

Questions

Q1.

Answer the question with a cross in the box you think is correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

A cylinder of aluminium has a weight of 35.0 N and a volume of $1.32 \times 10^{-3} \text{ m}^3$.

Which of the following calculations gives the density of aluminium in kg m^{-3} ?

☐ A $\frac{9.81 \times 1.32 \times 10^{-3}}{35.0}$

☐ B $\frac{1.32 \times 10^{-3}}{35.0 \times 9.81}$

☐ C $\frac{35.0}{9.81 \times 1.32 \times 10^{-3}}$

☐ D $\frac{35.0 \times 9.81}{1.32 \times 10^{-3}}$

(Total for question = 1 mark)

Q2.

Answer the question with a cross in the box you think is correct (☐). If you change your mind about an answer, put a line through the box (☒) and then mark your new answer with a cross (☐).

A ball bearing falls through oil at a terminal velocity.

Which row of the table is correct when the temperature of the oil decreases?

	Viscosity of oil	Terminal velocity of ball bearing
☐ A	decreases	decreases
☐ B	decreases	increases
☐ C	increases	decreases
☐ D	increases	increases

(Total for question = 1 mark)

Q3.

Answer the question with a cross in the box you think is correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

A sample of sea water is collected using a beaker. The sample contains some particles of sand which settle at the bottom of the beaker.

Which of the following would result in a decrease in the time taken for the sand to settle?

- ☒ **A** smaller particles of sand
- ☐ **B** lower temperature of the sea water
- ☐ **C** smaller terminal velocity of sand particles
- ☐ **D** lower viscosity of the sea water

(Total for question = 1 mark)

Q4.

A student determined the viscosity of a liquid using the falling-ball method.

(a) When the ball is falling at terminal velocity the following equation applies

$$\text{drag force} = \text{weight of ball} - \text{upthrust}$$

The density of the liquid was known.

The student used a balance and a digital calliper to make measurements on the ball.

Describe how the student could use her measurements to calculate a value for the drag force acting on the ball.

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(b) When falling through the liquid, the ball reached terminal velocity.

The flow of liquid around the ball was laminar.

Calculate the viscosity of the liquid.

terminal velocity of ball = $5.4 \times 10^{-4} \text{ m s}^{-1}$
radius of ball = $0.50 \times 10^{-2} \text{ m}$
drag force = $1.1 \times 10^{-2} \text{ N}$

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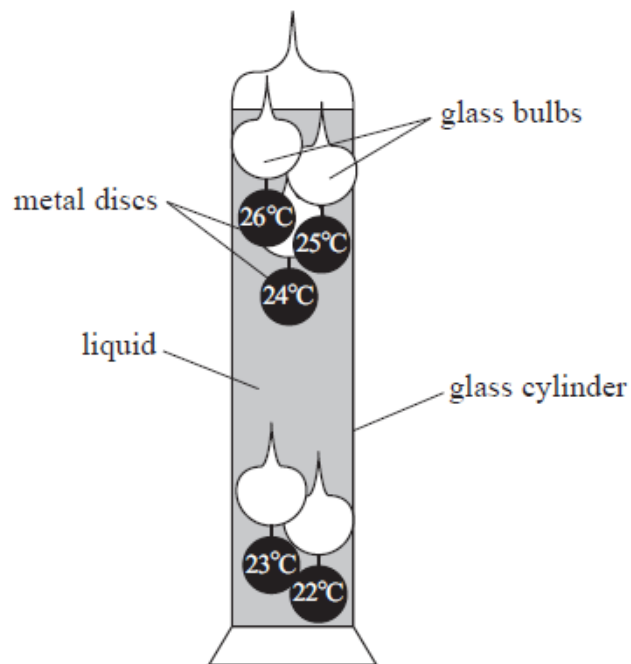
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Viscosity of liquid =

(Total for question = 6 marks)

Q5.

A Galilean thermometer consists of a closed glass cylinder containing a liquid. In the liquid there are several identical sealed glass bulbs, as shown. Attached to each bulb is a metal disc labelled with a temperature. Each disc has a different mass.



As the temperature increases, the density of the liquid decreases. This can cause the bulbs to move within the liquid.

Explain why a particular bulb will float until the temperature of the liquid exceeds a certain value.

[illegible]

Stokes' law can be used to determine the magnitude of the viscous drag for small, spherical objects moving through a fluid.

(1)

Assess whether Stokes' law can be applied to the falling sphere.

diameter of ball bearing = 6.0×10^{-3} m
mass of steel ball bearing = 9.1×10^{-4} kg
upthrust on ball bearing = 1.1×10^{-3} N
viscosity of water = 8.9×10^{-4} Pa s

[illegible]

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(Total for question = 6 marks)

Q7.

A grain of sand quickly reaches terminal velocity when it falls into water.

(a) State why the grain of sand reaches terminal velocity.

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(b) A spherical grain of sand has a weight of 4.3×10^{-5} N. The grain of sand displaces water with a weight of 1.5×10^{-5} N.

The terminal velocity of the grain of sand as it falls through the water is about 0.050 m s^{-1} .

Deduce whether Stokes' law applies to the grain of sand as it falls at terminal velocity.

viscosity of water = $1.2 \times 10^{-3} \text{ Pa s}$

diameter of grain of sand = $1.5 \times 10^{-3} \text{ m}$

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(c) Explain how the temperature of the water affects the terminal velocity of a grain of sand if Stokes' law does apply.

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(Total for question = 6 marks)

Q8.

A small sphere is moving horizontally through a viscous liquid.

(a) Stokes' law can be used to calculate the drag force on an object.

State the conditions that must apply for Stokes' law to be valid.

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(b) There is a constant force of 2.3×10^{-5} N acting horizontally on the sphere.

diameter of sphere = 4.5×10^{-3} m

viscosity of liquid = 7.1×10^{-2} Pa s

(i) At one instant, the speed of the sphere is 5.2×10^{-3} m s⁻¹.

Calculate the resultant horizontal force on the sphere.

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Resultant horizontal force =

(ii) Calculate the maximum speed of the sphere in the horizontal direction.

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Maximum horizontal speed =

(c) A larger diameter sphere in the same liquid is acted upon by the same constant force as in (b). The liquid is at a lower temperature.

Explain the effect these changes have on the maximum speed of this sphere.

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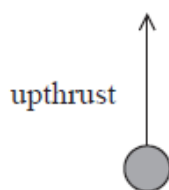
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(Total for question = 11 marks)

Q9.

A spherical polystyrene bead is immersed in oil. The bead has diameter 4.00×10^{-3} m. The bead is released and moves upwards through the oil at a constant velocity.

(a) Complete the free body force diagram below to show all the forces acting on the polystyrene bead.

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(b) Show that the upthrust the oil exerts on the bead is about 3.1×10^{-4} N.

density of oil = 930 kg m^{-3}

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(c) Stokes' law shows how the viscous drag on a sphere is related to its velocity through a fluid. Stokes' law is only valid if the bead is moving sufficiently slowly through the oil.

(i) State the reason for this condition.

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(ii) For Stokes' law to be valid the speed of the bead through the oil must be less than v_R , where

$$v_R = \frac{10 \times \text{viscosity of oil}}{\text{density of oil} \times \text{diameter of the bead}}$$

Deduce whether Stokes' law can be applied to this bead.

viscosity of oil = $4.90 \times 10^{-2} \text{ Pa s}$

weight of polystyrene bead = $1.05 \times 10^{-5} \text{ N}$

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(Total for question = 11 marks)

Q10.

Water is dropped into a container of oil. The water forms small spherical droplets that move slowly downwards.

(a) A droplet moves downwards at a constant speed. The flow of oil around the droplet is laminar.

(i) State what is meant by laminar flow.

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(ii) State the condition necessary for the speed of the droplet to be constant.

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(b) A spherical droplet has a volume of $3.35 \times 10^{-8} \text{ m}^3$.

(i) Calculate the weight of the droplet.

density of water = $1.00 \times 10^3 \text{ kg m}^{-3}$

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Weight of droplet =

(ii) Show that the upthrust on the water droplet when it's completely submerged in oil is about 3×10^{-4} N.

density of oil = $0.94 \times 10^3 \text{ kg m}^{-3}$

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(iii) Calculate the terminal velocity of this water droplet in the oil.

viscosity of oil = 0.11 Pa s

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Terminal velocity =

(Total for question = 11 marks)

Q11.

A deep-sea diver is a person who swims at great depths below the surface of the sea.

(a) To help a deep-sea diver move downwards quickly, spherical masses are attached to the diver.

During a dive, one mass became unattached and fell to the bottom of the sea.

(i) State the conditions for Stokes' law to apply.

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(ii) The mass accelerated to terminal velocity as it fell to the bottom of the sea.

At terminal velocity, the mass fell 25 m in a time of 0.36 s.

There was a difference of 4.6 N between the weight of the mass and the upthrust on the mass.

The spherical mass has a volume of 45 cm^3 .

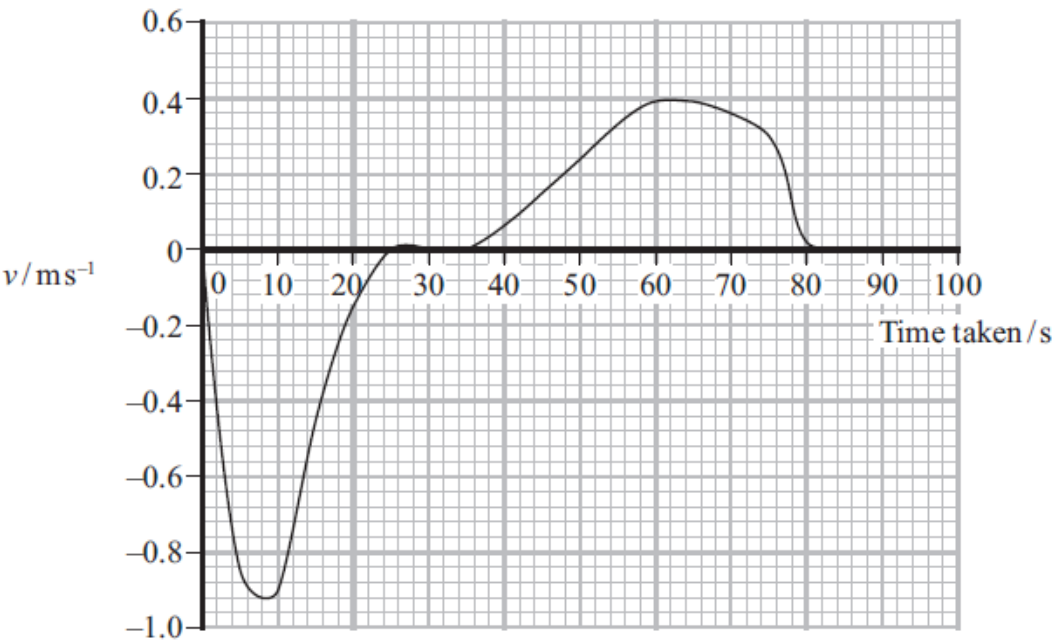
Deduce whether Stokes' law applied as the mass fell through the water.

$$\eta_{water} = 1.2 \times 10^{-3} \text{ Pa s}$$

(5)

[illegible]

(b) The graph shows how the vertical velocity v of the diver varied during a dive.



(i) The diver was at the surface of the sea at 0 s.

Explain how the graph could be used to show that the diver reached the surface of the sea again at 82 s.

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(ii) Determine the vertical acceleration of the diver at 70 seconds.

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Acceleration =

(Total for question = 12 marks)

Q12.

An object of mass 35 kg fell from a boat to the seabed.

(a) The object reached terminal velocity as it fell.

(i) Show that the drag force acting on the object at terminal velocity was about 200 N.

volume of object = $1.60 \times 10^{-2} \text{ m}^3$

density of seawater = $1.03 \times 10^3 \text{ kg m}^{-3}$

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(ii) The drag force D on the object obeyed the formula

$$D = kv^2$$

where v is the speed of the object.

Determine the terminal velocity of the object.

$k = 2.2 \text{ N s}^2 \text{ m}^{-2}$

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Terminal velocity =

(iii) Give **two** reasons why Stokes' law could **not** be used to calculate the terminal velocity of the object.

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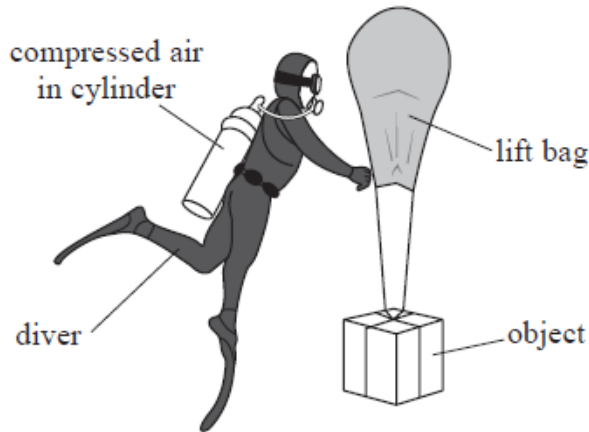
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(b) To lift the heavy object from the seabed, a diver used a 'lift bag'.
The diver used compressed air from a cylinder to fill the lift bag, as shown.



When released, the lift bag and object accelerated upwards until they reached a maximum velocity.

Explain why the lift bag and object reached a maximum velocity.

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(Total for question = 12 marks)

A student carried out an experiment using a data logger to record the motion of a ball-bearing as it fell through a liquid.

(a) State the conditions under which Stokes' law applies to an object moving through a fluid.

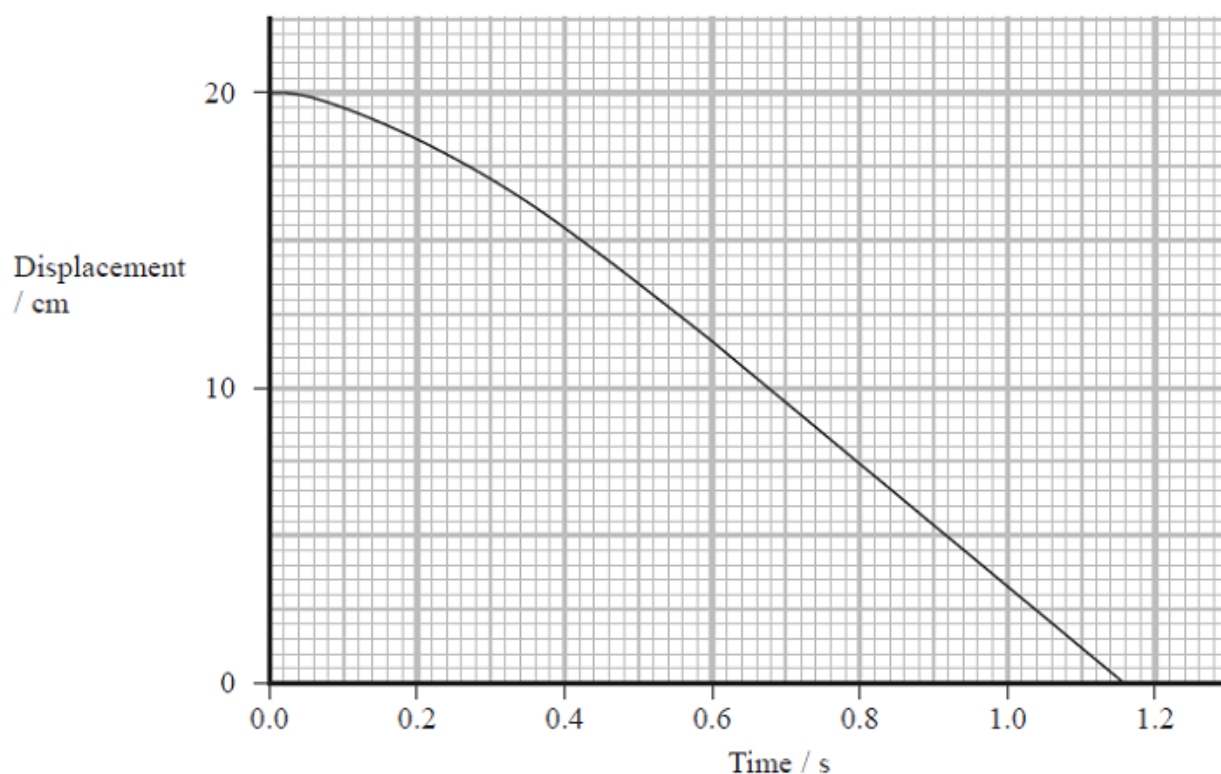
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(b) The graph obtained by the student is shown below.



(i) Explain the shape of the graph.

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(ii) The ball-bearing had a diameter of 1.6 mm.

The difference between the upthrust on the ball-bearing and the weight of the ball-bearing is 1.45×10^{-4} N.

Calculate the viscosity of the liquid. Assume that Stokes' law applies.

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Viscosity = Pa s

(iii) The student heated the liquid and repeated the experiment.

The ball-bearing took less time to fall a given distance in the liquid when the liquid was at a higher temperature.

Explain why. Assume the density of the liquid is constant.

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(Total for question = 13 marks)