1. Nov/2021/Paper_23/No.1

(a) A solid cylinder of weight 24 N is made of material of density 850 kg m^{-3}. The cylinder has a length of 0.18 m, as shown in Fig. 1.1.

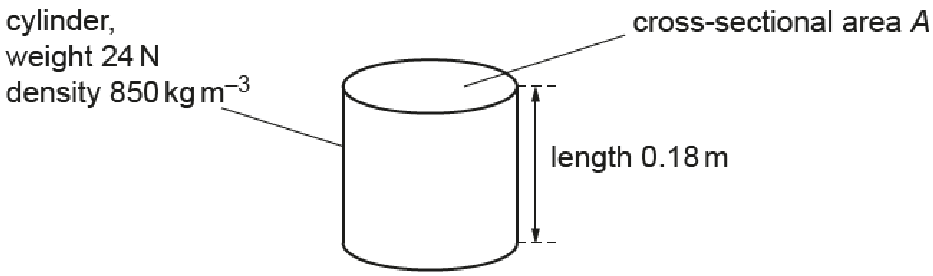

Fig. 1.1

Show that the cross-sectional area A of the cylinder is 0.016 m^2.

[3]

(b) The cylinder in **(a)** is attached by a spring to the bottom of a rigid container of liquid, as shown in Fig. 1.2.

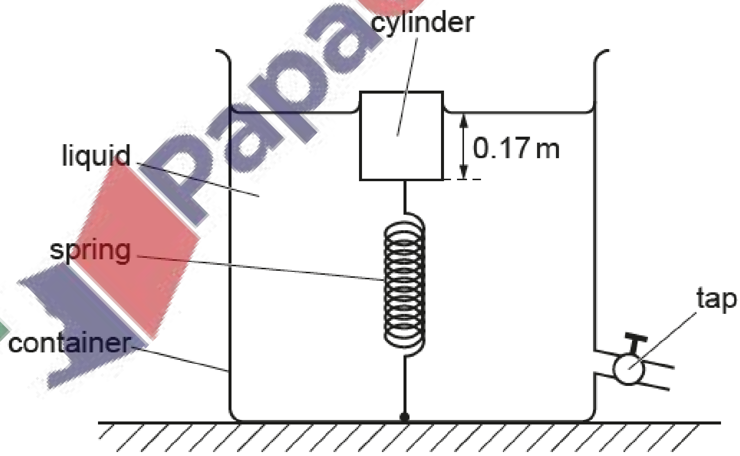

Fig. 1.2 (not to scale)

The cylinder is in equilibrium with its bottom face at a depth of 0.17 m below the surface of the liquid. The tension in the spring is 8.0 N.

(i) Show that the upthrust acting on the cylinder due to the liquid is 32 N.

[1]

(ii) Calculate the density of the liquid.

density = ... kg m^{-3} [3]

(c) Fig. 1.3 shows the variation of the tension *F* with the length of the spring in **(b)**.

Fig. 1.3

(i) The tap at the bottom of the container is opened so that a fixed amount of liquid flows out of the container. The cylinder moves downwards so that the tension in the spring changes from 8.0 N to 4.0 N.

Determine the change in the elastic potential energy of the spring.

change in elastic potential energy = ... J [3]

(ii) More liquid is let out of the container until the upthrust on the cylinder becomes 24 N.

For the upthrust of 24 N, determine the length of the spring.

length = ... cm [1]

[Total: 11]

2. June/2021/Paper_21/No.3

A pendulum consists of a solid sphere suspended by a string from a fixed point P, as shown in Fig. 3.1.

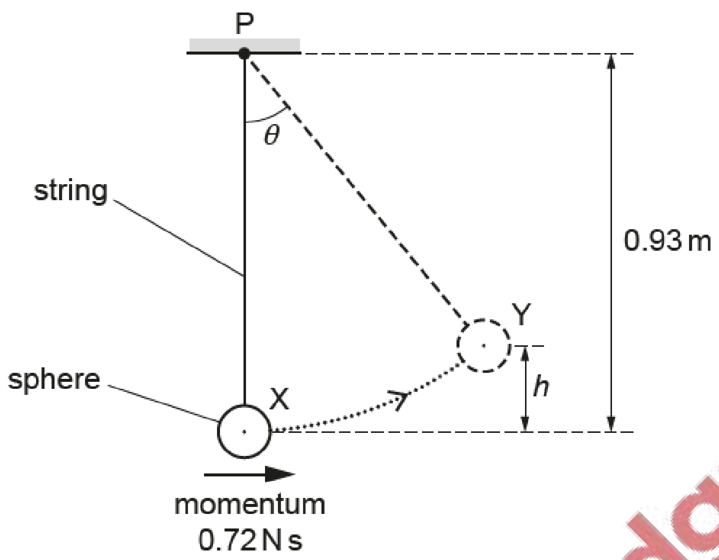

Fig. 3.1 (not to scale)

The sphere swings from side to side. At one instant the sphere is at its lowest position X, where it has kinetic energy 0.86 J and momentum 0.72 N s in a horizontal direction. A short time later the sphere is at position Y, where it is momentarily stationary at a maximum vertical height h above position X.

The string has a fixed length and negligible weight. Air resistance is also negligible.

(a) On Fig. 3.1, draw a solid line to represent the displacement of the centre of the sphere at position Y from position X. [1]

(b) Show that the mass of the sphere is 0.30 kg.

[3]

(c) Calculate height h.

h = ... m [2]

(d) The distance between point P and the centre of the sphere is 0.93 m. When the sphere is at position Y, the string is at an angle θ to the vertical.

Show that θ is 47°.

[1]

(e) For the sphere at position Y, calculate the moment of its weight about point P.

moment = ... N m [2]

(f) State and explain whether the sphere is in equilibrium when it is stationary at position Y.

....

.... [1]

[Total: 10]

3. June/2021/Paper_22/No.1

(a) Complete Table 1.1 by stating whether each of the quantities is a vector or a scalar.

Table 1.1

quantity	vector or scalar
acceleration	
electrical resistance	
momentum	

[2]

(b) State the conditions for an object to be in equilibrium.

....

....

....

.... [2]

(c) A floating solid cylinder is attached by a wire to the sea bed, as shown in Fig. 1.1.

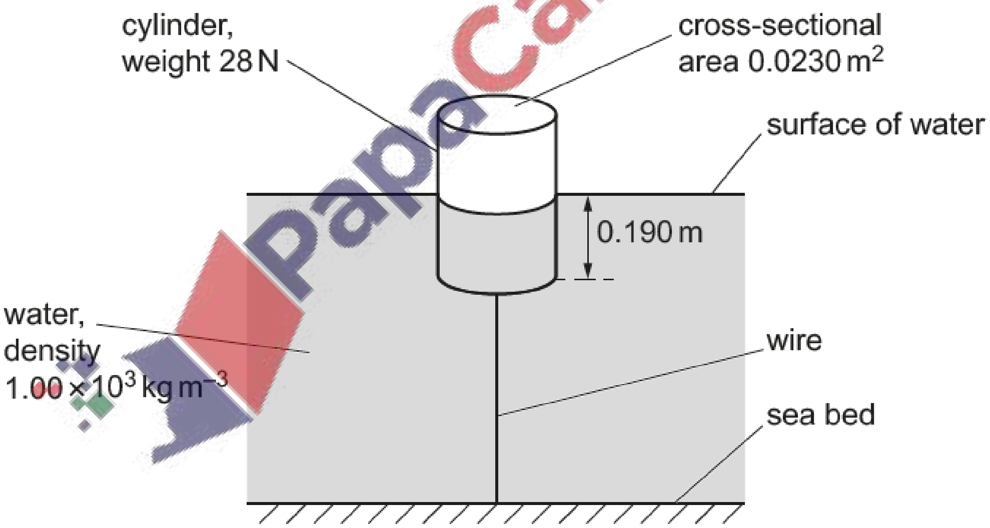

Fig. 1.1 (not to scale)

The density of the water is $1.00 \times 10^3\,\text{kg m}^{-3}$. The base of the cylinder is at a depth of 0.190 m below the surface of the water. The cylinder has a weight of 28 N and a cross-sectional area of $0.0230\,\text{m}^2$.

The wire and the central axis of the cylinder are both vertical. The cylinder is in equilibrium.

(i) Calculate, to three significant figures, the upthrust acting on the cylinder due to the water.

upthrust = ... N [2]

(ii) Show that the tension T in the wire is 15 N.

[1]

(iii) The wire has a cross-sectional area of 3.2 mm^2.

Calculate the stress in the wire.

stress = ... Pa [2]

(iv) The surface of the water gradually rises until it is level with the top face of the cylinder.

State and explain, qualitatively, the variation of the strain energy stored in the wire as the water surface rises.

....

....

....

.... [2]

[Total: 11]

4. June/2021/Paper_23/No.3

(a) Define the *moment* of a force about a point.

....

....

.... [2]

(b) Fig. 3.1 shows a type of balance that is used for measuring mass.

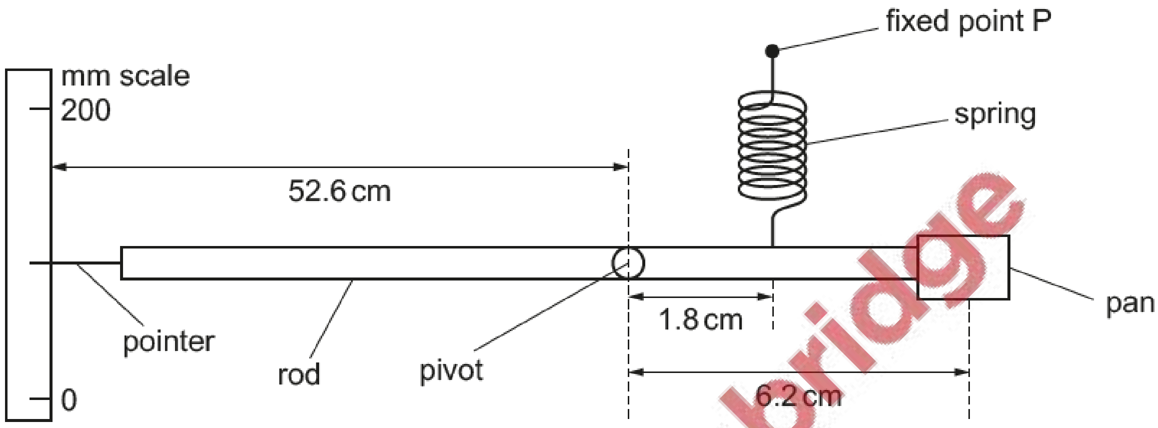

Fig. 3.1 (not to scale)

A rigid rod is pivoted about a point 6.2 cm from the centre of a pan which is attached to one end. The object being measured is placed on the centre of this pan.

A spring, attached to the rod 1.8 cm from the pivot, is attached at its other end to a fixed point P. The spring obeys Hooke's law over the full range of operation of the balance.

A pointer, on the other side of the pivot, is set against a millimetre scale which is a distance 52.6 cm from the pivot.

When the system is in equilibrium with no mass on the pan, the rod is horizontal and the pointer indicates a reading on the scale of 86 mm.

An object of mass 0.472 kg is now placed on the pan. As a result, the pointer moves to indicate a reading of 123 mm on the scale when the system is again in equilibrium.

(i) Show that the increase in the length of the spring is approximately 1.3 mm.

[2]

(ii) Calculate the magnitude of the moment about the pivot of the weight of the object.

moment = ... N m [2]

(iii) Use your answer in **(b)(ii)** to determine the increase in the tension in the spring due to the 0.472 kg mass.

increase in tension = ... N [2]

(iv) Use the information in **(b)(i)** and your answer in **(b)(iii)** to determine the spring constant k of the spring. Give a unit with your answer.

k = ... unit .... [2]

[Total: 10]

5. March/2021/Paper_22/No.1c

(c) **(i)** Define *force*.

....

.... [1]

(ii) The motion represented in Fig. 1.1 is caused by a resultant force *F* acting on the object.

On Fig. 1.2, sketch the variation of *F* with time *t* from *t* = 0 to *t* = 12.0 s.
Numerical values of *F* are not required.

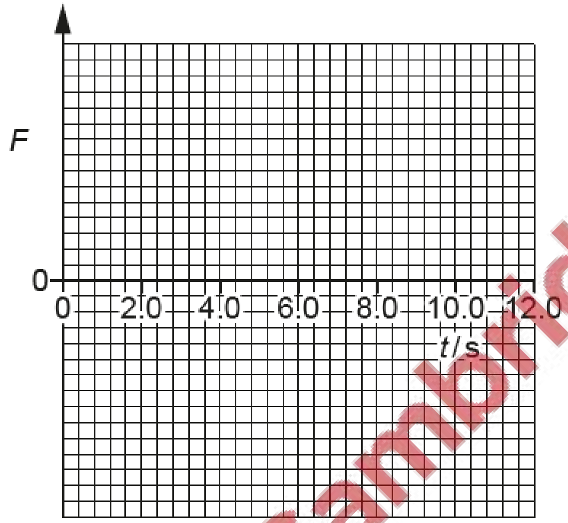

Fig. 1.2

[3]

[Total: 10]