A Level

Physics

Session: 1957 June
Type: Question paper
Code: 22

PHYSICS **190**

ADVANCED LEVEL

PAPER I

(*Two hours and a half*)

Answer **five** *questions.*

Mathematical tables and squared paper are provided.

[$g = 980$ cm. sec.$^{-2}$]

1. **Either** Describe **two** simple experiments by which you could demonstrate osmosis, including one experiment that enables a rough measurement of osmotic pressure to be made.

Find the osmotic pressure at 15° C. of a solution of 2·4 gm. of sugar of molecular weight 340 dissolved in 1 litre of water, giving your answer in cm. of mercury.

[$R = 8{\cdot}3 \times 10^7$ ergs ° C.$^{-1}$ (gm. mol.)$^{-1}$; density of mercury = 13·6 gm. cm.$^{-3}$]

Or Given that the displacement x of a particle from its rest position varies with time, t, according to the relation

$$x = a \sin (wt + \delta),$$

prove that the acceleration of the particle is proportional to the displacement. What physical meanings may be attached to the constants a, $w/2\pi$ and δ? If in a particular case, $a = 5{\cdot}0$ cm., $w = 7{\cdot}0$ sec.$^{-1}$, and the mass of the particle is 100 gm., find (*a*) the frequency of vibration, (*b*) the kinetic energy possessed by the particle when its displacement is 3·0 cm. from its rest position, (*c*) the total energy, kinetic plus potential.

2. Draw a simplified diagram of a Fortin barometer showing the principal features of its construction, and explain how a reading is taken. Explain briefly how the temperature of the barometer affects readings taken with it. [Equations for corrections are not required.]

If the smallest change in level of the mercury that can be detected is 0·01 cm., what is the least change in altitude that can be detected, and what is the least change in the value of gravitational acceleration that can be detected?

[Density of air = 0·0013 gm. cm.$^{-3}$; density of mercury = 13·6 gm. cm.$^{-3}$]

3. Draw a diagram of Hare's apparatus (inverted U-tube) for comparing the densities of two liquids, and indicate the lengths to be measured.

The following readings were taken with an apparatus similar to Hare's, but having tubes only 1·0 mm. diameter:

Length of liquid column (cm.): 5·4, 12·1, 20·1, 27·2.

Length of water column (cm.): 6·5, 12·3, 19·4, 25·6.

Plot a graph showing the length of the water column (upwards) against the length of the liquid column (along).

(*a*) Explain why the graph does not go through the origin.

(*b*) Find from the graph the density of the liquid, assuming that the density of water is 1·00 gm. cm.$^{-3}$

(*c*) Calculate the length of the water column when the pressure inside the apparatus is the same as that outside, given that the surface tension of water is 73 dyne cm.$^{-1}$

(*d*) Find from the graph the length of the liquid column when the pressure inside and outside is the same, and hence,

(*e*) calculate the surface tension of the liquid, assuming that the angle of contact with glass is 0° for both water and liquid.

4. Define *coefficient of viscosity* and use your definition to obtain the units, in cm., gm. and sec., in which it is measured. State Poiseuille's equation for flow of a liquid through a tube, and state the C.G.S. units of each quantity in the equation.

When viscosity coefficients are found by the flow method, the radius of the tube might be determined either by means of a travelling microscope, or by measuring and weighing a mercury column. Describe how you would carry out each determination, and state which method you prefer, giving your reasons.

5. Describe (*a*) some form of gas thermometer, (*b*) a thermo-electric thermometer, and point out the particular advantages of each type.

A thermo-electric thermometer with one junction at 0° C. gives an E.M.F. of 0·65 millivolt when the second junction is at 100° C., and 3·92 millivolts when at the temperature of boiling sulphur. Calculate the value of this temperature on the scale of the thermometer. The temperature of boiling sulphur on the gas scale is 445° C.; comment on the difference.

6. Describe briefly the experiments and conclusions of (*a*) Rumford, (*b*) Joule, upon the relation between heat and work.

In one of his experiments on the boring of cannon, Rumford found that the work done by one horse raised the temperature of 26·6 lb. of water from 32° F. to 212° F. in 2·5 hr. Assuming the horse to have been working at the rate of 550 ft. lb.-wt. sec.$^{-1}$, calculate from these figures a value for the mechanical equivalent of heat.

7. State briefly some of the reasons for supposing that liquids and gases are made up of molecules in constant rapid motion. Derive the kinetic theory equation for the pressure of a gas in terms of its density and the root mean square velocity of its molecules. Illustrate the arithmetical difference between root mean square and average velocities by finding these velocities for four molecules having actual velocities of 1, 3, 5 and 7 km. sec.$^{-1}$

8. Define *coefficient of thermal conductivity*.

A steam engine boiler has iron plates 2·0 cm. thick, and an effective area of 2·5 square metres is heated by the furnace. High pressure steam at 172° C. is generated at a rate of 1·2 kilograms per minute.

[Latent heat of steam at 172° C. = 500 cal. gm.$^{-1}$; thermal conductivity of iron = 0·16 cal. cm.$^{-1}$ sec.$^{-1}$ ° C.$^{-1}$]

(*a*) Assuming that the inner face is at 172° C., find the temperature of the face of the iron exposed to the furnace.

(*b*) Explain why this temperature is much less than the temperature of the furnace.

(*c*) Describe some very simple laboratory demonstration that illustrates the same phenomenon.

(*d*) Explain why reducing the thickness of the iron from 2 cm. to 1 cm. would make very little difference to the rate at which steam is generated.

9. (*a*) Draw diagrams to illustrate the difference in wave-form between (i) two notes that differ only in pitch, (ii) two notes that differ only in tone quality, (iii) two notes that differ only in loudness.

(*b*) By considering a simple case of two notes of frequencies 256 and 258 cycles per sec. heard together, explain the formation of beats.

(*c*) Two open organ pipes of effective lengths l and $l+x$, x being small, are sounded simultaneously; show that the number of beats per second is approximately $\frac{cx}{2l^2}$, where c is the velocity of sound in air.

PHYSICS 191

ADVANCED LEVEL

PAPER II

(*Two hours and a half*)

Answer **five** *questions.*

Mathematical tables are provided.

[$g = 980$ cm. sec.$^{-2}$; 4·2 joules = 1 calorie.]

1. Explain how a converging lens forms an image of a point source on its axis.

What is the purpose of using a sign convention in optical problems? Give a statement of the convention that you employ.

A real image 1·24 cm. long is cast on to a screen by a converging lens, the screen being normal to the axis of the lens. A diverging lens is placed between the converging lens and the screen, and the latter moved to restore focus. The final image is found to be 3·85 cm. long, the screen then being 52·0 cm. from the diverging lens. Calculate the focal length of this lens.

2. What is meant by the *illumination of a surface*, and in what units may it be given?

A small source of light having luminous intensity 80 candle-power in all directions is supported at height 6 ft. above a horizontal table. Find an expression for the illumination on the table at a point at distance x from the point immediately under the lamp. Find the value of x for which the illumination is half as great as that immediately under the lamp.

Describe how you would check this value by experiment.

3. (*a*) Explain how you would produce a beam of plane polarized light.

A parallel beam of ordinary light falls upon a plane sheet of unsilvered opaque glass. How would you test the reflected light

to see whether it is partially plane polarized, and what result would you expect to find?

(*b*) Describe how you would demonstrate the presence of infra-red and ultra-violet radiation in sunlight.

4. State the law of force between electric charges, and give the definition of unit charge in the electrostatic system. Give also the definition of one other unit of charge.

Two conducting balls, each of mass 0·50 gm. and diameter 0·60 cm., hang from the same support by light insulating threads 1 metre long. When the balls are given equal charges they separate so that their centres are 3·84 cm. apart. Calculate (*a*) the charge on each ball, (*b*) the potential of each ball due to its own charge.

5. Describe experiments by which you would show how the magnetic field at the centre of a circular coil, due to a current in it, depends upon (*a*) the number of turns in the coil, (*b*) the radius of the turns.

A plane coil having 50 turns of mean radius 10·0 cm. is set up with its axis at right angles to the magnetic meridian. A small bar magnet is placed with its axis along the axis of the coil and its centre 25·0 cm. from the centre of the coil, where there is a compass needle. The magnet causes the compass needle to deflect from the north-south position, but the deflection is reduced to zero when a current of 0·127 amp. passes through the coil. Calculate the moment of the bar magnet.

6. How does the electrical resistance of a metallic conductor vary when its temperature is changed? Describe an experiment by which you could study the variation in resistance of copper for temperatures between 0° C. and 100° C.

The resistance of the nichrome element of an electric fire is found to be 39·23 ohms when the current passing through it is very small, the room temperature being 20° C. If, in use, the current passing is found to be 4·92 amp. with a potential difference across the element of 220 volts, calculate (*a*) the rate of heat production in the element, (*b*) the steady temperature reached by it.

[The temperature coefficient of resistance of nichrome may be assumed to have the constant value $1{\cdot}70 \times 10^{-4}$ ° C.$^{-1}$ over the range of temperature involved.]

7. Explain how to use a potentiometer to measure a current, and describe how you would apply this method to calibrate an ammeter reading up to 1·5 amp.

A potentiometer wire of length 200 cm. and resistance 4·00 ohms is joined to an accumulator through a coil of resistance 1000 ohms and a variable resistance. The variable resistance is adjusted until the potential difference across the 1000 ohms coil is exactly equal to the E.M.F. of a standard cell, 1·018 volts. When this is so the E.M.F. of a thermocouple is balanced against the potential difference across a length of the wire, and it is found that the detecting galvanometer shows no deflection for lengths between 124·0 cm. and 126·0 cm. What is the E.M.F. of the thermocouple?

8. What is meant by saying that an electric supply is at 220 volts, 50 cycles A.C.? Describe an instrument for measuring such a voltage.

An electric lamp and a condenser are joined in series and connected to an A.C. supply, and it is found that the lamp glows. Why is this so? Describe and explain how the current which passes through the lamp is affected by (*a*) changing the capacitance of the condenser, (*b*) changing the frequency of the alternating current, if the supply voltage is the same in all cases.

9. Give an account of a simple method for the production of X-rays in the laboratory. Why is it necessary to use a high voltage for this purpose? Describe the apparatus you would use to obtain a supply at suitable voltage **either** from a 12-volt battery, **or** from 220-volt A.C. mains.

A gold leaf electroscope is placed near an apparatus for producing X-rays. The electroscope is charged, and it is observed

that the leaves remain deflected for a long time if the X-ray apparatus is not working, but fall rapidly when it is switched on. Account for these observations, and suggest any uses that may be made of the effect.

PHYSICS **192**

ADVANCED LEVEL

PRACTICAL TEST

(*Three hours and a quarter*)

Answer Question 1 *and select* **one** *other question.*

Candidates will not be allowed to start work with the apparatus for the first fifteen minutes.

Squared paper and mathematical tables, including reciprocals, are provided.

Marks are given mainly for a clear record of the observations actually made, for their suitability and accuracy, and for the use made of them, but a brief statement of the method used should be given. The theory of the experiment is not required unless specially asked for. All working is to be sent up.

1. You are provided with a liquid **A** and two uniform capillary tubes which have been cleaned and rinsed with water, and which have different diameters. Use Archimedes' principle to determine the density of **A**. Using one tube, make measurements to enable you to determine as accurately as possible the surface tension of **A**. Repeat the measurements, using the second tube in order to check your results. You may assume that the surface tension of water is 72 dyne cm.$^{-1}$, and that in this experiment the elevation of a liquid in a given tube is proportional to the surface tension divided by the density.

2. Use the lens **L** with the apparatus provided to find five suitable values of the object distance (u cm.) and the corresponding image distance (v cm.) from the lens. Plot $\frac{1}{u}$ against $\frac{1}{v}$, and from your graph deduce the focal length of **L**.

Place a dark screen behind **L** and arrange an object so as to coincide with its real image formed by refraction at the first face of the lens, reflection normally at the second face, and a second refraction at the first face. In this case the centre of curvature of the second face is the virtual image, formed by refraction through the lens, of a point in the object. Make measurements to enable you to deduce the radius of curvature of the second face. Similarly find the radius of curvature of the first face. Use your results to deduce the refractive index of the material of **L**.

3. Set up the given deflection magnetometer with the arm perpendicular to the magnetic meridian. Place the given magnet with its axis along the magnetometer arm and adjust its position until the deflection of the needle is between 25° and 30°. Find as accurately as you can the deflection (θ degrees) corresponding to a measured distance (d cm.) between the centre of the magnet and the centre of the needle. Repeat for five more positions of the magnet. These positions should be chosen so that the largest deflection is between 60° and 65°. Assuming that

$$d^2 = A + B\sqrt{d \cot \theta},$$

where A and B are constants, plot a suitable graph, and deduce the value of A.

PHYSICS **192**

SCHOLARSHIP

PRACTICAL TEST

(Three hours and a quarter)

Answer Question 1 *and select* **one** *other question.*

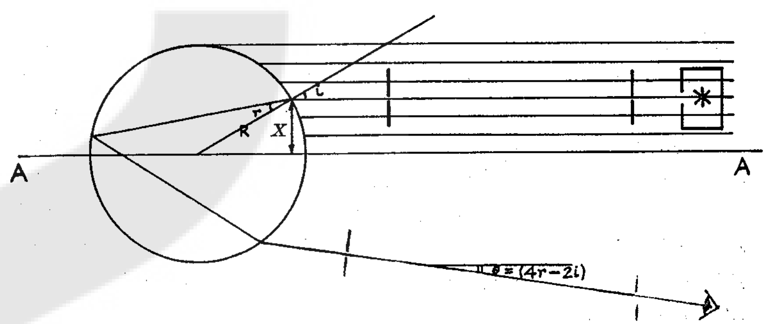
Candidates will not be allowed to start work with the apparatus for the first fifteen minutes.

Squared paper and mathematical tables, including reciprocals, are provided.

Marks are given mainly for a clear record of the observations actually made, for their suitability and accuracy, and for the use made of them, but a brief statement of the method used should be given. The theory of the experiment is not required unless specially asked for. All working is to be sent up.

1. You are provided with a liquid **A** and two uniform capillary tubes which have been cleaned and rinsed with water, and which have different diameters. Use Archimedes' Principle to determine the density of **A**. Using one tube, make measurements to enable you to determine as accurately as possible the surface tension of **A**. Repeat the measurements, using the second tube in order to check your results. You may assume that the surface tension of water is 72 dyne cm.$^{-1}$, and that in this experiment the elevation of a liquid in a given tube is proportional to the surface tension divided by the density.

2. Pin the large sheet of paper to the bench and draw near one end a circle of radius R equal to that of the beaker of solution B. Through the centre of the circle draw a straight line



AA extending the full length of the paper. On one side of the circle draw lines parallel to AA at about 0·2 in. spacing, or closer if you wish, until the edge of the circle is reached. Locate the beaker on the circle with a black screen behind it. Place the lamp at the edge of the paper and two of the cardboard slits on one of the lines at a distance X (say) from AA. (Before using the slits check that they are all truly vertical and then put in a second drawing pin to keep the card in place.) With the two remaining slits, determine for white light the acute angle θ between the ray parallel to AA incident on the beaker and the ray emerging after one internal reflection.

Plot θ against $\frac{X}{R}$, using on your graph the scales, 1 in. $=0{\cdot}2$ for $\frac{X}{R}$ and 1 in. $=10^\circ$ for θ.

Since $\frac{X}{R}=\sin i$ and $\theta=(4r-2i)$, determine from suitable points on your graph the value of $\mu=\frac{\sin i}{\sin r}$ for the liquid in the beaker, both when θ is small and when θ is large. Now replace the first two slits in the position $\frac{X}{R}=0{\cdot}5$ and make measurements to determine θ, and hence μ for the red and violet ends of the spectrum.

3. The object of this experiment is to investigate the rate of change of the field due to the bar magnet A in the broadside position. Pin the sheet of paper to the bench and draw on it a straight line as nearly as possible along the direction of the horizontal component of the earth's field. Place the suspended needle towards one end of the line and, using the magnet B on or near the line, cancel the horizontal component of the earth's field at the needle as perfectly as possible. Place the magnet A on the line in the broadside position, with its centre at a distance d from the needle approximately equal to $2l$ (the effective length of the magnet A).

Move A slightly ($\pm 0{\cdot}5$ cm. is suggested) about its mean position to distances d_1 and d_2, namely to $(d+0{\cdot}5$ cm.) and then to $(d-0{\cdot}5$ cm.), and measure the corresponding times T_1 and T_2 of oscillation of the suspended needle; repeat this for successively greater values of the mean distance d. About five values should be attempted.

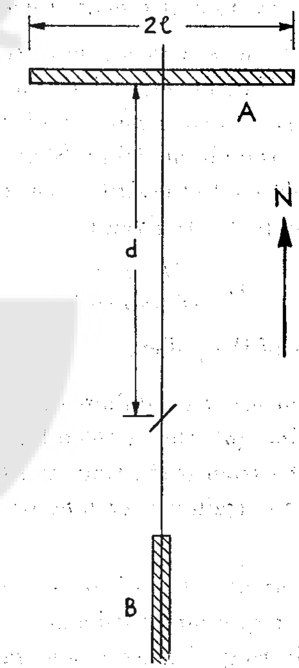
The quantities d, d_1, d_2, l, T_1, T_2 are related by the expression

$$\frac{T_1^2-T_2^2}{d_1-d_2}=k\left(d^2+\frac{l^2}{2}\right),$$

if d_1-d_2 is small compared with d.

Plot $\frac{T_1^2-T_2^2}{d_1-d_2}$ against d^2, and from your graph determine the value of $\frac{l^2}{2}$, and hence of $2l$ (the effective length of the magnet A).

State in your answer the length, breadth and thickness (or diameter) of A.



PHYSICS 193

SCHOLARSHIP PAPER

PAPER III

(Two hours and a half)

Answer **five** *questions.*

Mathematical tables and squared paper are provided.

1. State Newton's laws of motion. Deduce and state the Principle of the Conservation of Linear Momentum.

A string of negligible mass hangs over a frictionless pulley of moment of inertia I. Hanging on each end of the string, one on each side of the pulley, is a stationary monkey of mass m. One monkey commences to climb the string. Show that, when he has attained a speed v relative to the string, the speed v_1 with which he is approaching the pulley is given by

$$v_1 = \frac{v\,(I + mr^2)}{(I + 2mr^2)},$$

where r is the radius of the pulley.

2. How would you use a pendulum suspended in a railway carriage to determine (*a*) the acceleration in a horizontal straight line when the train is starting, and (*b*) the radius of a curve around which the train is travelling with constant known speed?

A flat horizontal circular disc of mass m and radius a, suspended by a wire, is performing torsional oscillations in a horizontal plane. A thin ring of mass m and radius $a/2$ is gently dropped on to the disc so as to be concentric with it. What is the effect on (*a*) the period of the oscillation, (*b*) the amplitude of the oscillation, and (*c*) the energy of the system, if the ring is dropped on (i) at the middle of the oscillation, (ii) at the end of a swing?

3. Give briefly the principles of a method of measuring the absolute coefficient of expansion of a liquid.

A mercury-in-glass thermometer is immersed first to the 0° C. mark and secondly to the 200° C. mark in a liquid at a temperature of 200° C. What is the difference in the readings, given that the coefficients of expansion of glass (cubical) is $27 \times 10^{-6}\,°\mathrm{C}^{-1}$, and of mercury $18 \times 10^{-5}\,°\mathrm{C}^{-1}$? The room temperature may be taken as 20° C.

4. (*a*) Suggest a calorimetric method for determining the relative amounts of (i) heat energy, and (ii) radiant energy transmitted by water, emitted by an incandescent electrical lamp.

(*b*) Show that the current i required to maintain a temperature T in a heated filament of a given material is related to the diameter d by the following relationship: $i^2 \propto d^3$.

[Neglect the conduction of heat down the leads.]

Show, further, that $i^2 \propto \dfrac{T^4 d^3}{s}$ if the filament obeys Stefan's law, where s is the resistivity of the filament material at temperature T.

5. Describe how to measure the wavelength of light by the method of Young's slits, stating carefully how you would make the necessary measurements.

Standing longitudinal waves are set up, by means of an oscillator, in a glass block. What must be the frequency of the oscillator in order that the block may act to light like a diffraction grating of 6000 lines per cm., given that the density of glass is 2·7 gm. cm.$^{-3}$ and the relevant elastic modulus of glass is 5×10^{11} dyne cm.$^{-2}$?

6. Light is travelling in glass and meets a glass-air boundary. Show, *using Huyghens' principle*, why there is an angle of incidence above which it is impossible for a wavefront to be formed in air.

At a point 500 ft. above the earth's surface the temperature of the air rises suddenly from 10° C. to 20° C. Show that a sound ray, incident on this boundary will, for certain angles, be totally reflected, and calculate the least distance from a source on the earth's surface at which the reflected ray may be received by an observer on the earth's surface. It may be assumed that the earth is flat and that the atmosphere consists of a perfect gas.

[Coefficient of expansion of air 0·00367° $C.^{-1}$]

7. Three long coils are wound on top of one another round a long iron rod. One coil is used to provide an adjustable magnetic field, another carries an alternating current of fixed magnitude, and the third is connected to an A.C. voltmeter. If the adjustable field is small enough, the voltmeter registers a large voltage, but if a sufficiently large steady field is applied, the voltage falls to a very much smaller value. Explain this behaviour.

What would be the effect on the voltmeter if, with the adjustable field at zero, the magnitude of the alternating current were steadily increased from zero?

8. Calculate the capacitance of two thin-walled concentric spheres, the outer of radius a and the inner of radius b, the space between the two being filled with material of dielectric constant ϵ, when (*a*) the outer sphere is earthed, (*b*) the inner sphere is earthed.

A slab of material with a dielectric constant ϵ_2 is partially inserted between the plates of an isolated parallel plate condenser, the space between which is filled with oil of dielectric constant ϵ_1. Calculate, by considering the energy of the system or otherwise, the condition that the force on the slab shall be such as to pull it further into the space between the plates.

9. Draw circuit diagrams, each of which includes a valve, of (*a*) a transformer coupled amplifying stage, (*b*) a resistance coupled amplifying stage, (*c*) an oscillator. Calculate the voltage amplification of a resistance coupled amplifier using a valve with a mutual conductance of 1·5 ma. $volt^{-1}$ and anode slope resistance 100,000 ohms with an anode load of 250,000 ohms.

E

PRACTICAL PHYSICS INSTRUCTIONS

PAPER 192 (ADVANCED AND SCHOLARSHIP LEVELS)

JUNE 1957

Instructions for preparing apparatus

In order to assist the laboratory staff in making preparations for the examination, the Chief of the Physics Staff may study the two question papers on 19 June. They are to be re-sealed with the other copies as soon as possible.

The apparatus required by each candidate for each question is set out below.

It is assumed that the ordinary apparatus of a physics laboratory will be available. If in doubt about the suitability of any items specified below, those responsible for their provision are asked to communicate with Syndicate Buildings before purchasing special material.

All candidates (both Advanced and Scholarship)

1. Apparatus for determining the density of a liquid using Archimedes' principle. A piece of metal or a glass stopper of volume between 5 c.c. and 15 c.c.

Two uniform glass capillary tubes having different diameters between about 0·05 and 0·10 cm. The tubes should be about 15 cm. long; and they should have been well cleaned and then rinsed with water.

A ruler graduated in mm., a clamp to hold it, and rubber bands to fix it to either of the tubes. Magnifying glass for reading the scale.

Two beakers of suitable size for the density measurements.

An adequate supply of industrial alcohol, labelled **A**. The density of this liquid is to be communicated to the examiner but **not** to the candidates.

For Advanced Level candidates only

2. Converging lens of focal length between 10 cm. and 20 cm. Object pin and locating pin suitable for ordinary parallax method. Scale. Means of holding lens vertically. A dark screen to place behind the lens.

3. A deflection magnetometer. A bar, cylindrical, or ball-ended magnet capable of giving a deflection of about 70° when used in the Gauss *A* position with its centre between 20 cm. and 30 cm. from the centre of the magnetometer.

For Scholarship candidates only

2. Lamp enclosed on four sides, except for a vertical slit about 1 cm. wide extending from 2 in. above the bench to 4 in. above; the top need not be closed.

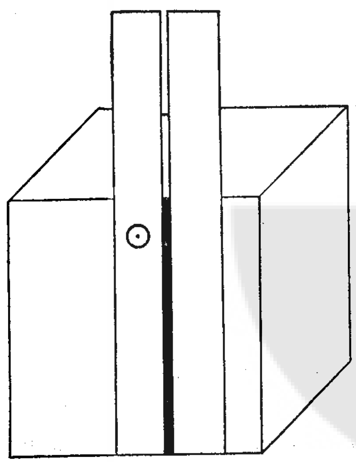


Fig. 1

Four wooden cubes approximately 2 in. per side and soft enough to take drawing pins.

Four pieces of thin card 1 in. × 4 in. with a $\frac{1}{2}$ mm. wide line ruled in ink centrally and parallel to the long side; 2 in. of the line to be cut out to form a $\frac{1}{2}$ mm. wide slit. Each card is to be pinned with one drawing pin to a wooden block with the slit vertical and clear of the block (Fig. 1).

Eight drawing pins, protractor, 4 in. diameter (1 litre) glass beaker, marked **B**, and filled to a depth of 5 in. with a solution of 20 gm. of NaCl in 100 gm. of water. Sheet of white paper at least 2 ft. square.

Graph paper in inches and tenths of an inch.

Vertical black screen as high and as wide as the beaker.

3. One bar magnet between 10 cm. and 20 cm. in length, marked **A**, and capable of producing in the broadside position at a distance equal to twice the length of the magnet a field at least equal to the horizontal component of the earth's field.

One bar magnet of any size greater than 10 cm. in length, marked **B**, and capable of producing in the end on position at a distance from one pole equal to the length of the magnet a field at least equal to the horizontal component of the earth's field.

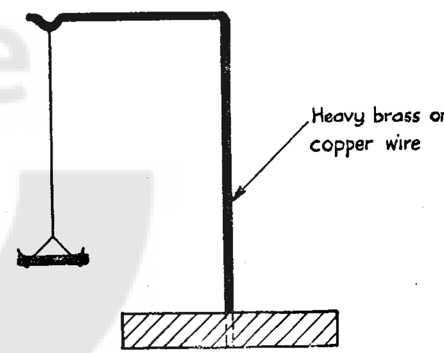


Fig. 2

Small magnet on 'torsionless' suspension, which has a frequency of oscillation in the horizontal component of the earth's field of not less than 100 per min.; the stirrup holding this magnet must ensure that it is accurately horizontal; it should be of about 30 S.W.G. copper wire of the form shown in Fig. 2, permitting the magnet to be aligned with a line or straight edge placed beneath it.

[A suitable suspension is 3 in. to 4 in. long and may be obtained by extracting a single fibre from the Nylon (*not*

Terylene) thread now sold for mending Nylon hosiery; a typical thread such as "Nylusta" or "Nylec" will comprise about 20 such fibres.]

The magnets **A** and **B** should be mounted on wooden blocks at the same height, and the suspended magnet should be adjustable to be at the same height from the bench as the centre-lines of **A** and **B**; it should be provided with a removable anti-draught shield such as a large inverted beaker.

Two feet square sheet of white paper. Graph paper in inches and tenths of an inch. Stop watch.

Bench space suitable for measurements on weak magnetic fields; Question 3 should therefore alternate in position with Question 1 and Question 2 to avoid mutual interaction.

One bench or shelf should be available at each centre where candidates can store their magnets remote from the experiment.

Instructions for the Physics Supervisor

The first 15 min. of the $3\frac{1}{4}$ hr. allowed for the examinations are to enable candidates to read the questions, choose which they will do, and plan their work. During this time they should be allowed to inspect the apparatus, but they must not start work with it.

Candidates should be informed that, if they find themselves in real difficulty, they may ask for assistance, but that the extent of this assistance will be reported to the Examiner who will make a deduction of marks.

The Supervisor should complete the questionnaire forms sent herewith and enclose them in the envelopes containing the answers of the candidates. A note of any help given to, or any particular difficulties experienced by, a candidate in either examination should also be enclosed, especially if the Examiner would be unable to discover these from the written answers.