01. A spiral spring of mass m_0 is hung vertically from the top end and a light scale pan is fastened to the : end of the spring. A mass M is placed in the scale pan and the system is allowed to oscillate vertically stretching the spring and then releasing it. The periodic time T for small vertical oscillations is given / expression.

$$T = 2\pi\sqrt{\frac{\left(M + \frac{m_0}{3}\right)}{k}}$$

where k is a constant.

In order to verify the above expression a student has measured the time for five oscillations for different values of M. The table shows the readings taken by the student.

M (kg)	Time for 5 oscillations (s)	Hence the period (
0.100	5.4	1.1
0.200	5.5	1.10
0.300	6.5	1.3
0.400	7.4	1.5
0.500,	8.3	1.65

(a) Is the above number of oscillations sufficient ? Give reasons for you answer. *(2 lines)*

(b) (i) Rearrange the above expression to draw a suitable graph in order to verify it. *(2 lines)*

(ii) To draw a suitable graph tabulate the above readings. *(5 readings for each x & y a x 15)*

(iii) Draw a suitable graph on the grid provided below. *(8 cm x 15 cm graph paper provided)*

(c) (i) Mark on the graph with arrows the two points which you would use in order to find the gradient of th graph , and write down the corresponding co-ordinates on the graph.

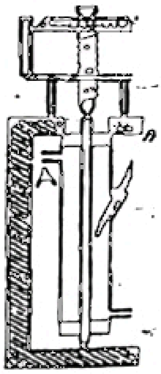
(ii) What is the gradient of the graph ? *(2 lines)*

(iii) Hence calculate the constant k (you may take $x^2 = 10$). *(2 lines)*

(d) (i) What is the intercept of the graph ? *(one line)*

(ii) Hence find mass m_0 of the spring. *(3 lines)*

02. The figure shows an experimental set up for determination of the linear expansivity of a metal in the form of a rod.



(a) Why do you use a long rod in this experiment ? *(2 lines)*

(b) (i) In this experiment cold water is passed through the jacket before taking the initial reading. Give reasons for this. *(2 lines)*

(ii) What inlet in the jacket would you use for this purpose (A or B) ? ....

(c) (i) After taking the initial reading of the spherometer what experimental step would you take next in connection with the spherometer before passing steam ? *(2 lines)*

(ii) The rod will be heated by passing steam through the jacket. Mark the steam inlet on the above diagram

(iii) Why do you use steam instead of hot water at boiling point to heat the rod? *(2 lines)*

(d) How and when doyou take the final reading of the spherometer ? *(3 lines)*

(e) Following is a set of readings obtained by a student from such an experiment.

Initial length of the rod	=	0.50 m	Initial reading of the thermometer	=	28°C
Initial reading of the spherometer	=	2.62 mm	Final reading of the thermometer	=	9
Final reading of the spherometer	=	1.22 mm			

Calculate the linear expansivity of the metal *(3 lines)*

(f) Why must the increase in length of the rod be measured so accurately while the initial length of the rod itself can be determined with a metre ruler ? *(2 lines)*

13. You are provided with a convex mirror, a plane mirror, a pin and a metre ruler.

(a) In the space provided below draw a sketch of the set-up that can be used to find the image distance of the pin due to the convex mirror. *(4 cm available)*

(b) Describe briefly how you would locate the image of the pin seen through the convex mirror *(3 lines)*

(c) (i) Once the image is correctly located, the distances of the pin and the plane mirror from the convex mirror are found to be u and x respectively. write down an expression for the image distance v in terms of u and x. *(one line)*

(ii) Also write down an expression for the focal length f of the convex mirror in terms of u and x.

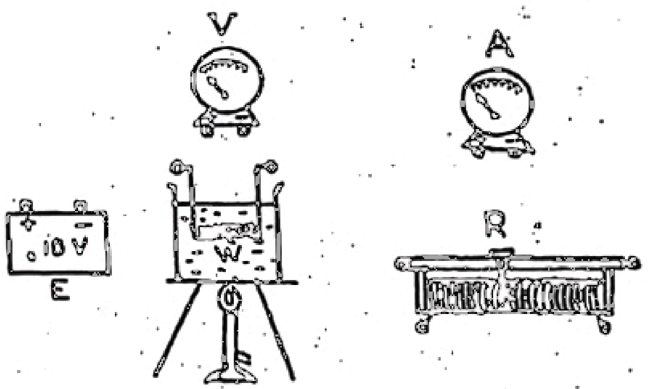
(iii) If $u = 20$ cm, and $x = 10$ cm find f of the mirror. *(2 lines)*

(d) If you are asked to verify the mirror formula for a convex mirror by plotting a suitable graph, it is desirable to use a mirror with a larger radius of curvature. what is the reason for this ? *(2 lines)*

(e) State the main advantage of using a convex mirror over a plane mirror as a side mirror in a vehicle. *(one line)*

(f) The focal length f of the mirror can also be determined with help of a convex lens. Draw such an arrangement with the corresponding ray diagram and locate the focal point of the mirror. *(5 cm available)*

14. Diagram below shows some of the apparatus which can be used in an experiment to investigaute the variation of the resistance x_θ of a coil of wire with the increase in temperature θ. in this experiment the coil is heated to different temperatures and its resistance is measured using an electrical circuit. The value of x_θ at the room temperature is given as 100Ω. The ammeter A provided has a full scale deflection of 50 mA. V is a voltmeter. R is a rheostat, E is a 10 V battery and W is a water bath in which the coil is immersed.



(a) In the above figure join the items given to form a suitable electrical circuit, which enables you to measure the resistance of the coil at various temperatures.

(b) What measurements would you take from this circuit in order to find x_θ *(one line)*

(c) What other items would you require to perform this experiment ? *(one line)*

(d) In this experiment the coil can be heated by using the current provided by the 10 V battery instead of using a burner. Give reasons as to why this method in not practicable. *(two reasons required ; two lines)*

(e) If the voltmeter has a finite resistance in what way does it affect the measurement x_θ ? *(2 lines)*

(f) Draw a rough sketch of x_θ versus θ which you would expect from this experiment.

(g) 50 mA full scale deflection of the ammeter imposes a limitation to the current through the circuit, How would you use this fact to select a voltmeter with a suitable full scale deflection ? *(2 lines)*

01. Answer either part (a) or part (b).

(a) Distinguish between the moment of a couple and the moment of a force. The beam of a balance in a shop is 51 cm long and pivoted at 26 cm from the left end of the beam. Mass of each pan of the balance is 100 g and the mass of the beam is negligible. In order to keep the beam of the balance horizontal, the shop keeper has sttached a small mass to one end of the beam.

(i) Calculate the value of this mass.

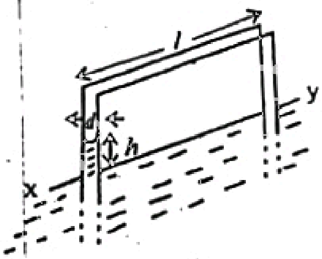
(ii) If the shop keeper weights sugar for a customer, by placing a 500 g weight on the left side pan, how much sugar will the customer receive ?

(iii) If the shop keeper weights sugar by placing the 500 g weight on the right side pan, how much sugar will the customer receive ?

(iv) If the beam is uniform and has a finite mass would you expect the same results as obtained in (ii) and (iii) once the beam of the balance is made horizontal by attaching a suitable mass prior to the weighing ? Explain your answer.

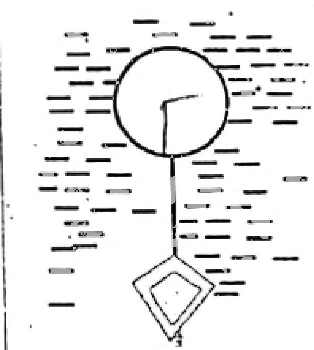
(b) Define surface tension.

A capillary tube of internal radius r is partially dipped in large vessel containing a liquid of surface tension T and density P. show that the mass of the liquid column above the liquid surface of the vessel depends on the internal radius of the tube



Two thin glass plates each of length l is placed distance d apart in the same liquid as shown in the figure. Derive an expression for the height h of the liquid column above the liquid suface XY if the angle of contact of the liquid and the glass is zero and $d << l$. If one plate is now removed leaving the other, draw the shape of the liquid surface near the plate and deduce the mass of the liquid above the liquid surface XY.

02. A metal object of mass 8 kg with an internal cavity is attached to an inflated spherical rubber baloon with an inextensible light string as shown in the figure. when the radius of the baloon is 10 cm the system just floats in a deep lake. Density of the metal is 8000 Kg m^{-3} and the density of water is 1000 Kg m^{-3}



(i) Neglecting the mass of the baloon, find the volume of the cavity in the metal object.

(ii) Calculate the tension in the string.

(iii) If the ballon is given a small push downwards, explain clearly the subsequent motion of the system without deriving any mathematical expressions.

03. An aluminium rod 50 cm in length and of uniform cross sectional area 2 cm^2 is inserted vertically into a thermally insulated vessel containing liquid helium at its boiling point of 4.2 K. The rod is initially at 300 K.

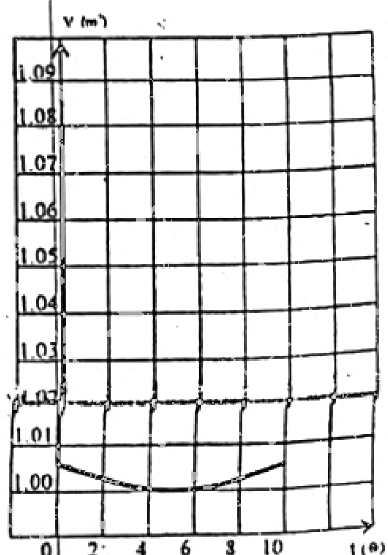
(i) If the whole rod is inserted carefully into liquid helium, how many litres of liquid helium will boil-off by the time when the rod cools down to 4.2 K ?

(ii) Now the upper half of the rod is lagged and its lower half is insarted into the liquid helium while maintaining the top of the rod at 300 K, what is the boil- off rate of liquid helium, once the rod has sttained the steady state?

(iii) Draw the variation of the temperature with the length of the rod starting from the top end, under the conditions mentioned in (ii) above.

Density of aluminium	=	2700 Kg m^{-3}
Thermal conductivity of aluminium	=	210 W m^{-1} K^{-1}
Specific heat capacity of aluminium	=	910 J kg^{-1} K^{-1}
Latent heat of vaporization of helium	=	2.1 x 10^4 J kg^{-1}
1 kg of helium corresponds to 8 litres		

04. The graph below shows the variations of the volume V of a mass of 10^3 kg of water with the temperature t at one atomospheric pressure,



(a) According to the graph.

(i) at 0°C there is a change in volume even without a change in temperature. what does this imply?

(ii) between 0°C and 4°C does water behave like other liquids ? If not what is the difference ?

(b) With reference to the above graph briefly explain the following statements.

(i) A, water filled glass bottle may crack when the water freezes inside.

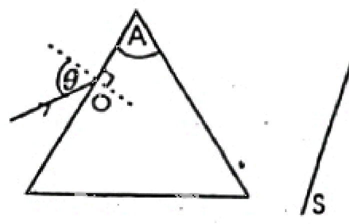
(ii) When water freezes, the ice forms first at the top surface of water

(iii) Water is an unsuitable liquid for use in liquid in glass thermometers for temperatures berween 4°C and 10°C.

(c) Use the graph to calculate the densities of water and ice at 0°C. Draw a sketch showig the variation of the density of water from 0°C to 10°C.

05. Answer either part (a) or part (b)

(a) The diagram shows a ray of white light incident on a glass prism of refracting angle A with an angle of incidence θ. Name the colours from bottom to top as seen on the screen S. If a beam of white light from a point source is incident instead of a ray what changes will occur in the spectrum seen above.



What additional apparatus are needed to produce a pure spectrum using the above arrangement ? where should these apparatus be placed ?

In the set-up shown above the prism is now rotated in anti- clockwise direction around a vertical axis that passes through point O, and perpendicular to the plane of the paper. As θ decreases the colour spectrum on the screen will totally disappear when $\theta = 29°30'$ what is the refracting angle A of the prism?

(Refractive index of the prism material for red colour = 1.52)

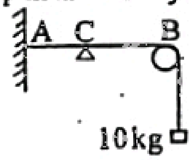
(b) What is the striking difference between the focussing mechanisms of a human eye and a camera.

In a very simple treatment, a human eye can be considered as an equiconvex lens surrounded by a medium of refractive index equal to f. When such an eye is focussed at a distant object the focal length of the lens becomes 2.5 cm. If the refractive index of the material of the eye lens is 1.4. calculate the radius of curvature of the lens when the eye clearly sees an object located at 30 cm from the lens. What is the difference between the radii of curvature of the lens in the first and the second situations mentioned above ?

Now a convex lens of focal length 10cm is placed 10 cm aways from the eye lens. can the eye still see a clear image of the object mentioned in the second situation ? Explain your answer

06. Explain the reason why it is practically difficult to produce nodes zero displacement in a standing wave.

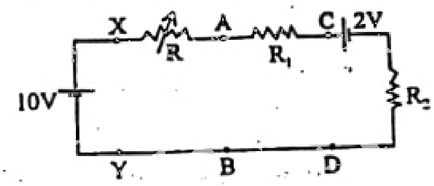
A metal wire AB of length 0.40 m and of cross sectional area $1.0 \times 10^{-6} m^2$ loaded with a block of mass 10 Kg. A smooth bridge is placed under the wire at C, 0.15 m from A as shown in the figure. Transverse waves are set up in the wire by using a variable frequency source. Find the highest wavelength for which standing waves are observed. What is the number of loop observed in AC. at this wave length? calculate the corresponding frequency. The density of the metal $= 2 \times 10^3 \ kgm^{-3}$



07. Answer either part (a) or part (b)

(a) When a certain voltmeter is connected across a battery of e.m.f. 12 V it reads 11.5 V If the internal resistance (R_s) of the battery is 20Ω what is the internal resistance (Rv) of the voltmeter? show in a circuit the way in which the battery R_s and R_v are connected, and across which points the measured voltage of 11.5 will appear.

In the circuit shown R is a variable resistor and both cells have negligible internal resistances, when R is made equal to 50Ω a voltmeter connected across AB reads 5 V , If the 10 V cell is removed and the points X and Y are joined together while keeping R at 50Ω a voltmeter connected across CD reads 1.5V . calculate R_1 and R_2



(b) State Biot-Savart Law.

Write down an expression for the magnitude of the magnetic flux density at a distance r from an infinitely long straight wire carrying a current I.

Two long wires ABC and DEF bent as shown in the figure are kept in a vertical plane so that the straight sections AB and EF are parallel and distance d apart. Another wire XY, vertically above AB and having a length l and mass m is free to slide up and down on the vertical parts of the above mentioned wires.

The two wires are connected through the sliding contacts and carry a current I. The wire XY is now brought down to its lowest position, a distance h above the wire AB and released from rest, Assuming that the magnetic forces on it are due to the currents in the wires AB and EF only.

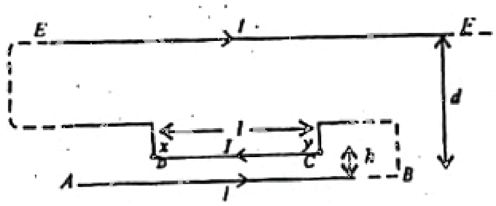
(i) indicate on a diagram the forces acting on the wire XY, when it is at its lowest position.

(ii) explain how you would find the direction in which XY begins to move depending on the magnitude of the various forces that you have indicated in (i).

(iii) derive an expression for the magnitude of the acceleration with XY begins to move.

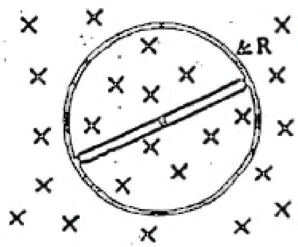
(iv) If d= 5×10^{-2} m, l=1m and m=7.5×10^{-3}kg calculate the magnitude of the current necessary to keep the wire XY stationary at a height of 2cm from AB.

$\left(\frac{\mu_0}{4\pi} = 10^{-7} Tm A^{-1}\right)$



State two methods by which the magnetic flux through a circuit can be changed. A metal rod is pivoted at its mid point to the end of a vertical metal axle which is going into the plane of the paper so that the rod can rotate freely on the plane of the paper with its both ends touching a fixed metal ring (R) as shown in the figure.

The arrangement is placed in a uniform vertical magnetic field of flux density 0.1 T and directed into the paper.



(i) If the length of the rod is 28 cm and its resistance is 0.4Ω , and all the other components have negligible resistance calculate the e.m.f. generated across the axle and the ring if the rod is rotated at a constant rate of 100 revolutions per second.

(ii) What is the rate at which the rod mentioned in (i) should be rotated in order to light a 1 W, 1 V electric bulb at its full brightness when connected across the ring and the axle

(iii) If large number of similar rods are fixed to the arrangement as mentioned above instead of a single rod.would you be able to obtain the same brightness as mentioned in (ii) by rotating all of them at a lower rate? Explain your answer.