3 A sphere of weight 2.5 N floats in water with ½ of its volume beneath the surface.

A force F is applied to the sphere, completely immersing it in the water as shown.

Which of the following is the minimum value of F?

☒ **A** 2×2.5 N

☒ **B** 1×2.5 N

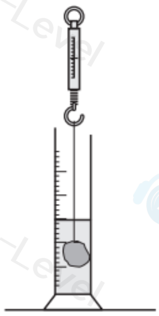
☒ **C** $\frac{1}{2} \times 2.5$ N

☒ **D** $\frac{1}{4} \times 2.5$ N

(Total for Question 3 = 1 mark)

7 An object of volume 2.4×10^{-5} m^3 was suspended from a spring balance in air and its weight, in newtons, was read from the scale.

The object was then placed in a measuring cylinder containing water of density 1000 kg m^{-3}.



The reading on the spring balance

☒ **A** decreased by $(2.4 \times 10^{-5}) \times (1000)$

☒ **B** decreased by $(2.4 \times 10^{-5}) \times (1000) \times (9.81)$

☒ **C** increased by $(2.4 \times 10^{-5}) \times (1000)$

☒ **D** increased by $(2.4 \times 10^{-5}) \times (1000) \times (9.81)$

(Total for Question 7 = 1 mark)

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1: A cube of volume V is placed in a liquid of density ρ. The cube displaces a weight W of the liquid.

Which of the following gives the magnitude of the upthrust acting on the cube?

☒ **A** $V \times W$

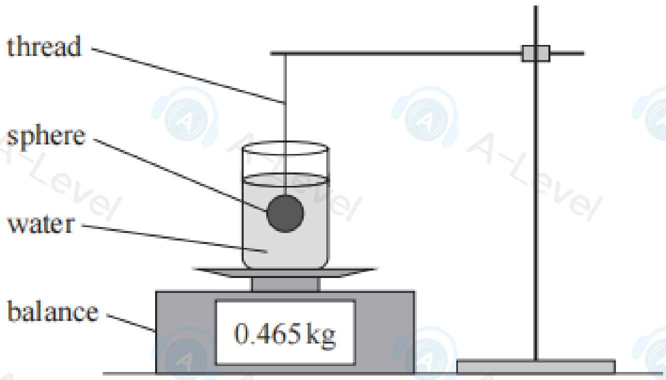
☒ **B** V

☒ **C** $V \times \rho$

☒ **D** W

(Total for Question 1 = 1 mark)

19 A student used the apparatus shown to investigate the forces acting on a uniform, solid sphere placed in water.



(a) Draw a free-body force diagram for the sphere when it is suspended in water as shown.

(3)

(b) As the sphere was lowered into the water, the reading on the balance increased from 315 g to 465 g as shown.

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(i) Explain the increase in the reading on the balance. Your answer should include a reference to Newton's third law.

(3)

(ii) Determine the mass of the sphere.

density of water $= 1000\,kg\,m^{-3}$
density of sphere $= 2000\,kg\,m^{-3}$

(4)

Mass of sphere = ...

(iii) The water was replaced with the same mass of oil and the experiment repeated. The density of the oil is less than the density of water.

Explain what happens to the final reading on the balance.

(2)

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13 A crane is used to remove an object from the bottom of a lake.

The object is a cylinder of height h and the depth of the lake is D, as shown in Figure 1.

The cylinder is moved vertically through the water at a slow and steady speed. The cylinder comes to rest in a position where it is completely above the surface of the water, as shown in Figure 2.

The diagrams are not to scale.

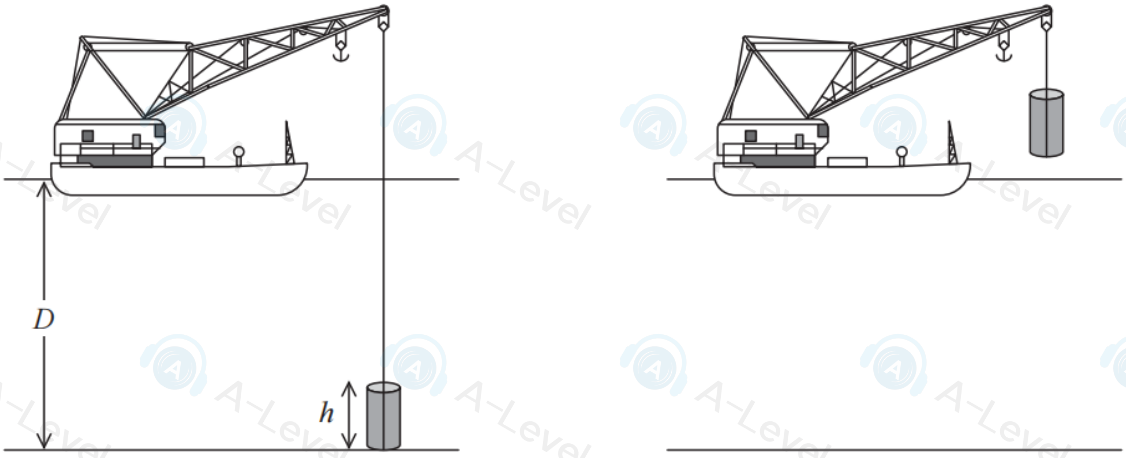
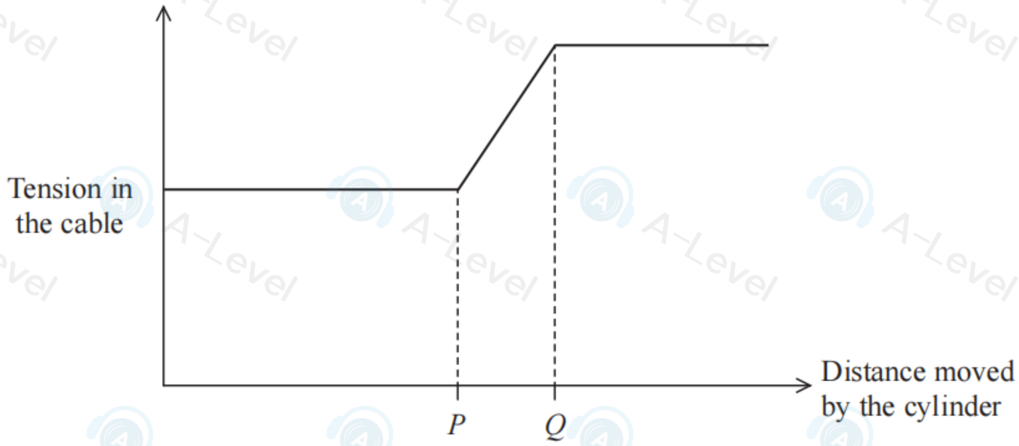


Figure 1 Figure 2

The graph shows how the tension in the cable varies with distance as the cylinder is lifted from the bottom of the lake to its position in Figure 2.



(a) State expressions for the distances P and Q.

(2)

Distance P = ...

Distance Q = ...

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*(b) Explain the shape of the graph.

(5)

(Total for Question 13 = 7 marks)

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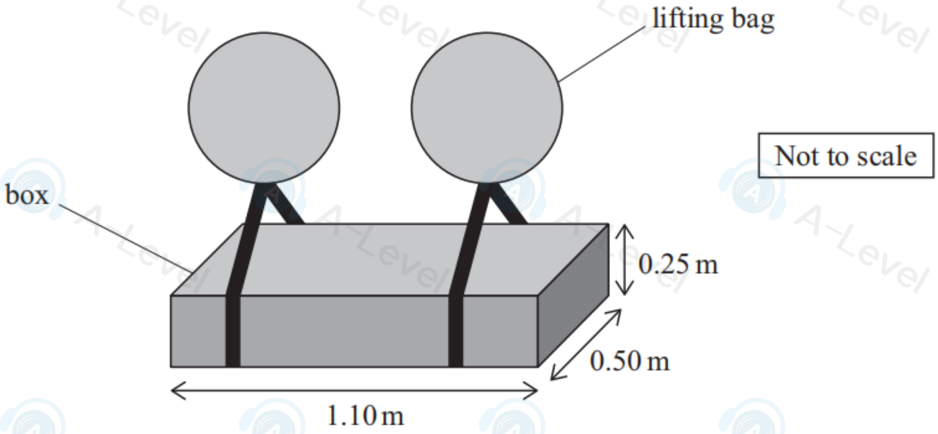
17 A ‘lifting bag’ is a bag that can be filled with air and used to lift heavy objects from the bottom of the sea.

Lifting bags are attached to an object and then filled with air.

(a) A person attaches two spherical lifting bags to a box at the bottom of the sea, as shown.



The total weight of the box and two lifting bags filled with air is 2500 N.
The diameter of each spherical lifting bag is 50 cm.

Deduce whether the box will lift from the bottom of the sea.

density of seawater = $1020\,\text{kg}\,\text{m}^{-3}$

(6)

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(b) As the person filled the lifting bags, a small bubble of air escaped and moved upwards through the seawater.

(i) Calculate the terminal velocity of the bubble of air predicted by Stokes' law.

weight of air in bubble = 1.82×10^{-6} N
upthrust on bubble = 4.77×10^{-4} N
viscosity of seawater = 8.60×10^{-4} Pa s
radius of bubble = 2.25×10^{-3} m

(3)

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Terminal velocity = ...

(ii) Give two reasons why the terminal velocity of the bubble may be different from the value predicted by Stokes' law.

(2)

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(Total for Question 17 = 11 marks)

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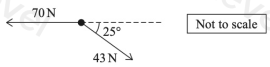
18 A small, remotely controlled submarine is used to explore the sea.

(a) The engine of the submarine produced a horizontal force of 70 N. The drag force on the submarine was 43 N at an angle of 25° to the horizontal, as shown.



Determine the resultant of these two forces on the submarine by drawing a scaled vector diagram in the space below.

(5)

Magnitude of resultant force = ...

Angle of resultant force to horizontal = ...

*(b) A crane on a ship can lift the submarine out of the sea, as shown.

(Source: adapted from © PJF Military Collection/Alamy Stock Photo)

The submarine is initially completely underwater and at rest just below the surface. A cable from the crane is attached to the submarine, so that the cable is vertical.

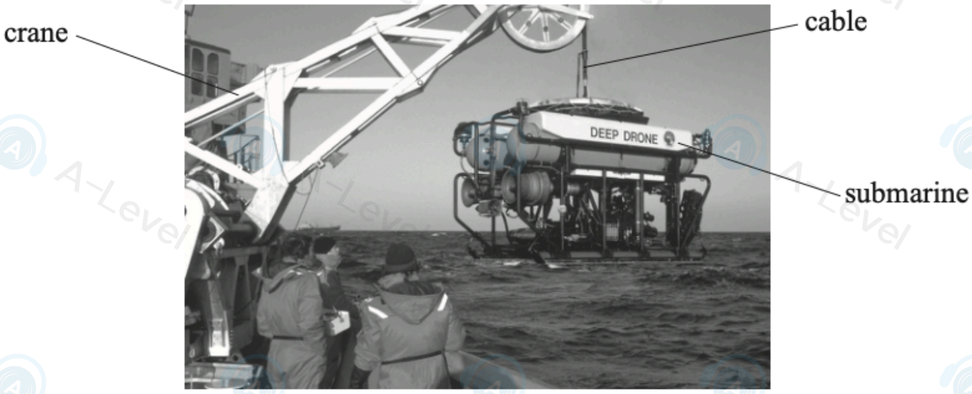
The crane pulls on the cable. The submarine moves vertically upwards at a constant speed until the whole submarine is out of the water.

Explain how the tension in the cable changes as the submarine moves from below the surface of the water to being completely out of the water.

You should assume the drag force on the submarine is negligible.

(6)

*(b) A crane on a ship can lift the submarine out of the sea, as shown.



(Source: adapted from © PJF Military Collection/Alamy Stock Photo)

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You should assume the drag force on the submarine is negligible.

(6)

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