2 A ball is thrown from a point P with an initial velocity u of $12\,m\,s^{-1}$ at 50° to the horizontal, as illustrated in Fig. 2.1.

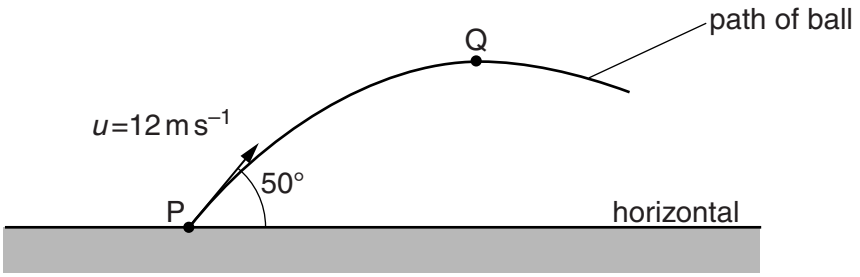

Fig. 2.1

The ball reaches maximum height at Q.

Air resistance is negligible.

(a) Calculate

(i) the horizontal component of u,

horizontal component = ... $m\,s^{-1}$ [1]

(ii) the vertical component of u.

vertical component = ... $m\,s^{-1}$ [1]

(b) Show that the maximum height reached by the ball is 4.3 m.

[2]

(c) Determine the magnitude of the displacement PQ.

displacement = ... m [4]

[Total: 8]

3 A ball of mass 150 g is at rest on a horizontal floor, as shown in Fig. 3.1.

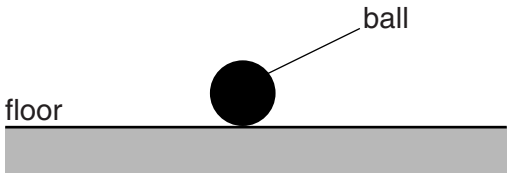

Fig. 3.1

(a) (i) Calculate the magnitude of the normal contact force from the floor acting on the ball.

force = ... N [1]

(ii) Explain your working in **(i)**.

.....

.....

.....[1]

(b) The ball is now lifted above the floor and dropped so that it falls vertically, as illustrated in Fig. 3.2.

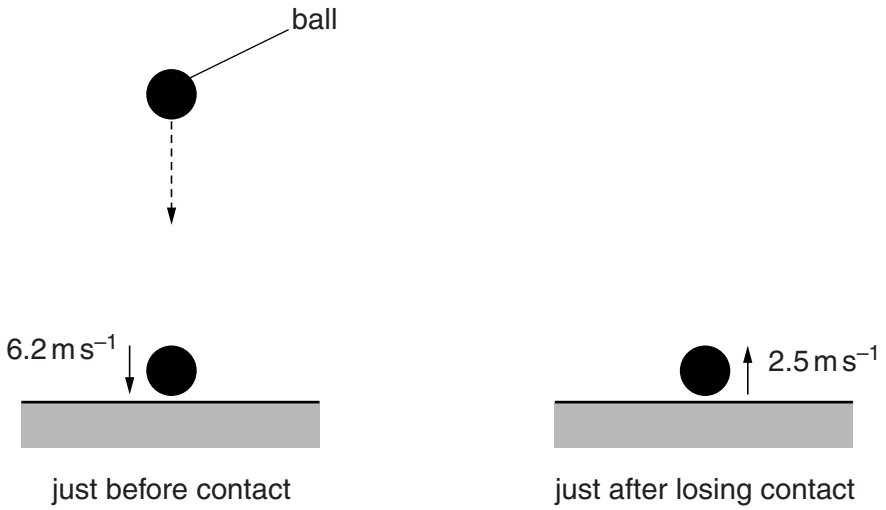

Fig. 3.2

Just before contact with the floor, the ball has velocity 6.2 m s^{-1} downwards. The ball bounces from the floor and its velocity just after losing contact with the floor is 2.5 m s^{-1} upwards. The ball is in contact with the floor for 0.12 s.

(i) State Newton's second law of motion.

.....

.....[1]

(ii) Calculate the average resultant force on the ball when it is in contact with the floor.

magnitude of force = ... N

direction of force .....

[3]

(iii) State and explain whether linear momentum is conserved during the collision of the ball with the floor.

.....

.....

.....

.....[2]

[Total: 8]

2 **(a)** Define *acceleration*.

.....

..... [1]

(b) A ball is kicked from horizontal ground towards the top of a vertical wall, as shown in Fig. 2.1.

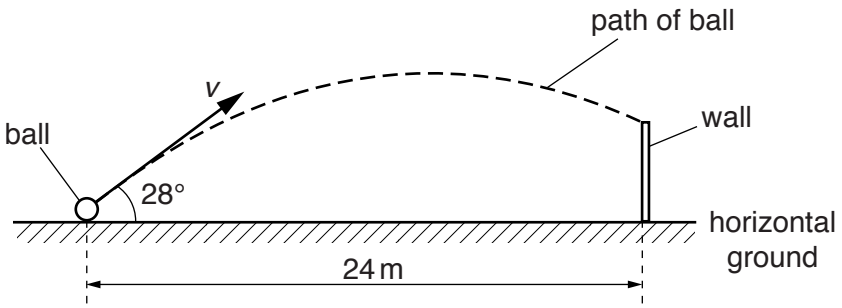

Fig. 2.1 (not to scale)

The horizontal distance between the initial position of the ball and the base of the wall is 24 m. The ball is kicked with an initial velocity v at an angle of 28° to the horizontal. The ball hits the top of the wall after a time of 1.5 s. Air resistance may be assumed to be negligible.

(i) Calculate the initial horizontal component v_X of the velocity of the ball.

v_X = ... $m\,s^{-1}$ [1]

(ii) Show that the initial vertical component v_Y of the velocity of the ball is $8.5\,m\,s^{-1}$.

[2]

(iii) Calculate the time taken for the ball to reach its maximum height above the ground.

time = ... s [2]

(iv) The ball is kicked at time $t = 0$. On Fig. 2.2, sketch the variation with time t of the vertical component v_Y of the velocity of the ball until it hits the wall. It may be assumed that velocity is positive when in the upwards direction.

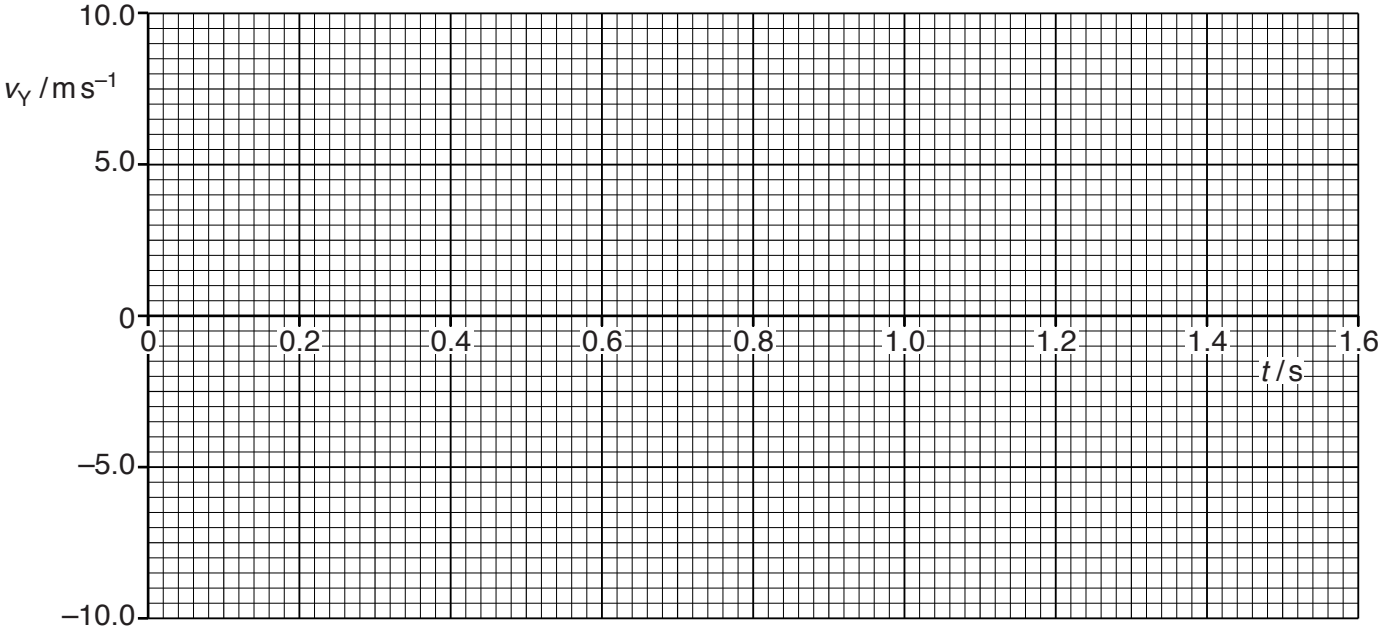

Fig. 2.2

[2]

(c) (i) Use the information in **(b)** to determine the maximum height of the ball above the ground.

maximum height = ... m [2]

(ii) The maximum gravitational potential energy of the ball above the ground is 22 J. Calculate the mass of the ball.

mass = ...kg [2]

(d) A ball of greater mass is kicked with the same velocity as the ball in **(b)**.
State and explain the effect, if any, of the increased mass on the maximum height reached by the ball. Air resistance is still assumed to be negligible.

.....

..... [1]

[Total: 13]

[Turn over

3 A steel ball falls from a platform on a tower to the ground below, as shown in Fig. 3.1.

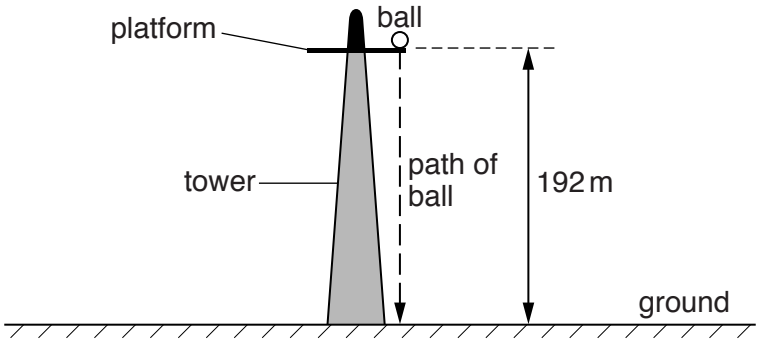

Fig. 3.1

The ball falls from rest through a vertical distance of 192 m. The mass of the ball is 270 g.

(a) Assume air resistance is negligible.

(i) Calculate

1. the time taken for the ball to fall to the ground,

time taken = ...s [2]

2. the maximum kinetic energy of the ball.

maximum kinetic energy = ...J [2]

(ii) State and explain the variation of the velocity of the ball with time as the ball falls to the ground.

.....

.....[1]

(iii) Show that the velocity of the ball on reaching the ground is approximately 60 m s^{-1}.

[1]

(b) In practice, air resistance is not negligible. The variation of the air resistance R with the velocity v of the ball is shown in Fig. 3.2.

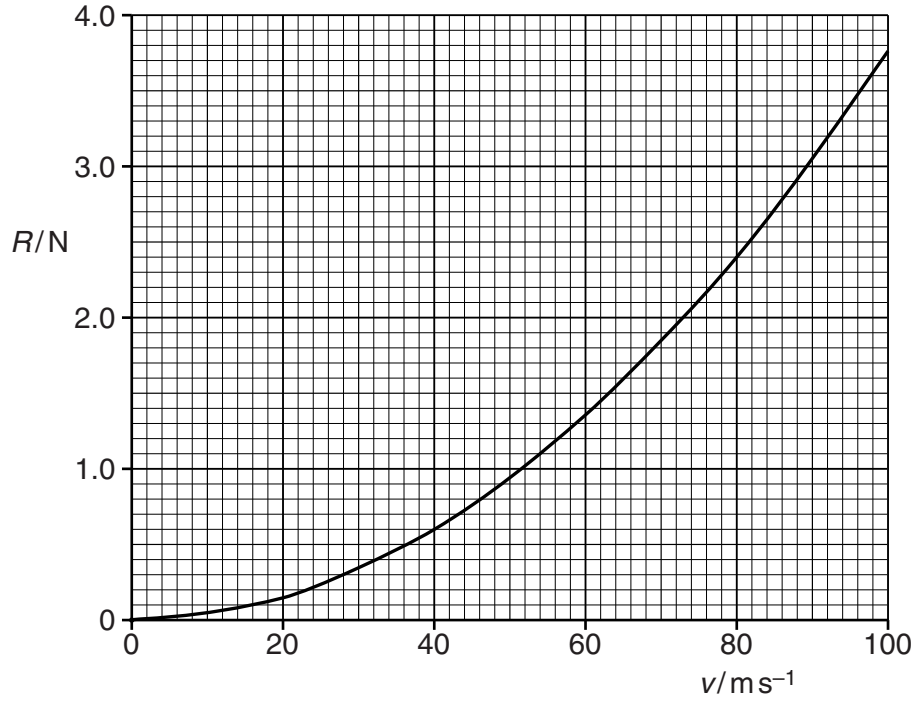

Fig. 3.2

(i) Use Fig. 3.2 to state and explain qualitatively the variation of the acceleration of the ball with the distance fallen by the ball.

.....

.....

.....

.....[3]

(ii) The speed of the ball reaches $40\,m\,s^{-1}$. Calculate its acceleration at this speed.

acceleration = ... $m\,s^{-2}$ [2]

(iii) Use information from **(a)(iii)** and Fig. 3.2 to state and explain whether the ball reaches terminal velocity.

.....

.....

.....[2]