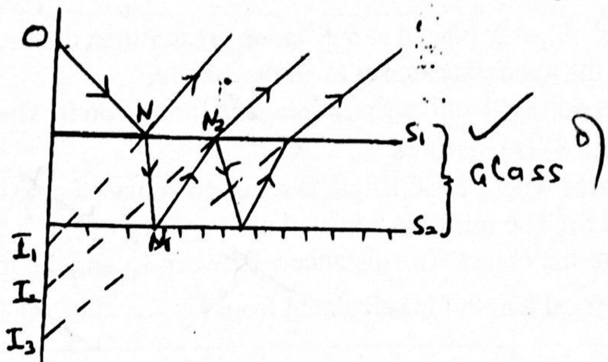
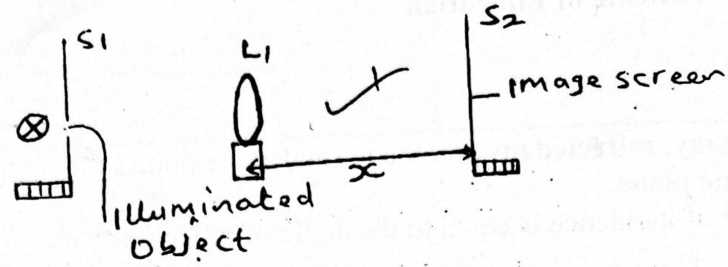
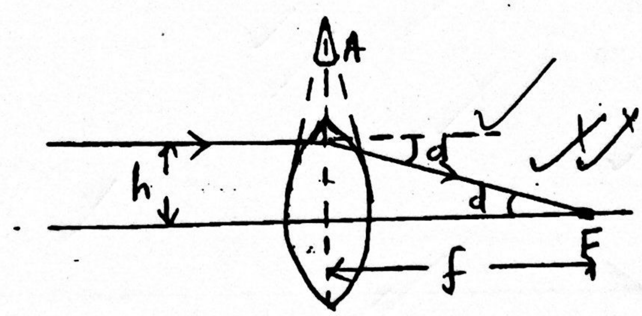
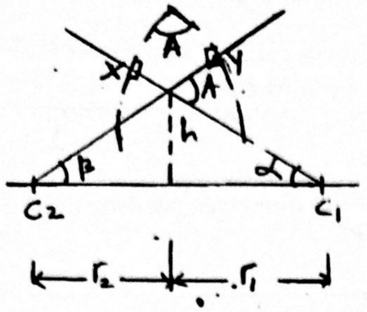
WAKISSHA JOINT MOCK EXAMINATIONS
MARKING GUIDE
Uganda Advanced Certificate of Education
PHYSICS P510/2
July/August 2024

1(a)(i)	The incident ray, reflected ray and the normal at the point of incidence all lie in the same plane. - The angle of incidence is equal to the angle of reflection. 	02
(ii)	Reflection takes place at the two surfaces S_1 and S_2. The reflection at the first surface at the point N leads to image I_1. The transmitted light is reflected at the silvered surface at point N_1. It undergoes partial reflection and refraction at N_2. The refracted light appears to originate from I_2 and this leads to formation of image I_2 .The successive internal reflections and refractions lead to formation of other images.	04
(b)(i)	Action of mirror A $\frac{1}{v}=\frac{1}{f}-\frac{1}{u}$ $=\frac{1}{20}-\frac{1}{30}$ V= 60cm Action of mirror B U = -10cm, f = 15cm $\frac{1}{v}=\frac{1}{f}-\frac{1}{u}$ $=\frac{-1}{15}+\frac{1}{10}$ V= 30cm	05
(ii)	$M= m_A \times m_B$ $=\frac{60}{30}\times\frac{30}{10}$ ≈ 6	02

(c)	 The illuminated object is placed at a distance greater than the focal length of the lens and the apparatus are set as shown above. The screen S_2 is adjusted until a sharp image is formed on it. The distance x between L_1 and S_2 is measured. The convex mirror whose focal length is required is placed coaxially between L_1 and S_2. The mirror is adjusted until a sharp image is focused on S_1 adjacent to the object. The distance y between L_1 and the mirror is measured. The focal length f is calculated from $f = \frac{x-y}{2}$	04
(d)	With mirrors of wider aperture, both the central and marginal rays converge at different points on the principal axis forming a blurred image. Mirrors of small aperture only allow central rays which converge at one point on the principal is forming a sharp image.	03
	TOTAL = 20 MARKS	
2(a)(i)	Refraction is the change in the direction of light as it travels from one medium into another.	01
(ii)	The incident ray, the refracted ray and the normal at the point of incidence all lie in the same plane. For two given media, the ratio of the sine of angle of incidence to the sine of angle of refraction is a constant.	02
(b)(i)	Consider a ray originally parallel and close to the principal axis, incident on the lens at a small distance h above the principal axis.  Since d is small $d \approx \tan d = \frac{h}{f}$ ----- (i) This is the deviation through a prism of small angle A formed by tangents at X and Y to the lens surfaces. $d=(n-1)A$, $\frac{h}{f}=(n-1)A$, $\frac{1}{f}=\frac{A}{h}(n-1)$ --- (ii)	05

The normals at X and Y pass respectively through the centers of curvature C_1, C_2 of the lens surfaces.



From geometry, $A = \alpha + \beta$

α and β are small angles measured in radians $\alpha \approx \tan\alpha = \frac{h}{r_1}$, $\beta = \tan\beta$

$= \frac{h}{r_2}$

$A = \frac{h}{r_1} + \frac{h}{r_2}$ and $\frac{A}{h} + \frac{1}{r_1} + \frac{1}{r_2}$

From (ii) and (iii)

$\frac{1}{f} = (n-1)\left(\frac{1}{r_1} + \frac{1}{r_2}\right)$

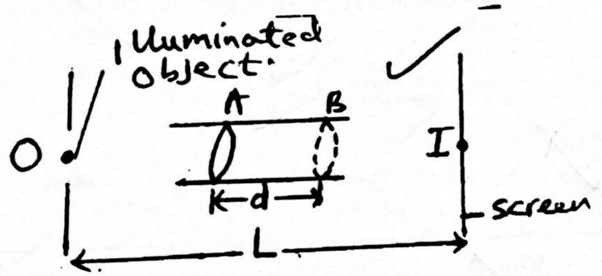
(ii) 02

$\frac{1}{f} = (n-1)\left(\frac{1}{r_1} + \frac{1}{r_2}\right)$

$\frac{1}{f} = (1.5-1)\left(\frac{1}{20} - \frac{1}{25}\right)$

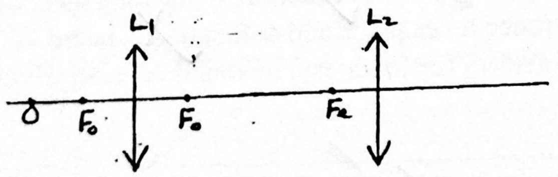
$f = 200\text{cm}$

(c) 05



An illuminated object, O is placed infront of a tube and the position of one end of the tube is marked, A.
The position of a clear image of O is located on the screen, I, The distance, L between the object and the screen is measured. Keeping the object, O and the screen at I fixed in position, the tube is displaced to obtain another clear image on the screen and the position is marked B. The distance between the two lens positions is measured, d. The focal length, f of the lens is calculated from $f = \frac{L^2 - d^2}{4L}$

(d) 03

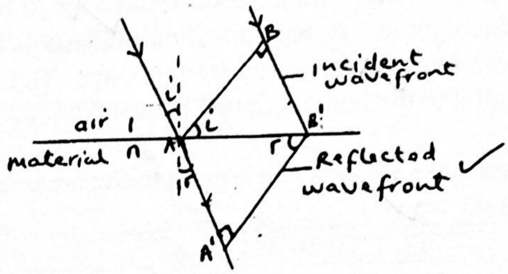


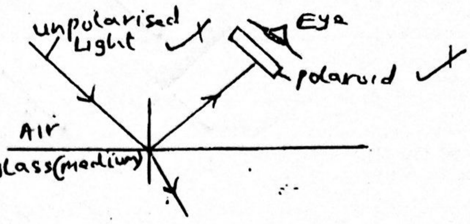
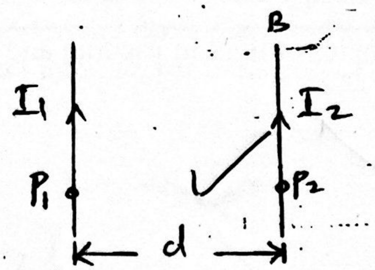
Action of L_1 u= 1.5cm, f = 1.2cm

$\frac{1}{f_0} = \frac{1}{u_0} + \frac{1}{v_0} \Rightarrow \frac{1}{1.2} = \frac{1}{1.5} + \frac{1}{v_0} \Rightarrow v_0 = 6.0\text{cm}$

Action of L_2, fe = 4.0cm, Ve = -25cm

	$\frac{1}{f_e}=\frac{1}{u_e}+\frac{1}{v_e} \Rightarrow \frac{1}{4.0}=\frac{1}{u_e}-\frac{1}{25} \Rightarrow u_e=3.45cm$ Separation of lenses = $v_0 + u_e$ = 6.0 + 3.45 = 9.45cm	
(e)	There is no chromatic aberration There is no spherical aberration. Relatively cheaper since only one face of the objective needs grinding. Has high resolving power Forms brighter images.	02
	TOTAL = 20 MARKS	
3(a)(i)	A transverse wave is a wave in which the particles vibrate perpendicular to the direction of propagation of the wave. A longitudinal wave is a wave in which the particles vibrate along the direction of propagation of the wave.	01 01
(b) (i)	y = 0.02sin2π(ft 3t – 0.02x) compare with $y = a\sin 2\pi\left(ft-\frac{x}{\lambda}\right)$ $y = 0.02\sin 2\Pi(3t-0.02x)$ $y = a\sin 2\Pi\left(ft-\frac{x}{\lambda}\right)$ ft = 3t ⇒ f = 3Hz	02
(ii)	$\frac{x}{\lambda}=0.02x \Rightarrow \lambda=50m$ $v=f\lambda$ $= 3 \times 50 = 150ms^{-1}$	02
(iii)	$\Delta Q=\frac{2\pi\Delta x}{\lambda}=\frac{2\pi}{50}\times 25 = \pi$ radians or 180^0 $=\pi$ radians OR 180^0	02
(c)(i)	When two waves of nearly equal frequencies and similar amplitudes are sounded together, they superpose. When they meet in phase, constructive interference takes place and a loud sound is heard. When they meet out of phase, destructive interference takes place and soft sound is heard. A periodic rise and fall intensity (or loudness) of sound is heard which is called beats.	03
(ii)	An instrument of standard frequency is sounded together with an instrument to be tuned. The frequency of the instrument to be turned is then adjusted until beats are heard. When the beats reduce to zero, the instrument is then turned.	03
(d)(i)	Speed of car = $30ms^{-1}$	03

	Wave length of sound received by the stationary observer $\lambda_a = \frac{V - U_s}{f}$ Apparent frequency $f_a = \frac{V}{\lambda_a} = \left(\frac{V}{V - U_s}\right) f$ $f_a = \frac{330 X 280}{330 - 30} = 308$ Hz	
(ii)	Wave length received by the observer $\lambda_a = \frac{V - U_s}{f}$ Apparent velocity $v_a = V + U_0$ Apparent frequency $f_a = \lambda_a = \frac{V_a}{\lambda_a} = \left(\frac{V + U_0}{V - U_s}\right) f$ $f_a = \left(\frac{330 + 30}{330 - 30}\right) \times 280$ $= 336$Hz	03
	TOTAL = 20 MARKS	
4(a)	Huygen's principle states that every point on a wave front may be regarded as a source of secondary wavelets and the new wave front is the envelope of the secondary wavelets.	01
b(i)	 Consider a plane wave front of light AB which is about to cross from air into a material. Let C and V be the velocities of light in air and material respectively. If a wave particle at B takes time, t to move to B^1, then the distance BB^1 = ct In the same time, a wave particle at A moves to A^1 a distance $AA^1 = Vt$ From triangles ABB^1 and AB^1A^1 $\frac{\sin i}{\sin r} = \frac{BB^1 / AB^1}{AA^1 / AB^1} = \frac{BB^1}{AA^1} = \frac{ct}{vt} = \frac{c}{v}$ But $\frac{c}{v} = n \Rightarrow v = \frac{c}{n}$	04
(ii)	Let f_0 and f be the frequencies of light in vacuum and in the medium respectively. Then $f = f_0 \Rightarrow \frac{v}{\lambda} = \frac{c}{\lambda_0}$ $\frac{\lambda_0}{\lambda} = \frac{c}{v} = n$ $\Rightarrow \lambda = \frac{\lambda_0}{n} = \frac{600}{1.5}$ $= 400$nm	03

(c)(i)	Plane polarized light is one whose electric vect or varies only one plane perpendicular to the direction of the light ray.  	01
(ii)	A narrow beam of unpolarised light is directed onto a medium and the reflected light is viewed through a polaroid. Starting with a small angle of incidence, the polaroid is rotated about an axis through its plane. The angle of incidence is gradually increased where by at each angle of incidence the polaroid is rotated. At one angle of incidence, the reflected light gets cut off, from the observer as the polaroid is rotated. At this point, the reflected light is completely plane polarised	04
(d)	$\frac{n_g}{n_L} = \tan i_p \Rightarrow \frac{1.52}{1.33} = \tan i_p \therefore i_p = 48.8^0$ $\Rightarrow r_p = 90 - 48.8 = 41.2^0$	04
(e)	The test slide is placed in contact with a standard flat slide to form an air wedge. Monochromatic light is directed almost normally onto the wedge and interference pattern formed are viewed from above. If regular fringes parallel to the line of contact is observed, the test slid is flat. Any areas showing irregular patterns correspond to the areas on the surface that are not flat.	03
	TOTAL 20 MARKS	
5(a)(i)	Magnetic flux density is the force experienced by a conductor of length 1m carrying a current of 1A placed perpendicular to the magnetic field. **OR** Magnetic flux density is the force experienced by a charge of 1C moving with velocity $1ms^{-1}$ at right angles to the magnetic field.	01
(ii)	The tesla is the magnetic flux density when the force on a conductor 1m long placed perpendicular to the magnetic field and carrying a current 1A is 1N.	01
(b)	 Consider two parallel conductors A and B above, carrying currents of I_1 and I_2 respectively. The magnetic flux density due to current I_1 at P_2 is B_1	04

$= \frac{N_0 I_1}{2\prod d}$

The force acting per meter length on wire B is $F_1 = B_1 I_2 = \frac{N_0 I_1 I_2}{2\prod d}$

Similarly the magnetic flux density due to current I_2 at P_1 is $B_2 = \frac{N_0 I_2}{2\prod d}$

The force per metre length on wire A

$F_2 = B_2 I_1 = \frac{N_0 I_2 I_1}{2\prod d}$

∴ Force per metre length between A and b

$F = F_1 = F_2 = \frac{N_0 I_1 I_2}{2\prod d}$

(c)(i) $B = \frac{N_0 NI}{2r}$ — **01**

(ii) Number of turns of the coil — **04**

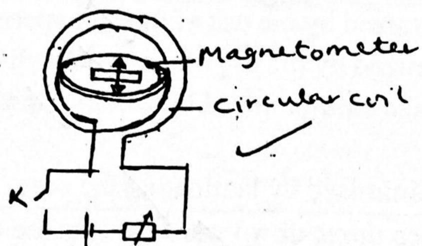
$N = \frac{8.0}{2\prod r} = \frac{8.0}{2\prod x 0.05}$

Magnetic flux density at the centre of the coil

$B = \frac{NoNI}{2\prod r} = \frac{4.0\prod X10^{-7} X2X8.0}{2X0.05X2\prod X0.05}$

$= 6.40 \text{ X } 10^{-4}$ T

(d) — **05**



The apparatus is arranged as shown above. The search coil is placed in the magnetic meridian such that the pointer of the magnetometer reads zero. switch K is closed and the pointer readings θ_1, θ_2 are noted. The average deflection is calculated from $\theta = \frac{\theta_1 + \theta_2}{2}$. If B_H and B_c are the earth's magnetic flux density and the magnetic flux density of the coil due to current respectively, then $\frac{B_c}{B_H} = \tan\theta$

(e) — **04**

Induced emf $E = BLV = B_v LV$

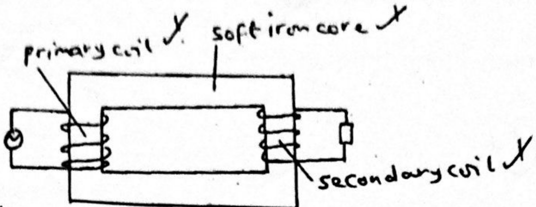
But $B_v = B_R \sin 40^0$

$\Rightarrow E = B_R \sin 40^0 LV$

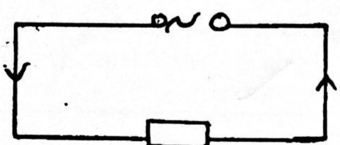
$B_R = \frac{E}{LV \sin 40^0} = \frac{6.0X10^{-3}}{20X250 \sin 40^0}$

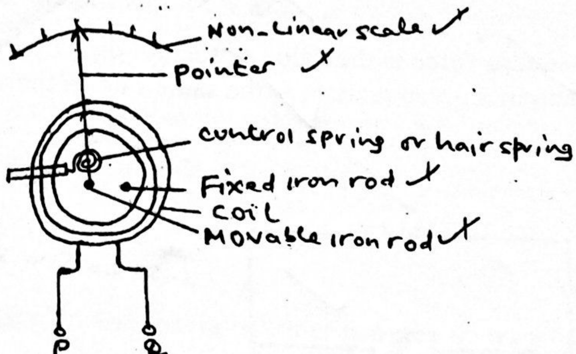
$= 1.87X10^{-6}$ T

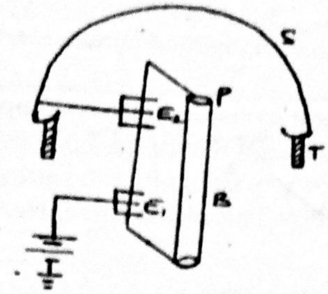
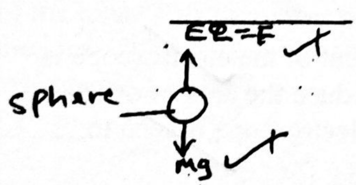
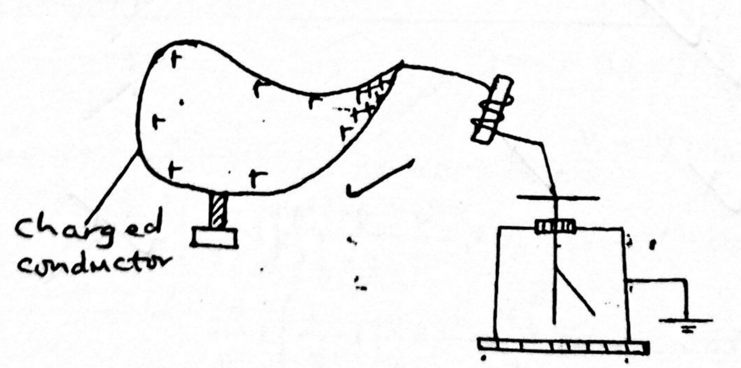
TOTAL 20 MARKS

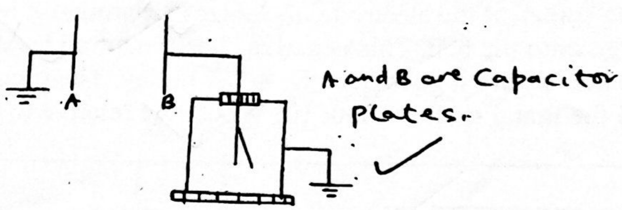
6(a)	Self-induction is the generation of emf in a coil due to changing current in the same coil.	01
	Mutual induction is the generation of emf in a circuit due to the changing current in a nearby coil / circuit.	01
(b)(i)	 An alternating voltage connected to the primary coil produces an alternating current in it. This sets up an alternating magnetic flux in the core which links the secondary coil thus induces an alternating emf in the secondary coil. The magnitude of the induced emf in the secondary coil is $V_s = N_sA\frac{dB}{dt}$ ………. (i) The changing magnetic flux also links the primary and induces a back emf in the same coil whose magnitude is $V_p = -N_pA\frac{dB}{dt}$ ----- (ii) Thus $\frac{V_s}{V_p} = \frac{N_s}{N_p}$ 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 it is a step-down transformer.	05
(ii)	- Ohmic loss, minimized by the use of thick copper wire. - Hysteresis, minimized by the use of a magnetically soft material. - Magnetic flux leakage, minimized by winding the secondary coil on the primary coil. - Eddy currents, minimised by laminating the core.	04
(c)(i)	When the rod begins to move down wards, it cuts the magnetic field and current is induced in the circuit. Magnetic force comes into play which opposes the motion of the conductor. The force increases with the increase in speed. When the force becomes equal to the weight of the rod, the rod begins to move with the constant velocity.	03
(ii)	At steady speed $F = BIL = mg$ $I = \frac{V}{R} = \frac{BLU}{R}$ $U = \frac{B^2L^2U}{R} = mg$ $U = \frac{mgR}{B^2L^2}$	03

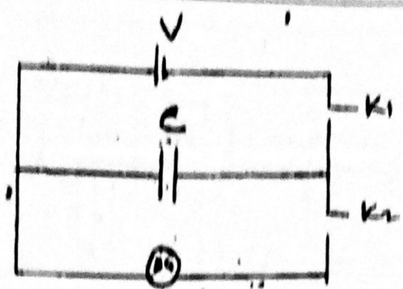
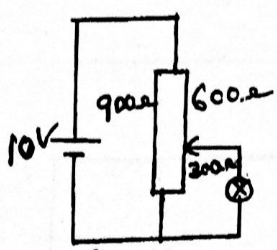
	$= \frac{0.04 X 9.81 X 0.05}{0.3^2 X 0.6^2}$ $= 0.606\ ms^{-1}$	
(d)	Induced e.m.f $E = 2\Pi fNBA \sin 2\Pi ft$ Maximum e.m.f $E_0 = 2\Pi fNBA$ Maximum induced e.m.f thus increases with increase in - frequency or angular velocity - Number of turns of the coil. - Area of the coil. - Magnetic flux density	03
	TOTAL 20 MARKS	

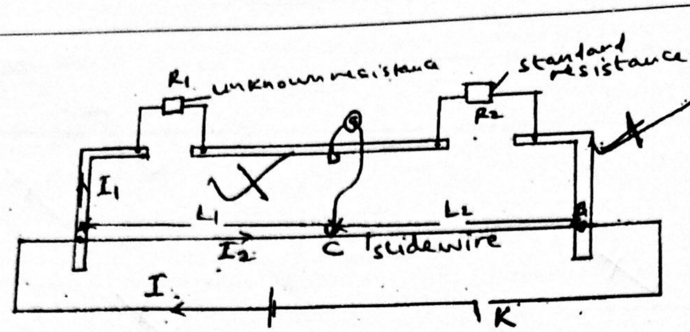
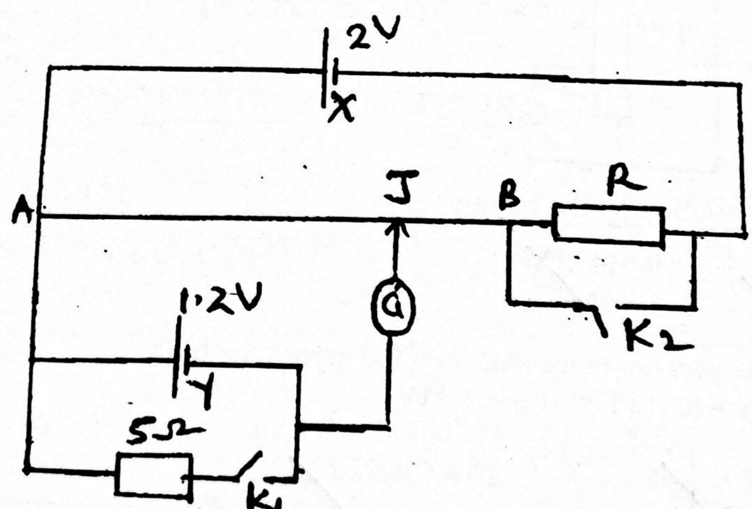
7(a)(i)	Peak value is the maximum value of the alternating current. Root mean square value is the value of steady/ direct current which dissipates heat in a given resistor at the same rate as the alternating current.	01 01
(b)	 $I = I_0 \sin 2\pi ft$ Instantaneous power dissipated $P = I^2R$ $P = I_0^2 \sin^2 2\Pi ftR$ $<P> \; < I_0^2 R \sin^2 2\Pi ft >$ $= I_0^2 R \angle \sin^2 2\Pi ft >$ But $< \sin^2 2\Pi ft > = \frac{1}{2}$ $<P> = \frac{1}{2} I_0^2 R$ Let Irms be the steady current that dissipates heat in the resistor at the same rate as the a.c then $<P> = I^2_{rms} R$ $I^2_{rms} R = \frac{1}{2} I_0^2 R$ $I^2_{rms} = \frac{I_0^2}{2}$ $I_{rms} = \frac{I_0}{\sqrt{2}}$	04
(c)	Vrms = 20V, f= 80Hz, L = 0.6H $I_{rms} = \frac{V_{rms}}{X_L} = \frac{V_{rms}}{2\Pi fL} = \frac{20}{2X3.14X80X0.6}$ = 0.066A	03

(d)(i)	When the switch K is closed, the bulb lights dimly and gradually increases to full brightness. When it is switched off, the bulb dims and gradually goes off.	02
(ii)	When the switch is closed, a large back e.m.f is induced, in the coil which opposes the flow of current in the circuit, very little current flows through the bulb hence dim light. The rate of change of current reduces gradually and the back e.m.f reduces to zero. leading to maximum current and the bulb lights to full brightness. When the switch is opened, the decaying magnetic field in the coil induces an e.m.f in the circuit which tends to reinforce the decaying current. The glow of the bulb reduces gradually and goes off.	04
(e)	 Current to be measured is passed through the coil. The iron rods get magnetized in the same sense and repel. The movable iron rod is pushed away and as it moves, the pointer rotates over the scale until it is stopped by the restoring torque of the hair spring. The deflecting torque is proportional to the force of repulsion which is proportional to the square of the current. Hence the deflection $\theta \propto \langle I^2 \rangle$	05
	TOTAL = 20 MARKS	
8(a)	Electric field intensity is the force acting on 1C of positive charge at a point in an electric field. Electric potential is the work done to transfer 1C of positive charge from infinity to a point against the electrostatic field.	02
(b)	The divergence of the gold leaf electroscope gradually reduces. At the tip of the pin, there is high charge density thus high electric field intensity. The air around the pin gets ionized, ions of opposite charge to that on the pin are attracted and neutralize some of the charge on the pin and the electroscope. The electroscope thus discharges gradually.	03

(c)	 B – silk belt E_1E_2 – Metal electrodes S- Spherical metal shell T – Insulating stand P – Pulley The lower electrode is maintained at high positive potential relative to the earth. The high electric field intensity at the spikes of the electrode ionizes air around the spikes. Positive ions are repelled onto the silk belt driven by the motor. The positive charge is carried up wards by the belt. As the charge approaches the upper electrode, it induces negative charge on the spikes of the electrode and repels positive charge on to the outer surface of the metal sphere through the connecting rod. The high electric field intensity at the spikes of the electrode, E_2 ionizes air around it repelling negative charge onto the belt. This negative charge neutralizes the positive charge on the belt before it goes over the upper pulley. The process is repeated until the metal shell is about 10^6 V positive relative to earth.	05
(d)	 Since the sphere is stationary, ⇒ EQ = mg where Q is the charge on the sphere. $E = \frac{v}{d} \Rightarrow \frac{v}{d} = mg$ $\frac{v}{d} \Rightarrow Q = \frac{mgd}{v} = \frac{8.0X10^{-3}X9.81X40X10^{-2}}{6000}$ $= 5.23X10^{-6}$ C	04
(e)	 A wire wound on an insulating rod is connected to the cap of a neutral gold leaf electroscope. The free end of the wire is moved over the surface of the conductor. The divergence of the leaf remains the same as the wire is moved from	04

	one point to another on the surface of the conductor. The potential is constant over the pear shaped charged conductor.	
(f)	When a neutral metal body is brought near a charged material opposite charge is induced on the near side of the metal that of the body on the far side. Since opposite charges are now closer to each other the attraction force between the material is greater than the repulsion force. Hence the metal body is attracted.	02
	TOTAL = 20 MARKS	
9(a)(i)	Capacitance is the ratio of the magnitude of charge on either plate of the capacitor to the potential difference across its plates.	01
(ii)	$V = \frac{q}{4\pi\varepsilon r} \Rightarrow \varepsilon = \frac{q}{4\pi r v} = \frac{8.0X10^{-10}}{4\pi X 0.11 X 60}$ $= 9.65X10^{-12}\ Fm^{-1}$	03
(b)	 Plate B is charged and the divergence of the leaf of the electroscope is noted. Plate A is then displaced upwards to reduce the area of overlap of the plates. The divergence of the leaf of the electroscope is seen to increase since $C = \frac{q}{v}$, capacitance has reduced. ie $C \propto A$.	04
(c)	$C = \frac{\varepsilon_0 A}{d}$ $Q = CV = \frac{\varepsilon_0 A}{d} = \frac{8.85X10^{-12} X 2X10^{-4} X 10{,}000}{5X10^{-3}}$ $= 3.54X10^{-9}\ C$	03
(d)	From $V = \frac{q}{c}, C_1 = \varepsilon_r C \quad C_2 = C$ $\Rightarrow V_1 = \frac{q}{\varepsilon c}$ and $V_2 = \frac{q}{c}$ Change in pd = $V_2 - V_1 = \Rightarrow V_1 = \frac{q}{c} - \frac{q}{\varepsilon_r c} = \frac{q}{C}\left(1 - \frac{1}{\varepsilon_r}\right)$ Fractional change in pd = $\frac{V_2 - V_1}{V_1} = \frac{q}{c}\left(1 - \frac{1}{\varepsilon_r}\right) X \frac{\varepsilon_r c}{q}$ $= \varepsilon_r\left(1 - \frac{1}{\varepsilon_r}\right) = \varepsilon_r - 1$	03
(e)(i)	Relative permittivity is the ratio of permittivity of the material to permittivity of free space.	01

(ii)		
	A capacitor with air between the plates is connected as above. Switch K_1 is closed and after a short time it is opened. K_2 is closed and the first deflection θ_0 of B_1 G is noted. K_2 is opened. The test dielectric is placed between the plates and k_1 is closed. After a short time K_1 is opened and K_2 is closed. The first deflection θ of B_1 G is noted. Relative permittivity ε_r is found from $\varepsilon_r = \frac{\theta}{\theta_0}c$	05
	TOTAL = 20 MARKS	
10(a)(i)	Resistance of a conductor is the opposition to flow of current through a conductor.	01
(ii)	Length: Increase in length leads to a longer path for electrons. This leads to more collisions with the material ions. This reduces the current and hence in resistance. Temperature: Increase in temperature increases the amplitude of vibration of the ions. This increases the rate of collision between the electrons and the ions. This reduces the amount of current flowing implying a higher resistance.	1½ 1 ½
(b)	 Effective resistance Rp $= \frac{300X150}{300+150}$ $= 100\,\Omega$ Total resistance RT $= 100 + 600$ $= 700\,\Omega$ Current supplied by the battery $I = \frac{V}{Rr} = \frac{10}{700} = 0.0143A$ P.d across parallel combination = P.d across the bulb Vp = IRp = 0.0143 X 100 = 1.43V Energy E $= \frac{V^2}{R}t = \frac{(1.43)^2}{150}X5 = 0.0682J$	04

(c)(i)	 At balance the galvanometer shows no deflection P.d across R_1 = P.d across L_1 and P.d across R_2 = P.d across L_2 Current through R_1 = current through R_2 And current through L_1 = current through L_2 $\Rightarrow I_1R_1 = I_2KL_1$ ....(1) $I_2R_2 = I_2KL_2$ ....(2) K is the resistance per cm of the slide wire 1/2 $\frac{R_1}{R_2} = \frac{L_1}{L_2}$	04
(ii)	R_1 must be chosen such that the balance point is near the middle of the wire AB. Any 2 After determining the balance length L_1 and L_2, R_1 and R_2 should be interchanged in order to get the average values of the balance lengths. The resistance wire AB should not be scrapped by the Jockey. This is to avoid spoiling the uniformity of the wire.	02
(d)	 $R = \frac{\rho L}{A} = \frac{9.0X10^{-6} X1}{1.5X10^{-6}} = 6.0\Omega$ With K_1 open, p.d across AJ = E_y = 1.2 V	04

	Pd/cm = $\frac{1.2Vcm^{-1}}{75}$ $I_D = \frac{2}{6+R} \Rightarrow p.d/cm = I_D R/cm = \frac{2}{6+R} X \frac{6}{100} = \frac{12}{(6+R)100}$ $\Rightarrow \frac{12}{(6+R)100} = \frac{1.2}{75} \Rightarrow R = \left(\frac{12X75}{120}\right) - 6.0$ $R = 1.5\Omega$		
(ii)	Let the balance Length be L With K_1 closed, $I = \frac{E}{R+r} = \frac{1.2}{5+1} = 0.2A$ V= IR = 0.2 X 5 = IV p.d/cm = $\frac{2}{100}Vcm^{-1}$ p.d across L = $\frac{2L}{100}$ $\frac{2L}{100} = 1 \Rightarrow L = \frac{100X1}{2} = 50.0cm$	02	
	TOTAL = 20 MARKS		

END