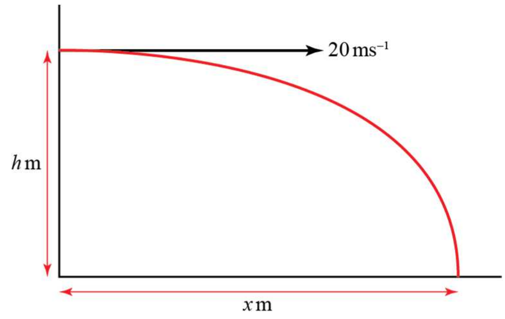
Exercise 1A



1 a R(↓): $u_y = 0$, $t = 5$ s, $a = g = 9.8$ ms^{-2}, $s = h$

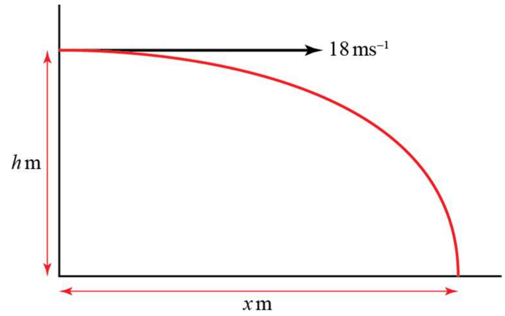
$$s = ut + \tfrac{1}{2}at^2$$
$$h = 0 + \frac{1}{2} \times 9.8 \times 5^2$$
$$= 122.5$$

The height h is 122.5 m.

b R(→): $u_x = 20$ ms^{-1}, $t = 5$ s, $s = x$

$$s = vt$$
$$x = 20 \times 5$$
$$= 100$$

The particle travels a horizontal distance of 100 m.



2 a R(→): $u_x = 18$ m s^{-1}, $t = 2$ s, $s = x$

$$s = vt$$
$$x = 18 \times 2$$
$$= 36$$

R(↓): $u_y = 0$, $t = 2$ s, $a = g = 9.8$ ms^{-2}, $s = y$

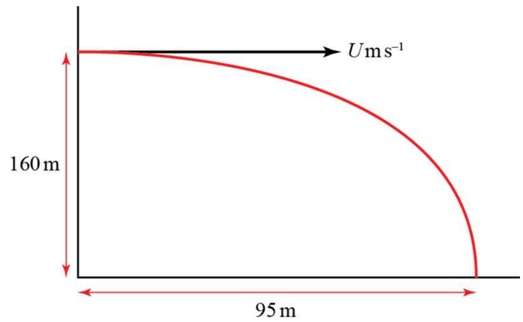
$$s = ut + \frac{1}{2}at^2$$
$$h = 0 + \frac{1}{2} \times 9.8 \times 2^2$$
$$= 19.6$$

The horizontal and vertical components of the displacement are 36 m and 19.6 m respectively.

b $d^2 = 36^2 + 19.6^2$

$d = \sqrt{1680.16} = 40.989...$

The distance from the starting point is 41.0 m (3 s.f.).



3 R(↓): $u_y = 0$, $a = g = 9.8$ ms^{-2}, $s = 160$ m, $t = ?$

$$s = ut + \frac{1}{2}at^2$$
$$160 = 0 + \frac{1}{2} \times 9.8 \times t^2$$
$$t^2 = \frac{160}{4.9}$$
$$t = \pm\frac{40}{7}$$

The negative root can be ignored.

R(→): $u_x = U$, $t = \frac{40}{7}$ s, $s = 95$ m

$$s = vt$$
$$95 = U \times \frac{40}{7}$$
$$U = \frac{7 \times 95}{40} = 16.625$$

The projection speed is 16.6 ms^{-1} (3s.f.).

4 $R(\downarrow)$

$$u = 0, \quad s = 16, \quad a = 9.8, \quad t = ?$$
$$s = ut + \frac{1}{2}at^2$$
$$16 = 0 + 4.9t^2$$
$$t^2 = \frac{16}{4.9} = 3.265...$$
$$t = 1.807$$

Let the speed of the projection be $u\,\text{m s}^{-1}$

$R(\rightarrow)$

$$s = ut$$
$$140 = u \times 1.807...$$
$$u = \frac{140}{1.807...}$$
$$= 77.475$$

The speed of projection of the particle is
$77.5\,\text{m s}^{-1}$ (3 s.f.)

5 Whilst particle is on the table:

$R(\rightarrow)$

$s = vt$

$2 = 20 \times t$

$t = 0.1$

Once particle leaves the table:

R(↓) $u_y = 0$, $a = g = 9.8\ \text{ms}^{-2}$, $s = 1.2$ m, $t = ?$

$s = ut + \frac{1}{2}at^2$

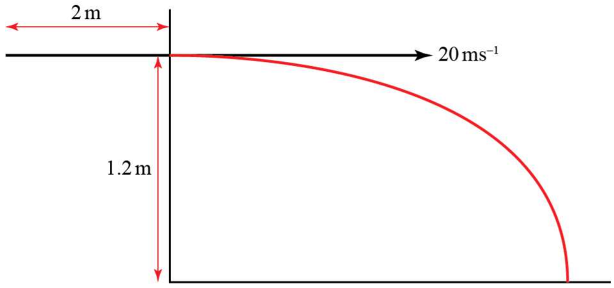
$1.2 = 0 + \frac{1}{2} \times 9.8 \times t^2$

$t^2 = \frac{1.2}{4.9}$

$t = \pm 0.49487...$

The negative root can be ignored.

The total time the particle takes to reach the floor is 0.1 + 0.49 = 0.59 s (2s.f.).



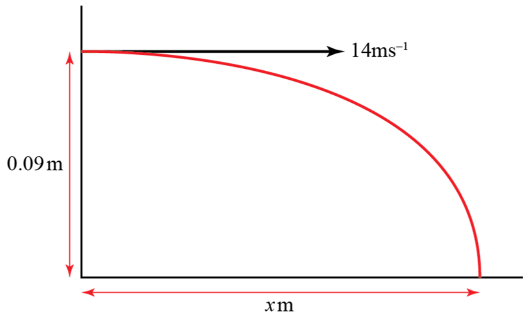
6 R(↓) $u_y = 0$, $a = g = 9.8\ \text{ms}^{-2}$, $s = 9$ cm $= 0.09$ m, $t = ?$

$s = ut + \frac{1}{2}at^2$

$0.09 = 0 + \frac{1}{2} \times 9.8 \times t^2$

$t^2 = \frac{0.09}{4.9}$

$t = \pm 0.13552...$



The negative root can be ignored.

R(→): $u_x = 14\ \text{ms}^{-1}$, $t = 0.13552\ldots$ s, $s = x$

$s = vt$

$x = 14 \times 0.13552...$

$x = 1.8973...$

The dart is thrown from a point 1.90 m (3s.f.) from the board.

7 **a** Once particle leaves the table:

R(↓) $u_y = 0$, $a = g = 9.8\ \text{ms}^{-2}$, $s = 1.2$ m, $t = ?$

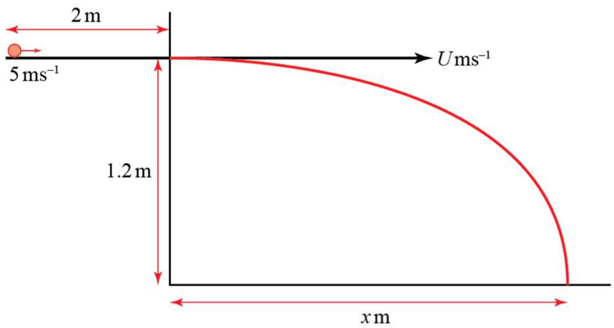
$s = ut + \frac{1}{2}at^2$

$1.2 = 0 + \frac{1}{2} \times 9.8 \times t^2$

$t^2 = \frac{1.2}{4.9}$

$t = \pm 0.49487...$

Total travel time is 1.0 s, so particle is in contact with the table for 1.0 – 0.49 = 0.51 s (2s.f.).



7 b Considering forces acting on particle while on table:
R(↓): $R = mg$

R(→): $F = ma$

$-\mu R = ma$ since $F = F_{MAX}$

$-\mu mg = ma$

$a = -\mu g$ **(1)**

Use equations of motion to calculate the acceleration of the particle whilst on the table:
$s = 2$ m, $u = 5$ ms^{-1}, $t = 0.50513\ldots$ s, $a = ?$

$$s = ut + \frac{1}{2}at^2$$

$$2 = (5 \times 0.50513...) + \left(\frac{1}{2} \times a \times 0.50513...^2\right)$$

$$0.12757... \times a = 2 - 2.5256...$$

$$a = \frac{-0.52564...}{0.12757...}$$

$$a = -4.1201... \quad \textbf{(2)}$$

Substitute **(2)** in **(1)**:

$$-4.1201... = -\mu g$$

$$-4.1201... = -9.8 \times \mu$$

$$\mu = 0.42042...$$

The coefficient of friction is 0.42 (2s.f.).

7 c While particle is on the table: $s = 2$ m, $u = 5$ m s^{-1}, $t = 0.50513\ldots$ s, $v = U$

$$s = \frac{1}{2}(u + v)t$$

$$2 = \frac{1}{2}(5 + U)0.50513\ldots$$

$$5 + U = \frac{4}{0.50513...}$$

$$U = 7.9187... - 5 = 2.9187...$$

Considering horizontal motion of particle once it has left the table:
R(→): $u_x = U = 2.9187\ \ldots$ m s^{-1}, $t = 0.495$ s, $s = x$

$$s = vt$$

$$x = 2.9187... \times 0.495$$

$$x = 1.445$$

The total distance travelled = 1.45 + 2 = 3.45 m (3 s.f.).