UNIVERSITIES OF MANCHESTER LIVERPOOL LEEDS SHEFFIELD AND BIRMINGHAM

Joint Matriculation Board

General Certificate of Education

PHYSICS. SYLLABUS I. PAPER I

ADVANCED

MONDAY 17 JUNE 1957, 9.30-12.30

Answer **six** *questions including:*

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

(*b*) *at least* **one** *question 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.

(*Assume that the acceleration due to gravity is 981 cm. sec.*$^{-2}$)

SECTION (1)

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

1. State the laws of friction between solid surfaces. Describe in detail an experiment for the determination of the coefficient of sliding friction between the surfaces of a block of wood and a board.

A friction band hangs over a drum of diameter 15 cm. which can be rotated about a horizontal axis by a motor. A 4 kgm. weight is attached to one end of the band, the other end being joined to the hook of a spring balance whose frame is secured to the ground. When the drum is rotated at 400 r.p.m. the friction band supports the weight in a stationary position and the spring balance reads 200 gm. wt. Draw a diagram of the arrangement showing the direction of rotation of the drum and calculate the power output of the motor in watts. Explain briefly why the friction band is never made of metal when this arrangement is used to determine the mechanical equivalent of heat.

2. Show that the time period of the small oscillations of a simple pendulum is independent of the mass of the bob.

Describe how, using a simple pendulum of adjustable length suspended from the ceiling of a laboratory, you would determine the height of the ceiling above the floor and the acceleration due to gravity.

Two simple pendulums, *A* 90 cm. long and *B* 100 cm. long, suspended one in front of the other, are set into oscillation in the usual manner. Find the interval of time between consecutive instants when the motions are in phase.

3. Distinguish between *progressive* and *stationary waves*, illustrating your answer by diagrams.

A uniform string is stretched between two fixed supports and set into transverse vibration. Write down an expression for the frequency of the fundamental vibration and show how the frequencies of the first two overtones are related to this frequency. State and

explain qualitatively the effect, if any, on the fundamental frequency and on the frequency of the first overtone of attaching a small piece of lead to the mid-point of the vibrating string.

A tuning fork of frequency 300 vibrations per sec. and a wire in which the tension is 10·0 kgm. wt. give 5 beats per sec. when sounded together. The number of beats per sec. is found to increase if the tension is slightly increased. To what value must the tension be altered to bring the two notes into unison?

4. What is meant by (*a*) an ideal gas, (*b*) absolute temperature?

Gay-Lussac found that : ' Between 0° C. and 100° C. the expansion of a gas is exactly proportional to the expansion of mercury, and that at constant pressure, for every degree centigrade all gases expand by 0·00375 of the volume which they occupy at the temperature of melting ice.'

Comment on these statements. Describe how you would attempt to test them experimentally.

5. Define *temperature gradient*.

The ends *A* and *C* of a straight metal bar of circular cross section are maintained at constant temperatures, *A* being hotter than *C*, and the sides of the bar, whose mid-point is *B*, are perfectly lagged. Explain how the temperature varies along the bar when the conditions are steady if (*a*) the radius of the bar is constant from *A* to *C*, (*b*) the constant radius of the portion *AB* exceeds the constant radius of the portion *BC*, (*c*) the bar is tapered, the radius decreasing uniformly from *A* to *C*.

Find the heat conducted per square metre per hour through a wall consisting of a 2·0 cm. thick layer of cement on brick 15 cm. thick if the temperature of the exposed surface of the brick is 27 deg. C. above that of the exposed surface of the cement.

Assume that the thermal conductivities of brick and cement are $4{\cdot}5\times10^{-4}$ and $7{\cdot}5\times10^{-4}$ c.g.s. centigrade units respectively.

6. Define *dew point* and explain what is meant by *relative humidity*.

If the dew point is known, describe in detail how you would determine by experiment the additional data required in order to calculate the relative humidity of the atmosphere.

Calculate the dew point when the air temperature is 19·5° C. and the relative humidity 80% assuming that the saturation vapour pressure of water, p mm. of mercury, at t° C. is given by the equation

$$p = 12{\cdot}80 + 0{\cdot}92(t - 15)$$

for values of t between 15°C. and 20° C.

7. Give a labelled diagram to show the arrangement of a deflection magnetometer and other apparatus set up to determine how the intensity of magnetization I of a hard steel rod varies with the intensity of the magnetizing field H when the rod, initially unmagnetized, is magnetized to saturation and then taken round a cycle of magnetization. Give brief statements of the purpose of each part of the apparatus. (Descriptions of the experimental procedure and calculation are not required.) How would you ensure that the steel was initially unmagnetized?

Sketch the graph of I against H and, by reference to it, indicate why hard steel is suitable for making a permanent magnet and unsuitable for a transformer core.

SECTION (2)

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

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

8. Define *moment of inertia* and describe, with full experimental details, how you would determine the value of this quantity for a flywheel about its axis of rotation.

A thin uniform disc, of radius 10 cm., is freely mounted on a horizontal axis passing through the centre of the disc and normal to its plane. A small piece of wax, of mass 1 gm., is now attached to the edge of the disc at its lowest point. On being slightly displaced the loaded disc is found to execute simple harmonic vibrations of period 10 sec. What is the mass of the disc?

9. What is meant by *angle of contact*? Illustrate your answer by a suitable diagram. How would you find the value of this angle for mercury against glass?

A wide vertical glass tube is drawn out at its lower end and connected by means of flexible rubber tubing to another vertical glass tube of internal diameter 1 mm., the upper ends of both tubes being open to the atmosphere. Mercury is now poured into the wide tube so as partly to fill both tubes. What is the difference between the mercury levels in the two tubes? Derive any formula used.

Assume that the surface tension of mercury is 480 dyne $cm.^{-1}$, that its angle of contact with glass is 137° and that its density is 13·6 $gm.\ cm.^{-3}$

10. What are the advantages and disadvantages of continuous flow calorimetry? Describe how this method has been applied to determine **either** (*a*) the latent heat of steam, **or** (*b*) the specific heat of a gas at constant pressure.

A liquid flows at a steady rate along a tube containing an electric heating element. When the power supplied to this heater is 10 watts and the rate of flow of the liquid is 50 gm. per min., the outflow temperature of the liquid is 5 deg. C. higher than the inflow temperature. When the rate of flow is doubled, the power supplied to the heater must be increased to 19 watts for the outflow temperature to be unchanged. If the inflow temperature is the same in each experiment, calculate a value for the specific heat of the liquid. (Assume that 4·2 joules = 1 calorie.)

11. What is the Joule-Thomson effect? State the main features of the results of the experimental work to which it relates.

Give a labelled diagram, with explanatory detail, to illustrate a method of liquefying gases which makes use of the Joule-Thomson effect.

12. State what you understand by the term *lapse rate*. Describe briefly how its value is determined by experiment and indicate the general nature of the results obtained.

Discuss the state of the atmosphere when there is (*a*) a high lapse rate, (*b*) a negative lapse rate, and indicate the possible weather characteristics under each of these conditions.