SECTION A

1. (a) (i) A ray of light from a fixed ray box is directed at an angle onto a plane mirror. The mirror is then rotated through an angle θ. Show with the aid of a ray diagram that the reflected ray turns through an angle 2θ. (3 marks)

(ii) Describe the structure and mode of operation of an optical lever galvanometer. (4 marks)

(b) (i) Define focal length of a convex lens. (1 mark)

(ii) Derive an expression for the lens formula, $\frac{1}{u}+\frac{1}{u}=\frac{1}{f}$ where, u, v and f are object distance, image distance and focal length respectively of the lens. (4 marks)

(c) Figure 1 shows a concave mirror M, of focal length 10.0 cm arranged coaxially with a convex lens L of focal length 8.0 cm placed a distance of 20.0 cm apart. A real point object O is placed 15.0 cm in front of the mirror M.

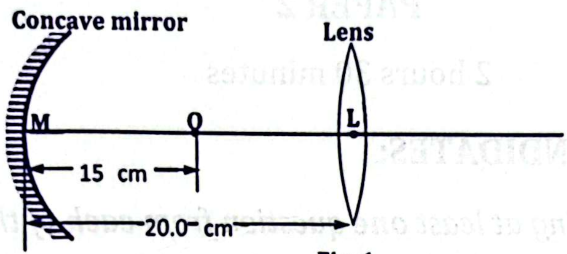

Fig. 1

(i) Determine the position and nature of the final image formed first by reflection in M then refraction by L. (4 marks)

(ii) Determine the magnification of the final image. (2 marks)

(iii) Draw a ray diagram to show the formation of the final image. (2 marks)

2. (a) (i) Define the term radius of curvature of a concave mirror. (1 mark)

(ii) Describe an experiment to determine the refractive index of a liquid using a concave mirror. (5 marks)

(b) An optical clamped above a concave mirror containing a liquid L_1 of refractive index 1.35 and thickness 0.2 cm coincides with its own image at a height of 15.0 cm above the liquid surface. When liquid L_1 is replaced with liquid L_2 of the same thickness, the pin coincides with its own image at a height of 18.0 cm above liquid surface. Determine the,

(i) radius of curvature of the mirror (3 marks)

(ii) refractive index of liquid L_2. (2 marks)

(c) (i) Draw a labelled diagram of a slide projector. (3 marks)

(ii) A slide projector having square slides of width 5.08 cm, produces an image that is 2.00 m wide on a screen located 3.50 m away.
Determine the focal length of the projector lens. (4 marks)

(d) Explain how chromatic aberration can be minimized in a camera. (2 marks)

SECTION B

3. (a) (i) Distinguish between transverse waves and longitudinal waves. (3 marks)

(ii) Give two examples of each of the waves in (i) above. (4 marks)

(b) (i) What are *overtones*? (1 mark)

(ii) Explain why unstopped piped instruments produce better quality musical notes than stopped piped instruments. (3 marks)

(c) (i) What is ***Doppler effect***? (1 mark)

(ii) Two sources of sound waves A and **B** lying on a straight line sound sirens of the same frequency f of 500 Hz. An observer O located between the sources is moving from source A towards source B at a velocity u_0 of 5.0 ms^{-1}. Given that source B is stationary while source A is moving away from source B at a velocity u_A of 10 ms^{-1}. Write down the expressions for the apparent frequencies of sound heard by observer O from the two sources, hence calculate the beat frequency. (5 marks)

(d) Explain how beats are produced in sound waves. (3 marks)

4. (a) (i) What is diffraction of waves? (1 mark)

(ii) State two factors that influence the extent of diffraction of waves. (2 marks)

(b) (i) Define the term ***path difference*** of waves. (1 mark)

(ii) Derive an expression for the fringe separation in an air wedge. (4 marks)

(iii) Give two applications of interference of light waves. (2 marks)

(c) (i) Write down the formula for determining the fringe width or fringe separation in Young's double slit experiment and define all the terms used. (2 marks)

(ii) The distance between the second bright fringe and the 5[th] dark band in Young's double slit experiment is 2.0 cm. Given that the slit separation is 1.5 mm while the plane of the slits is 3.0 m from the screen. Determine the wavelength of the light incident on the slits. (4 marks)

(d) (i) What is the effect of reducing the distance between the slits on the fringe separation? (1 mark)

(ii) State three conditions necessary for the fringes to be observed on a screen in the Young's double slit experiment. (3 marks)

SECTION C

5. (a) Define the following terms as applied to magnetism: -

(i) Angle of dip. (1 mark)

(ii) Magnetic meridian, (1 mark)

(b) (i) Describe how a search coil of known geometry can be used to measure the angle of dip of the earth's magnetic field. (6 marks)

(ii) The horizontal and vertical components of the earth's magnetic field at a certain location are $2.52.50 \times 10^{-3}\,T$ and $4.33 \times 10^{-3}\,T$ respectively. Determine the resultant magnetic field and the angle of dip. (4 marks)

(c) A plane circular coil carrying a current in a vacuum, has N turns of the wire each of mean radius R. Given that the magnetic flux density in tesla at its centre is $\frac{\pi}{2}$, show that the current flowing through the coil is $\frac{\pi R}{\mu o N}$ amperes.

(3 marks)

(d) Figure 2 shows two straight and parallel wires **Q** and **R** placed 5.0 cm apart in air along the x – axis and carrying currents of **4.0A** and **3.0A** respectively out and into the x – y plane as shown.

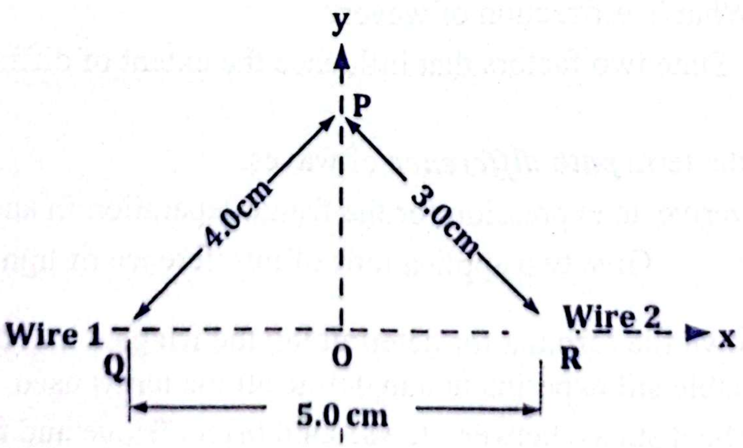

Fig. 1

Calculate the magnitude of the resultant magnetic flux density at a point P, located 4.0 cm from Q and 3.0 cm from R. (5 marks)

6. (a) (i) Define the term, ***electromagnetic induction***. (1 mark)

(ii) State the laws of electromagnetic induction. (2 marks)

(b) (i) Derive an expression for the e.m.f. induced across a straight conductor of length **L** being moved perpendicularly across a uniform magnetic field of flux density, **B** at a constant velocity, **V**. (4 marks)

(ii) A glider aircraft of wing span 40 m is moving horizontally at a velocity of 250 ms^{-1} in a plane where the angle of dip is 30°. If the e.m.f. induced across the tips of the wings is 10 mV.

Find the value of the Earth's magnetic flux density and state the sign of chargeon each wing. (4 marks)

(c) Describe an absolute method of measuring resistance using Faraday's metal disc, (5 marks)

(d) A transformer inside a portable CD player has 500 turns in the primary coil. It supplies an e.m.f. of amplitude 6.8 V when plugged to the a.c. mains of amplitude 1.70 V.

(i) How many turns does the secondary coil have? (2 marks)

(ii) If the amplitude of the current drawn by the CD player has amplitude of 1.50 A, what is the amplitude of the current in the primary? (2 marks)

7. (a) (i) Define the term ***root mean square current.*** (1 mark)

(ii) Derive an expression for the average power dissipated in a resistor of resistance **R** when alternating current $I = I_0 \sin 2\pi f t$ amperes flows through it. (3 marks)

(b) (i) Derive an expression for reactance X_C of a capacitor of capacitance, C connected across an alternating voltage $V = V_0 \cos 2\pi f t$ *volts* (4 marks)

(ii) Sketch using the same axes the variation of applied voltage and current flowing through the capacitor, with time. (2 marks)

(c) (i) Describe the structure and mode of operation of a repulsive type of moving iron ammeter. (5 marks)

(ii) Outline three advantages of the meter in (i) above over a moving coil ammeter. (3 marks)

(d) Explain why a light flattened metallic bottle top placed on top of an enameled coil of copper wire connected to a large battery via a switch, jumps off the coil and later falls back when the switch is closed. (2 marks)

SECTION D

8. (a) (i) Define the term ***electric field intensity*** and state is SI Unit. (2 marks)

(ii) Derive an expression for the electric field intensity at a point due to a charge +Q. (3 marks)

(b) (i) What is an equipotential surface? (3 marks)

(ii) Explain why electric field lines are normal to the surface of a charged metal conductor. (4 marks)

(c) Three-point charges of $+2.5\ \mu C$, $-5.0\ \mu C$ and $+3.0\ \mu C$ and are placed at points A, B, and C as shown in figure 2, with point **P** located 3.0 cm from point C along the x – axis, while BC = 2.0 cm and AC = 4.0 cm.

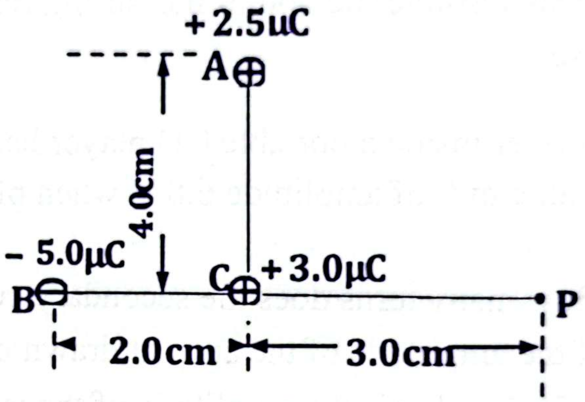

Fig. 2

Determine the resultant electric field intensity at point P. (5 marks)

(d) Explain how lightening is created in the earth's atmosphere. (3 marks)

9. (a) (i) What is a capacitor? (2 marks)

(ii) Give three industrial uses of capacitors. (3 marks)

(b) Derive an expression for the effective capacitance, C of three capacitors of capacitances C_1, C_2 and C_3 arranged in series all of which are connected across a battery of e.m.f, V. (4 marks)

(c) Six parallel plate capacitors of $1\ \mu F$, $2\ \mu F$, $3\ \mu F$, $6\ \mu F$, $8\ \mu F$ *and* $15\ \mu F$ are all connected as shown in figure 3 across a 12 V battery.

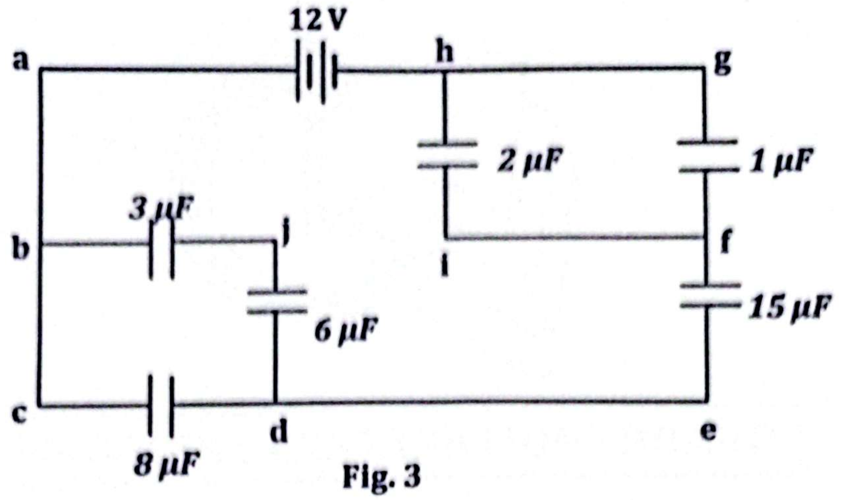

Fig. 3

Determine the;

(i) Effective capacitance of the network. (4 marks)

(ii) Charge stored in the whole system. (2 marks)

(d) Describe how a calibrated gold leaf electroscope can be used to investigate the effect of increasing the distance of separation between the plates of a charged capacitor on its capacitance. (5 marks)

10. (a) (i) Define ***temperature coefficient of resistance*** of a material. (1 mark)

(ii) Describe an experiment to measure temperature coefficient of resistance of copper. (6 marks)

(b) A variable resistance, **R**, is connected across a battery of e.m.f. **E** and internal resistance, **r**. Derive an expression for the;

(i) Efficiency of the circuit. (3 marks)

(ii) Maximum power output of the circuit. (4 marks)

(iii) Sketch using the same axes graphs of power and efficiency against resistance. (2 marks)

(c) How can a galvanometer having a coil of resistance 2 Ω and full-scale deflection of 5 mA be converted into a voltmeter having a range of (0 – 3 V)? (4 marks)