Vectors & Equilibrium (Theory)

Nov 01

3 (a) State the two conditions necessary for the equilibrium of a body which is acted upon by
a number of forces.
1.....
2..... [2]

(b) Three identical springs S_1, S_2 and S_3 are attached to a point A such that the angle between any two of the springs is 120°, as shown in Fig. 3.1.

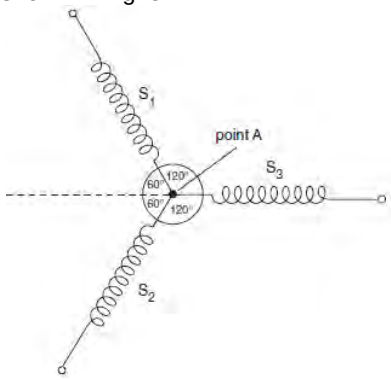


Fig. 3.1

The springs have extended elastically and the extensions of S_1 and S_2 are *x*.
Determine, in terms of *x*, the extension of S_3 such that the system of springs is in equilibrium. Explain your working.
extension of S_3 = ... [3]

(c) The lid of a box is hinged along one edge E, as shown in Fig. 3.2.

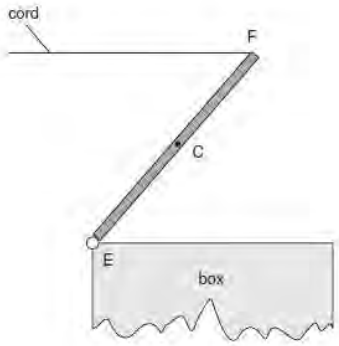


Fig. 3.2

The lid is held open by means of a horizontal cord attached to the edge F of the lid. The centre of gravity of the lid is at point C.
On Fig. 3.2 draw
(i) an arrow, labelled W, to represent the weight of the lid,
(ii) an arrow, labelled T, to represent the tension in the cord acting on the lid,
(iii) an arrow, labelled R, to represent the force of the hinge on the lid. [3]

May 02

3 (a) Explain what is meant by the *centre of gravity* of an object. [2]

(b) A non-uniform plank of wood XY is 2.50 m long and weighs 950 N. Force-meters (spring balances) A and B are attached to the plank at a distance of 0.40 m from each end, as illustrated in Fig. 3.1.

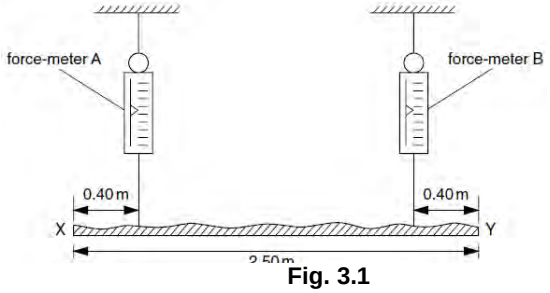


Fig. 3.1

When the plank is horizontal, force-meter A records 570 N.

(i) Calculate the reading on force-meter B.
reading = ... N

(ii) On Fig. 3.1, mark a likely position for the centre of gravity of the plank.

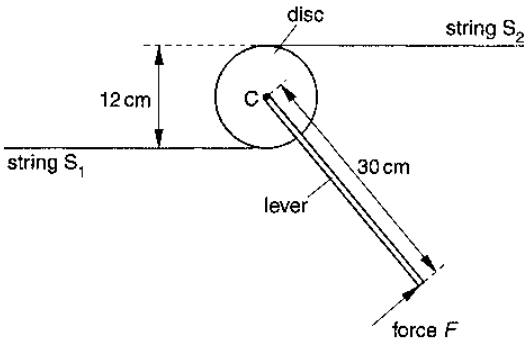
(iii) Determine the distance of the centre of gravity from the end X of the plank.
distance = ... m [6]

Nov 03

3 (a) Define the *moment* of a force.

(b) State the two conditions necessary for a body to be in equilibrium.

(c) Two parallel strings S- and S, are attached to a disc of diameter 12cm, as shown in Fig;3.1.



The disc is free to rotate about an axis normal to its plane. The axis passes through the centre C of the disc.
A lever of length 30 cm is attached to the disc. When a force *F* is applied at right angles to the lever at its end, equal forces are produced in S, and S_2. The disc remains in equilibrium.
(i) On Fig. 3.1, show the direction of the force in each string that acts on the disc.
(ii) For a force Fof magnitude 150 N, determine
1. the moment of force F about the centre of the disc,
moment= .....
2. the torque of the couple produced by the forces in the strings, [4]

3. the force in S_1 Force=……..[4]

May 04

1 (a) State the difference between a scalar quantity and a vector quantity. [2]

(b) Two forces of magnitude 6.0N and 8.0N act at a point P. Both forces act away from point P and the angle between them is 40°. Fig. 1.1 shows two lines at an angle of 40° to one another.

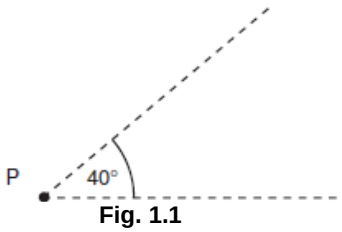


Fig. 1.1

On Fig. 1.1, draw a vector diagram to determine the magnitude of the resultant of the two forces.
magnitude of resultant = ... N [4]

May 04

5 Two forces, each of magnitude *F*, form a couple acting on the edge of a disc of radius *r*, as shown in Fig. 5.1.

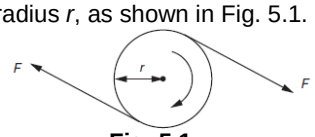


Fig. 5.1

(a) The disc is made to complete *n* revolutions about an axis through its centre, normal to the plane of the disc. Write down an expression for
(i) the distance moved by a point on the circumference of the disc, distance = ...
(ii) the work done by one of the two forces.
work done = ... [2]

(b) Using your answer to **(a)**, show that the work *W* done by a couple producing a torque *T* when it turns through *n* revolutions is given by

$W = 2\pi nT$. [2]

(c) A car engine produces a torque of 470Nm at 2400 revolutions per minute. Calculate the output power of the engine. power = ... W [2]

Nov 05

2 (a) Explain what is meant by the *centre of gravity* of a body. [2]

(b) An irregularly-shaped piece of cardboard is hung freely from one point near its edge, as shown in Fig. 2.1.

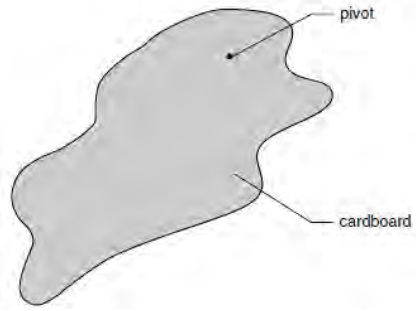


Fig. 2.1

Explain why the cardboard will come to rest with its centre of gravity vertically below the pivot. You may draw on Fig. 2.1 if you wish. [2]

Nov 05

3-cThe stone has a weight of 5.0 N. When the string makes an angle of 35° to the vertical, the tension in the string is 6.1 N, as illustrated in Fig. 3.2.

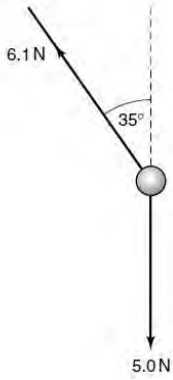


Fig. 3.2

Determine the resultant force acting on the stone in the position shown.

magnitude of force = ... N

direction of force..... [4]

May 06

2 A rod AB is hinged to a wall at A. The rod is held horizontally by means of a cord BD, attached to the rod at end B and to the wall at D, as shown in Fig. 2.1.

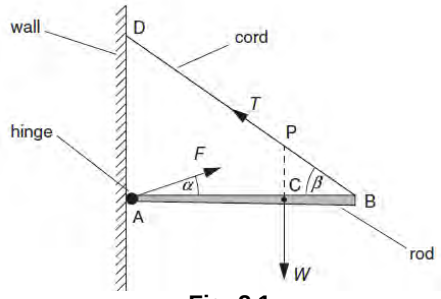


Fig. 2.1

The rod has weight *W* and the centre of gravity of the rod is at C. The rod is held in equilibrium by a force *T* in the cord and a force *F* produced at the hinge.

(a) Explain what is meant by

(i) the *centre of gravity* of a body, [2]

(ii) the *equilibrium* of a body. [2]

(b) The line of action of the weight *W* of the rod passes through the cord at point P.

Explain why, for the rod to be in equilibrium, the force *F* produced at the hinge must also pass through point P. [2]

(c) The forces *F* and *T* make angles α and β respectively with the rod and AC = 2/3 AB, as shown in Fig. 2.1.

Write down equations, in terms of *F*, *W*, *T*, α and β, to represent

(i) the resolution of forces horizontally, [1]

(ii) the resolution of forces vertically, [1]

(iii) the taking of moments about A. [1]

Nov 08

3 (a) Distinguish between the moment of a force and the torque of a couple. [4]

(b) One type of weighing machine, known as a steelyard, is illustrated in Fig. 3.1.

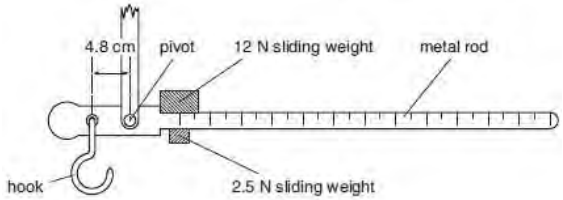


Fig. 3.1

The two sliding weights can be moved independently along the rod.

With no load on the hook and the sliding weights at the zero mark on the metal rod, the metal rod is horizontal. The hook is 4.8 cm from the pivot.

A sack of flour is suspended from the hook. In order to return the metal rod to the horizontal position, the 12 N sliding weight is moved 84 cm along the rod and the 2.5 N weight is moved 72 cm.

(i) Calculate the weight of the sack of flour. weight = ……N [2]

(ii) Suggest why this steelyard would be imprecise when weighing objects with a weight of about 25 N.[1]

May 09

3 (a) Define the *torque* of a couple. [2]

(b) A torque wrench is a type of spanner for tightening a nut and bolt to a particular torque, as illustrated in Fig. 3.1.

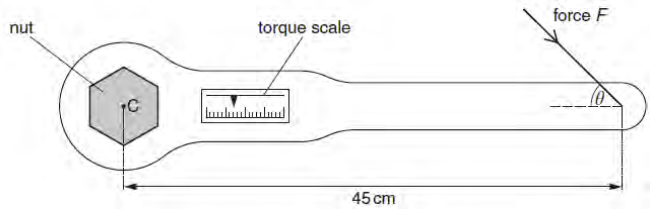


Fig. 3.1

The wrench is put on the nut and a force is applied to the handle. A scale indicates the torque applied.

The wheel nuts on a particular car must be tightened to a torque of 130 N m. This is achieved by applying a force *F* to the wrench at a distance of 45 cm from its centre of rotation C. This force *F* may be applied at any angle θ to the axis of the handle, as shown in Fig. 3.1.

For the minimum value of *F* to achieve this torque,

(i) State the magnitude of the angle θ that should be used,

θ = ... ° [1]

(ii) Calculate the magnitude of F *F* = ... N [2]