LEAVING CERTIFICATE EXAMINATION, 1985

PHYSICS–HIGHER LEVEL

WEDNESDAY, 26 JUNE–MORNING, 9.30 to 12.30

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 the unit of force, i.e. the newton.

(*b*) A mass of 6 kg, moving with a velocity of 5 m s^{-1} in a certain direction, collides with a mass of 3 kg moving at 2 m s^{-1} in the same direction. After the collision the two masses coalesce and move off together as a combined mass. Calculate the velocity of the combined mass.

(*c*) Two forces, each of 12 N, are applied to the ends of a bar of length 2 m as shown in Fig. 1. What is the moment of the resulting couple?

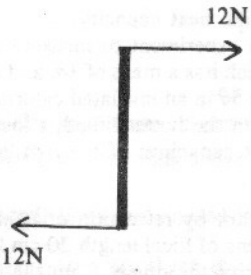

Fig. 1

(*d*) In the kinetic theory equation $p = \frac{1}{3}\rho\overline{c^2}$, what do the symbols $\overline{c^2}$ and ρ represent?

(*e*) How is temperature interpreted in terms of the kinetic theory of gases?

(*f*) Complete the statement: ..... aberration occurs in ..... but not in mirrors.

(*g*) Calculate the real depth of a swimming pool which has an apparent depth of 1·5 m given that the critical angle for water is 48·5°. (Take sin 48·5° = 0·75.)

(*h*) Monochromatic light is incident normally on a diffraction grating which has 500 lines per millimetre. Calculate the wavelength of the light if the second order diffracted image is at an angle of 30° to the central image.

(*i*) Write down an expression for Coulomb's law of force between electric charges.

(*j*) Given that θ in Fig. 2 is the angle of dip what do the vectors AB and AC represent?

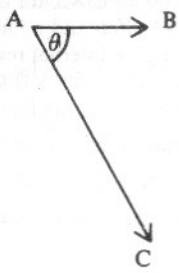

Fig. 2

(*k*) State the physical principle on which the definition of the ampere is based.

(*l*) What is the maximum energy of an X-ray photon produced in a tube in which the potential difference between the electrodes is 100 kV? (Charge on an electron, $e = 1{\cdot}6 \times 10^{-19}$ C.)

(*m*) How are the frequencies of spectral lines related to energy levels in an atom?

(*n*) What is meant by pair production?

(*o*) If the activity of a sample of a radioactive isotope decays to one sixteenth of its original value after 96 years what is the half-life of the isotope?

(*p*) What is meant by nuclear fusion?

2. State the principle of conservation of energy.
Show that, for a body falling freely under gravity, the sum of the kinetic and potential energies is constant.
What is meant by centripetal force?
A small metal sphere is held at rest at the top of a metal shute, AB (Fig. 3). The shute is in the form of an arc of a circle of radius r and it subtends an angle of 60° at the centre as shown.
The sphere, on being released, moves down the shute. As it is leaving the shute at B it is travelling horizontally with a velocity v. Neglecting the effects of friction and the radius of the sphere, derive an expression for v.

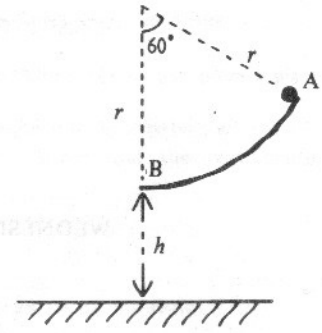

Fig. 3

If B is at a height h above the ground establish an expression for (i) the time it takes the sphere to travel from B to the ground, (ii) the horizontal displacement of the sphere from B when it strikes the ground. Given that the horizontal and vertical displacements of the sphere from B when it strikes the ground are equal, show that $h = 2r$.
If the mass of the sphere is 0·04 kg what is the force exerted on it by the shute at B?
(Take $g = 9{\cdot}8\ \text{m s}^{-2}$.)

3. (*a*) State the principles underlying the establishment of a temperature scale.
Describe how you would use a thermocouple thermometer to measure temperature. Give one advantage which this type of thermometer has compared with a resistance thermometer.

(*b*) Define specific heat capacity.
Describe an experiment to measure the specific heat capacity of *either* a liquid *or* a metal.
A liquid which has a mass of $3m$ and a temperature θ is added to another liquid which has a mass m and a temperature 5θ in an insulated calorimeter. The final temperature of the resulting mixture is 2θ. If 10% of the heat from the hotter liquid is lost to the calorimeter and the surroundings calculate the ratio of the specific heat capacities of the two liquids.

4. (*a*) What is meant by refraction of light?
A convex lens of focal length 20 cm forms a virtual image which is 5 times the size of the object. What is the distance of the object from the lens?
Draw a ray diagram to show the formation of the final image in a compound microscope.
How does the optical arrangement of an astronomical telescope differ from that of a compound microscope?

(*b*) Explain the terms: interference; standing (stationary) wave; harmonics.
On what does (i) the loudness, (ii) the pitch, (iii) the quality, of a musical note depend?
A standing wave is set up between a loudspeaker, which is emitting a note of 2,000 Hz, and a wall. If the distance between the first and eleventh nodes is 85 cm calculate the velocity of the sound.

5. Define the terms: potential difference; capacitance.
Derive an expression for the energy of a charged capacitor in terms of its capacitance and the potential difference between its plates.
How may it be demonstrated that a charged capacitor stores energy?
Fig. 4 shows a 200 μF capacitor connected in series with a 40 kΩ resistor, a switch and a battery of e.m.f. 12V. (The battery is of negligible internal resistance.) Given that at a particular instant after the switch is closed the current flowing in the circuit is found to be 130 μA, calculate:

(i) the potential difference across the capacitor,

(ii) the charge on the capacitor,

(iii) the energy stored in the capacitor.

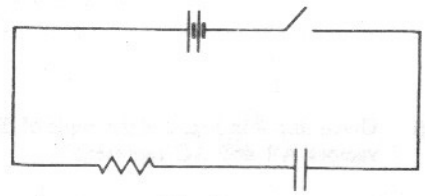
Fig. 4

Why is the energy stored in the capacitor less than the work done by the battery?

6. Describe an experiment to show that a current-carrying conductor in a magnetic field experiences a force.
Draw a labelled diagram of a moving coil galvanometer and explain how it works.
A straight wire of length 2 cm was placed at right angles to a magnetic field of uniform magnetic flux density. The force on the conductor was measured for a series of values of the current flowing in the wire and the following results were obtained.

I(A)	0·5	1·0	1·5	2·0	2·5	3·0	3·5	4·0	4·5	5·0
F(mN)	9	18	31	39	50	59	68	78	86	95

Plot a graph of F against I and, from the graph, calculate the magnetic flux density of the field.

7. (*a*) Describe an experiment to measure the internal resistance of a cell.

(*b*) Describe an experiment to measure the refractive index of the glass of a prism.

Give the theory associated with *either* (*a*) *or* (*b*).

8. State *two* properties of the electron.
Outline a laboratory experiment to determine the specific charge (e/m) of the electron.
Write down an expression for Einstein's photoelectric law. On what does (i) the maximum energy, (ii) the rate of emission, of the photoelectrons depend?
In an experiment to measure Planck's constant, h, the potential difference required to stop electrons leaving a metal, i.e. the stopping potential, was measured for different values of the frequency of the incident light. A graph was plotted of stopping potential, V_s, against frequency, f (Fig. 5).

(i) What is the relationship between the slope of the graph and Planck's constant?

(ii) From the information given on the graph calculate the value of Planck's constant.

(Charge on an electron, $e = 1{\cdot}6 \times 10^{-19}$ C.)

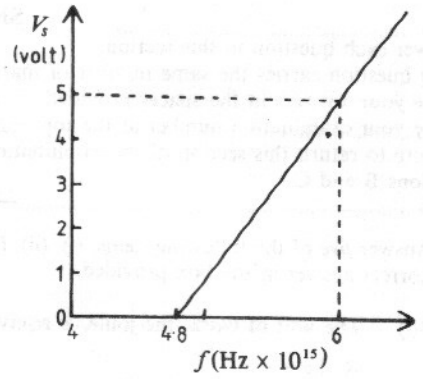

Fig. 5

9. What is meant by radioactivity?
In what respect are neutrons more effective than α–particles in the production of radioactive isotopes?
Calculate the number of (i) α-particles, (ii) β-particles, emitted in the radioactive decay of $^{238}_{92}U$ to $^{230}_{90}Th$.
Describe how it may be shown experimentally that α, β and γ-radiations are emitted in the decay of some radioactive substances.
The isotope $^{239}_{94}Pu$ decays by α-emission and has a decay constant of $9 \times 10^{-13}\ s^{-1}$. Calculate the number of α-particles emitted per second in a source of mass 1 gram.
(Take Avogadro's constant (number) $= 6{\cdot}0 \times 10^{23}\ mol^{-1}$.)
Indicate the role of neutrons in the breeding of plutonium in uranium.

10. Answer any *two* of the following.

(*a*) Give an expression for Newton's law of gravitation.
Describe an experiment to measure the acceleration due to gravity, g.
A satellite is travelling at a constant speed in a circular orbit at a height of $2r$ above the surface of the earth, where r is the radius of the earth. What is the acceleration of the satellite? (Take the value of g on the surface of the earth to be $9{\cdot}81\ m\ s^{-2}$.)

(*b*) State Faraday's laws of electrolysis.
Describe an experiment to measure the electrochemical equivalent of an element.
Explain briefly the process of electrical conduction in electrolytes.

(*c*) Explain what is meant by thermionic emission and name *two* devices, other than the diode, which are based on this principle.
Describe an experiment to plot the characteristic curve of a thermionic diode.

(*d*) State the laws of electromagnetic induction.
Explain the principle involved in each of the following.

(i) When an electric motor slows down due to an increased load, the current flowing through the motor increases.

(ii) The core of a transformer is laminated.

(iii) An induction motor consists of a metal cylinder which is free to rotate between two electromagnets.