P510/2
PHYSICS
Paper 2
Nov./Dec. 2010
2½ hours

UGANDA NATIONAL EXAMINATIONS BOARD

Uganda Advanced Certificate of Education

PHYSICS

Paper 2

2 hours 30 minutes

INSTRUCTIONS TO CANDIDATES:

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

Mathematical tables and squared paper will be provided.

Non-programmable scientific calculators may be used.

Assume where necessary:

Acceleration due to gravity, g	=	$9.81\ ms^{-2}$
Speed of light in a vacuum, c	=	$3.0 \times 10^{8}\ ms^{-1}$
Electron charge, e	=	1.6×10^{-19} C
Electron mass	=	9.11×10^{-31} kg
Plank's constant, h	=	6.6×10^{-34} Js
Permeability of free space, μ_0	=	$4.0\pi \times 10^{-7}\ Hm^{-1}$
Permittivity of free space, ε_0	=	$8.85 \times 10^{-12}\ Fm^{-1}$
The constant $\frac{1}{4\pi\varepsilon_0}$	=	$9.0 \times 10^{9}\ F^{-1}$ m
One electron volt (eV)	=	1.6×10^{-19} J
Avogadro's number, N_A	=	$6.02 \times 10^{23}\ mol^{-1}$
Resistivity of Nichrome wire at 25°C	=	$1.2 \times 10^{-6}\ \Omega m$
Specific heat capacity of water	=	$4.2 \times 10^{3}\ J\ kg^{-1}K^{-1}$

SECTION A

1. (a) (i) Define **principal focus** of a concave lens. *(01 mark)*

(ii) Draw a ray diagram to show formation of an image of a finite object by a concave lens. *(02 marks)*

(iii) Describe the image formed in (a) (ii). *(01 mark)*

(b) A concave mirror of radius of curvature 20 cm is arranged coaxially with a concave lens of focal length 15 cm, placed 10 cm from the mirror. An object, 3 cm tall is placed in front of the concave lens and its image is formed on a screen 40 cm away from the lens.

(i) Find the position of the object. *(07 marks)*
(ii) What is the height of the image formed? *(03 marks)*
(iii) Explain what would happen if the lens was replaced with a similar one but of a much smaller focal length. *(03 marks)*

(c) Explain how spherical aberration is minimized in a photographic camera. *(03 marks)*

2. (a) Define **refractive index.** *(01 mark)*

(b) (i) Describe with the aid of a diagram, how the refractive index of a liquid can be determined using an air cell. *(05 marks)*

(ii) Derive the expression used to obtain the refractive index of the liquid in (b) (i). *(03 marks)*

(c) A prism of refractive angle 60° has refractive indices 1.515 and 1.529 for red and violet light respectively. When white light is incident on one face of the prism, red light undergoes minimum deviation. Calculate the angle of

(i) incidence for the white light. *(04 marks)*
(ii) emergence for violet light. *(03 marks)*

(d) Describe the adjustments that have to be made before a spectrometer can be used. *(04 marks)*

3. (a) (i) Define **amplitude** of a wave. *(01 mark)*

(ii) State **two** characteristics of a stationary wave. *(02 marks)*

(iii) A progressive wave $y = a \sin(\omega t - kx)$ is reflected at a barrier to interfere with the incoming wave. Show that the resultant wave is a stationary one. *(04 marks)*

(b) (i) What is meant by **beats?** *(02 marks)*

(ii) Describe how you can determine the frequency of a musical note using beats. *(05 marks)*

(c) Two open pipes of length 92 cm and 93 cm are found to give beat frequency of 3.0 Hz when each is sounding in its fundamental note. If the end errors are 1.5 cm and 1.8 cm respectively, calculate the

(i) velocity of sound in air. *(04 marks)*

(ii) frequency of each note. *(02 marks)*

4. (a) (i) Define the term **diffraction.** *(01 mark)*

(ii) What is meant by **plane polarized light?** *(01 mark)*

(b) (i) Describe how polarized light is produced by double refraction. *(05 marks)*

(ii) State **two** uses of polarised light. *(02 marks)*

(iii) A parallel beam of unpolarised light incident on a transparent medium of refractive index 1.62, is reflected as plane polarized light. Calculate the angle of incidence in air and angle of refraction in the medium. *(03 marks)*

(c) (i) What is a **diffraction grating?** *(01 mark)*

(ii) Sodium light of wavelengths 5.890×10^{-7}m and 5.896×10^{-7}m falls normally on a diffraction grating. If in the first order beam, the two sodium lines are separated by 2 minutes, find the spacing of the grating. *(04 marks)*

(d) State **three** differences between the spectra produced by a prism and that by a diffraction grating. *(03 marks)*

SECTION B

5. (a) Define the term **magnetic flux density.** *(01 mark)*

(b) Write the expressions for the

(i) magnetic flux density at a perpendicular distance R from a long straight wire carrying current, I in air. *(01 mark)*

(ii) force on a straight conductor of length, l (metres) carrying current, I (amperes) at an angle, θ, to a uniform magnetic field of flux density, B (tesla). *(01 mark)*

(c) Two straight long and parallel wires of negligible cross-sectional area carry currents of 6.0A and 3.0A in opposite directions as shown in figure 1.

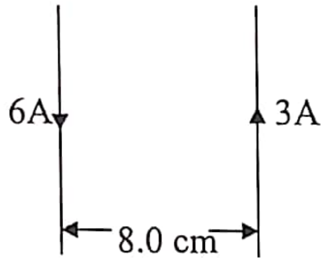

Figure 1

If the wires are separated by a distance of 8.0 cm, find the;

(i) magnetic flux density at a point mid-way between the wires. *(04 marks)*

(ii) force per metre between the wires. *(03 marks)*

(d) Define:

(i) **angle of dip.** *(01 mark)*

(ii) **angle of declination.** *(01 mark)*

(e) A straight conductor of length l, is perpendicular to a magnetic field of flux density B. If the conductor moves with velocity U at an angle θ to the magnetic field, derive the expression for the e.m.f induced. *(04 marks)*

(f) An aircraft of wing span 20 m is moving horizontally from west to east at a velocity of 250 ms^{-1} in a place where the angle of dip is 40°. The e.m.f induced across the tips of the wings is 6mV. Find the magnetic flux density of the earth field. *(04 marks)*

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

(b) The e.m.f generated in a coil rotating in a uniform magnetic field is given by $\boldsymbol{E_0 \sin \omega t}$

(i) State the meanings of the symbols used and give their units. *(03 marks)*

(ii) Draw diagrams showing the relative position of the coil and the magnetic field when t is zero and when the e.m.f generated is E_0. *(03 marks)*

(c) A rectangular coil of 50 turns is 15.0 cm wide and 30.0 cm long. If it rotates at a uniform rate of 2000 revolutions per minute about an axis parallel to its long side and at right angles to a uniform magnetic field of flux density 0.04T, find the peak value of the e.m.f induced in the coil. *(03 marks)*

(d) A solenoid of, n, turns per metre, a resistor, R, an ammeter, A, and a rheostat are connected to the battery as shown, in figure 2. A disc of radius, r, is mounted inside the solenoid with its axis coincident with that of the solenoid. The centre and rim of the disc are connected across, R. The disc is rotated with its plane perpendicular to the axis of the solenoid at a frequency, f.

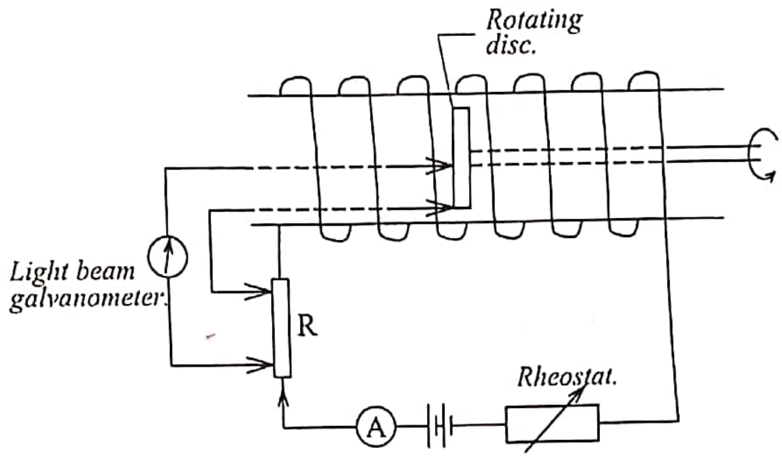

Figure 2

The rheostat is adjusted until the galvanometer shows no deflection, and ammeter reads a current of I amperes.

(i) Show that the e.m.f induced between the centre and rim of the disc is $\pi B r^2 f$, where B is magnetic flux density inside the solenoid. *(04 marks)*

(ii) Deduce an expression for the resistance of R, in terms of n, f, I and r. *(03 marks)*

(iii) State **two** limitations of the above set up in measurement of resistance. *(02 marks)*

7. (a) (i) Distinguish between **root mean square value** and **peak value** of an alternating current. *(02 marks)*

(ii) What is the peak value of the voltage from a 240V **a.c.** mains? *(02 marks)*

(b)

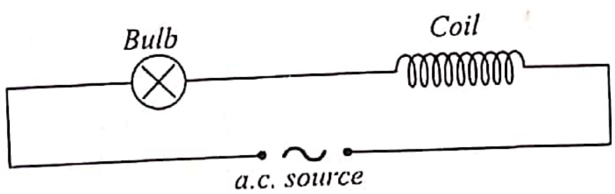

Figure 3

An air-cored coil, a bulb and an **a.c.** source are connected as shown in figure 3. When a solid iron core is introduced into the coil, the bulb becomes dimmer and the core hot. Explain the observations. *(06 marks)*

Turn Over

(c) (i) What is meant by the term **inductive reactance?** (01 mark)

(ii) Derive an expression for the reactance of an inductor of inductance L when a sinusoidally varying **a.c** of frequency, f, passes through it. (05 marks)

(iii) A sinusoidal alternating voltage of $6.0V_{rms}$ and frequency 1kHz is applied to a coil of inductance 0.5 H. Assuming that the coil has negligible resistance, calculate the root mean square value of the current. (03 marks)

(d) State **one** advantage of **a.c** over **d.c.** (01 mark)

SECTION C

8. (a) (i) Define **electrical resistivity** and state its units. (02 marks)

(ii) What is meant by **e.m.f** and **internal resistance** of a battery? (02 marks)

(b) Explain why the resistance of a metal increases when the temperature of the metal is increased. (02 marks)

(c) Describe with the aid of a labelled diagram, how a slide wire potentiometer may be used to determine the e.m.f of a battery. (06 marks)

(d)

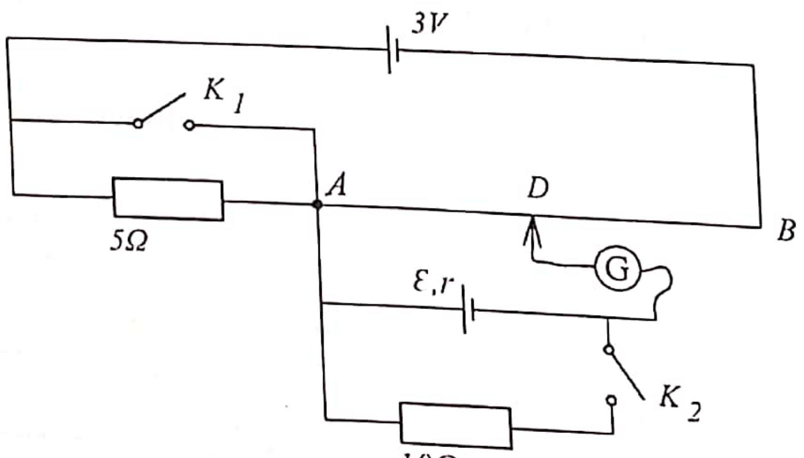

Figure 4

The circuit in figure 4 shows a uniform slide wire AB of length 100 cm and resistance of 15Ω. The wire is connected in series with a resistor of resistance 5Ω across a 3.0V battery of negligible internal resistance. A cell of e.m.f, $\mathcal{E}$, and internal resistance, r, is connected as shown. With switches K_1 and K_2 open, the galvanometer, G shows no deflection when AD is 75.0 cm. with K_1 open and K_2 closed, the galvanometer shows no deflection when AD is 65.0 cm. Find the

(i) value of e.m.f, $\mathcal{E}$ *(03 marks)*

(ii) internal resistance, r *(03 marks)*

(iii) balance length when K_1 is closed and K_2 is open. *(02 marks)*

9. (a) (i) Define **electric potential.** *(01 mark)*

(ii) Derive an expression for electric potential at a point which is a distance r from a point charge Q. *(04 marks)*

(b) Two charges of magnitude $6\mu C$ and $^{-}10\mu C$ are placed at the corners of a rectangle ABCD as shown in figure 5.

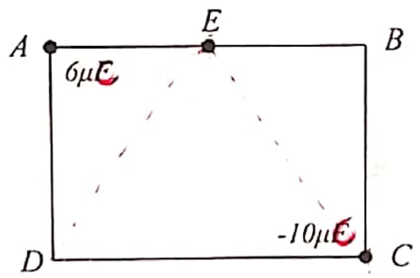

Figure 5

AB = 6 cm and BC = 4 cm. Point E is the mid-point of AB. Find the work done in taking a point charge of 1.6×10^{-10}C from D to E. *(05 marks)*

(c) A negatively charged ebonite rod is brought up to an uncharged pith-ball suspended by a silk thread. The pith-ball first moves to the rod, touches it and then moves away. Explain these observations. *(04 marks)*

Turn Over

(d) (i) A positively charged metal sphere P is placed adjacent to a neutral conductor R as shown in figure 6.

Figure 6

Sketch a graph to show how the electric field intensity varies with the horizontal distance from the left of P to a point on the right of R.

(03 marks)

(ii) Explain why a charged spherical conductor loses charge faster when a pin is attached to it.

(03 marks)

10. (a) (i) Define term **dielectric constant.**

(01 mark)

(ii) State **two** uses of a dielectric in a capacitor.

(02 marks)

(b) (i) Define **capacitance** of a capacitor.

(01 mark)

(ii) Explain the effect of placing an insulator between the poles of a charged capacitor.

(05 marks)

(c)

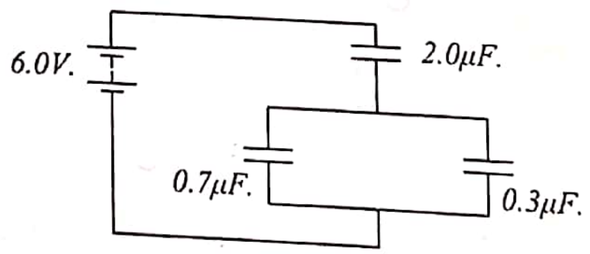

Figure 7

Three capacitors of capacitances $0.7\mu F$, $2.0\mu F$, and $0.3\mu F$ are connected as shown in figure 7. Calculate the energy stored in the $2.0\mu F$ capacitor when fully charged.

(06 marks)

(d) Explain with aid of a suitable graph the function of a capacitor in a full-wave rectifier.

(05 marks)

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A

MARKING GUIDE FOR PHYSICS P510/2 2010

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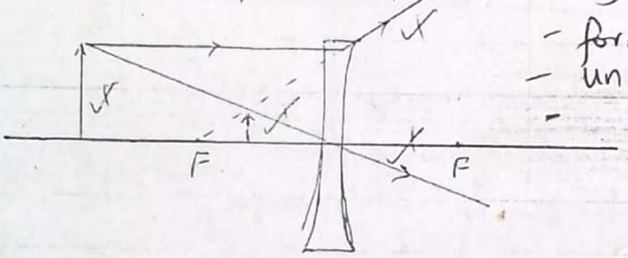
1(a) (i) principal focus of a concave lens is the point on the principal axis of the lens where rays of light originally parallel and close to the principal axis appear to diverge from after refraction by the lens. (1)

(ii)



- formation of virtual image
- undeviated ray.

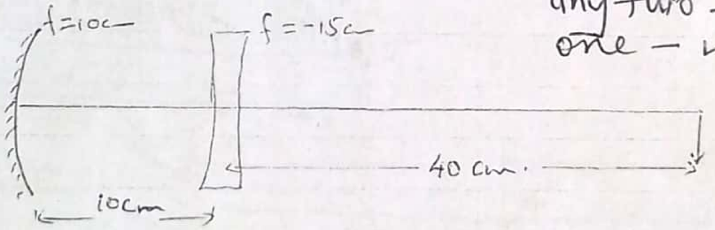
(2).

(iii) The image is virtual, diminished and upright. (1)

any two — ~~[illegible]~~

one — ✓

(b)



Action of the concave lens

$v = 40cm$, $f = -15cm$

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

$= -\frac{1}{15} - \frac{1}{40}$

$= \frac{-8-3}{120}$

$u = -\frac{120}{11}$ cm

$= -10.91$ cm.

Action of the concave mirror

$v = \frac{230}{11}$ cm, $f = 10$ cm

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

$= +\frac{1}{10} - \frac{11}{230}$

$= \frac{23-11}{230}$

$u = \frac{230}{12}$ cm $= 19.17$ cm

Action of the concave lens

$v = -\frac{110}{12}$ cm, $f = -15$ cm

$\frac{1}{u} = -\frac{1}{15} + \frac{12}{110}$

$= \frac{-7.33+12}{110}$

$= 23.55$ cm

The object is 23.55 cm infront of the lens.

(7)

(2)

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Transfer of error for atleast two actions mirror & lens.

(ii) $m = \frac{v_1}{u_1} \times \frac{v_2}{u_2} \times \frac{v_3}{u_3}$ can be given on substitution correctly.

$= \frac{-40 \times 11}{120} \times \frac{230 \times 12}{11 \times 230} \times \frac{110}{12} \times \frac{1}{23.55}$ (3)

$= 1.56$ => image height is 1.56×3

$m = \frac{h_i}{h_o}$ $= 4.68$ cm

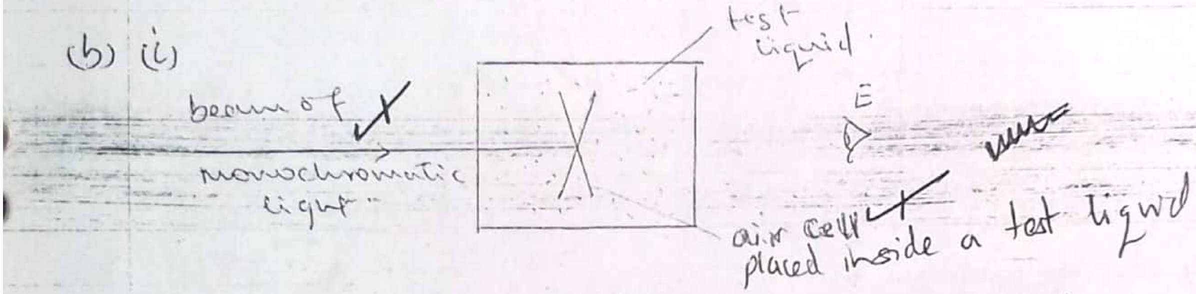
(iii) If the lens was replaced with one of smaller focal length, the final image would have been ~~bigger~~ smaller. This is because power of a lens = therefore a lens of smaller focal length has larger magnifying power or magnification (3)

(C) - Spherical aberration in photographic camera is minimised by the diaphragm or stop. The diaphragm allows in only a small central beam which forms a sharp image. (3)

OR - plano convex lenses with the convex side facing the incident beam is also used. Placed this way, the lens produces least spherical aberration. / no spherical aberration or sharp image.

2(a) Refractive index of a medium is the ratio of the speed of light in vacuum to the speed of light in the medium. (1) or $n = \frac{\sin i}{\sin r}$ from air/vacuum to medium.

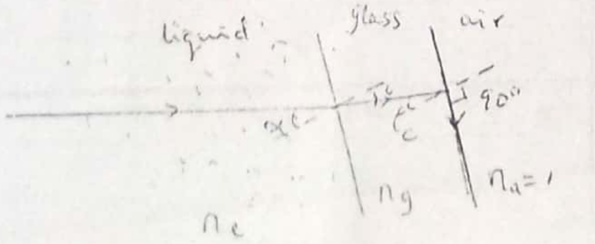
(b) (i)



The liquid is poured in a parallel sided glass vessel. The air cell is now suspended in the liquid. A narrow beam of monochromatic light is directed perpendicularly on the side of the vessel and through the air cell ~~the air cell is~~ ~~now rotated in~~ and viewed from opposite side at E. The air cell is now rotated in one direction, keeping the emergent light in view until it is just cut off from the observer. This position is noted (or marked). The air cell is again rotated in opposite direction until the light is just cut off from the observer and this new position is marked. The angle between the two positions, θ, is measured, and the refractive index of the test liquid, n, is calculated. (05)

$$n = \frac{1}{\sin(\theta/2)}$$

(ii)



- order of media L-G-A

- grazing emergency.

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When the light is just cut off from the observer, it just grazes the glass air boundary as above.
from Snell's laws, (Snell's Law) (substitution)

$n_t \sin\alpha = n_g \sin c = n_a \sin 90 = 1 \times 1$

$\Rightarrow \quad n_e \sin\alpha = 1$

$\Leftrightarrow \quad n_e = \frac{1}{\sin\alpha}$

now the angle between the two positions $\theta = 2\alpha$. (3)

$\therefore \quad n_e = \frac{1}{\sin(\theta/2)}$

(c)(i) At minimum deviation;

$n_r = \frac{\sin\frac{D+A}{2}}{\sin A/2} = \frac{\sin i}{\sin A/2}$

$\therefore \sin i = n_r \sin A/2$

$= 1.515 \sin\frac{60}{2} = 0.7575$

$\therefore \quad i = 49.24°$

$2r = 60°; \quad r = 30°$

$n\sin i = $ a constant

$1.515 \sin 30° = \sin i$

$i = 49.2°$ (4)

(ii) At the first surface, $\sin i = n \sin r$

$\Rightarrow \sin r = \frac{\sin 49.24}{1.529} \Rightarrow r = 29.7°$

now $\frac{\sin i}{\sin r} = \frac{\sin i_2}{\sin(60-r)}$

$\Rightarrow \sin i_2 = \frac{\sin i \sin(60-r)}{\sin r} = \frac{\sin 49.24 \sin 30.3}{\sin 29.7}$ (3)

$= \frac{0.7575 \times 0.5045}{0.4955} = 0.7713$

$i_2 = 50.5°$

$\sin 49.2 = 1.529 \sin r_1, \quad r = 29.7°$

$r_1 + r_2 = 60°$

$r_2 = 30.3°$

$1.529 \sin 30.3° = \sin i$ (03)

$i_2 = 50.4°$

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(d) The telescope is turned to face a distant object. The length of the telescope is adjusted until the image of the object is seen clearly on the cross wires. The collimator slit is now illuminated using strong source of monochromatic source of light. The telescope is now turned ~~to face~~ the collimator and the collimator ~~length~~ adjusted until the image of its slit is seen clearly on the cross wires. The prism is now placed on the spectrometer table. If the image of the slit seen is off the centre of the field of view, the screws are adjusted in or out to bring the image to the centre of the field of view. This way the spectrometer is adjusted and ready for use. (4)

(6)

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3(a) (i) It is the maximum displacement of a particle in the transmitting medium from its equilibrium position. (1)

maxm displacement of the wave from the eqm posn

(ii) – Amplitude of the wave varies from place to place along the profile.
– Wave energy is not ~~transmitted~~ along the wave profile. (2) any two
– At certain points called nodes the particles are permanently at rest.
– Has nodes and antinodes

(iii) Incident wave $y_1 = a\sin(\omega t - kx)$
reflected wave $y_2 = a\sin(\omega t + kx)$
resultant wave $y = y_1 + y_2$

$= a\sin(\omega t - kx) + a\sin(\omega t + kx)$

$= 2a\sin\frac{2\omega t}{2}\cos\left(\frac{-2kx}{2}\right)$

$= 2a\sin\omega t\cos kx$

$= (2a\cos kx)\sin\omega t$

$= A\sin\omega t$

where A is the amplitude of the wave. Now $A = 2a\cos kx$ varies with ~~position~~ distance x. Therefore the wave is a stationary one. (4)

(b) (i) When two notes of ~~nearly equal frequency~~ different frequencies are sounded together, a sound which rises and falls in intensity periodically is heard. (2)
The periodic rise and drop in intensity is what is called beats.

(7)

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(ii) The musical note is sounded together with a tuning fork of known frequency, f_T. The number of beats in t seconds, n are counted and the beat frequency $f_b = \frac{n}{t}$ Calculated. One prongs of the tuning fork is loaded with plasticine and then the experiment repeated. The new beat frequency f_b' is determined.

accept any figure for t

If $f_b > f_b'$ then the frequency of the test note f_n is calculated from

$$f_n = f_T - f_b$$

$f_b = f_T - f_n$

If $f_b < f_b'$ then the frequency of the test note f_n is calculated from $f_n = f_b + f_T$ (5)

(c) (i) beat frequency $f_0 = \frac{v}{2(l_1 + 2c_1)}$

$$f_b = f_0' - f_0'' = \frac{v}{2(l_1+2c_1)} - \frac{v}{2(l_2+2c_2)}$$

$$= \frac{v}{2}\left(\frac{1}{0.92+0.03} - \frac{1}{0.93+0.036}\right) = 3.0$$

$f = \frac{v}{2(l_1+c_1)}$

award but check of the substitution for (0.015×2) and (0.018×2)

$$v\left(\frac{0.966 - 0.95}{0.95\times0.966}\right) = 6.0$$

$$\therefore v = \frac{6\times0.95\times0.966}{0.016}$$

$$= 344.14 \text{ m/s}$$

accept the negative answer (4)

(ii) $f_0' = \frac{344.14}{2\times0.95} = 181.13$ Hz

(2)

$f_0'' = \frac{344.14}{2\times0.966} = 178.13$ Hz

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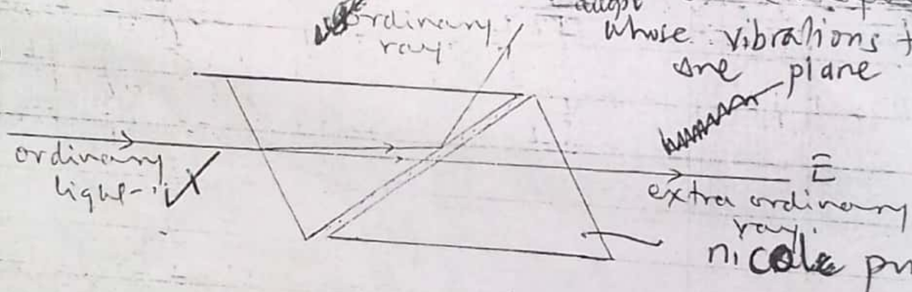
4(a) (i) Diffraction is the spreading of a wave beyond its geometrical shadow (or boundaries) leading to interference. (1)

(ii) Plane polarised light is one in which the ~~vibration of its electric vector~~ ~~takes place~~ ~~in only one plane (and also the magnetic vector)~~ whose vibrations take place in only one plane. (1)

(b) (i)

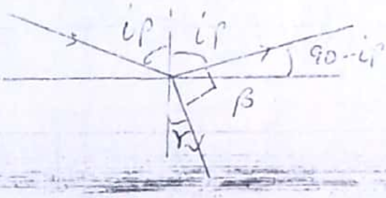


A narrow beam of ordinary light is made incident on one side of a nicolo prism as above and then observed from opposite side through a polaroid or another nicol prism called analyser. The angle of incidence is varied and for each angle of incidence the analyser is rotated about the line of view. Beyond some angle of incidence, the intensity of light received reduces until the light is extinguished. This emergent light is completely plane polarised. (5)

(ii) - Used in saccharimetry to determine the concentration of sugar in solutions
- Used in sunglasses to reduce glare
- Used in photoelasticity to identify regions of stress in a material. (2)

any two

(iii) By Brewster's law if the reflected light is polarised then $\tan i_p = n$
$= 1.62$
$\Rightarrow i_p = 58.3°$



~~From above diagram~~ $\beta = i_p$
$\Rightarrow r = 90 - i_p$
$= 90 - 58.3$
$= 31.7°$ (3)

(c)(i) A diffraction grating is a transparent plate with many small parallel lines drawn on it using diamond pencil. (1)

(ii) For first order diffraction,
$d \sin\theta = \lambda$
$\therefore \sin\theta_1 = \frac{\lambda_1}{d}$ ...(1) and $\sin\theta_2 = \frac{\lambda_2}{d}$ ...(2)

but $\theta_2 = \left(\theta_1 + \frac{2}{60} \times \frac{\pi}{180}\right)$ (04)

$\therefore$ (2) − (1)
$\sin\left(\theta_1 + \frac{\pi}{30\times180}\right) - \sin\theta_1 = \frac{\lambda_2 - \lambda_1}{d}$

$\Leftrightarrow 2\cos\left(\theta_1 + \frac{\pi}{60\times180}\right)\sin\frac{0.0333}{60\times180} = \frac{\lambda_2 - \lambda_1}{d} = \frac{(5.896 - 5.890)\times10^{-7}}{d}$

or $2\cos\left(\theta_1 + \frac{0.0333}{2}\right)\sin\frac{0.0333}{2} = \frac{\lambda_2 - \lambda}{d} = \frac{6\times10^{-9}}{d}$

(d)

Prism	Diffraction grating.
Produce single spectrum at a time	many spectra at a time
- Shorter wavelengths are deviated most	- longer wavelengths are deviated most
- produce less pure spectrum	- produce more pure spectrum.

(3)

(IC)

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Force acting on a conductor of 1m carrying a current of 1A placed ~~nor~~ to the magnetic field.

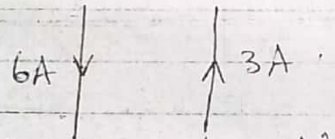
5(a) Magnetic flux density in a magnetic field is the force acting on a charge of 1C moving with a velocity of $1ms^{-1}$ at right angle to the magnetic field. (1)

do not accept ~~it~~ deduct $\frac{1}{2}$ for wrong symbol

(b)(i) $\bar{B} = \frac{\mu_0 I}{2\pi R}$

(ii) $\bar{F} = BIl \sin\theta$. (1)

(c) (i)



Magnetic flux density midway between the wires.

$\bar{B} = \bar{B}_1 + \bar{B}_2$

$B_1 = \frac{6\mu_0}{2\pi \times 0.04}$
$= 3\times10^{-5}T$

$B_2 = \frac{3\mu_0}{2\pi\times0.04}$
$= 1.5\times10^{-5}T$

$= \frac{\mu_0 I_1}{2\pi R} + \frac{\mu_0 I_2}{2\pi R}$

$= \frac{6\mu_0}{2\pi\times0.04} + \frac{3\mu_0}{2\pi\times0.04} = \frac{9\times4\pi\times10^{-7}}{2\pi\times0.04}$.

or

$= 4.5\times10^{-5}T$ perpendicularly out of the page. (4)

(ii) $F/l = BI$

$= \frac{\mu_0 I_1 I_2}{2\pi a}$ (3)

$= \frac{4\pi\times10^{-7}\times6\times3}{2\pi\times0.08} = 4.5\times10^{-5}Nm^{-1}$

(d) (i) Angle of dip is the angle between the earth's resultant magnetic flux density ~~and~~ the horizontal. (1)

(11)

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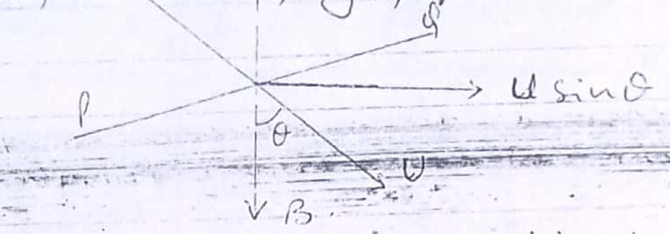
(ii) Angle of declination is the angle between the earth's magnetic and geographic axes. (1)
or angle b/n earth's meridian & geographical meridian.

(e)



Component of the velocity perpendicular to B is $U\sin\theta$.

Area swept by the conductor in one second is $lU\sin\theta$.

Change in magnetic flux linkage in 1s $= BlU\sin\theta$

But induced emf $\mathcal{E} = -\frac{d\phi}{dt}$ accept without a negative (4)

$\therefore |\mathcal{E}| = BlU\sin\theta$.

(f) Component of B_E perpendicular to $U = B_E\sin\theta$.

$\therefore$ Induced emf $\mathcal{E} = (B_E\sin\theta) \times lU$

$\Rightarrow B_E = \frac{\mathcal{E}}{lU\sin\theta}$ (4)

deduct ½ for wrong substitution of voltage

$= \frac{6\times10^{-3}}{20\times250\times\sin40} = \frac{1.2\times10^{-6}}{\sin40}$

$= 1.867\times10^{-6}$ T

2(e) Component of B ⊥ar to u is $B\sin\theta$

Electric field intensity along the rod

$E = \frac{V}{l}$ where V is emf induced

Now force on n electrons displaced

$F = neE = \frac{neV}{l}$

magnetic force on n electrons $= neVB\sin\theta$

In eqm, $\frac{neV}{l} = Un eB\sin\theta$

$\Rightarrow V = BlU\sin\theta$

(04)

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6(a) - The magnitude of the induced e.m.f. is directly proportional to the rate of change of the magnetic flux linking the circuit or conductor. (2)

- The direction of the induced e.m.f is such that it tends to oppose the change causing it.

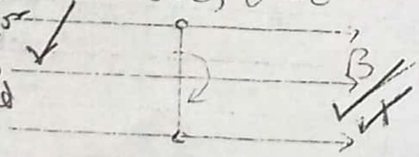
(b) (i) e.m.f generated $E = E_0 \sin \omega t$

E_0 is peak (or max) value of e.m.f, in volts

ω is the steady angular velocity of the coil, in radians per second.

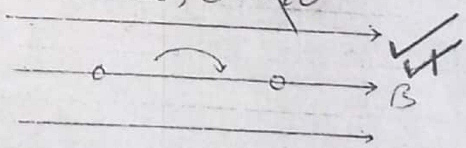
t is time taken from start of rotation in seconds. (3)

(ii) When $t=0$, $\theta = 0°$



magnetic field
correct orientation of the coil w.r.t magnetic field

When $E = E_0$, $\theta = 90°$



(3)

(c) Induced emf $E = \omega NAB \sin \omega t$.

where $E_0 = \omega NAB$ $\qquad \omega = 2\pi f = 2\pi \times \frac{2000}{60}$

$= \frac{2000}{60} \times 2\pi \times 50 \times 0.15 \times 0.30 \times 0.04$ (3)

$= 18.84\,V$

(d) (i) Magnetic flux linkage with the disc $\phi = BA$.

Now induced e.m.f. $E = -\frac{d\phi}{dt} = \frac{d\,BA}{dt} = B\frac{dA}{dt}$

but $\frac{dA}{dt} = \frac{\pi r^2}{T} = \pi r^2 f$ since $\frac{1}{T} = f$

$\therefore |E| = B\pi r^2 f$. (4)

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Index No .... $R = \frac{\mu_0 n \pi r^2 f}{I}$ Name

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$E = IR$
$E = B\pi r^2 f$
$IR = B\pi r^2 f$
$R = \frac{B\pi r^2 f}{I}$

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(ii) When the galvanometer shows no deflection,

$IR = B\pi r^2 f$ but $B = \mu_0 n I$

$\therefore IR = \mu_0 n I \pi r^2 f$ (3)

$\Rightarrow R = \mu_0 n \pi r^2 f$

(iii) ~~Since the emf generated is very small,~~ the method is used to measure only very small resistances. (2)

- The earth's magnetic field affects the induced e.m.f.
- The effect of thermal emf generated due the friction at the contact. any two.

d(i) velocity at the centre $= 0$

velocity at the rim $= v_1 = r\omega$

average velocity $= \frac{v_1}{2} = \frac{r\omega}{2}$

Induced e.m.f $E = Blv = \frac{Br^2\omega}{2}$

But $\omega = 2\pi f$

$\Rightarrow E = \frac{Br^2 \cdot 2\pi f}{2}$

$= B\pi r^2 f$

(14)

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7(a) (i) Root mean square value of an alternating current is the value of steady or direct current which dissipates heat in a given resistor at the same rate as the alternating current while peak value is the maximum value of the current (2)

or For a given alternating current, Irms is always smaller than the peak value.

(ii) $V_{rms} = 240$

now $V_0 = \sqrt{2}\, V_{rms}$

$= \sqrt{2} \times 240$ (2)

$= 339.4V$

(b) When the iron core is introduced into the coil, the magnetic flux linkage with the coil increases. The rate of change of magnetic flux linkage with the coil increases, and hence an increase in the induced back emf. This leads to a reduction in the current flowing through the bulb, Hence the bulb dims. (4)

either The changing magnetic flux in the coil induces eddy currents in the iron core. These currents cause the core to heat by I^2R mechanism. (2)

OR. The changing magnetic field continuously reverses magnetisation of the core thus reversing magnetic domains of the core. This leads to heating of the core due to friction between ~~[illegible]~~ domains or hysteresis.

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(c) (i) Inductive reactance is the non-resistive opposition to flow of alternating current through the inductor. (1)

(ii) Suppose current $I = I_o \sin 2\pi ft$ flows through the inductor, where I_o is amplitude.

Induced back emf $\mathcal{E} = -L\frac{dI}{dt}$

$$= -L\frac{d(I_o \sin 2\pi ft)}{dt}$$

$$= -2\pi f L I_o \cos 2\pi ft$$

For finite current in a pure inductor applied voltage $V = -\mathcal{E}$.

$\therefore V = 2\pi f L I_o \cos 2\pi ft = V_o \cos 2\pi ft$

where $V_o = 2\pi f L I_o$

now reactance $X_L = \frac{V_o}{I_o} = \frac{2\pi f L I_o}{I_o}$ (5)

$$= 2\pi f L$$

(iii) $I_{rms} = \frac{V_{rms}}{X_L} = \frac{V_{rms}}{2\pi f L}$ (3)

$$= \frac{6.0}{2 \times 3.14 \times 1000 \times 0.5}$$

$$= 1.9 \times 10^{-3}\ A$$

(d) - A.c. can easily and cheaply be changed from one voltage to another. ~~This makes~~ It's possible to transmit power ~~over~~ long distances with little loss. (1)

any one

- ~~Ac can easily be converted to dc~~
- Ac can ~~easily and~~ cheaply be generated in
- Ac can easily ...

(17)

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The circuit is connected as above. Switch K_1 is closed. Switch K_2 is connected to 1. The contact D is tapped at different points along wire AB until a point is found where galvanometer G shows no deflection. P is adjusted if necessary to move the balance point near the mid point of AB. The balance length l_0 is measured. K_2 is then connected to 2 and D is again used to locate the balance point along AB. The balance length l is measured. If the emf. of the test cell is $\mathcal{E}$ and that of the standard cell $\mathcal{E}_s$ then

$$\mathcal{E} = \mathcal{E}_s \times \frac{l}{l_0}$$ (5)

d (i) At balance with K_1, K_2 open

emf $\mathcal{E}$ = p.d. across AD $= I \times R$

$$= \frac{3}{(15+5)} \times \frac{15}{100} \times 75$$ (3)

$$= 1.69\ V$$

Current in the driver circuit $I = \frac{3}{15+5}$

$d/cm = \frac{3}{20} \times \frac{15}{100} = 0.0225\ V/cm$

$E = 0.0225 \times 75$
$= 1.69\ V$

(ii) When K_1 is open and K_2 is closed

p.d. across 10Ω resistor $V = \frac{3 \times 15}{20} \times \frac{65}{100}$

$$= 1.46\ V$$

now $\frac{\mathcal{E}}{V} = \left(\frac{R+r}{R}\right)$

(18)

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or $r = R\left(\frac{l_0}{l} - 1\right)$ ✓

$= 10\left(\frac{75}{65} - 1\right)$ ✓

$= 1.538\,\Omega$ ✓

(3)

$\Rightarrow \frac{1.69}{1.46} = 1 + \frac{r}{10}$. ✓

$\Rightarrow r = 1.6\,\Omega$. ✓

(iii) K_1 closed and K_2 open, ✓

p.d./cm of AB $= \frac{3}{100}$ V cm^{-1}.

If the balance length is l_0' then

$\frac{3}{100} \times l_0' = 1.69$. ✓

$\Rightarrow l_0' = 56.3$ cm. ✓

(2)

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9 (a)(i) Electric potential is the work done in moving 1C of positive charge from infinity to a point in an electric field. (1)

(ii) Force on 1C of a charge, $F = \frac{Q}{4\pi\varepsilon x^2}$

Work done to move the charge through Δx against the field $\Delta W = -F\Delta x$

deduct ½ if -ve is missing and follow the ex

Total work done to bring the charge from infinity to a point a distance r from the charge of Q,

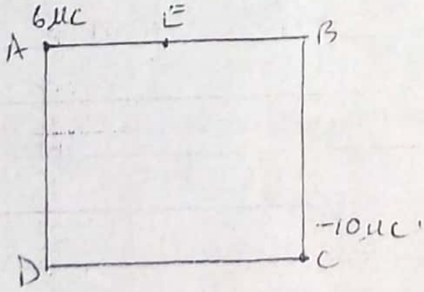
$$W = \int_{\infty}^{r} -F\,dx = \int_{\infty}^{r} -\frac{Q}{4\pi\varepsilon x^2}\,dx$$

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

(4)

$$= \frac{Q}{4\pi\varepsilon r}$$

(b)



$V_A = \frac{6\times10^{-6}}{4\times10^{-2}} =$

$V_C = \frac{-10\times10^{-6}}{6\times10^{-2}} =$

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

$$V_D = 9.0\times10^{9}\left(\frac{6\times10^{-6}}{4\times10^{-2}} - \frac{10\times10^{-6}}{6\times10^{-2}}\right)$$

$$= -1.5\times10^{5}\,V$$

(20)

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$\overline{CE} = \overline{ED}$

$\overline{CE} = \sqrt{3^2+4^2} = 5\,cm$

$V_E = 9\times10^9\left(\frac{6\times10^{-6}}{3\times10^{-2}} - \frac{10\times10^{-6}}{5\times10^{-2}}\right)$

$= 0$

$V_{DE} = 0 - -1.5\times10^5$

$= 1.5\times10^5\,V$

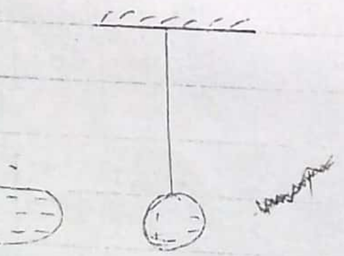
$W = QV$

$= 1.6\times10^{-10}\times1.5\times10^5$

$= 2.4\times10^{-5}\,J$

(5)

(c)

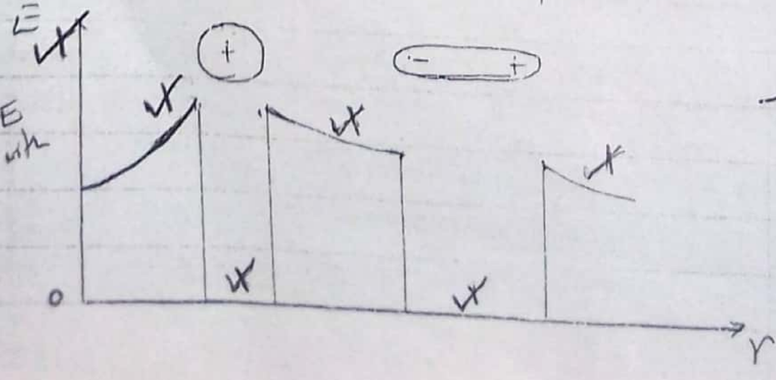


The charged ~~ebonite~~ rod induces positive charge on the near side of the ball ~~rod~~ and negative ~~positive~~ charge on the far side. The ball is thus attracted and moved to the rod. When it touches the rod, all its positive charge is neutralised leaving it with excess negative charge. Since they both have negative charge, they repel and the ball moves away.

(4)

(d) (i)

only if the E axis starts with a zero.



– accept without diagrams but correct nature graph.

(3)

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(ii) When the pin is attached to the conductor, its free end forms a sharp point on the conductor. charge tends to concentrate at the sharp ends of charged conductors. This leads to high electric field intensity around the sharp point, which ionises air around it. ions of similar charge to that on the conductor are repelled while those of opposite charge are attracted and charge on the conductor is neutralised. This way the conductor loses charge faster. (3)

(22)

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10(a) (i) Dielectric constant is the ratio of permittivity of a material to the permittivity of free space. (1)

(ii) - to increase capacitance of a capacitor.
- To reduce the chances of dielectric breakdown. (2)
- to keep the plates of the capacitor apart. any two.

(b) (i) Capacitance of a capacitor is the ratio of the magnitude of charge on either plates of a capacitor to the potential difference between the plates. (01)

(ii) The molecules of the insulator get polarised. Charge inside the material cancel each other's influence but the surfaces adjacent to the plates develops charge opposite to that on the near plate. Since the charges are bound, electric field intensity develops between the opposite faces of the insulator in opposition to the applied field. The resultant electric field intensity between the plates is thus reduced. But electric field intensity $E = \frac{V}{d}$, potential gradient, thus the p.d. between the plates reduces, since capacitance $C = \frac{Q}{V}$, capacitance increases. (5)

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(c) Effective capacitance in parallel

$C_2 = 0.7 + 0.3 = 1.0\ \mu F$.

Total capacitance in the network, C_3 is

$\frac{1}{C_3} = \frac{1}{1.0} + \frac{1}{2.0} = \frac{3.0}{2.0}$.

$\therefore C_3 = \frac{2}{3}\ \mu F$

Charge stored in the network

$Q = C_3 V = \frac{2}{3} \times 10^{-6} \times 6$

$= 4.0 \times 10^{-6}\ C$.

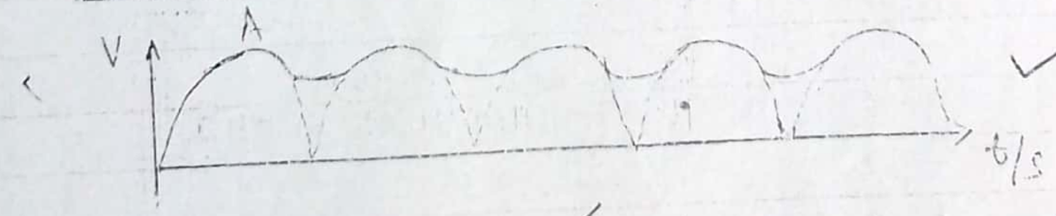
Energy stored in the 2.0 μF capacitor

$E = \frac{Q^2}{2C} = \frac{(4.0 \times 10^{-6})^2}{2 \times 2 \times 10^{-6}}$

(6)

$= 4.0 \times 10^{-6}\ J$

(d)



The voltage increases to a peak at A as the capacitor charges. When the p.d. begins to drop, the capacitor supplies charge (current) to the load, thus raising the p.d. across the load (P.d = IR). The resultant drop in p.d. across the load is thus small. As the p.d. begins to increase again the capacitor charges, and the cycle is repeated. Thus the fluctuations in p.d. is effectively reduced.

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5(f) $\frac{B_V}{B_H} = \tan\theta$

$E = B_V L V$

$B_V = \frac{E}{LV} = \frac{6\times10^{-3}}{20\times250} = 1.2\times10^{-6}$

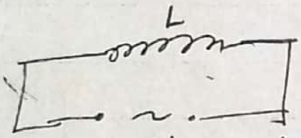
$B_H = \frac{B_V}{\tan\theta} = \frac{1.2\times10^{-6}}{\tan 40^\circ} = 1.43\times10^{-6}$

$B_E = \sqrt{B_V^2+B_H^2} = \sqrt{(1.2\times10^{-6})^2+(1.43\times10^{-6})^2}$ (04

$= \sqrt{3.485\times10^{-12}}$

$= 1.87\times10^{-6}$ T

7c(ii)



$V = V_0 \sin\omega t$

Suppose an alternating voltage is connected across an inductor of inductance L,

Induced Emf, $E = -L\frac{dI}{dt}$

For a finite current through the inductor

Applied voltage $V = -E$

$L\frac{dI}{dt} = V_0 \sin\omega t$

$\Rightarrow \frac{dI}{dt} = \frac{V_0}{L}\sin\omega t$

$dI = \frac{V_0}{L}\sin 2\pi f t \, dt$

$I = -\frac{V_0}{2\pi f L}\cos 2\pi f t$

$= -I_0 \cos 2\pi f t$

where $I_0 = +\frac{V_0}{2\pi f L}$

Now $X_L = \frac{V_0}{I_0} = V_0 / \frac{V_0}{2\pi f L}$