

9.5) Vertical motion under gravity

Worked example

A book falls off the top shelf of a bookcase. The shelf is 2.8 m above a wooden floor. Find:
(a) the time the book takes to reach the floor,
(b) the speed with which the book strikes the floor.

Your turn

A book falls off the top shelf of a bookcase. The shelf is 1.4 m above a wooden floor. Find:
(a) the time the book takes to reach the floor,
(b) the speed with which the book strikes the floor.

a) 0.53 s

b) 5.2 ms^{-1}

Worked example

A ball is projected vertically upwards, from a point X which is 5m above the ground, with speed 15 ms^{-1} . Find

- (a) the greatest height above the ground reached by the ball,
- (b) the time of flight of the ball

Your turn

A ball is projected vertically upwards, from a point X which is 7m above the ground, with speed 21 ms^{-1} . Find

- (a) the greatest height above the ground reached by the ball,
- (b) the time of flight of the ball

a) 30 m (2 sf)

b) 4.6 s (2 sf)

Worked example

A ball is projected vertically upwards from ground level at a speed of 40 ms^{-1} .

Determine the amount of time the ball is at least 20m above ground level.

Your turn

A ball is projected vertically upwards from ground level at a speed of 20 ms^{-1} .

Determine the amount of time the ball is at least 10m above ground level.

2.9 s (2 sf)

Worked example

A ball is projected vertically upwards with initial speed of 20 ms^{-1} .

It hits the ground 5 s later.

Find the height above the ground from which the ball was thrown.

Your turn

A ball is projected vertically upwards with initial speed of 15 ms^{-1} .

It hits the ground 5 s later.

Find the height above the ground from which the ball was thrown.

47.5 m

Worked example

A stone is thrown vertically upward from a point which is 8 m above the ground with speed 5 ms^{-1} .

Find:

- a) The time of flight of the stone
- b) The total distance travelled by the stone

Your turn

A stone is thrown vertically upward from a point which is 5 m above the ground with speed 8 ms^{-1} .

Find:

- a) The time of flight of the stone
- b) The total distance travelled by the stone

a) 2.1 s (2 sf)

b) 12 m (2 sf)

Worked example

Ball A falls vertically from rest from the top of a tower 48 m high. At the same time as A begins to fall, another ball B is projected vertically upwards from the bottom of the tower with speed 24 ms^{-1} . The balls collide. Find the distance to the point where the balls collide from the bottom of the tower.

Your turn

Ball A falls vertically from rest from the top of a tower 63 m high. At the same time as A begins to fall, another ball B is projected vertically upwards from the bottom of the tower with speed 21 ms^{-1} . The balls collide. Find the distance to the point where the balls collide from the bottom of the tower.

19 m (2 sf)

Worked example

At time $t = 0$, two balls A and B are projected vertically upwards. Ball A is projected upwards with speed 3 ms^{-1} from a point 40 m above the horizontal ground. Ball B is projected vertically upwards from the ground with speed 30 ms^{-1} . The balls are modelled as particles moving freely under gravity. Find the time and the height at which the balls are at the same vertical height.

Your turn

At time $t = 0$, two balls A and B are projected vertically upwards. Ball A is projected upwards with speed 2 ms^{-1} from a point 50 m above the horizontal ground. Ball B is projected vertically upwards from the ground with speed 20 ms^{-1} . The balls are modelled as particles moving freely under gravity. Find the time and the height at which the balls are at the same vertical height.

$$t = 2.8 \text{ s (2 sf)}$$

$$h = 18 \text{ m (2 sf)}$$

Worked example

A ball is released from rest at a point which is 20 m above a wooden floor. Each time the ball strikes the floor, it rebounds with $\frac{2}{3}$ of the speed with which it strikes the floor.

Find the greatest height above the floor reached by the ball:

- a) The first time it rebounds from the floor
- b) The second time it rebounds from the floor.

Your turn

A ball is released from rest at a point which is 10 m above a wooden floor. Each time the ball strikes the floor, it rebounds with $\frac{3}{4}$ of the speed with which it strikes the floor.

Find the greatest height above the floor reached by the ball:

- a) The first time it rebounds from the floor
- b) The second time it rebounds from the floor.

a) 5.6 m (2 sf)

b) 3.2 m (2 sf)