

AS Level Physics B
H157/02 Physics in depth

Question Set 8

1

This question is about the movement of a table-tennis ball falling in air.

On release, but before the ball starts moving, there are two forces acting on it:

- Its weight, W
- The upthrust, U , which is equal to the weight of air which would have occupied the space that the ball now occupies.

These forces are shown in **Fig. 1.1**.



(not to scale)
Fig. 1.1

- (a) Show that the upthrust U acting on a table-tennis ball in air of density 1.2 kg m^{-3} is less than 2% of the weight W of the ball.

$$\text{weight of table-tennis ball} = 0.026 \text{ N}$$

$$\text{volume of table-tennis ball} = 3.4 \times 10^{-5} \text{ m}^3$$

[4]

- (b) When the ball moves at a velocity v , it experiences a force D due to air drag given by

$$D = \frac{1}{2} \rho A C_d v^2$$

where ρ is the air density, A is the cross-sectional area of the ball, and C_d is a dimensionless constant called the drag coefficient.

$$\text{radius of table-tennis ball} = 0.020 \text{ m}$$

$$\text{density of air} = 1.2 \text{ kg m}^{-3}$$

$$\text{the drag coefficient } C_d = 0.4 \text{ for a table-tennis ball falling in air}$$

Use the data above to calculate the drag force acting on a table-tennis ball at its **terminal velocity** of 9.3 m s^{-1} and explain why you would expect the drag to have this value.

$$D = \dots\dots\dots \text{ N} \quad \text{[3]}$$

- (c) The graph in **Fig. 1.2** shows how the displacement s of the table-tennis ball changed with time t from the instant it was released.

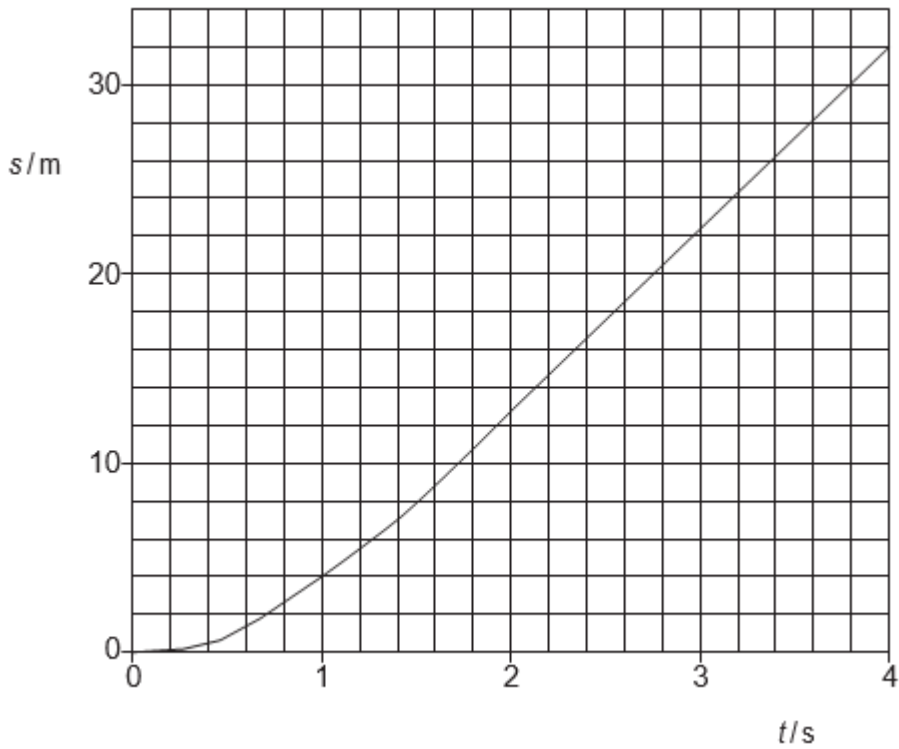


Fig. 1.2

- (i) Calculate, as accurately as the data allow, the velocity v of the ball after it has fallen for 1 s.
Show your working.
 $v = \dots\dots\dots \text{ m s}^{-1}$ **[3]**
- (c) (ii) State how the graph shows that the ball has reached its terminal velocity within about 3 s of being released. **[1]**
- (d) Explain how the way in which a table-tennis ball falls would be different if it were dropped in an atmosphere of argon, which is denser and has a larger drag coefficient than air. You should refer to upthrust and to the equation $D = \frac{1}{2} \rho A C_d v^2$ in your answer **[4]**

[Question total: 15]

Total Marks for Question Set 8: 15

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