1.5 Density, Upthrust & Viscous Drag MCQ

1 ✓ 1 mark

A student measured the terminal velocity of different objects as they fell through a liquid. The student used the measurements and Stokes' Law to calculate the viscosity of the liquid.

For which of the following conditions does Stokes' Law apply?

A. spherical objects and laminar flow

B. spherical objects and low viscosity

C. cylindrical objects and laminar flow

D. cylindrical objects and low viscosity

2 ✓ 1 mark

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

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

Structured Questions

Medium

1a

4 marks

The photograph shows a submarine below the surface of the sea.

(Source: noraismail/Shutterstock)

The submarine has a volume of $5.83 \times 10^3\ m^3$. The submarine is stationary in a region of the sea where the density of the seawater is $1.03 \times 10^3\ kg\ m^{-3}$.

i) Calculate the upthrust exerted on the submarine by the seawater.

(2)

Upthrust = ...

ii) Explain why the mass of the submarine must be 6.0×10^6 kg.

(2)

1b

5 marks

The submarine now moves into a region of the sea where the water is less salty, and the density of the water reduces to 1.01×10^3 kg m^{-3}.

i) Explain what would happen to the submarine as it moves into this region of lower density seawater.

(3)

ii) The submarine alters its weight by pumping water in or out of its internal tanks.

Determine the mass of water that the submarine should pump, in or out of its tanks, to maintain its depth below the surface of the sea.

(2)

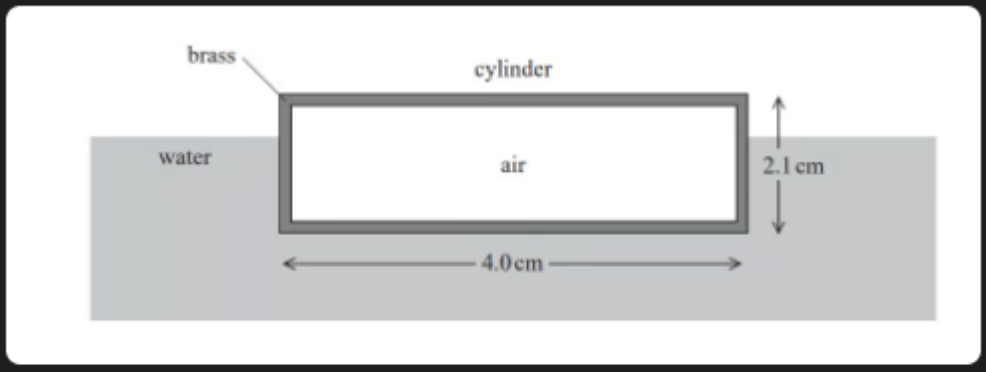
Mass of water = ...

2a

2 marks

A hollow brass cylinder with closed ends is floating on the surface of water.

The cylinder has a length of 4.0 cm and an external diameter of 2.1 cm as shown.



63% of the volume of the cylinder is submerged. The cylinder contains negligible weight of air.

Explain why the brass cylinder floats.

2b

8 marks

The density of water is 1.0×10^3 kg m^{-3}

i) Show that the mass of the cylinder is about 9×10^{-3} kg.

(4)

ii) Deduce whether an identical hollow cylinder made of gold would also float.

Assume that the volume of gold is the same as the volume of brass.

density of gold = 19.3×10^3 kg m^{-3}
density of brass = 8.7×10^3 kg m^{-3}

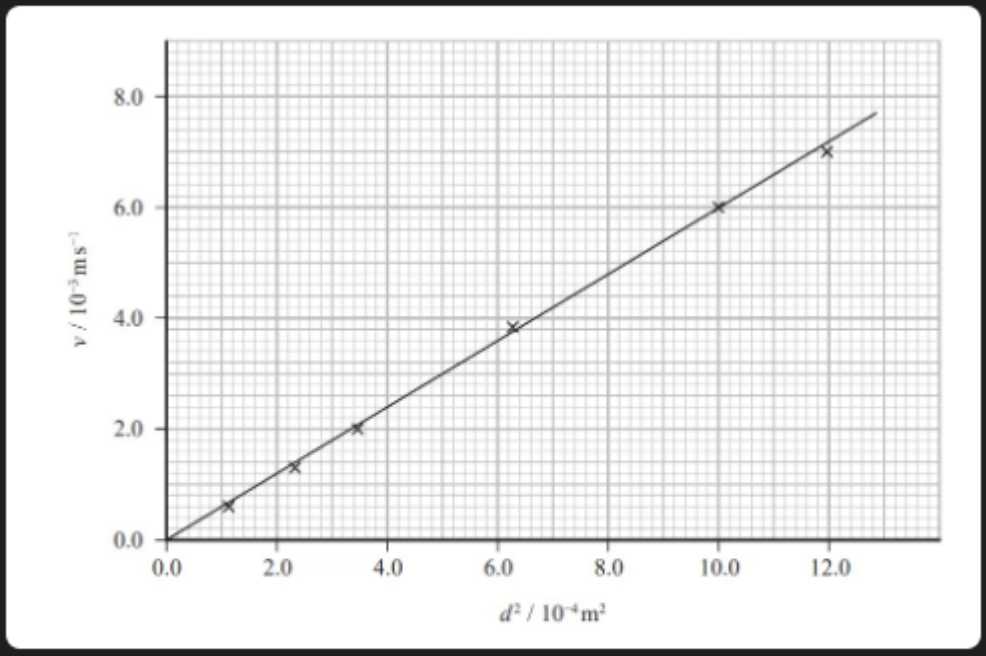
(4)

3a

2 marks

A student carried out an experiment to determine the viscosity of a liquid. He measured the terminal velocities v of several different glass spheres of diameter d, as they fell through the liquid.

The student used his measurements to plot the graph of v against d^2 shown below.



Explain what is meant by terminal velocity.

3b

5 marks

A glass sphere of diameter 35 mm is travelling through the fluid at terminal velocity.

Show that the drag force on this sphere is about 0.2 N.

density of glass $\rho_g = 2.52 \times 10^3$ kg m^{-3}
density of liquid $\rho_s = 1.43 \times 10^3$ kg m^{-3}

3c

8 marks

The student reads in a textbook that if Stokes' law is obeyed

$$v = kd^2$$

where k is a constant.

i) Deduce from the graph whether the flow of liquid around the spheres was laminar.

(3)

ii) Determine a value for k using the student's graph.

(3)

k = ...

iii) The constant k is given by

$$k = \frac{(\rho_g - \rho_s)g}{18\eta}$$

where η is the viscosity of the liquid.

Determine a value for η.

density of glass $\rho_g = 2.52 \times 10^3$ kg m^{-3}
density of liquid $\rho_s = 1.43 \times 10^3$ kg m^{-3}

(2)

η = ...

4a

2 marks

A small sphere is moving horizontally through a viscous liquid.

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.

4b

5 marks

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.

(3)

Resultant horizontal force = ...

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

(2)

Maximum horizontal speed = ...

4c

4 marks

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.

Hard

1a

2 marks

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

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.

(1)

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

(1)

1b

9 marks

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

i) Calculate the weight of the droplet.
density of water = $1.00 \times 10^3\ kg\ m^{-3}$

(3)

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 = $0.94 \times 10^3\ kg\ m^{-3}$

(2)

iii) Calculate the terminal velocity of this water droplet in the oil.
viscosity of oil = 0.11 Pa s

(4)

Terminal velocity = ...