P510/2
PHYSICS
Paper 2
Jul/Aug. 2023
2½ hours

UGANDA TEACHERS' EDUCATION CONSULT (UTEC)

Uganda Advanced Certificate of Education

PHYSICS

Paper 2

INSTRUCTIONS TO CANDIDATES

Answer **five** *questions, including at least one from each section, but not more than one from any of the sections A and B.*

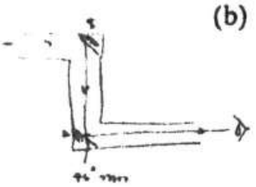
Where necessary assume the following constants:

Acceleration due to gravity, g	=	$9.81ms^{-2}$
Speed of light in vacuum, c	=	$3.0 \times 10^{8}ms^{-1}$
Speed of sound in air, v	=	$340ms^{-1}$
Electronic Charge, e	=	$1.6 \times 10^{-19}C$
Electronic mass, me	=	$9.1 \times 10^{-31}kg$
Permeability of free space, μ_o	=	$4.0\pi \times 10^{-7}Hm^{-1}$
Permittivity of free space, ε_o	=	$8.85 \times 10^{-12} Fm^{-1}$
The Constant, $^1/_4 \pi\varepsilon_o$	=	$9.0 \times 10^{9} mF^{-1}$

SECTION A

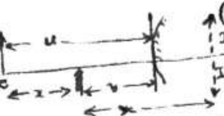
1. (a) State the *laws of reflection.* [02marks]

(b) (i) Explain with the aid of a diagram, the operation of the plane mirror periscope. [05marks]



(ii) State two advantages of total internal reflecting prisms over plane mirrors when used in periscopes. [02marks]

- No need to silvering the inside
- Prism no significant loss of light in TIR
- Can be used to invert an image



(c) Describe an experiment to determine the focal length of a convex mirror using a plane mirror and no parallax method. [05marks]

$\frac{1}{f}=\frac{1}{u}+\frac{1}{v}$ / $\frac{1}{f}=\frac{1}{x+y}-\frac{1}{x-y}$ /

(d) (i) A plane mirror is placed 10cm in front of a convex mirror so that it covers half of the mirror surface. A pin20cm in front of the plane mirror gives an image which coincides with that of the pin in the convex mirror. Find the focal length of the convex mirror. [05marks]

$y=10cm$, $x=20cm$
$u=x+y$, $v=-(x-y)$
$\frac{1}{f}=\frac{1}{u}+\frac{1}{v}$ $f=-15cm$

(ii) State one difference between images formed by a concave mirror and a plane mirror. [01mark]

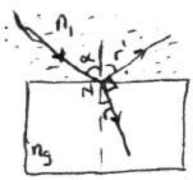
upright, virtual and same size irrespective the position of image

inverted, real and diminished if the object is at distance beyond F

2. (a) (i) What is the meant by the term *absolute refractive index.* [01mark]

Ratio of velocity of light in vacuum to the velocity of light in the medium

(ii) A glass block of refractive index, n_g is immersed in a liquid of refractive index, n_1. A ray of light is partially reflected and partially refracted at the interface such that the angle between the reflected ray and the refracted ray is 90^0.



using Snell's law at N
$n_1 \sin\alpha = n_g \sin r$ — *
$\Rightarrow r'+90+r=180$
$r'=90-r$ — (i)
But $r'=\alpha$
so $r'=90-\alpha$
$n_1\sin\alpha = n_g\sin(90-\alpha)$
$n_1\sin\alpha = n_g\cos\alpha$
$n_g = \frac{n_1\sin\alpha}{\cos\alpha}$
$\boxed{n_g = n_1\tan\alpha}$

(i) Show that $n_g = n_1 \tan a$ where α is the angle of incidence at the liquid glass-interface. [02marks]

(ii) When the above procedure is repeated with liquid removed, the angle of incidence increases by 8^0. Find a and n_g given that $n_1 = 1.33$. [04marks]

before removing $n_g = 1.33\tan\alpha$ — (i)
After removing $n_g = 1.00\tan(\alpha+8)$ — (ii)
$1.33\tan\alpha = \tan(\alpha+8)$

(b) Describe how the *refractive index* of a material of a glass prism of known refracting angle can be determined using a spectrometer [06marks]

$r = 24cm$ $f_{liq} = -12cm$
$F = 40cm$
$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_{lens}}$
$\frac{1}{f_1} = (n_1 - 1)(\frac{1}{r_1} + \frac{1}{r_2})$

(c) A biconcave lens of radius of curvature 24cm is placed on a liquid film on a plane mirror. A pin clamped horizontally above the lens coincides with image at a distance of 40cm above the lens. If the refractive index of the liquid is 1.4, what is the refractive index of the material of the lens material? [05marks]

(d) State two advantages of a Galilean telescope over astronomical telescope. [02marks]

- Final image is upright
- Shorter than A.T in NA

SECTION B

3. (a) With the aid of suitable sketch diagrams, explain *free* and *damped* oscillation. [05marks]

Free y t Damped y $t(s)$

(b) (i) What is meant by *beats* in sound? [01mark]

(ii) Explain how beats can be used to tune a musical instrument to a given note. [04marks]

(c) (i) What is meant by the term *Doppler Effect*? [01mark]

(ii) A police car traveling at 108km/hr is chasing a lorry which is traveling at 72km/hr. Both are about to pass a stationary by-stander and the police car siren emits a sound of frequency 400Hz. Calculate the apparent frequency of the note from the siren as observed by the lorry driver. [04marks]

(d) (i) Explain why open pipes are preferred as musical instruments to closed pipes. [02marks]

(ii) A cylindrical pipe of length 29cmis closed at one end. The air in the pipe resonates with a tuning fork of frequency 860Hzsounded near the open end of the tube. Determine the mode of vibration and find the end correction. [03marks]

4. (a) (i) What is meant by *interference* of waves? [02marks]

(ii) State the conditions necessary for the observation of interference pattern. [02marks]

(iii) Describe how interference can be used to test for the flatness of surface. [03marks]

(b) Describe with the aid of a labeled diagram, how the wavelength of monochromatic light is measured using Young's double-slit method. [05marks]

(c) Two microscope slides are in contact at one end and are separated by a thin piece of paper at the other end. Monochromatic light is directed normally on the wedge.

(i) What type of fringes will be observed? [01mark]

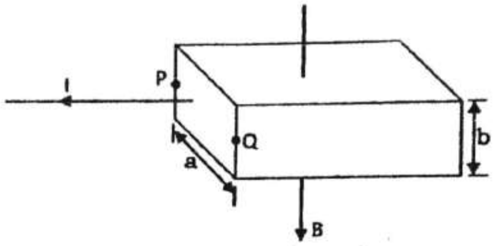
(ii) Explain what will be observed if a liquid is introduced between the slides. [03marks]

(d) When monochromatic light of wavelength 5.0×10^{-7} m is incident normally on a transmission grating, the second order diffraction line is observed at an angle of 27^0. How many lines per centimetre does the grating have? [04 marks]

SECTION C

5. (a) What is *a tesla*? [01mark]

(b) A magnetic field of flux density B is applied normally to a metal strip carrying current I as shown in the figure below.



(i) Account for the occurrence of a potential difference between points P and Q, indicating the polarity of this p.d. [03marks]

(ii) Derive an expression for the electric intensity between **P** and **Q** if the drift velocity of the conduction electrons is **v**. [03marks]

(c) (i) With the aid of a labeled diagram, describe the mode of action of a simple d.c generator. [05marks]

(ii) Sketch the output against time of a simple d.c generator. [01mark]

(iii) Explain how a back emf is developed in a motor. [03marks]

(d) A square coil of side 10 cm has 120turns. The coil is arranged to rotate at 2000 rev min^{-1} about a vertical axis perpendicular to the horizontal uniform magnetic field of flux density 0.8 T. The axis of rotation passes through the mid-points of a pair of opposite sides of the coil. Calculate the emf induced in the coil when the plane of the coil makes an angle of 30^0 with the field. [04marks]

6. (a) State the *laws of electromagnetic induction.* [02marks]

(b). A coil of area **A** is rotated at a frequency **f** in a uniform magnetic field of flux density **B** about an axis which is perpendicular to the field.

(i) Derive an expression for the emf generated. [03marks]

(ii) Deduce at least four of the factors on which the emf depends. [02marks]

(iii) State any two factors that reduce the efficiency of an a.c. generator to less than 100%. [02marks]

(c) A rectangular coil of **20 turns** is **10.0 cm** wide and **20.0 cm** long. If it rotates at a uniform rate of **300** revolutions per minute about an axis parallel to its long side and at right angles to a uniform magnetic field of flux density **0.02T**, find the peak value of the emf induced in the coil. [02marks]

(d) (i) A metallic circular disc of diameter **d** is in a uniform magnetic field of flux density **B** and the plane of the disc is perpendicular to the field. If the disc is rotated at a frequency **f**, derive an expression for the **emf** developed between its center and rim. [04marks]

(ii) With the aid of a diagram, describe the absolute method of determining resistance. [05marks]

7. (a) Define the term *root-mean-square value* as applied to an alternating current. [01mark]

(b) An alternating voltage, of r.m.s value **V**, and frequency **f**, is connected across a pure capacitor of capacitance **C**. Derive an expression for the current that flows. [04marks]

(c) (i) Explain why a capacitor allows flow of alternating current but not direct current. [03marks]

(ii) With the aid of a labeled diagram, describe the *structure* and mode of *operation* of a moving-iron ammeter of the repulsion type. [05marks]

(d) A sinusoidal alternating voltage **V= 200 sin 160t** is applied across a coil of inductance **0.5 H** and resistance **60Ω**. Find: -

(i) The phase difference between the current and the applied voltage. [02marks]

(ii) The current through the coil. [02marks]

(iii) The power dissipated in the coil. [02marks]

SECTION D

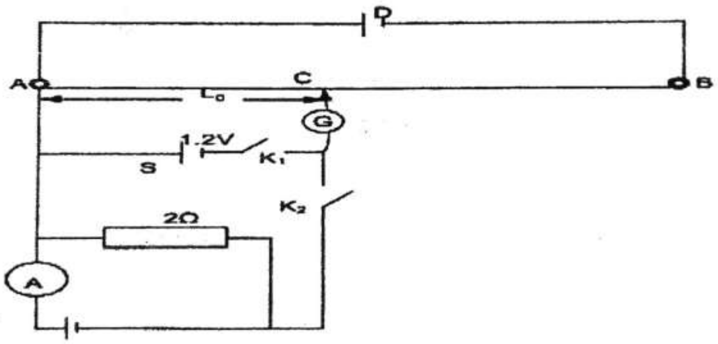
8. (a) Distinguish between the term *temperature coefficient of resistance* and *Resistivity* of a material. [02marks]

(b) (i) Explain the origin of the *heating effect* of electric current in a metallic conductor. [03marks]

(ii) Describe with the aid of an I-V sketch the variation of current with p.d across an electrolyte. [02marks]

(c) Describe an experiment to determine the *resistivity* of a material using a metre bridge. [06marks]

(d)



In the circuit above, S is a standard cell of e.m.f 1.2 V. When switch K_1 is closed and K_2 is open, a balance length $AC = 30.2\ cm$ is obtained. When K_1 is opened and K_2 is closed, the balance length is 26.8 cm and the ammeter, A reads 0.4A. Find the percentage error in the ammeter reading. [06marks]

9. (a) (i) What is meant by the terms; corona discharge and space discharge? [02marks]

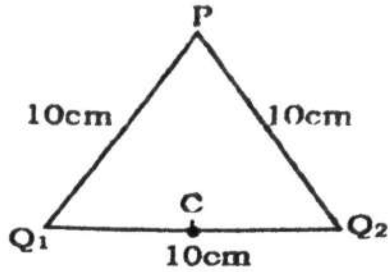
(ii) Explain why a charged body attracts a neutral conductor. [03marks]

(b) (i) Define the term electric potential. [01mark]

(ii) Describe an experiment to investigate the charge distribution over a hollow conductor, showing how the conclusion is arrived at. [04marks]

(c) (i) Derive an expression for the electric potential at a point, a distance, d, from a point charge Q in a medium of permittivity ε. [05 marks]

(d) The figure below shows two-point charges Q_1 and Q_2 of **+6μC** and **+4μC** respectively.



Find the electric potential at C and hence calculate the work done in moving a charge of **– 4μC** from point P to point C mid-way between Q_1 and Q_2 and interpret the significance of the sign of the answer you have obtained. [05 marks]

10. (a) (i) Distinguish between dielectric field strength and dielectric constant. [03marks]

(ii) Explain the effect of inserting a dielectric material to fill all the space between the plates of a parallel plate capacitor. [04marks]

(b) Four capacitors of equivalent capacitances of 6 μF are to be connected across a 12 V d.c. supply.

(i) Draw an arrangement that you would set up in order to provide the maximum capacitance in the circuit. [02marks]

(ii) Calculate the energy stored in the arrangement in (b) (i) above. [03marks]

(c) A fully charged capacitor is disconnected from the source and isolated in air. The space between its plates is then doubled while the other factors are kept constant. Explain the change in the energy stored in the capacitor as a result of doubling the distance between the plates. [03 marks]

(d) A charged parallel plate capacitor with a plate separation, **d**, and area of overlap A, is filled with a dielectric material, of dielectric constant εr. The dielectric has one third of it pulled out of the plates. Show that the capacitance, C, of the resultant capacitor is given by,

$C = \varepsilon_0 A\left(\frac{1+2\,\varepsilon_r}{3d}\right)$ where, ε_o *is the permittivity of free space or air.* [03marks]

(e) State two industrial applications of capacitors. [02marks]

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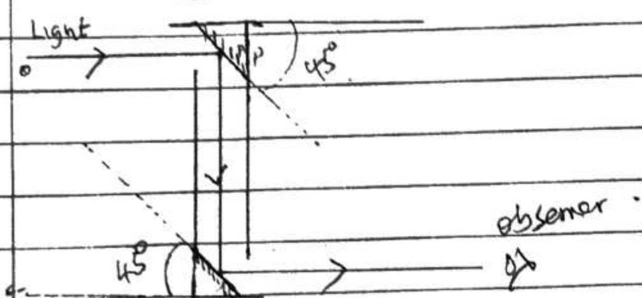
Qn 1 (a)(i) SECTION A

- The Incident ray, the reflected ray and the normal at the point of Incidence all lie in the same plane. 02

Or The angle of Incidence is Equal to the angle of reflection.



- A periscope is an application of the law of reflection, the plane mirrors are placed at 45° angle as light always reflects away from a mirror at the same angle that it hits it. 05
light from an object O hits/strikes the top mirror at 45° and bounces off at the same angle. This sends light directly down the tube and onto the lower mirror. This mirror also at a 45° angle, reflects light directly to ~~your~~ the eye

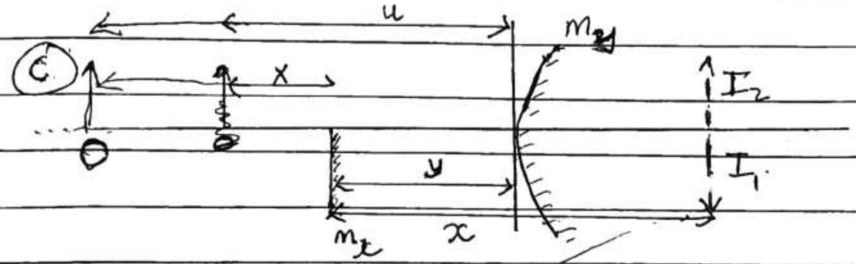
b (ii)

- No significant loss of light energy in total internal reflection, hence in prisms, the reflected ray has a whole of the energy incident light wave so a brighter image is formed in prisms unlike in plane mirrors. Any 2

- No need of silvering in ~~requi~~ prisms
- Total reflecting prism can be used to invert an image, while a plane mirror cannot.

(2)

(c)



- An object pin O is placed in front of convex mirror M_y such that it forms a virtual diminished image I_1. The distance u of object O from convex is measured and recorded.
- A plane mirror M_x is then placed between object O and the convex mirror such that it covers half aperture of the convex mirror.
- The plane mirror M_x is adjusted until its own image I_2 of O coincides with image I_1 by no parallax method.
- Measure distances x & y.
- Focal length f of a concave mirror is got from $\frac{1}{u}+\frac{1}{v}=\frac{1}{f}$, where

$u = x + y$

$v = -(x - y)$.

(05)

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d(i) $y = 10cm$.

$x = 20cm$.

$u = y + x = 10 + 20 = 30cm$

$v = -(x-y) = -(20-10) = -10cm$.

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

$\frac{1}{30} - \frac{1}{10} = \frac{1}{f}$ $\quad f = -15cm$.

The Image fome.

(ii) The Image formed by a plane mirr is always upright, virtual and ~~samg~~ same size as the object no matter where the object in front of the mirror. Images formd in Concave mirror is Inverted, real and diminished if the ~~Object~~ is at a distance farion than ~~the~~ focal length.

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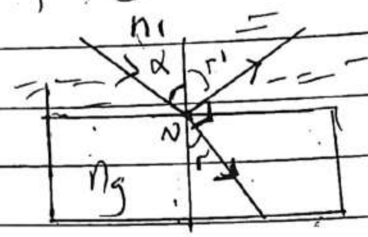
(2) (a) (i).

Absolute Refractive Index of a medium is the ratio of the velocity of light in vacuum to the velocity of light in the medium.

a (ii).



Apply Snell's at N:

$n_1 \sin\alpha = n_g \sin r$ — (1)

$\Rightarrow$ Since $r' + 90 + r = 180$, $r = 90 - r'$

but $r' = \alpha$ (laws of Reflection):

hence $r = 90 - \alpha$ — (2)

Substitute (2) ~~in~~ in (1)

$$n_1 \sin\alpha = n_g \sin(90 - \alpha).$$

$$n_1 \sin\alpha = n_g \sin 90 \cos\alpha - \sin\alpha \cos 90$$

$$n_1 \sin\alpha = n_g \cos\alpha - 0.$$

$$\frac{n_1 \sin\alpha}{\cos\alpha} = n_g$$

$$\boxed{n_g = n_1 \tan\alpha.}$$

(II)

Before Removal; $n_g = 1.33 \tan\alpha$ — (1)

After Removal $n_g = 1 \tan(\alpha + 8)$ — (2)

Equating (1) and (2)

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$1.33\tan\alpha = \tan(\alpha+8).$

$1.33\tan\alpha = \dfrac{\tan\alpha + \tan 8}{1 - \tan\alpha\tan 8}.$

let $\tan\alpha$ be x, and $\tan 8$ be y

$1.33x(1 - xy) = x + y.$

$1.33x - 1.33x^2y = x + y.$

but $y = \tan 8 =$

$1.33x - 0.186919x^2 = x + 0.1405$

$0.33x - 0.186919x^2 = 0.1405$

$0.186919x^2 - 0.33x - 0.1405 = 0$ --- (1)

$x_1 = -0.3546$ (not applicable). and $x_2 = 2.12$

but $\tan\alpha = 2.12$

$\alpha = \tan^{-1}(2.12) = 64.7^\circ$

$n_g = 1.33\tan\alpha$

$= 1.33 \times 2.12$

$= 2.8196$

From the equation above; ---- (1)

$x_1 = 0.7172$ and $x_2 = 1.0484$

For $x_1 = \tan\alpha_1$

$\alpha_1 = \tan^{-1}(0.7172)$ $\quad\alpha_2 = \tan^{-1}(1.0484)$

$\alpha_1 = 35.6^\circ$ or $\alpha_2 = 46.4^\circ$

$n_g = 1.33\tan$ ... or $n_g = 1.33\tan$ ...

$n_g = 1.33 \times 0.7172$ or $n_g = 1.33 \times 1.0484$

$n_g = 0.95$ $\quad n_g = 1.40$

$\therefore n_g = 1.40$ and $\alpha = 46.4$

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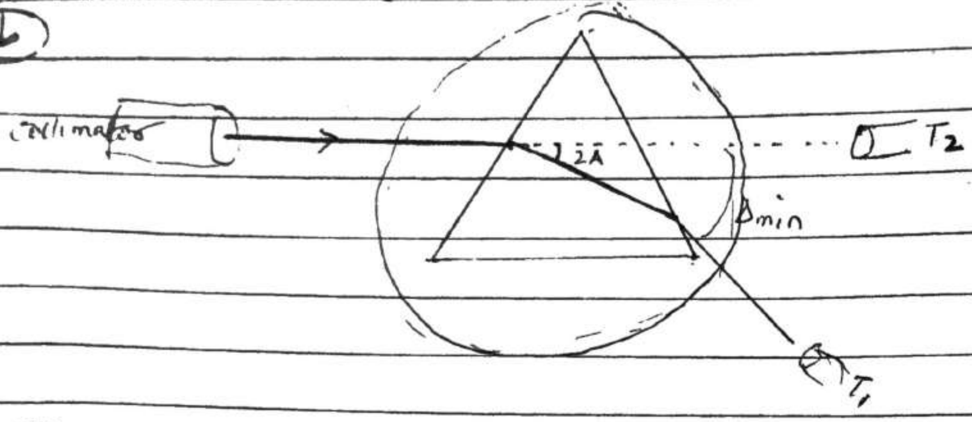
(b)



- The collimator is adjusted to produce parallel rays of light.
- The telescope is adjusted to receive light from the collimator on its cross wire
- The turntable is levelled.
- The prism is placed with the refracting angle facing away from the collimator as shown above.
- The telescope is turned to receive refracted light from the opposite face of the prism.
- The table is now turned while keeping the refracted light in view until a point when the ray begins to move backwards. Mark T_1
- The prism is removed and the telescope is turned to to receive light directly from the collimator. The new position T_2 is now noted.
- The angle between T_1 and T_2 is determined and is the angle of minimum deviation, d_{min}
- Since the refracting angle, A, is known, then the refractive index $n = \frac{\sin\left(\frac{d_m + A}{2}\right)}{\sin\left(\frac{A}{2}\right)}$

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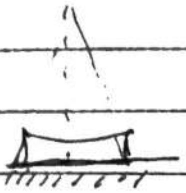
2(c). $r_{lens} = 24cm$, $f = -\cancel{12cm}$.



$F = 40cm$

$$\frac{1}{F} = \frac{1}{f_L} + \frac{1}{f_{lens}}$$

$$\frac{1}{40} = \frac{1}{f_L} + \frac{1}{-12}$$

For liquid lens: $$\frac{1}{f_L} = (n_L - 1)\left(\frac{1}{r_1} + \frac{1}{r_2}\right)$$ 05

$$\frac{1}{f_L} = (1.4-1)\left(\frac{1}{24} + \frac{1}{\infty}\right)$$

$$f_L = 60cm.$$

$$\Rightarrow \frac{1}{40} = \frac{1}{60} + \frac{1}{f_{lens}}$$

$$f_{lens} = -24cm.$$

$$\frac{1}{24} = (n_g - 1)\left(\frac{1}{-24} + \frac{1}{-24}\right).$$

$$n_g = 1.5.$$ 05

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2(d).

- Final Image is upright
- ~~Jt has a virtual eye ring.~~ Any 2 02
- Jt is Shorter than astronomical telescope when in normal adjustment.

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SECTION B

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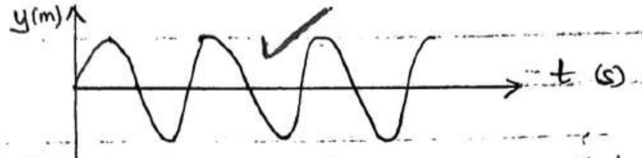
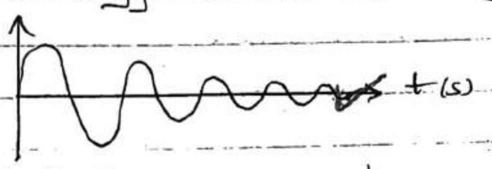
3 (a) Free oscillations are oscillations that take in absence of dissipative forces such as air resistance and the amplitude of oscillation remains the same. 06



Damped oscillations are oscillations that take place in presence of dissipative forces and the amplitude of oscillation keeps on reducing with time due to loss energy to the surrounding.



B(i) Beats are periodic rise or fall in the intensity of sound heard when two notes of nearly the same frequency are played together. 01

(ii) A tuning fork of known frequency f_T is sounded together with a musical instrument of unknown frequency f,

The number of beats (n) per second are counted and beat frequency is noted as

$$f_b = \frac{n}{t}$$

One prong of a tuning fork is loaded with plasticine and sounded again together with the musical instrument and the new beat frequency f_b' is noted.

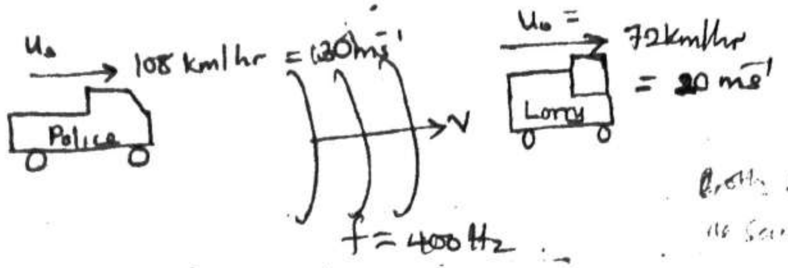
~~If $f_b' < f_b$ then frequency of the musical~~

When two notes are perfectly in tune, beats stop and the interference becomes purely constructive

04

c(i) Doppler effect is the apparent change in the frequency of waves 01 heard due to relative motion

(ii)



$$f_a = \left(\frac{v - u_o}{v - u_s}\right) f$$

$$f_a = \left(\frac{340 - 20}{340 - 30}\right) \times 400 \quad 03$$

$$f_a = \underline{412.9\ Hz}$$

d(i) Closed pipes give only odd harmonics while open pipes give both odd and even harmonics/tones. The more overtones 02 the better the quality of sound thus open.

(ii) $f_n = \frac{nV}{4l}$ $n = 1, 3, 5, 7, 9$ - - - -

$$860 = \frac{n \times 340}{4 \times 0.29}$$

$$n = 2.9 \simeq 3$$

The mode of vibration is the 3rd harmonic

Using

$$f_n = \frac{nV}{4(l+c)}$$

$$c = \left(\frac{3 \times 340}{4 \times 860}\right) - 0.29$$

$$c = 0.2965 - 0.29 \quad 03$$

$$c = 0.0065\ m.$$

T = 20

If the path difference differ by a half number of wave-lengths, destructive Interference occurs.

For maximum brightness $n\lambda = d\sin\theta$

minimum brightness $(n+\frac{1}{2})\lambda = d\sin\theta$

05

Where λ is Wavelength and d is the distance of separation between the two slits.

(c)(i) Equally spaced bright and dark fringes are observed and these fringes are parallel to the thin end of the wedge 02

(ii) The line of contact will still be a dark fringe but wavelength of light in water is less than in air hence the fringe separation is reduced. 02

(d) $\lambda = 5.8 \times 10^{-7}$ m.

$n = 2$ (second order).

$\theta = 27°$

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

$$d = \frac{n\lambda}{\sin\theta}$$

$$= \cancel{\frac{2 \times 5.8 \times 10^{-7}}{}}$$

$$\frac{1}{d} = \frac{1}{\frac{n\lambda}{\sin\theta}}$$

$$\left(\frac{1}{d}\right) = \frac{\sin\theta}{n\lambda}.$$

$\left(\frac{1}{d}\right)$ No of lines per metre $= \frac{\sin 27}{2 \times 5.8 \times 10^{-7}}$.

$= 3.91 \times 10^{3}$ lines/cm

04

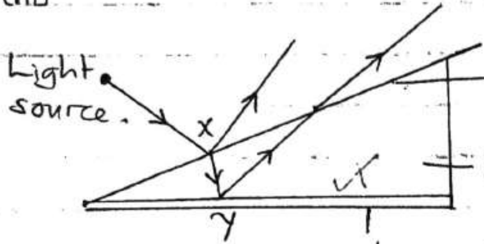
4(a)(i) Intereference is the overlapping of waves from different two coherent sources resulting into alternate regions of maximum and minimum intensity.

(ii) - Coherent sources must be close to each other.

(02) any two

- Wave trains must have nearly equal amplitudes
- Waves sources must be coherent or have constant phase relationship.
- The screen must be as far as possible from the source.

(iii)



- The surface to be tested is placed in contact with an optical flat surface to form an air wedge as shown below.

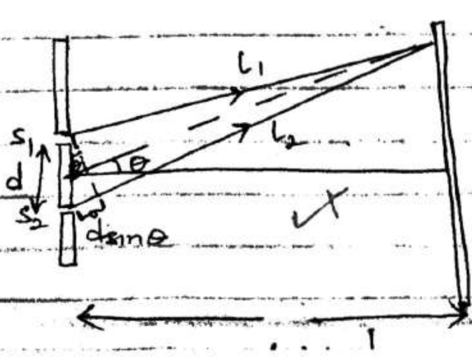
- Monochromatic light is made incident almost normally onto the upper glass slide.

It's partly reflected back at X and partly transmitted in the air film and reflected at Y.

The interference patterns produced by the reflected light from the air wedge is observed. (03)

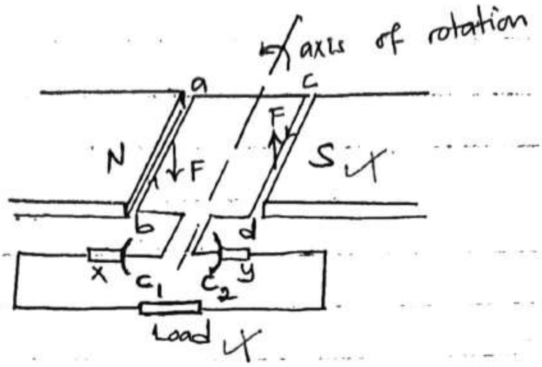
If the surface is flat, straight parallel and equally spaced bands will be observed and for if not flat, uneven bands will be seen

(b).



- Consider two coherent sources of waves S_1 and S_2 at a distance of separation d, and the two waves meet at P.
- The path difference of the two waves S_1 and S_2 is d sin θ
- If the path difference is

(c) (i)



When a coil is in the vertical position, a mechanical force is applied to move the coil in an anti-clockwise direction.

Side ab moves downwards and cd upwards.

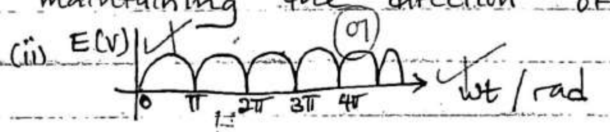
As the coil rotates, the flux linking it changes, emf is induced causing a current to flow according the direction determined by Fleming's Left Hand Rule.

After the next vertical position ab & cd moves up and down respectively and this reverses the direction of current induced.

The output does not change in direction. It's because after the vertical position, the commutators change contacts from one carbon brush to another hence maintaining the direction of current at the output ie

05

(ii)



07

(iii) When the coil rotates in a magnetic field, there is a change in flux and an emf is induced. But the direction of the induced current acts in such a way to oppose the emf generated and this is referred to as back emf.

03

(d) $f = 2000 \text{ rev min}^{-1} = \left(\frac{2000}{60}\right) \text{Hz} = 33.3 \text{ Hz}$

$B = 0.8 \text{ T}$ $N = 120 \text{ turns}$, $s = 10 \text{ cm}$

$E = BAN\omega \cos\theta$

$E = 0.8 \times (0.1)^2 \times 120 \times 2\pi \times 2000 \times \cos 30$

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SEC C

5 (a) Tesla is the magnetic flux density experience by a current carrying conductor of length 1m carrying a current of 1A placed at right angles to uniform magnetic field.

(b) (i) When a conductor is placed at right angles in magnetic field B and current is passed through it transversely.

The electrons in the conductor experience a force on side P and drift to side Q according to Fleming's left Hand Rule.

This makes side Q to gain a negative charge and side P gains a positive charge hence causing an electric field intensity between P and Q until a maximum p.d is created.

This p.d is called hall voltage and it accounts for the occurrence of p.d between P and Q.

(ii) Electrons experience an electric force F_E due to electric field;

At equilibrium $F_E = F_B$

$E_e = BeV\sin\theta$

$E = BV$ --① but $\sin\theta = 90°$

But $\frac{V_H}{d} = E_H$ --② and v is velocity of electrons

substitute eqn ② in ①

$\left(\frac{V_H}{d}\right) = BV$ and $d = a$

$E = B\left(\frac{I}{neA}\right)$

$V_H = BVa$ and $I = nevA$

$\boxed{E = \frac{BI}{neA}}$

$v = \frac{I}{neA}$

$V_H = \frac{BIa}{neA}$

where A - cross sectional area A.

but $A = a \times t$

$V_H = \frac{BI \times a}{ne \cdot at}$

$\boxed{V_H = \frac{BI}{net}}$ where t - thickness of conductor

(iii) - Energy losses in form of heat due to eddy currents. (02)

- I^2R losses

(c) $N = 20$

$L = 10.0$ cm

$w = 20.0$ cm

$f = 300 \text{ rev min}^{-1} = \left(\frac{300}{60}\right)$ Hz

$\theta = 90^\circ$

$B = 0.02T$

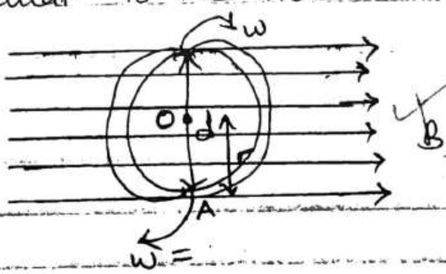
$E_{max} = NABw$

$= NAB2\pi f$

$= 20 \times 0.1 \times 0.2 \times 0.02 \times 2\pi \times \frac{300}{60}$

$= 0.25$ V (02)

(d) (i) Consider a metallic circular disc of diameter d rotating in a uniform magnetic field of flux density B at frequency f with its plane perpendicular to the field.



where r - radius.
$d = 2r$.

OA cuts the cuts the magnetic field continously; Average velocity of OA $= \frac{0 + rw}{2}$

$v = \frac{rw}{2}$

Induced emf $E = BLV$

$E = BrV = Br \cdot \frac{rw}{2} = \frac{Br^2w}{2}$

$E = \frac{Br^2 \times 2\pi f}{2}$ since $w = 2\pi f$.

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

$|E| = BAf$ where A $= \pi d^2/4$

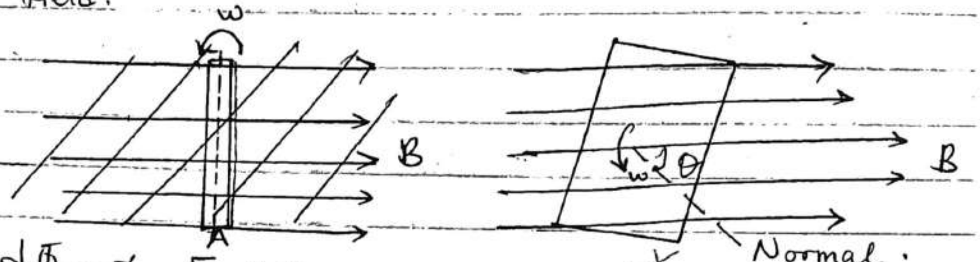
6(a) Faraday's law states that the rate of change magnetic flux is proportional to emf induced in the conductor.

(01)

Lenz's law states that the induced emf in a conductor acts in such a way so as to oppose the change causing it.

(01)

(b)(i) Consider a coil of area A being rotated at a frequency f in a uniform magnetic field of flux density B about an axis which is perpendicular to the field.



From $\frac{d\Phi}{dt} \propto E$ for N- turns

$E = -N\frac{d\Phi}{dt}$ but $\Phi = BA\cos\theta$

$\theta = \omega t$, for time t that has elapsed

$E = -N\frac{d}{dt}(BA)\cos\omega t$

$\theta = 90°$

$E = -NB\left(\frac{dA}{dt}\right)\cos\omega t$

$\omega t = 90°$

$E = -NAB\frac{d}{dt}(\cos\omega t)$

$E = -NAB(-\omega\sin\omega t)$.

$E = BAN\omega(\sin\omega t)$ but $\omega = 2\pi f$ and $\omega t = 90°$

$E = BAN(2\pi f)$

$\boxed{E = 2BAN\pi f}$

04

(ii) Number of turns of the coil

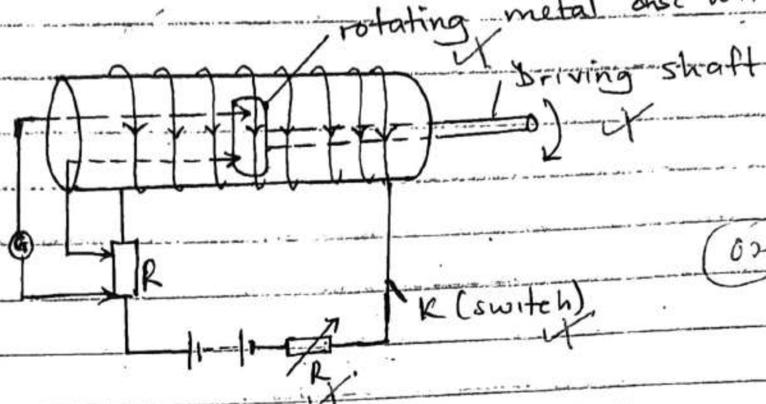
Cross sectional area of the coil

Speed of rotation of the coil

Strength of magnetic field.

(02)

(ii) Using a solenoid.



(02)

The metal disc is placed at the centre of the solenoid and attached to the ciruit carrying current through the solenoid when switch K is closed.

The plane of the disc is made perdendicular to the magnetic field.

The disc is rotated by the driving shaft and the speed of rotation is adjusted ~~by~~ until the galvanometer gives no deflection.

The number of rotations / revolutions of the disc in a given time t is counted and frequency f is determined.

The resistance ~~of~~ is calculated from;

$E = B\pi r^2 f$ but $E = IR$ and $B = \mu_0 nI$

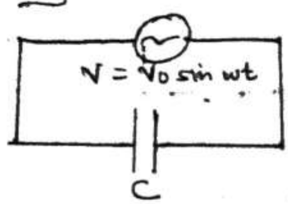
$\Rightarrow R = \dfrac{B\pi r^2 f}{I}$ (05)

$R = \mu_0 n \pi r^2 f$ where n is the number of turns per metre of the solenoid.

T = 20

Qn. 7(a) Root mean square value of a.c is the steady value of current that dissipates heat in the resistor at the same rate as the alternating current.

(b) Consider a capacitor of capacitance C connected to alternating source of voltage $V = V_0 \sin wt$.



Instantaneous charge on the capacitor is given:

$Q = CV$ and

Instantaneous current $I = \frac{dQ}{dt}$

$$I = \frac{d}{dt} CV_0 \sin wt$$

$$I = CV_0 \frac{d}{dt}(\sin wt)$$

$$I = CV_0 w \cos wt \quad \text{but } I = I_0 \cos wt.$$

$$I_0 \cos wt = CV_0 \cos wt$$

$$I_0 = CV_0 w \text{ (peak value of current)}$$

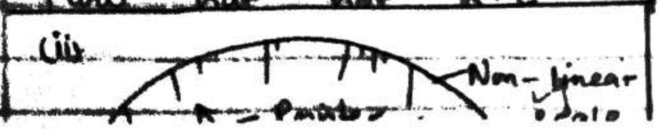
$$\Rightarrow \boxed{I = CV_0 w \cos wt.}$$

c(i) From capacitative reactance, $X_c = \frac{1}{2\pi f c}$ to direct current is too much (infinity) since the frequency of d.c is zero while for a.c current, frequency is not zero hence the opposition by capacitor is smaller than that of direct current hence a capacitor allows a.c to flow but not d.c.

(OR) c (i)

> When a capacitor is connected to a d.c source, it charge ... to a ...

(ii)



The a-c current to be measured is passed through terminals X and Y.

Iron rods A and B are magnetised in the same sense and so they repel.

Rods A and B repel each other with the a force proportional to the square of the current I.

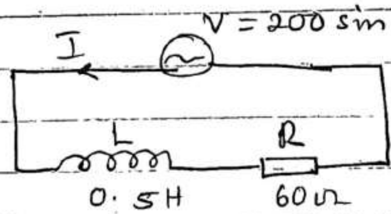
The moveable rod moves with the pointer connected to the hair spring to provide the restoring torque to balance the repulsive force. (03)

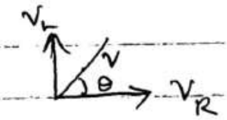
The deflection θ is proportional to the average value of square of current I ie

$\theta \propto I^2$.

05

(d) (i) $V = 200 \sin 160t$.





$$\theta = \tan^{-1}\left[\left(\frac{V_L}{V_R}\right) = \left(\frac{IX_L}{IR}\right) = \frac{X_L}{R}\right]$$ but $X_L = \omega L$

$X_L = 160 \times 0.5$

$$\theta = \tan^{-1}\left(\frac{\omega L}{R}\right)$$

$$\theta = \tan^{-1}\left(\frac{160 \times 0.5}{60}\right)$$ (02) $X_L = 80\,\Omega$

$$\theta = 53.1^\circ$$

(ii) Using $Z = \sqrt{X_L^2 + R^2}$

$$Z = \sqrt{80^2 + 60^2}$$

$$Z = 100\,\Omega$$

but From $V_0 = I_0 R$.

$$I_0 = \frac{V_0}{Z} = \frac{200}{100}$$ (03)

$$I_0 = 2.0\,A$$

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SEC B

8(a) Temperature coefficient of resistance is the fractional change in resistance of a conductor at 0°C per degree celsius rise in temperature. (01)

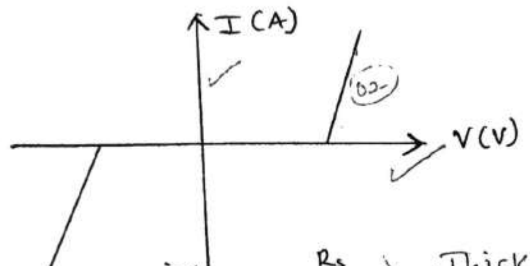
Resistivity is resistance ~~of a~~ across opposite faces of a cubical conductor of length of 1m. (01)

b(i) When a current is applied to pass across the conductor, conduction electrons gain kinetic energy and they drift in a direction opposite the applied ~~E~~ current.

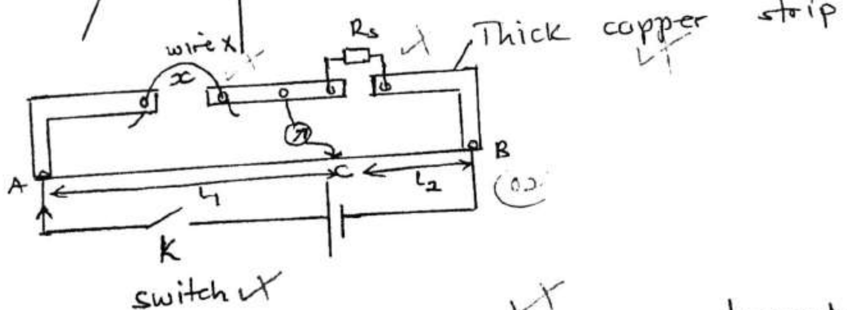
They collide with ions and lose their kinetic energy to them.

The ions vibrate with increased (03) amplitude as a result temperature of the wire rises due to multiple collisions.

(ii)



(c)



Using a micrometer screw gauge, diameter of wire d, is measured and it's cross sectional area A is determined from $A = \frac{\pi d^2}{4}$

Connect a length ~~x~~ ~~of~~ the wire across the left hand gap and a standard resistance Rs in the right hand gap as shown above.

Close switch K and tap the jockey along AB until a suitable balance length l_1 is obtained when the galvanometer shows no deflection.

l_2 is also noted

Repeat the procedure for different values of x and tabulate your results in a suitable table.

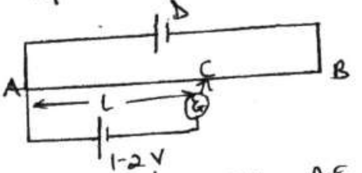
x	L_1	l_2	R_x
=	=	=	=

Plot a graph of R_x against x and determine the slope s of the graph.

Determine the resistivity of the wire $\rho = sA$

$$\rho = \left(\frac{s\pi d^2}{4}\right)$$ where s – slope, d – diameter of wire.

(d) If K_1 is closed and K_2 open.



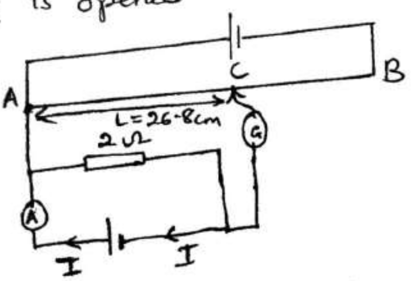
At balance p.d across $AC = 1.2$.

$30.2 \times K = 1.2$

$K = \frac{1.2}{30.2}$

$K = 0.0397\ Vcm^{-1}$

If K_1 is opened and K_2 closed.



At balance p.d across AC = p.d across 2Ω.

$K \times L = I_a R$

$0.0397 \times 26.8 = I_a \times 2$.

$\Rightarrow I_a = 0.532\ A$

Error in ammeter reading $e = I_a - I_r$

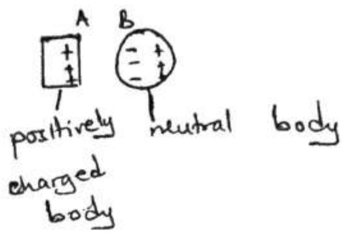
$e = 0.532 - 4.0$

$e = 0.132\ A$.

07

③

9(a)(i) When a positively charged body is brought near a neutral body, electrons in the neutral body gets re-distributed within the neutral body such that they are attracted towards the positively charged body since unlike charges attract each other ie.

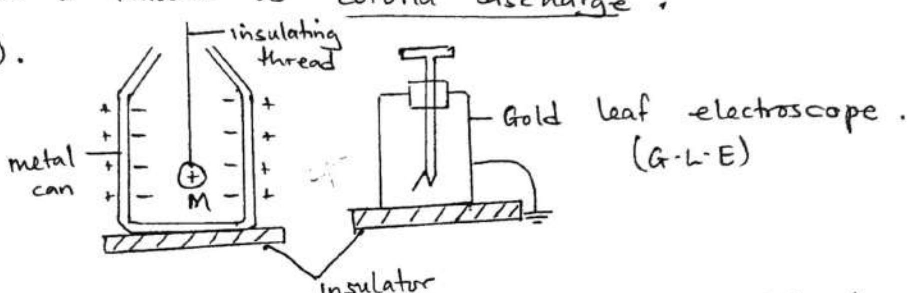


(ii) At sharp points, there is high electric field intensity which ionizes air around the charged conductor at sharp points.

The ions of opposite charge are attracted to the sharp point to neutralize the charge there.

This leads to loss of charge by the conductor which is known as corona discharge.

(B).



A positively charged metal sphere M is lowered into a metal can without touching it which is connected to a G·L·E and the leaf diverges.

M is withdrawn and the leaf of G·L·E collapses

Again M is lowered into the metal can (without touching it) and the leaf diverges to the same extent as before.

M is allowed to touch the can and the divergence remains unchanged.

M is withdrawn and on testing, it's found to have no charge.

Since M remains with no charge and the leaf of G·L·E remains ...

(c) Consider +1C charge, ~~x~~ metres away from +Q (4)

moved from C to B through a small displacement Δx.

Force on +1C $F = \frac{Q}{4\varepsilon\pi x^2}$

Work-done to move the charge through Δx against the field is;

$$\Delta W = -F\Delta x$$

Total work done to bring the charge from infinity to a point at a distance d from the charge is;

$$W = \int_{\infty}^{d} -F\,dx$$

$$= \int_{\infty}^{d} -\frac{Q}{4\pi\varepsilon x^2}\,dx$$

$$= -\frac{Q}{4\pi\varepsilon}\left[-\frac{1}{x}\right]_{\infty}^{d}$$

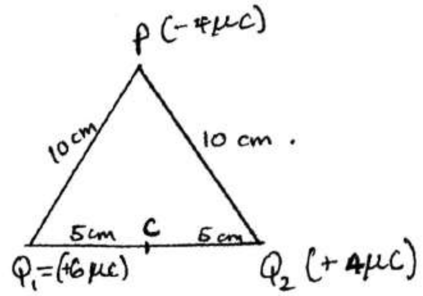
$$= -\frac{Q}{4\pi\varepsilon}\left(-\frac{1}{d} - -\frac{1}{\infty}\right)$$

$$W = \frac{Q}{4\pi\varepsilon d}$$

05

Hence $V = \frac{Q}{4\pi\varepsilon d}$

(d)



Using $V = \frac{Q}{4\pi\varepsilon_0 r}$

$$V_{Q_1} = \frac{6\times10^{-6}\times 9.0\times10^{9}}{0.05} = 1.08\times10^{6}\,V$$

potential at C $= V_{Q_1} + V_{Q_2}$

$= (1.08\times10^{6} + 7.2\times10^{5})$

$= 1.8\times10^{6}$ V

Workdone, $W = QV$

$= (-4\times10^{-6} \times 1.8\times10^{6})$

05

$= -7.2$ J (negative sign means that work is done by the charge to overcame forces of attraction or repulsion) or against electrostatic forces of attraction and repulsion.

T = 20

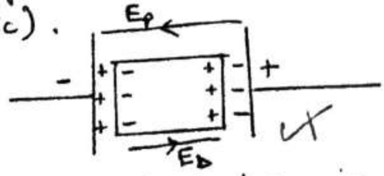
Qn. 10 (a) (i) Dielectric field strength is the maximum p.d a dielectric material/insulator can withstand without conducting

OR

Is the maximum electric field (intensity) an insulator can withstand without conducting.

A dielectric constant is the ratio of capacitance of a capacitor when the insulating material (dielectric) is placed between it's plates to the capacitance of the same capacitor with a vacuum between it's plates (without a dielectric).

(ii)

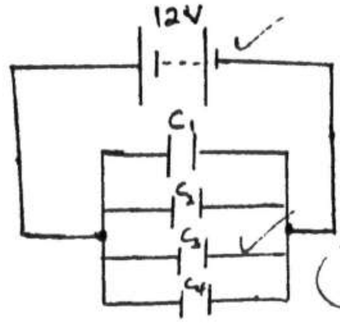


When a dielectric is placed between two parallel plates of a charged capacitor, it's molecules get polarized and it's surfaces adjacent to the plates develop charges opposite to that on the plate of the capacitor.

This result into developed of electric field intensity E_D between the polarized molecules of the dielectric it opposes ~~and~~ electric field intensity E_p due to the plates of the capacitor.

The resultant electric field intensity, E_R between E_p and E_D is given by: $E_R = E_p - E_D$ (E ...

10 B : (i)



02

Where $C_1 = C_2 = C_3 = C_4 = 6\mu F$

(ii) Using $E = \frac{1}{2} C V^2$

But $C_E = C_1 + C_2 + C_3 + C_4$

$= 6 + 6 + 6 + 6$

$= 24\mu F$

Energy, $E = \frac{1}{2} \times 24 \times 10^{-6} \times 12 \times 12$

$E = (0.000144 \times 12)$ J 03

$E = 0.0017$J or 1.7×10^{-3} J

10(c) Initially energy stored by the capacitor is given by $E = \frac{1}{2} C V^2$ but $V = \frac{Q}{C}$ and

$C = \frac{\varepsilon_0 A}{d}$ (initial capacitance)

$E = \frac{1}{2} C \left(\frac{Q}{\varepsilon_0 A / d}\right)^2$

$E = \frac{1}{2} \frac{d Q^2}{\varepsilon_0 A}$ -- (1)

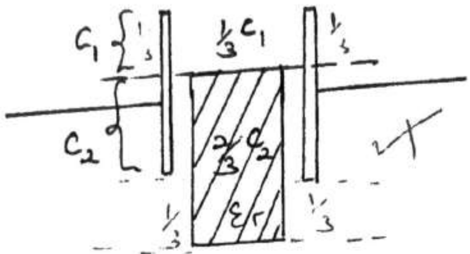
Therefore doubling the distance between the plates of the capacitor when disconneted from the source;

distance = 2 d

$E' = \frac{1}{2} \cdot \frac{(2d) Q^2}{\varepsilon_0 A} = 2 \left(\frac{1}{2} \frac{d Q^2}{\varepsilon_0 A}\right)$

$E' = 2E$ (from equation (1))

Thus energy will be doubled 03 if the separation (d).



$$C_1 = \frac{\varepsilon_0 A}{d}$$

$$\frac{\varepsilon_0 \varepsilon_r A}{d} = C_2.$$

Now C_1 ~~ared~~ C_2 are in parallel connection.

The resultant capacitance $C = C_1 + C_2$.

$$C = \frac{C_1}{3} + \frac{2C_2}{3}$$

$$C = \frac{\varepsilon_0 A}{3d} + \frac{2\varepsilon_0 A \varepsilon_r}{3d}$$

$$C = \left(\frac{\varepsilon_0 A + 2\varepsilon_0 A \varepsilon_r}{3d}\right)$$

$$C = \varepsilon_0 A \left(\frac{1 + 2\varepsilon_r}{3d}\right)$$ as required 03

(e) - storing energy
- Sensors.
- Tuning circuits
- Radios, and other electronic devices.
- Timing components
- Power conditioning systems

any 02

T = 20

END.