LEAVING CERTIFICATE EXAMINATION, 1983

PHYSICS—HIGHER LEVEL

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 work, i.e. the joule.

   (*b*) What is the magnitude of the centripetal force on a body of mass 2 kg which is moving in a circle of radius 50 cm with a constant angular velocity of 5 rad s^{-1}?

   (*c*) A ball is thrown horizontally from the top of a building and reaches the ground 2 s later. Find the height of the building given that $g = 10$ m s^{-2}.

   (*d*) Fig. 1 shows a narrow-bore glass tube partly immersed in a beaker of mercury. What phenomenon does this demonstrate?

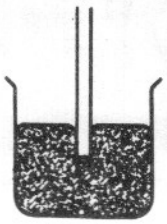

Fig. 1

   (*e*) Explain the term: chromatic aberration.

   (*f*) What property distinguishes transverse waves from longitudinal waves?

   (*g*) What are harmonics?

   (*h*) Name the type of emission spectrum obtained from each of the following: (i) a monatomic gas, (ii) a solid.

   (*i*) Name the substance used to reduce polarisation in a Daniell cell *or* a Leclanché cell.

   (*j*) The horizontal component of the earth's magnetic flux density is $2{\cdot}5 \times 10^{-5}$ T (Wb m^{-2}) at a point on the earth's surface where the angle of dip is 60°. What is the total value of the earth's magnetic flux density at this point?

   (*k*) Fig. 2 shows the relationship between the resistance of a certain device and its temperature. What type of device is it?

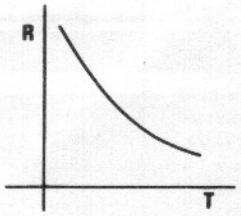

Fig. 2

Phy - Section A Q5

$$\frac{Q}{4\pi\epsilon r^2} = \frac{Q}{4\pi\epsilon(x^2+y^2)}$$

$$\int_0^d \int_0^b \frac{Q}{4\pi\epsilon(x^2+y^2)}\, dx\, dy$$

(l) Define the ampere.

(*m*) What are the factors which determine the rate at which energy is 'lost' from a cable carrying electrical energy?

(*n*) What can be deduced from the Compton effect regarding the nature of electromagnetic radiation?

(*o*) Sketch a graph showing how the activity of a sample of radioactive material changes with time.

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

2. State (*a*) Newton's second law of motion, (*b*) the law of conservation of momentum.
Describe an experiment to verify that the acceleration of a body of constant mass is proportional to the force acting on it.

A steel pile of mass $2{\cdot}0 \times 10^3$ kg is being driven into the ground by dropping a block of mass 400 kg from a height of 5 m onto it. (See Fig. 3). When the block strikes the pile, the block bounces vertically upwards a distance of 1·8 cm. Assuming that momentum is conserved in the collision, calculate

(i) the upward velocity of the block immediately after the collision,

(ii) the downward velocity of the pile immediately after the collision.

(Take $g = 10$ m s^{-2})

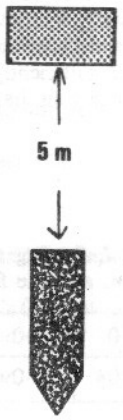

Fig. 3

3. (*a*) Define specific heat capacity.
In an experiment to measure the specific heat capacity of copper by the method of mixtures, i.e. by adding hot copper to cold water, the following measurements were noted.

Mass of calorimeter	=	80 g
Mass of calorimeter and water	=	140 g
Initial temperature of water and calorimeter	=	15°C
Mass of copper	=	45 g
Initial temperature of copper	=	100°C
Final temperature of water, copper and calorimeter	=	20°C

Given that the calorimeter was made of copper and that the specific heat capacity of water is $4{\cdot}2 \times 10^3$ J kg^{-1} K^{-1}, calculate the specific heat capacity of copper.
Mention two precautions which might have been taken to improve the accuracy of the result.

(*b*) State the principles underlying the establishment of a temperature scale.
Describe, with the aid of a labelled diagram, a constant volume gas thermometer. Give one reason why this type of thermometer is used as the standard thermometer from which other thermometers are calibrated.

4. (*a*) Explain the terms: refractive index; critical angle; total internal reflection.

Fig. 4 shows a ray of light passing through a glass prism of refracting angle A. The angle of incidence on the face ac is i. If the value of A is 60° and the refractive index of the glass is 1·5 calculate, correct to the nearest degree, the value of i for which the ray will just leave the prism at the face ab.

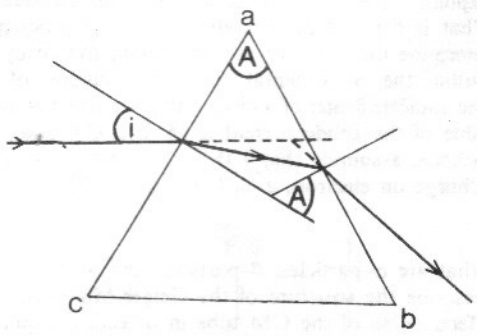

Fig. 4

(*b*) What is meant by (i) interference, (ii) diffraction? Explain how each of these may be demonstrated experimentally in the case of light waves.
Why is it more difficult to demonstrate these phenomena for light waves than it is for sound waves?

5. Answer (*a*) **and** either (*b*) **or** (*c*).

(*a*) Explain how a body may be charged by induction. How would you show experimentally that the induced charge is equal in magnitude and opposite in sign to the inducing charge?

(*b*) Define capacitance.
Using the circuit of Fig. 5 the capacitor, C, is first charged by being connected to the d.c. power supply, P, and is then discharged through the resistor R. The switch, S, allows the charging and discharging of the capacitor to take place 50 times per second. R is sufficiently small so that the capacitor is completely discharged each time.

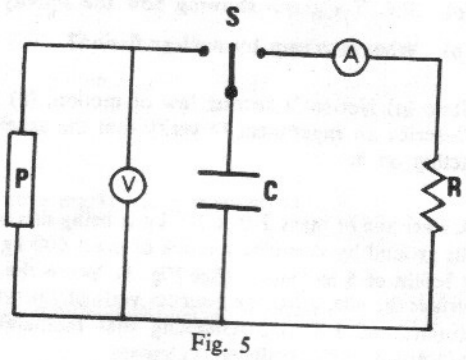

Fig. 5

The average current, I, flowing through the resistor was measured for a series of values of the applied potential difference, V, and the following results were obtained.

V (volt)	1·0	2·0	3·0	4·0	5·0	6·0	7·0	8·0	9·0
I (ampere)	0·04	0·09	0·15	0·20	0·25	0·29	0·36	0·41	0·46

Show that $I = 50\,Q$, where Q is the charge added to the capacitor each time it is charged.
Plot a graph of V against I and, from the graph, determine the capacitance of the capacitor.

(*c*) Derive the expression $C = \dfrac{\varepsilon_0 A}{d}$ for the capacitance of a parallel plate air capacitor, where A is the area of either plate, d is the distance between the plates and ε_0 is the permittivity of vacuum (or air). Outline how the relationship between C and d may be illustrated experimentally.

6. Describe an experiment which shows 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 moving-coil galvanometer has a resistance of 20 Ω and gives a full scale deflection with a current of 10 mA. Calculate the value of the resistance required to convert the galvanometer to a voltmeter reading from 0 – 15 V full scale.
If such a voltmeter is used to measure the electromotive force (e.m.f.) of a battery the reading on the voltmeter is less than the e.m.f. of the battery. Why?

7. Describe how you would carry out the following experiments in the laboratory:

(*a*) to determine the specific charge (e/m) of the electron,

(*b*) to determine the speed of sound in a gas other than air.

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

8. Explain the terms: thermionic emission; cathode rays.
What is the role of cathode rays in the production of X-rays? Refer in your answer to the factors which determine the intensity and maximum frequency of the X-rays.
Outline the experimental evidence in support of the wave nature of X-rays.
The cathode heater of a diode valve is connected to a 9 V battery. The heater current is 2·0 A when the saturation value of the anode current is 96 mA. Calculate the average kinetic energy of the electrons emitted from the cathode, assuming that 1·0% of the energy supplied by the 9 V battery is converted to this form of energy.
(Charge on electron, $e = 1{\cdot}6 \times 10^{-19}$ C)

9. What are α–particles, β–particles and γ–rays?
Describe the structure of the Geiger-Muller (GM) tube and explain how it works. Comment on the relative effectiveness of the GM tube in detecting α–particles, β–particles and γ–rays.
When a γ–ray strikes a metal an electron and a positron may be produced.

(i) If the wavelength of the γ–ray is $1{\cdot}2 \times 10^{-12}$ m what is the kinetic energy of each of the particles produced?

(ii) What happens when the positron collides with an electron?

(Mass of electron, assumed constant = $9{\cdot}1 \times 10^{-31}$ kg; $c = 3{\cdot}0 \times 10^{8}$ m s^{-1}; $h = 6{\cdot}6 \times 10^{-34}$ J s)

10. Answer any *two* of the following.

(*a*) Use a ray diagram to show the formation of a real, diminished image by a convex lens.
Compare the optical system of the eye with that of the camera.

(*b*) Describe, with the aid of a labelled diagram, the structure and operation of a transformer *or* an induction coil.
A filament lamp and a coil with an iron core are connected in series with an a.c. power supply of variable frequency and fixed voltage. If the frequency is increased the lamp becomes dimmer. Why?

(*c*) State *four* of the basic assumptions of the kinetic theory of gases.
From the kinetic theory equation

$$p = \frac{1}{3}\,\frac{nm\overline{c^2}}{v}$$

derive an expression for (i) the pressure of a gas, (ii) the root-mean-square velocity of the molecules of a gas, in terms of its density.
Use the kinetic theory to explain why the density of a gas decreases when its temperature is increased at constant pressure.

(*d*) Define simple harmonic motion.
Give the condition necessary in order that the motion of a simple pendulum may be considered to be simple harmonic motion.
The periodic time of a simple pendulum on the surface of the earth is 0·4 s. What would be its periodic time at a height above the earth equal to three times the radius of the earth?