Oxford Cambridge and RSA

AS Level Physics B

H157/02 Physics in depth

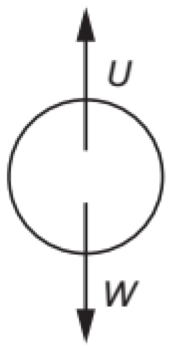
Question Set 8

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 spacethat 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.

weight of table-tennis ball = 0.026 N

volume of table-tennis ball = 3.4×10^{-5} m^3

[4]

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

$$D = ½ \rho A C_d v^2$$

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.

radius of table-tennis ball = 0.020 m
density of air = 1.2 kg m^{-3}
the drag coefficient C_d = 0.4 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 = ……………………….. N **[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.

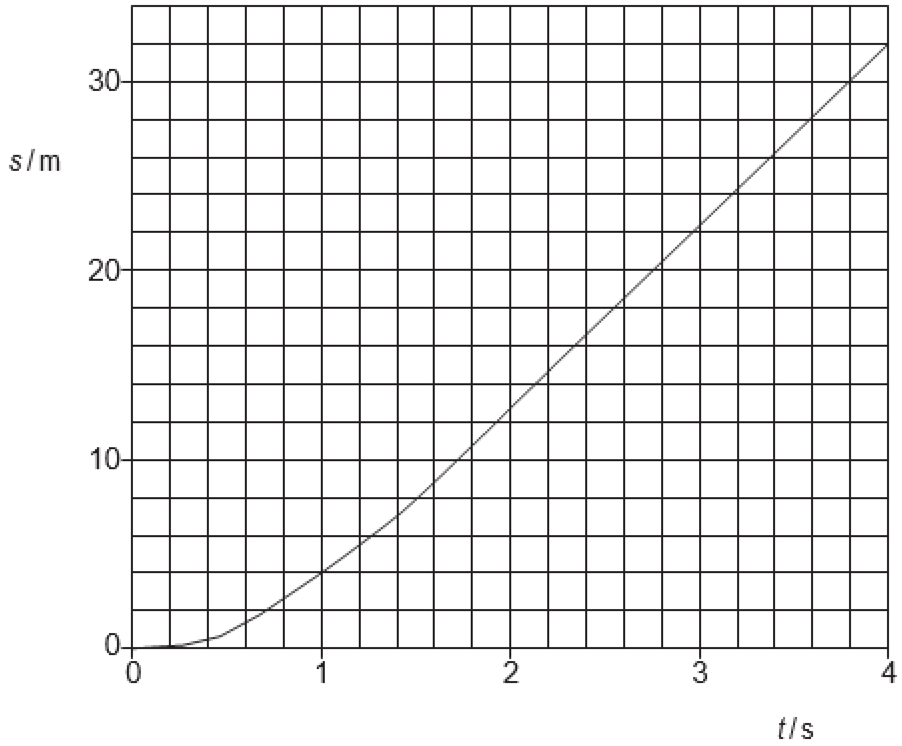


Fig. 1.2

(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 = ……………………………. 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 droppedin an atmosphere of argon, which is denser and has a larger drag coefficient than air. You should refer to upthrust and to the equation $D = ½ \rho A C_d v^2$ in your answer **[4]**

[Question total: 15]

Total Marks for Question Set 8: 15