

$\Rightarrow \quad \frac{\mu_0 I_X}{2\pi d} = \frac{\mu_0 I_w}{2\pi (d+0.03)}$

$\therefore \frac{4}{d} = \frac{10}{(d + 0.03)}$

$4d + 0.12 = 10d$ ⇒ 20cm

$\therefore d = 0.120\,m$ or $12.0\,cm$ from wire, X **[03]**

(ii) Force per metre of wire W due to wire X

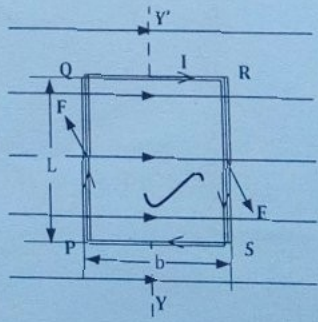
$\frac{F}{L} = \frac{\mu_0 I_X I_W}{2\pi x_o}$ where $x_o = 0.03m$

$= \frac{4\pi \times 10^{-7} \times 4 \times 10}{2\pi \times 0.03}$

$\therefore \quad \frac{F}{L} = 2.67 \times 10^{-4}\ Nm^{-1}$ **[02]**

(c) Force on side PQ F = BINL in to the plane of the coil force on side **RS** F = BILN out of the plane of the coil.

There are no magnetic forces acting on sides QR and SP



Force on side **PQ**, F = BILN into the paper

Force on side **RS**, F = BILN out of the paper

Sides **QR** and **SP** experience zero force

The two forces F constitute a couple whose

Turning moment or Torque, $T = F \times b$

i.e. $T = BIN(L \times b)$ where $L \times b = A$ (Area of the plane)

Torque on coil $\quad T = F \times b$

$= BIN(L \times b)$

$T = BINA$

[04

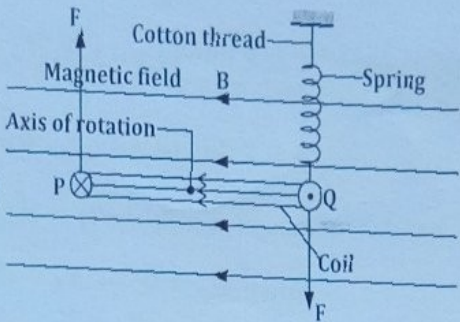
(d) (i) Force on side Q, $F = BILN$

But $\quad F = kx$

$\Rightarrow kx = BILN$

$\therefore x = \frac{BILN}{k} = \frac{1.30 \times 0.90 \times 0.060 \times 10}{550}$

Extension, $x = 1.276 \times 10^{-3} m$



(ii) ***The Deflection torque on a coil is increased by :-***

- *Increasing the size of current flowing in the coil.*
- *Increasing the number of turns of the coil.*
- *Increasing magnetic field strength, B in the region of the coil.*
- *Increasing the area, A, of the plane of the coil.*

Any two @ 1 mark

[02]

(e) A metal conductor with its largest face placed normal to the field, has current passed through the smallest face.

Electrons are urged by the field to the left face leaving positive charge on the opposite face.

A strong electric field is built up between the opposite charged faces.

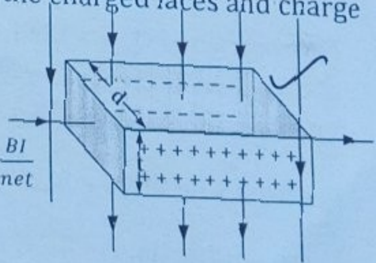
When electric force acting on the electron equals the magnetic force.

i.e. $\quad Ee = Bev$

a large p.d called Hall voltage is set up between the charged faces and charge separation stops.

But $\quad E = \frac{V_H}{d} \Rightarrow \frac{V_H}{d} = Bv$

$\therefore \quad V_H = Bvd$ or $V_H = \frac{BI}{net}$



Where $v =$ *drift velocity of the electrons*

[04]

6\. (a) (i) **Electromagnetic induction** – is the production of an induced e.m.f. in a coil, (conductor or circuit) whenever the magnetic flux linked with it changes.

[01]

(ii) **Laws of electromagnetic induction.**

- The *magnitude* of the e.m.f. induced in a coil or conductor is directly proportional the rate of change of magnetic flux linked with it.
- The direction of the induced e.m.f. in a coil or closed circuit acts in such a way as to oppose the change (of magnetic flux) that caused it.

[02]

(b) $N_2 = 100\ turns \quad n_1 = 500\ turns\ per\ metre$

Using $E = -M\frac{dI}{dt}$ where , $M = \mu_0 n_1 N_2 A$

$Since,\ I = 10\sin 120\pi\, t$

$\therefore \frac{dI}{dt} = 1200\pi \cos 120\,\pi\, t$

$\therefore E = -1200\pi\mu_0 n_1 N_2 A \cos 120\pi\, t$ (Ignore (–))

$\therefore$ Amplitude $E_0 = 1200\pi\mu_0 n_1 N_2 A$

$E_0 = 120\pi \times 4\pi \times 10^{-7} \times 500 \times 100 \times \pi(0.08)^2$

$E_0 = 4.76\times 10^{-1}\, V$

[04]

(c) (i) **Eddy currents** – is induced currents generated in the armature or in a conductor moving across a magnetic field or placed in a changing magnetic field.

[01]

They always act in such a direction as to oppose the action that caused their creation.

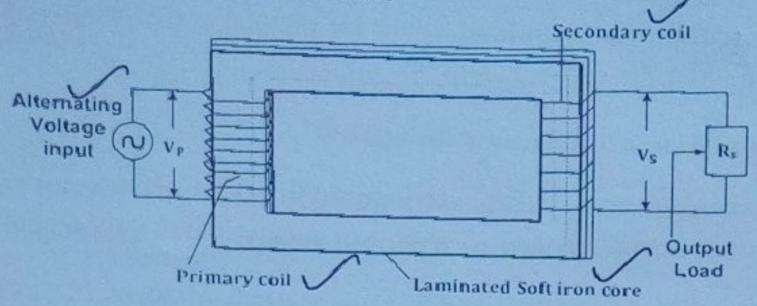
(ii) **Uses of Eddy currents:**

- *Heating and melting off metals in induction furnaces.*
- *Damping in moving coil instruments.*
- *Act as electromagnetic brakes in trains, cranes e.t.c.*
- *Operation of speedometers.*
- *Operation of ATMs and vending machines.*
- *Sorting metals from non – metals.*

Any three @ 1 mark

[03]

(d) (i) **The A.C. Transformer;**



- An alternating voltage connected to the primary coil produces an alternating current in it, which in turn produces a changing magnetic flux in it.
- The changing magnetic flux links the primary inducing a back e.m.f in the same coil, $V_p = -N_p A\frac{dB}{dt}$ ……………………………(i)
- This sets up an *alternating magnetic flux* in the core which links up the secondary coil and thus *induces an alternating* e.m.f, V_s in the secondary coil.
- The magnitude of the e.m.f induced in the secondary coil is

$V_s = N_s A\frac{dB}{dt}$ ……………………(ii) Thus from (i) and (ii),

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

NB: The negative implies the primary and secondary voltage are 180° out of phase i.e. Anti-phase.

*When $N_s > N_p$, $V_s > V_p$ and the transformer is **a step up transformer**.*

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

[05]

(ii) ***Energy losses in an a. c. transformer are caused by the following;***

- *Heat dissipated in the core in the form I^2R – mechanism due to **eddy currents**.*
- *Heat dissipated in the windings in the form I^2R – mechanism due **to resistance of the windings** i.e. the primary and secondary coils.*
- *Internal resistance in the core due to Hysteresis power loss causing the heating up of the core resulting from the opposition to continuous magnetic dipole reversals.*
- *Poor magnetic flux linkage between the primary coil and the secondary coil as a result of some air gap in the core or poor design of the transformer.*

Any three factors @ 1 mark

[03]

(a) (i) ***Inductive reactance*** – is the non-dissipative opposition to the passage of a.c. or changing current through pure inductor. **[01]**

(ii) Suppose current, $I = I_0 \sin 2\pi ft$ is passed through a pure inductor,

Back e.m.f. $\varepsilon_b = -L\frac{dI}{dt} = -L\frac{d(I_0 \sin 2\pi ft)}{dt} = -2\pi f L I_0 \cos 2\pi ft$

$\therefore \varepsilon_b = -2\pi f L I_0 \cos 2\pi ft$

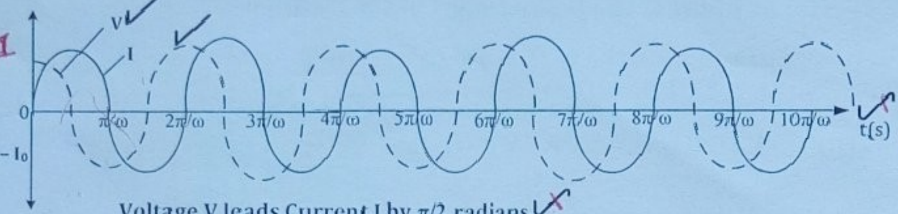
But $\varepsilon_b = -V$, where V = applied a.c voltage

$\therefore V = 2\pi f L I_0 \cos 2\pi ft$

Where, $V_0 = 2\pi f L I_0$ (peak voltage)

$\therefore X_L = \frac{V_0}{I_0} = 2\pi f L$ **[03]**

(b) (i) Voltage – current graphs against time for an inductor.



Voltage V leads Current I by $\pi/2$ radians

Mr. Daws
782908006

[03]

(ii) When the circuit is just completed (switched on), *current flowing is zero*, but the *rate of flow of current in the inductor circuit is very high.*

The *rapidly changing magnetic flux linking the plane of the coil* (inductor) induces *a large back e.m.f. in the coil causing maximum p.d* (induced e,m.f.) across the Inductor.

As the *current gradually increases to a maximum value*, in a quarter of a cycle the rate of flow of the current in the circuit reduces to zero, hence *the back e.m.f. (i.e. p.d across the inductor) becomes zero.*

Thus ***when current is zero*** the p.d. or ***voltage across the inductor is a maximum*** and vice –versa. This implies voltage leads current by 90° or $\frac{\pi}{2}$ radians. **[03]**

(c) (i) $V = 340\sin(100\pi t)$ $C = 10\mu F$ $I_0 = ?$

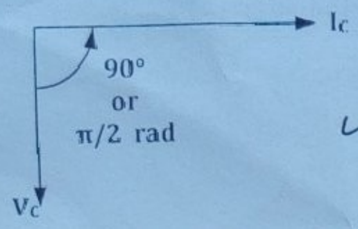
$V_0 = 340\ V,\ X_c = \frac{1}{2\pi fC} = \frac{V_0}{I_0}$ but $f = 50 H_z$

$\therefore I_0 = 2\pi f C V_0 = 2\pi \times 50 \times 10 \times 10^{-6} \times 340$

$\Rightarrow I_0 = 1.068\ A$

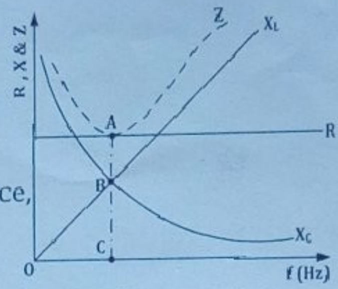
[03]

(ii) Phasor diagram:



Current leads Voltage by 90° **[01]**

(d) (i) At point A, the ***impedance* Z**, of the circuit is at its **minimum value** i.e $Z_{min} = R$ ✓



Resonance is attained at ***point B***, where Capacitive reactance equals inductive reactance, ie $X_c = X_L$ ✓

At ***point C***, the ***frequency***, f of the circuit is ***at resonance*** i.e $f = f_0$ ✓ when $X_c = X_L$ ie $f_0 = \frac{1}{2\pi\sqrt{LC}}$ **[03]**

(ii) L =5.0 mH = $5.0\times 10^{-3}H,\ f_0 = 60H_z$

Using $f_0 = \frac{1}{2\pi\sqrt{LC}}$ ✓

$$\sqrt{LC} = \frac{1}{2\pi f_0} \Rightarrow LC = \left(\frac{1}{2\pi f_0}\right)^2$$

$$\therefore\ C = \left(\frac{1}{2\pi f_0}\right)^2 \times \frac{1}{L}$$

$$C = \left(\frac{1}{2\pi\times 60}\right)^2 \times \frac{1}{50\times 10^{-3}}$$ ✓

C = $1.407\times 10^{\cancel{-4}\,-3}F$ *or* $140.7\mu F$ ✓ **[03]**

SECTION D

8. (a) (i) **volt** – is the p.d. across opposite faces of a conductor or resistor having a resistance of 1Ω and a current of 1 A flowing through it. ✓

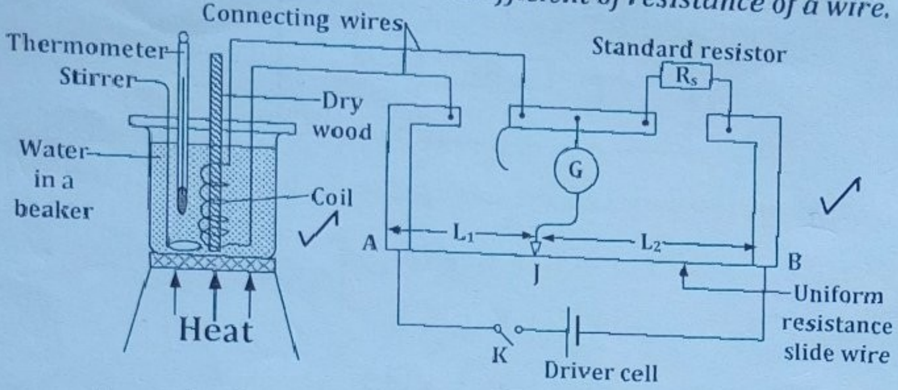
E.m.f. – is the work done to move 1 C of charge around a complete circuit to which the battery itself is connected. ✓ **[02]**

(ii) When a p.d is applied across the ends of a metal conductor, the electric field set up in it *accelerate electrons in one direction* and a current flows in the opposite direction.

Electrons collide with the lattice ions and give off some of their energy to these *ions that vibrate with larger amplitudes* and pass on their vibrational energy in form of increase in internal energy (heat) to the surface atoms. **[03]**

(b) (i) ***Temperature coefficient of resistance*** – is the *fraction change* in resistance of the material at 0°C per kelvin rise in temperature. **[01]**

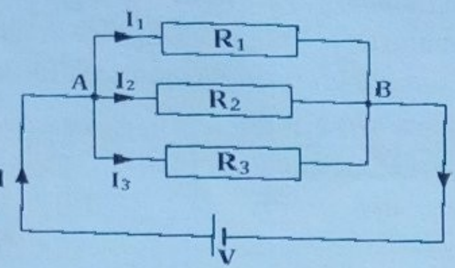
(ii) ***Measurement of temperature coefficient of resistance of a wire.***



- A sample of a material of copper is made into a coil of wire is wrapped around a dry piece of wood and immersed inside a beaker of water with its ends connected to the left hand gap of a metre bridge as shown.
- At room temperature, switch K is closed and the sliding contact J is tapped along the slide wire until the centre zero galvanometer G shows no deflection.
- Balance lengths L_1 and L_2 or $(100 - L_1)$ are measured using a metre rule and recorded.
- The liquid containing the coil is then heated gradually while stirring, at a given temperature, θ, K is closed at the balance point and balance lengths are noted.
- The experiment is repeated for several increasing values of θ, and at any given temperature, a corresponding balance point and balance lengths are noted.
- The results are tabulated in a suitable table including values of θ, L_1, L_2 and $R_\theta = R_S\left(\frac{L_1}{L_2}\right)$ where R_S is the resistance of a standard resistor connected on the right hand gap of the metre bridge.

- A graph of R_θ against θ is plotted with the temperature axis starting at zero as the origin.
- The *slope* S of the graph is then determined together with the *intercept* R_0 on the resistance axis when $\theta = 0°C$.
- The *temperature coefficient of resistance* α of copper is then calculated from the expression, $\alpha = \frac{R_0}{s}$. $\alpha = \frac{S}{R_0}$ **[06]**

(c) (i) Let R_1, R_2 *and* R_3 *be the resistnces of three resiscor in parallel.*



All the resistors have the ***same p.d*** across but different currents.

$$I = I_1 + I_2 + I_3$$

$$= \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

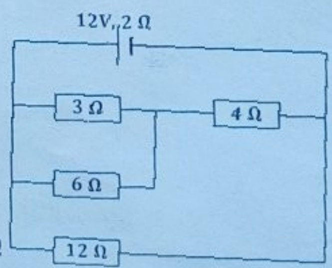
$$I = V\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)$$

774533P352 $\therefore$ $$\frac{I}{V} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$\frac{I}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

But $\frac{I}{V} = \frac{I}{R}$ where ***R is the effective resistance*** of the circuit. **[03]**

(ii) 3Ω and 6Ω are in parallel $R' = \frac{6 \times 3}{6+3} = \frac{18}{9} = 2\Omega$



2Ω is in series with 4Ω $R'' = 2 + 4 = 6\Omega$

6Ω is now in parallel with the 12Ω resistor

$$R''' = \frac{6 \times 12}{6+12} = \frac{72}{18} = 4\Omega$$

Now the 4Ω is in series with internal resistance of 2Ω

$\therefore$ *Effective resisttance*, $R = 2 + 4 = 6\Omega$

Using, $I = \frac{V}{R}$ $\Rightarrow$ current, $I = \frac{12}{6} = 2\ A$

[04]

(d) **Super conductors** are used:

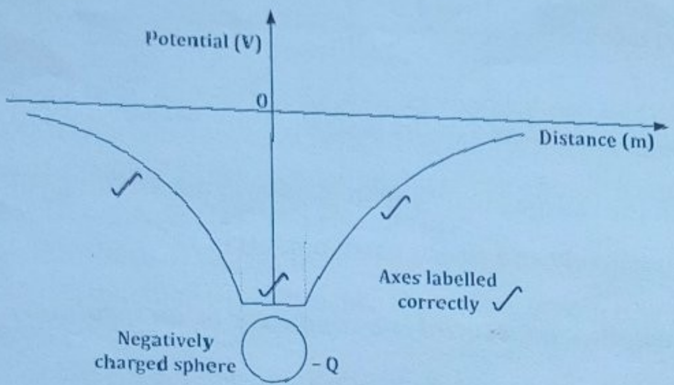
- *To make extremely powerful electromagnets.*
- *To accelerate changed particles very first to (near the speed of light)*
- *In the operation of maglev trains (i.e. Magnetic levitation)*
- *In magnetic resonance imaging (MRI) i.e. used to see inside patients.*
- *In nuclear magnetic resonance (NMR) machines.*
- *In fusing magnets used in nuclear reactors.*
- *Electric transmission netwons in computers and electronics.*
- *Mobile phones bass stations and boat turbines.*

Any one of these @ 1 mark

[01]

9. (a) (i) **Electric potential** - is the work done to move a +1C charge from infinity to a point in an electric field against electrostatic repulsive forces. **[01]**

(ii)



[02]

(b) Let Electric potential at O due to Q_1 be V_1, ...

$$V_1 = \frac{Q_1}{4\pi\varepsilon_0 r_1} = \frac{1.5 \times 10^{-6} \times 9.0 \times 10^{9}}{0.03} = +4.50 \times 10^{5}\ V$$

$$V_2 = \frac{-3.0 \times 10^{-6} \times 9.0 \times 10^{9}}{0.03} = -9.00 \times 10^{5}\ V$$

$$V_3 = \frac{6.0 \times 10^{-6} \times 9.0 \times 10^{9}}{0.03} = +1.80 \times 10^{6}\ V$$

$$V_4 = \frac{-1.8 \times 10^{-6} \times 9.0 \times 10^{9}}{0.03} = -5.40 \times 10^{5}\ V$$

$$V = V_1 + V_2 + V_3 + V_4 = (4.50 - 9.00 + 18.0 - 5.40) \times 10^{5}$$

$$V = 8.10 \times 10^{5}\ V$$

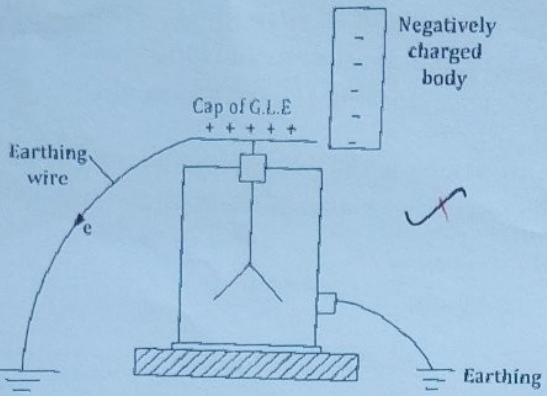
$$\Rightarrow \text{E.P.E} = QV = 2.0 \times 10^{-6} \times 8.10 \times 10^{5}$$

$$= \mathbf{1.62\ J}$$

[05]

(c) (i) ***Charging a G.L.E. positively by induction at zero potential.***

- A neutral gold leaf electroscope (GLE) is stood on an insulating stand.
- A negatively charged ebonite rod (or body) is brought near the cap of the GLE.
- With the negatively charged body in place, the cap of the GLE is earthed.

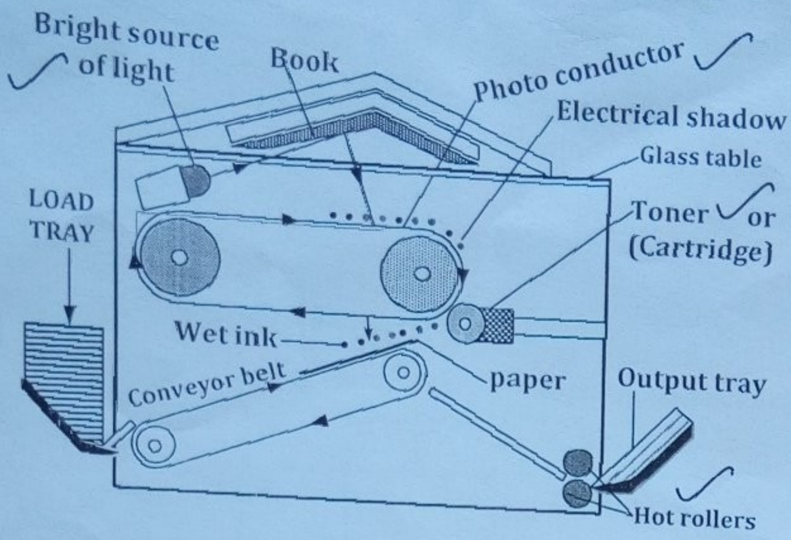


- With both the charged body still in place and the earthing still on, the GLE is charged positively and also at earth potential. **[03]**

(ii) ***Testing whether a material is a conductor or an insulator.***

- A gold leaf electroscope (GLE) is first charged say positively.
- A neutral copper rod is now placed on the cap of the GLE so that the two bodies are in contact with each other.
- The golf leaf is seen to collapse.
- The copper rod is removed from the cap and the GLE is charged a fresh say positively.
- A neutral glass rod is now placed on the cap of the GLE so that the two bodies are in contact with each other.
- The GLE is noted to show an insignificant change in the divergence of the golf leaf.
- Thus a more significant change in the divergence of the leaf of a charged GLE corresponds to a conductor(Copper), while no change or insignificant change in the divergence of the gold leaf corresponds to an insulator(glass). **[04]**

(d) *The structure and mode of operation of A paper photo copier.*



- A document to be photocopied is placed upside down on the glass table.
- An extremely bright source of light scans across the document and sends an "electrical shadow" of the page on to the photo photoconductor (conveyor belt coated with a chemical called selenium).
- As the belt rotates, it carries the electrical shadow around with it and passes near an ink drum touching the belt which then coats it with tiny particles of the powdered ink (toner).
- The toner has been given an electrical charge, so that it sticks on to the electrical shadow and makes an inked image of the original page on the conveyor belt (photo conductor).
- A sheet of paper from a hopper (Load tray) on the other side of the copier feeds up towards the first belt on another conveyor belt. As it moves along, the paper is given a strong electrical charge.
- When the paper moves near the upper belt, its strong charge attracts the charged toner particles away from the belt and the image is rapidly transferred from the belt onto the paper.
- The inked paper passes through two hot rollers (the fuser unit) where the heat and pressure from the rollers then fuse the toner particles permanently onto the paper, then a final copy emerges from the side of the copier (output tray). **[05]**

10. (a) (i) ***Capacitance*** – is the ratio of the ***magnitude*** of charge on either plate to the p.d between the plates of the capacitor.

(ii) Let C_0 be capacitance of an air capacitor C' capacitance of the same capacitor with a dielectric between its plates.

$\therefore C' = \varepsilon_r C_0$

p.d across the plate $V' = \frac{Q}{C'} = \frac{Q}{\varepsilon_r C_0}$

Let V_0 be the new p.d when the dielectric is removed, but charge remains Q

$\therefore V_0 = \frac{Q}{C_0}$

$\Rightarrow$ change in p.d , $\Delta V = V_0 - V' = \frac{Q}{C_0} - \frac{Q}{C_0 \varepsilon_r}$

$= \frac{Q}{C_0}\left(1 - \frac{1}{\varepsilon_r}\right)$

$= \frac{Q}{C_0 \varepsilon_r}(\varepsilon_r - 1)$

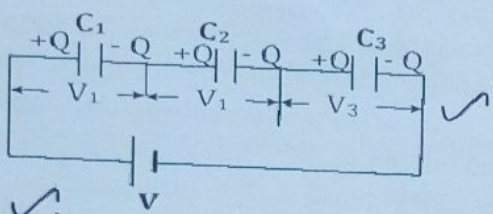
$\therefore$ Fractional change in p.d

$\frac{\Delta V}{V'} = \frac{Q}{C_0 \varepsilon_r}(\varepsilon_r - 1) \times \frac{\varepsilon_r C_0}{Q}$

$\therefore \frac{\Delta V}{V'} = (\varepsilon_r - 1)$

[04]

(b) (i)



Same charge is induced on all the plates of the capacitor

Net p.d, $V = V_1 + V_2 + V_3$

But $V_1 = \frac{Q}{C_1}$, and $V_2 = \frac{Q}{C_2}$ and $V_3 = \frac{Q}{C_3} \Rightarrow \mathrm{V} = \frac{Q}{C_1} + \frac{Q}{C_2} + \frac{Q}{C_3}$

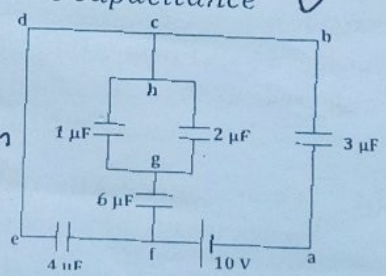
$\mathrm{V} = \mathrm{Q}\left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}\right)$

$\frac{\mathrm{V}}{\mathrm{Q}} = \left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}\right)$

But $\frac{\mathrm{V}}{\mathrm{Q}} = \frac{1}{\mathrm{C}}$ *where C is the effective capacitance*

$\frac{1}{\mathrm{C}} = \left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}\right)$

[04]



(ii) Along **gh**: $C' = 1.0 + 2.0 = 3.0\mu F$

Along **cf**: $C'' = \frac{3.0 \times 6.0}{3.0 + 6.0} = 2\mu\mathrm{F}$

$\therefore C''' = 4.0 + 2.0 = 6.0\ \mu\mathrm{F}$

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

∴ Effective capacitance of the circuit networks

$$C = \frac{6.0 \times 3.0}{6.0 + 3.0} = 2.0\,\mu F$$

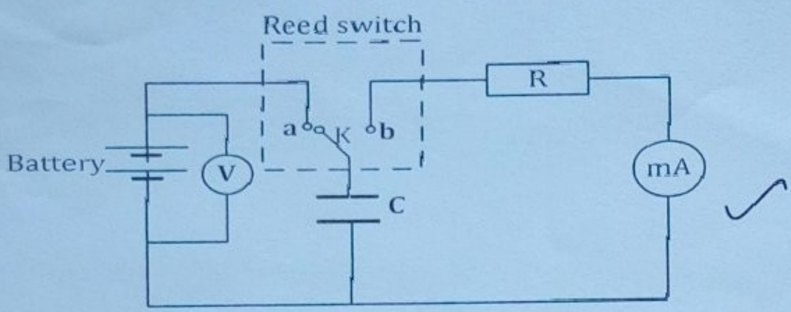
Energy stored in the system

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

$$= \frac{1}{2} \times 2.0 \times 10^{-6} \times (10)^2$$

$$\therefore \quad E = 1.0 \times 10^{-4}\, J$$ with unit **[04]**

(c)



Using the set up shown above, a capacitor with maximum area of overlap A connected to the circuit with distance between the plates filled with air. The reed switch is set on and the steady reading I_0 is registered on the milli-ammeter mA.

The space between the plates is then filled with a dielectric material of permittivity ε.

The reed switch is set on again and the steady reading I_1 is registered on the milli-ammeter mA.

Its observed that $I_0 < I_1$ and from the expression for capacitance of a capacitor,

$$C = \frac{Q}{V} = \frac{I}{fV} = \frac{\varepsilon A}{d} \Rightarrow C \propto I \quad thus\ C_1 > C_0 \ \ since\ I_1 > I_0$$

Hence capacitance of a capacitor increases when a dielectric is inserted between the plates of a charged capacitor. **[05]**

NB: Accept other alternative methods

The ballistic galvanometer method and
The gold leaf electroscope method.

(d) ***Uses of capacitors include:***

- Tuning radio and T.V receivers.
- Preventing sparking in large current operated switches.
- Smoothing rectified a.c. circuits.
- Filtering rectified a.c. circuits.
- in microphones.
- Storing charges in Phones and cameras.

[02]

NB: Mark only the first two uses of capacitors as provided by the candidate.

= END =

P510/2
PHYSICS
Paper 2
August, 2019
2½ hours

JINJA JOINT EXAMINATIONS BOARD

Uganda Advanced Certificate of Education

MOCK EXAMINATIONS –AUGUST, 2019

PHYSICS

Paper 2

(Principal Subject)

2 hours 30 minutes

INSTRUCTIONS TO CANDIDATES:

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

*Any additional question(s) answered will **not** be marked.*

Mathematical tables and squared paper will be provided.

Non-programmable Silent Scientific Calculators may be used.

Assume where necessary;

Acceleration due gravity, g	=	$9.81\ m\ s^{-2}$
Speed of light in vacuum, c	=	$3.0 \times 10^{8}\ m\ s^{-1}$
Speed of sound in air	=	$340\ m\ s^{-1}$
Electronic charge, e	=	$1.60 \times 10^{-19}\ C$
Electronic mass, m_e	=	$9.11 \times 10^{-31}\ kg$
Permeability of free space, μ_o	=	$4.0\pi \times 10^{-7}\ H\ m^{-1}$
Permittivity of free space, ε_0	=	$8.85 \times 10^{-12}\ F\ m^{-1}$
The Constant, $\frac{1}{4\pi\varepsilon_o}$	=	$9.0 \times 10^{9}\ F^{-1}\ m$

SECTION A

1. (a) (i) State the laws of refraction of light. (2 marks)

(ii) A ray of monochromatic light is incident from air onto a right angled prism of refractive index 1.52 at an angle θ as shown in figure 1.

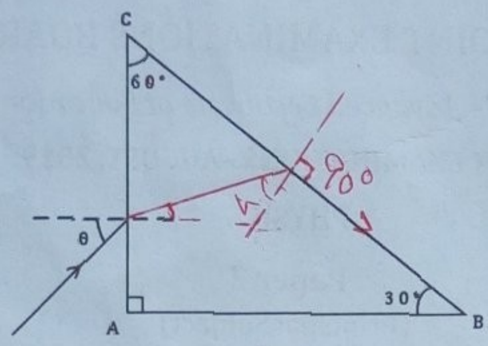


Fig. 1

Determine the maximum value of angle θ for which the ray just emerges into air after refraction by the prism. (4 marks)

(b) (i) Define the term *reflection* of light. (1 mark)

(ii) In an amusement park maze, all the walls are covered with plane mirrors as shown in figure 2. With normal N_3 and line L_1 being parallel to each other. John sees Mary's image after three successive reflections by the mirrors, M_1 , M_2 and M_3.

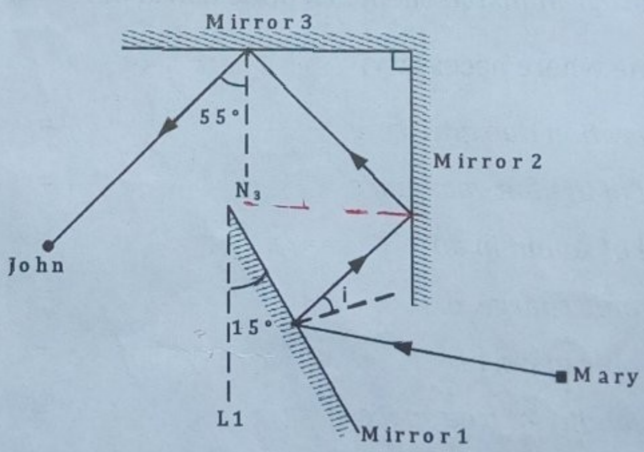


Fig. 2

If the angle of reflection in mirror 3 is 55° for the mirror arrangement, determine the angle of incidence, i in mirror 1.

(3 marks)

(c) (i) Derive an expression relating, the focal length and the radius of curvature of a concave mirror. (3 marks)

(ii) A real finite object is placed in front of a concave mirror of focal length, f and produces a real magnified image of magnification m. When the object is displaced towards the mirror, a virtual image of the same magnification, m is obtained. Show that the displacement, of the object, $d = \frac{2f}{m}$ (4 marks)

(d) Explain why some Stars twinkle at night, when observed from the Earth's surface. (3 marks)

2. (a) Define the following terms as applied to convex lenses.

(i) *optical centre.* (1 mark)

(ii) *focal plane.* (1 mark)

(b) A wild daisy having a radius of 0.6 cm is at a distance of 90.0 cm from the camera's zoom lens. The focal length of the lens is 15.0 cm. Determine the;

(i) distance from the lens to the film of the camera. (3 marks)

(ii) size of the image of the daisy on the film. (2 marks)

(c) (i) Describe the structure and mode of operation of a compound microscope in normal adjustment. (5 marks)

(ii) Derive an expression for the angular magnification of the microscope in (i) above. (3 marks)

(d) (i) Distinguish between compound microscopes and astronomical telescopes when both are in normal use. (3 marks)

(ii) Explain the significance of the Eye-ring in an optical instrument. (2 marks)

SECTION B

3. (a) Distinguish between;

(i) Electromagnetic waves and Mechanical waves. (2 marks)

(i) Light waves and Sound waves. (2 marks)

(b) Describe an experiment to demonstrate the interference effect of sound waves, using two coherent sources of sound, a microphone and other essential apparatus. (5 marks)

(c) (i) State the laws of vibration of stringed instrument. (3 marks)

(ii) A guitar wire of thickness 0.30 mm made of a metal of density 780 kg m^{-3} and held under a tension of 100 N is plucked in the middle so as to set it vibrate at its first harmonic of frequency 842 Hz. Determine the length of the wire used. (4 marks)

(d) (i) Define the term *Doppler effect*. (1 mark)

(ii) A referee blowing a whistle sounding at a frequency 600 Hz is running at a steady speed of 4.0 m s^{-1} towards an injured groaning player limping towards the referee at 0.5 m s^{-1}. Calculate the apparent frequency of sound heard by the injured player, given that speed of sound in air is 340 m s^{-1}. (3 marks)

4. (a) (i) Define the term *interference of light* waves. (1 mark)

(ii) State three conditions necessary for the occurrence of interference of light by division of wave front. (3 marks)

(b) (i) Derive using well defined symbols an expression for the fringe separation in Young's double slit experiment. (4 marks)

(ii) In Young's double slit experiment, the separation between the two slits is a distance of 0.127 mm while the screen is 3.30 m from the common plane of the slits. Calculate the distance of separation between the third and fifth bright fringes formed on the screen, when the slits are illuminated with light of wavelength of 6.34×10^{-7} m. (3 marks)

(c) (i) Distinguish between plane polarized light and un – polarized light. (2 marks)

(ii) Explain how sun glasses help to reduce glare in the eyes of a person observing a bright object. (3 marks)

(d) Explain why the Sky appears blue on the Earth and Dark on the moon (4 mark)

SECTION C

5. (a) Define the terms:

(i) *tesla*. (1 mark)

(ii) *weber*. (1 mark)

(b) Figure 3 shows two straight and parallel copper wires **W** and **X**, placed 3.0 cm apart in air and carrying currents of **10 A** and **4 A** respectively.

(i) Determine the value of the distance, d, from wire **X** for which the resultant magnetic flux density at point **P**, is zero. (3 marks)

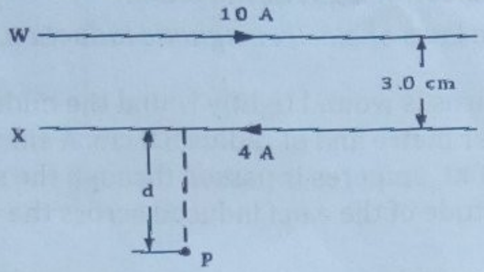


Fig. 3

(ii) Calculate the force per metre exerted on wire **W**. (2 marks)

(c) Derive an expression for the magnetic torque experienced by a rectangular coil of N turns each of area A, and carrying a current I, when its plane is parallel to a uniform magnetic field of flux density B tesla. (4 marks)

(d) Figure 4 shows a plane square coil of wire of side 0.060 m having 10 turns of wire each carrying a current of 0.90 A as indicated.

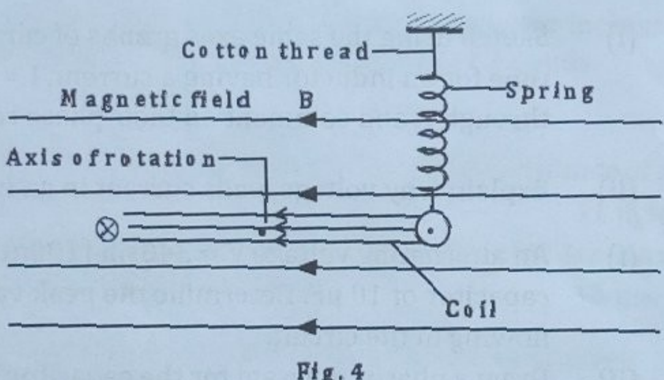


Fig. 4

When a magnetic field of flux density **1.30 T** is applied from right to left parallel to the plane of the coil turns about the axis through a small angle θ while the spring of force constant 550 Nm^{-1} remains vertical. Determine the;

(i) Extension produced in the spring. (3 marks)

(ii) State two ways in which the deflection torque of the coil above can be increased. (2 marks)

(e) Explain the origin of Hall voltage across a metal conductor placed across a uniform magnetic field when a current flows through the conductor and derive its expression. (4 marks)

6. (a) (i) What is *electromagnetic induction*? (1 mark)
(ii) State the laws of *electromagnetic induction.* (2 marks)

(b) A coil of 100 turns is wound tightly round the middle of a long solenoid of 500 turns per metre and of radius 8.0 cm. A sinusoidal current $I = 10\sin 120\,\pi t$ amperes is passed through the solenoid winding. Find the amplitude of the e.m.f induced across the terminals of the coil. (4 marks)

(c) (i) What are eddy currents? (1 mark)
(ii) State three uses of Eddy currents. (3 marks)

(d) (i) Describe the structure and mode of operation of an a.c. transformer. (5 marks)
(ii) What are the energy losses in a transformer? (4 marks)

7. (a) (i) Define the term *inductive reactance.* (1 mark)
(ii) Derive an expression for the reactance of a pure inductor when a sinusoidal current is passed through it. (3 marks)

(b) (i) Sketch using the same axes graphs of current and voltage against time for an inductor having a current, $I = I_0\sin(2\pi ft)$ flowing through it and comment on their phase relationship. (3 marks)
(ii) Explain why voltage leads current in an inductor. (3 marks)

(c) (i) An alternating voltage $V = 340\sin(100\pi t)$ is connected across a capacitor of 10 μF. Determine the peak value of the current flowing in the circuit. (3 marks)
(ii) Draw a phasor diagram for the capacitor in (i) above. (1 mark)

(d) Figure 5 shows graphs of resistance, **R**, reactance **X** and impedance **Z** of a series circuit containing a capacitor a pure inductor and a resistor.

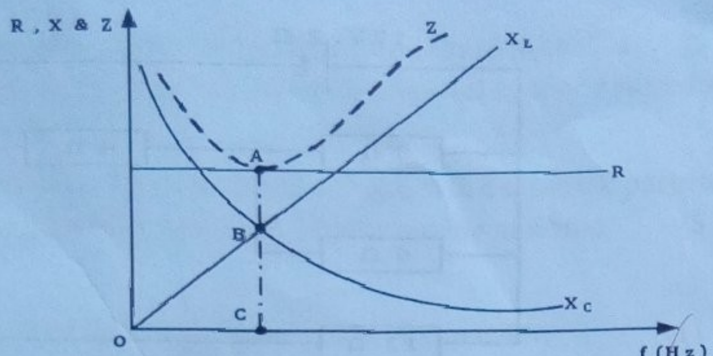


Fig. 5

(i) Identify significance of points A, B and C. (3 marks)

(ii) A variable air capacitor used in a reactive circuit having a pure inductor of self-inductance 5.0 mH connected in series with is tuned to receive a resonant signal of frequency 60.0 Hz. Determine the capacitance of the capacitor. (3 marks)

SECTION D

(a) (i) Define the term *volt and electromotive force* of a battery. (2)

(ii) Explain why the temperature of a metal conductor increases when a potential difference is applied across its ends. (3 marks)

(b) (i) What is meant by *temperature coefficient of resistance* of a material? (1 mark)

(ii) Describe an accurate experiment to determine the *temperature coefficient of resistance* of copper. (6 marks)

(c) (i) Derive an expression for the effective resistance of three resistors arranged in parallel. (3 marks)

(ii) Figure 6 shows a network of four external resistors of resistances 3 Ω, 4 Ω, 6 Ω and 12 Ω connected to a 12 V supply of internal resistance 2 Ω.

$R_\theta = R_0(1 + \alpha\theta)$ $y = mx + c$

$\frac{R_\theta}{R_0} = R_0 + \alpha\theta R_0$ $R_\theta = R_0\alpha\theta + R_0$

$\alpha = \frac{(R_\theta - R_0)}{R_0\theta}$ $S = R_0\alpha$

$\alpha = \frac{S}{R_0}$ $\alpha = \frac{S}{R_0}$

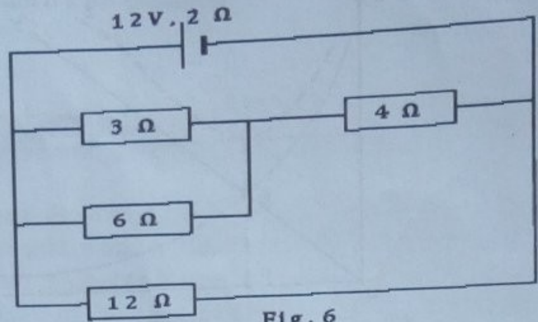


Fig. 6

Determine the value of the current supplied by the battery. (4 marks)

(d) Give one application of Super conductors. (1 mark)

9. (a) (i) Define the term *electric potential* at a point. (1 mark)

(ii) Sketch a graph showing the variation of electric potential with distance from the centre of a negatively charged metal sphere. (2 marks)

(b) Four point charges Q_1, Q_2, Q_3 and Q_4 of +1.5 μC, −3.0 μC, + 6.0μC and − 1.8 μC respectively, lie at the extremes of two perpendicular diameters of a circle of radius 3.0 cm, along the x–axis and y – axis as shown in figure 7.

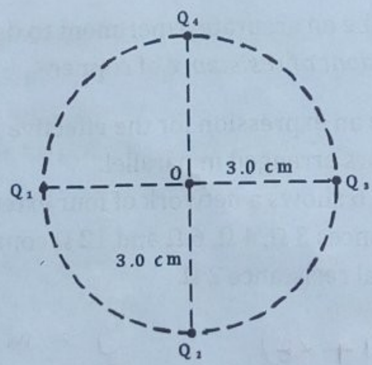


Fig. 7

Determine the resultant electric potential energy at point O when a charge of +2.0μC is placed at O. (5 marks)

(c) Explain how a gold leaf electroscope can be;

(i) charged positively by induction at zero potential. (3 marks)

(ii) used to distinguish between a neutral copper rod and a neutral glass rod. (4 marks)

(d) (i) Describe with the aid of a diagram the essential parts and the mode of operation of a photo copying machine. (5 marks)

(a) (i) Define the term *capacitance* of a capacitor. (1 mark)

(ii) A capacitor has the space between its plates filled with an insulator of dielectric constant ε_r. It's connected to a d.c. source and charged fully. It's then disconnected and isolated and the dielectric is removed. Show that the fractional change in the potential difference across the capacitor is $(\varepsilon_r - 1)$ (4 marks)

(b) (i) Derive an expression for the effective capacitance of three capacitors arranged in series. (4 marks)

(ii) The circuit in figure 8 shows a network of five capacitors of 1.0μF, 2.0 μF, 3.0 μF, 4.0 μF and 6.0 μF connected to a 10V d.c supply.

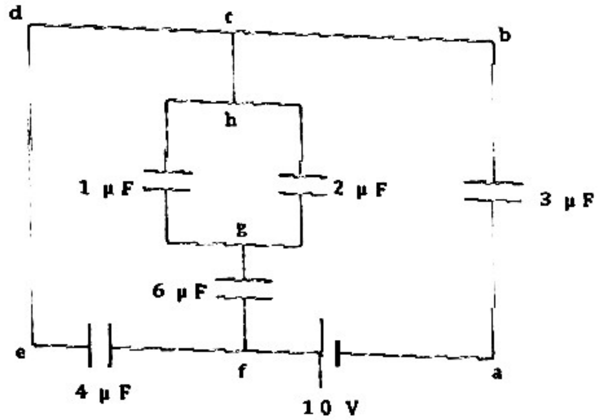


Fig. 8

Determine the total energy stored in the network. (4 marks)

(c) Describe an experiment to show the effect of inserting an insulator between the plates of a charged parallel plate capacitor. (5 marks)

(d) A part from storing charge, give two industrial uses of a capacitor. (2 marks)