UNIVERSITIES OF MANCHESTER LIVERPOOL LEEDS SHEFFIELD AND BIRMINGHAM

Joint Matriculation Board

General Certificate of Education

PHYSICS. SYLLABUS I. PAPER II

ADVANCED

MONDAY 17 JUNE 1957, 2-5

Answer **six** *questions including:*

(*a*) *at least* **three** *from* SECTION (1);

(*b*) *at least* **one** *from* SECTION (2).

Answers to Sections (1) and (2) must be written in different answer-books.

The books must be marked clearly either SECTION (1) *or* SECTION (2) *and handed in to the Supervisor separately.*

Candidates should wherever possible show by their answers that they have seen or themselves performed experiments on the subjects they are discussing.

For full credit it is not sufficient to obtain correct results to numerical questions; the principles involved and their bearing on the question must be clearly stated.

SECTION (1)

Answer at least **three** *questions from this section.*

1. Describe (*a*) an experiment to determine the focal length of a concave mirror, (*b*) an experiment to determine the focal length of a convex mirror. Give full experimental details.

Calculate the radius of curvature of the small convex mirror which, when placed 60 cm. from the pole and on the axis of a large concave mirror, radius of curvature 200 cm., will enable an image of a distant object to be formed at the centre of a hole drilled through the concave mirror at its pole.

2. What is meant by (*a*) *the magnifying power of a telescope*, (*b*) the statement that an astronomical telescope is *in normal adjustment*?

A telescope consisting of two thin converging lenses, of focal length 50 cm. and 10 cm. respectively, is used to view a very distant object, the final image being formed 25 cm. from the eye lens. Determine (i) the separation of the lenses, (ii) the magnifying power obtained by an observer if his eye is close to the eye lens. Draw a diagram showing the paths through the instrument of rays from a non-axial point on the object.

3. Using Huygens' concept of secondary wavelets show that a plane wave of monochromatic light incident obliquely on a plane surface separating air from glass may be refracted and proceed as a plane wave. Establish the physical significance of the refractive index of the glass.

In what circumstances does dispersion of light occur? How is it accounted for by the wave theory?

If the wavelength of yellow light in air is $6{\cdot}0\times10^{-5}$ cm., what is its wavelength in glass of refractive index 1·5?

4. Derive an expression for the energy of a condenser of capacitance C when the potential difference between its terminals is V.

A multi-plate air condenser of capacitance $3{\cdot}0 \times 10^{-4}$ microfarad is connected in a circuit with a battery of e.m.f. 120 volts, a sensitive galvanometer and a vibrating switch, in such a way that the condenser is fully charged by the battery and then fully discharged through the galvanometer 100 times a second. Draw a diagram of the circuit and calculate (*a*) the value of the apparently steady current through the galvanometer, (*b*) the mean rate at which the battery supplies energy, (*c*) the mean rate at which energy is obtained from the condenser.

Describe briefly how you would use an arrangement of this kind to measure the dielectric constant of oil.

5. Describe, with the aid of a circuit diagram, how you would use a potentiometer, a standard resistance and other necessary apparatus to measure the resistivity of the material of a wire.

Six resistances *AB*, *BC*, *CD*, *DE*, *EF* and *FA*, each of 10 ohms, are connected to form a closed loop and a 6 volt battery of negligible resistance is connected between *A* and *D*. Calculate (*a*) the potential difference between *C* and *F*, (*b*) the value of the additional resistance which must be connected between *F* and *D* so that no current flows through a galvanometer connected between *C* and *F*.

6. Describe the experiments you would carry out and the observations you would make in order to demonstrate (as far as possible) the laws of electromagnetic induction using a solenoid with clearly visible turns, a bar magnet with marked polarity, a cell of known polarity and a centre-zero galvanometer.

A straight metal propeller, of total length 4 metres, is rotated in a horizontal plane about a fixed vertical axis through its centre at a uniform rate of 300 revolutions per minute. The horizontal intensity of the earth's magnetic field at the spot is 0·20 oersted and the angle of dip is 68·2°. What is the potential difference, in volts, between (*a*) a tip of the propeller and the axis, (*b*) the tips of the propeller?

7. Draw graphs to show the way in which the current varies with the potential difference applied to (*a*) a tungsten filament lamp, (*b*) a voltameter containing acidulated water and platinum electrodes, (*c*) a thermionic vacuum diode. In each case give an explanation of the shape of the graph.

Give a brief account of the phenomenon of photoelectric emission.

SECTION (2)

(Answers to be written in a separate answer-book.)

Answer at least **one** *question from this section.*

8. (*a*) Distinguish between the *intensity* level and the *loudness* level of a sound. Define the *decibel* and compare the power outputs required to produce two sounds of the same frequency which are respectively 50 and 30 decibels above the minimum audible loudness at that frequency.

(*b*) Distinguish between *reverberation* and *echo*. Indicate how the design and equipment contribute materially to the good acoustical properties of an auditorium.

9. A small object, O, is situated in air at a distance OP from a spherical surface which bounds a medium of refractive index μ. Its image, I, formed by the refraction of paraxial rays proceeding from O, lies on the line OPC where C is the centre of curvature of the surface. Derive an equation connecting OP, PC and PI.

State and explain a sign convention which allows the application of the same equation for both concave and convex surfaces and also for real and virtual objects and images.

The maximum thickness of a large plano-convex lens is 4·8 cm. Its apparent thickness is 3·2 cm. when looked at from the plane side and 3·8 cm. when viewed through the curved face. Calculate (*a*) the refractive index of the material of the lens, (*b*) the radius of the curved surface.

10. Distinguish between *natural* light and *plane polarized* light and describe how plane polarized light may be produced by reflection.

Give an account of the mode of action of a Nicol prism. Explain how it is used in the detection of plane polarized light.

Describe and explain one application of plane polarized light.

11. Describe and explain the mode of action of some form of A.C. ammeter. What is the meaning of the term *root mean square value*?

Explain the term *self-inductance* and define the practical unit in which it is measured.

Give a descriptive account of the relation between current and applied potential difference in an A.C. series circuit containing self-inductance and resistance.

12. State the essential differences between the properties of electrons and those of the particles in positive rays.

An electron emitted from a hot filament in an exhausted tube is accelerated by a potential difference of 4,000 volts and then enters at right angles a uniform magnetic field of intensity 10·0 oersteds. Calculate the speed of the electron and determine its path in the magnetic field.

Calculate the intensity of the uniform electrostatic field which, when suitably applied, would compensate the effect of the magnetic field on the path of the electron and show in a diagram the relative directions of the electron and of the two fields.

(Assume that the ratio of the charge to the mass of an electron $= 1{\cdot}76 \times 10^7$ e.m.u. gm.$^{-1}$)