LEAVING CERTIFICATE EXAMINATION, 1978

PHYSICS—HIGHER LEVEL

THURSDAY, 22 JUNE—MORNING, 9.30 to 12.15

Any **six** questions to be answered.
All questions carry the same marks.

1. Answer *eleven* of the following items *(a), (b), (c),* etc. All the items carry the same marks. *Keep your answers short.*

(a) Define potential energy.

(b) The graph in Fig. I shows how the acceleration of a body varies as a result of different forces being applied to it. Calculate the mass of the body.

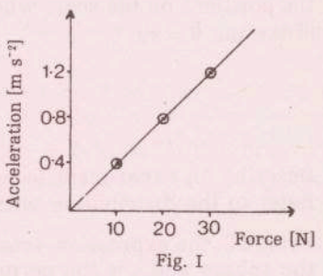


Fig. I

(c) What is the relation between the gravitational constant (G) and the acceleration due to gravity (g) in terms of the mass of the earth (M) and the radius of the earth (R)?

(d) A block of metal of mass M kg and with a temperature of 0°C comes in contact with a block of another metal of mass 2M kg and with a temperature of 100°C. Calculate the ratio of the specific heat capacities of the metals if the final steady temperature of the metals is 40°C. (Assume that there is no loss of heat to the surroundings.)

(e) If an object and its real image as formed by a convex lens have the same dimensions when the image distance is 0.2 m from the lens, calculate the focal length of the lens.

(f) What is the velocity of light in water if the refractive index of water is 4/3? (Take the velocity of light in a vacuum $= 3.0 \times 10^8$ m s^{-1})

(g) What are harmonics?

(h) In what respect does a thermionic diode differ from a triode?

(i) Show the relative positions of visible light, infra-red light, gamma rays, in the electromagnetic spectrum. Which has the shortest wavelength?

(j) What is the effect of light on a cadmium sulphide (CdS) cell?

(k) Write down an expression for the magnetic flux density at the centre of a solenoid of n turns per metre which has a current I amperes flowing through it.

(l) Fig. II shows the output voltage (solid line) of an electrical circuit used in rectification when an alternating voltage (broken line) is applied to the input of the circuit. Name two electrical components you would expect to find in the circuit.

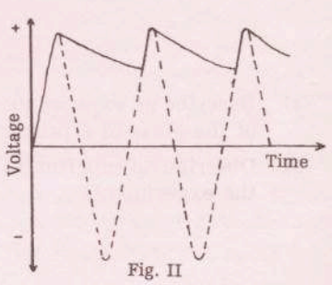


Fig. II

(m) What is (i) magnetic declination, (ii) magnetic dip?

(n) What does the Compton effect tell us about the nature of electromagnetic radiation?

(o) What is meant by nuclear fusion?

(p) Complete the nuclear reaction:

$$^{40}_{19}\mathrm{K} \rightarrow {}^{40}_{20}\mathrm{Ca} +$$

2. *(a)* Define (i) work, (ii) momentum.

A force of 10 N is applied to a body of mass 2 kg, initially at rest, for 4 seconds. Calculate (i) the velocity of the body at the end of this time, (ii) the work done by the force.

(b) Derive an expression for the centripetal force on a body of mass m moving in a circle of radius r with a uniform speed v.

A mass of 5 kg is attached to a string of length 0.1 m and maintained in circular motion in a vertical plane. The radius of the circle is equal to the length of the string. If the mass has a constant speed of 1.4 m s^{-1} calculate the tension in the string when the mass is at its highest point.
(Take $g = 9.8$ m s^{-2}).

3. Give an account of an experiment to show how the electrical resistance of a wire varies with temperature. Describe a resistance thermometer and show how it may be used to measure temperature.
Define temperature on the Celsius scale for a constant volume gas thermometer.

Given that $\frac{P_{100}}{P_0} = 1.36$ calculate the temperature of absolute zero on the Celsius scale when P_{100} is the pressure of a constant volume gas thermometer at the boiling point of pure water and P_0 the pressure at the ice-point, both being measured at atmospheric pressure.

4. With regard to wave motion explain the terms (i) interference, (ii) diffraction, and describe briefly an experiment to show interference without diffraction.
"Interference and diffraction both occur when monochromatic light is incident on a diffraction grating". Comment briefly on this statement.
A wavelength of 656 nm is emitted from a line-source hydrogen discharge tube which is placed at the centre of a metre scale. The source is viewed through a diffraction grating of 5×10^4 lines per metre with the lines of the grating parallel to the tube. The grating is at a distance of 2.5 m from the source. Calculate the positions on the scale where you would expect to see the first order images of this hydrogen line.
(Take $\tan \theta = \sin \theta$)

5. Describe an experiment to investigate the distribution of charge on the surface of a charged conductor. Refer to the distribution with regard to (i) a spherical conductor, (ii) a pear-shaped conductor.

Establish the expression $4\pi\varepsilon a$ for the capacitance of an isolated conducting sphere where a is the radius of the sphere and ε is the permittivity of the medium.
An earthed conductor is placed sufficiently close to the sphere of an electrostatic generator, e.g. a Van de Graaff generator, such that a spark crosses the gap between the sphere of the generator and the conductor once every second. If the potential of the sphere is 280 kV and its radius is 0.1 m and assuming that the sphere is completely discharged with each spark, calculate the average current in the spark. (Assume that the sphere of the generator can be regarded as an isolated sphere. Take the permittivity of air $= 9.0 \times 10^{-12}$ Fm^{-1} and $\pi = 22/7$)

6. State the principle on which each of the following is based (i) moving-coil galvanometer, (ii) dynamo. Outline the structure of a dynamo. How is the dynamo related to the electric motor?
Explain the following:
   (i) the scale of a moving-coil galvanometer is linear,
   (ii) when the coil of a galvanometer is swinging freely it may be rapidly brought to rest by short-circuiting the instrument,
   (iii) a starting resistance is sometimes necessary in an electric motor,
   (iv) the armature of an electric motor is laminated.

7. *(a)* Describe an experiment to measure the magnifying power of a simple telescope *or* the refractive index of the glass of a prism.
   (b) Describe an experiment to measure the internal resistance of a cell and give the theory associated with the experiment.

8. What are (i) electrons, (ii) photons?
Comment on the role of both photons and electrons in the photoelectric effect and in the production of X–rays.

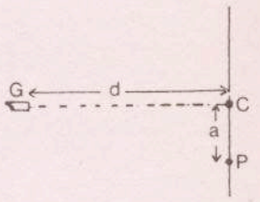
Write down Einstein's equation for photoelectric emission. Describe an experiment which demonstrates the effect of varying the intensity of the light incident on a metal surface.
When a metal surface is illuminated by radiation of frequency 6.4×10^{14} Hz the maximum kinetic energy of the photoelectrons emitted is 0.24 eV. Calculate (i) the work function of the metal, (ii) the threshold frequency for the metal. (Take $h = 6.6 \times 10^{-34}$ J s, electron charge $= 1.6 \times 10^{-19}$ C)

9. What is meant by (i) radioactive decay, (ii) alpha particles?
Give an account of an experiment which established the nature of alpha particles.
What experimental evidence led to the discovery of the neutron?
$^{234}_{92}U$ decays to $^{230}_{90}Th$ with the emission of an alpha particle and has a decay constant of $8.8 \times 10^{-14}\ s^{-1}$. Calculate the number of alpha particles emitted per second from 1.3×10^{-3} kg of $^{234}_{92}U$.
(Take Avogadro's constant = $6.0 \times 10^{23}\ mol^{-1}$)

10. Answer any *two* of the following.

(a) Give the basic assumptions of the kinetic theory of gases.
Derive the expression $p = \frac{1}{3}\frac{nm\overline{c^2}}{V}$

(b) The following experiment was performed to measure g, the acceleration due to gravity (see diagram). A gun (G) was directed horizontally at the centre (C) of a target a distance d away. A bullet was fired from the gun with a velocity v. The point of impact of the bullet was found to be a distance a vertically below the centre point of the target. Derive the expression that was used in the calculations for g in terms of v, d and a. (Neglect the effect of the resistance of air.)



(c) Describe an experiment to find the velocity of sound in a solid bar (e.g. glass, wood, brass etc.).

(d) Give an account of an experiment to measure the specific charge (the ratio of the charge to the mass) of the hydrogen ion.