Cambridge Assessment International Education

Cambridge International AS & A Level

3: Forces, work and materials – Topic questions

The questions in this document have been compiled from a number of past papers, as indicated in the table below.

Use these questions to formatively assess your learners' understanding of this topic.

Question	Year	Series	Paper number
3	2017	June	21
1	2017	March	22
2	2017	March	22

The mark scheme for each question is provided at the end of the document.

3 **(a)** A cylinder is made from a material of density 2.7 g cm^{-3}. The cylinder has diameter 2.4 cm and length 5.0 cm.

Show that the cylinder has weight 0.60 N.

[3]

(b) The cylinder in **(a)** is hung from the end A of a non-uniform bar AB, as shown in Fig. 3.1.

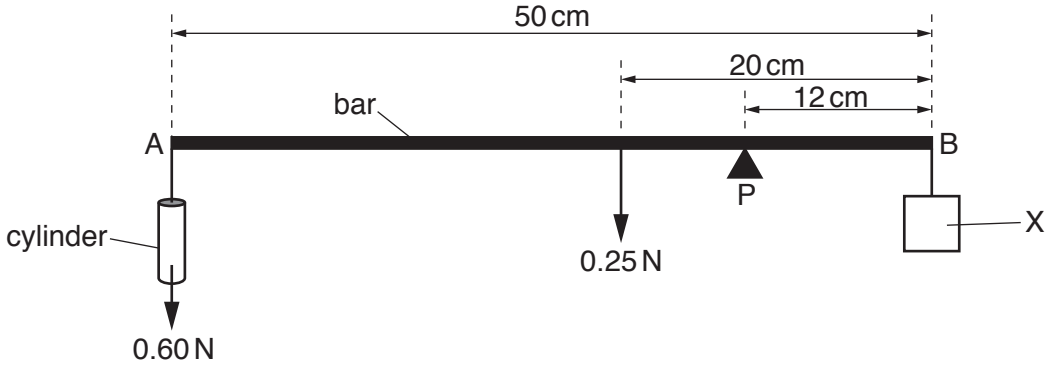

Fig. 3.1

The bar has length 50 cm and has weight 0.25 N. The centre of gravity of the bar is 20 cm from B. The bar is pivoted at P. The pivot is 12 cm from B.

An object X is hung from end B. The weight of X is adjusted until the bar is horizontal and in equilibrium.

(i) Explain what is meant by *centre of gravity*.

.....

.....[1]

(ii) Calculate the weight of X.

weight of X = ... N [3]

(c) The cylinder is now immersed in water, as illustrated in Fig. 3.2.

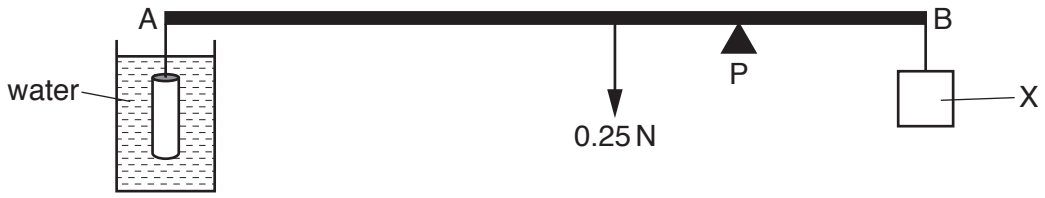

Fig. 3.2

An upthrust acts on the cylinder and the bar is not in equilibrium.

(i) Explain the origin of the upthrust.

.....

.....

.....

.....[2]

(ii) Explain why the weight of X must be reduced in order to obtain equilibrium for AB.

.....

.....

.....[1]

[Total: 10]

1 **(a)** Complete Fig. 1.1 by putting a tick (✓) in the appropriate column to indicate whether the listed quantities are scalars or vectors.

quantity	scalar	vector
acceleration		
force		
kinetic energy		
momentum		
power		
work		

Fig. 1.1 [2]

(b) A floating sphere is attached by a cable to the bottom of a river, as shown in Fig. 1.2.

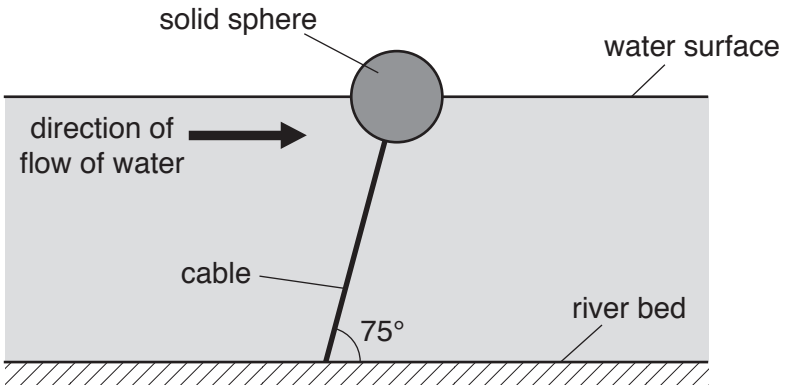

Fig. 1.2

The sphere is in equilibrium, with the cable at an angle of 75° to the horizontal. Assume that the force on the sphere due to the water flow is in the horizontal direction.

The radius of the sphere is 23 cm. The sphere is solid and is made from a material of density 82 kg m^{-3}.

(i) Show that the weight of the sphere is 41 N.

[2]

(ii) The tension in the cable is 290 N.

Determine the upthrust acting on the sphere.

upthrust = ... N [2]

(iii) Explain the origin of the upthrust acting on the sphere.

.....

.....

.....[1]

[Total: 7]

2 **(a)** State the *principle of conservation of momentum*.

.....

.....

.....[2]

(b) Two blocks, A and B, are on a horizontal frictionless surface. The blocks are joined together by a spring, as shown in Fig. 2.1.

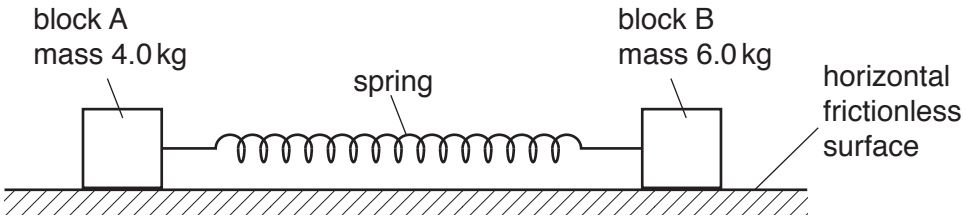

Fig. 2.1

Block A has mass 4.0 kg and block B has mass 6.0 kg.

The variation of the tension *F* with the extension *x* of the spring is shown in Fig. 2.2.

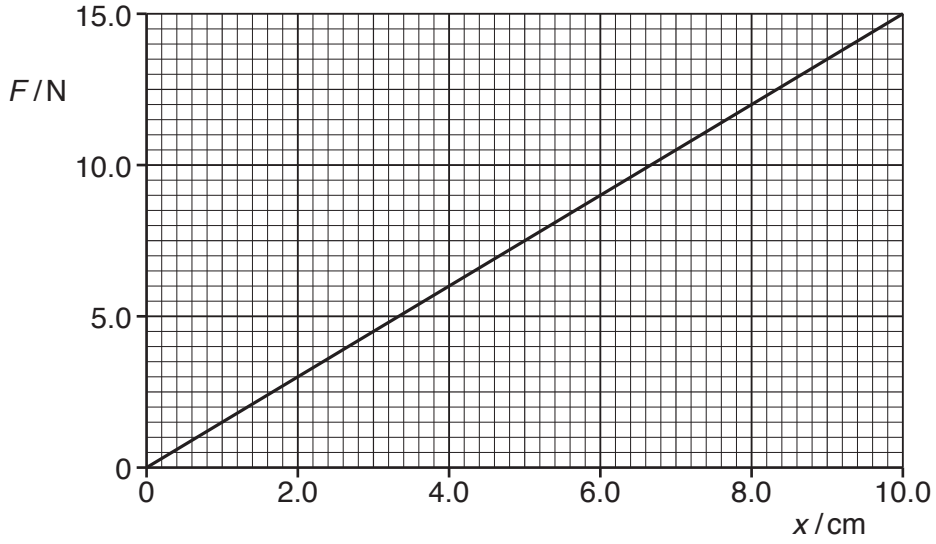

Fig. 2.2

The two blocks are held apart so that the spring has an extension of 8.0 cm.

(i) Show that the elastic potential energy of the spring at an extension of 8.0 cm is 0.48 J.

[2]

(ii) The blocks are released from rest at the same instant. When the extension of the spring becomes zero, block A has speed v_A and block B has speed v_B.

For the instant when the extension of the spring becomes zero,

1. use conservation of momentum to show that

$$\frac{\text{kinetic energy of block A}}{\text{kinetic energy of block B}} = 1.5$$

[3]

2. use the information in **(b)(i)** and **(b)(ii)1** to determine the kinetic energy of block A. It may be assumed that the spring has negligible kinetic energy and that air resistance is negligible.

kinetic energy of block A = ...J [2]

(iii) The blocks are released at time $t = 0$.

On Fig. 2.3, sketch a graph to show how the momentum of block A varies with time t until the extension of the spring becomes zero.
Numerical values of momentum and time are not required.

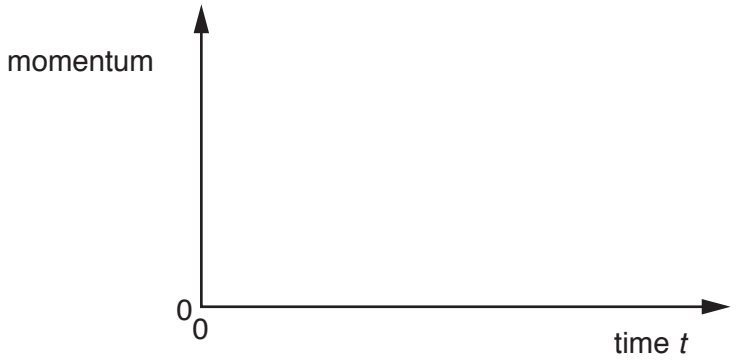

Fig. 2.3

[2]

[Total: 11]

Question	Answer	Marks
3 (a)	$\rho = m / V$	**1**
	$V = \pi d^2 L / 4$ **or** $\pi r^2 L$	**1**
	weight = $2.7 \times 10^3 \times \pi\ (1.2 \times 10^{-2})^2 \times 5.0 \times 10^{-2} \times 9.81 = 0.60$ N	**1**
3 (b) (i)	the point from where (all) the weight (of a body) seems to act	**1**
3 (b) (ii)	$W \times 12$	**1**
	$(0.25 \times 8) + (0.6 \times 38)$	**1**
	W = (2 + 22.8) / 12 = 2.1 (2.07) N	**1**
3 (c) (i)	pressure changes with depth (in water) **or** pressure on bottom (of cylinder) different from pressure on top	**1**
	pressure on bottom of cylinder greater than pressure on top **or** force (up) on bottom of cylinder greater than force (down) on top	**1**
3 (c) (ii)	anticlockwise moment reduced and reducing the weight of X reduces clockwise moment **or** anticlockwise moment reduced so clockwise moment now greater than (total) anticlockwise moment	**1**
		Total: 10
1 (a)	scalars: kinetic energy, power, work	**1**
	vectors: acceleration, force, momentum	**1**
1 (b) (i)	mass = volume × density *or* $m = V \times \rho$ = $4/3\ \pi\ (23 \times 10^{-2})^3 \times 82$	**1**
	weight = $4/3\ \pi\ (23 \times 10^{-2})^3 \times 82 \times 9.8 = 41$ N	**1**
1 (b) (ii)	vertical component of tension = 290 sin75° or 290 cos15° (= 280)	**1**
	upthrust = 290 sin75°+ 41 = 320 (321) N	**1**
1 (b) (iii)	the water pressure is greater than the air pressure *or* the pressure on lower surface (of sphere) is greater than the pressure on upper surface (of sphere)	**1**
		Total: 7

Question	Answer	Marks
2 (a)	sum / total momentum of bodies is constant *or* sum / total momentum of bodies before = sum / total momentum of bodies after	**1**
	for an isolated / closed system / no (resultant) external force	**1**
2 (b) (i)	EPE = area under graph or ½Fx or ½kx^2 and $F = kx$	**1**
	energy = ½ × 12.0 × 8.0 × 10^{-2} = 0.48 J *or* energy = ½ × 150 × $(8.0 \times 10^{-2})^2$ = 0.48 J	**1**
2 (b) (ii) 1	4.0 v_A = 6.0 v_B	**1**
	$E_K = ½mv^2$	**1**
	ratio = $\frac{0.50 \times 4.0}{0.50 \times 6.0}$ $\left(\frac{6.0}{4.0}\right)^2$ = 1.5 *or* = ratio = $\frac{1}{1.5} \times (1.5)^2$ = 1.5	**1**
2 (b) (ii) 2	0.48 = E_K of A + E_K of B = E_K of A + (E_K of A / 1.5) = 5/3 × E_K of A	**1**
	E_K of A = 0.29 (0.288) J	**1**
2 (b) (iii)	curve starts from origin and has decreasing gradient	**1**
	final gradient of graph line is zero	**1**
		Total: 11

Notes about the mark scheme are available separately.