2 A steel ball is projected horizontally from the top of a table, as shown in Fig. 2.1.

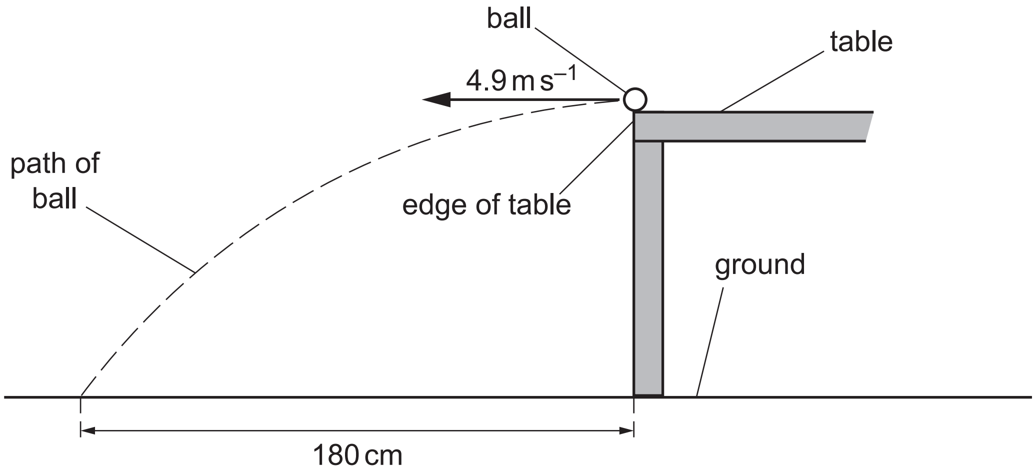

Fig. 2.1 (not to scale)

The ball is projected horizontally at a speed of 4.9 m s^{-1}. The ball lands on the ground a horizontal distance of 180 cm from the edge of the table.

Assume that air resistance is negligible.

(a) **(i)** Calculate the time taken for the ball to reach the ground.

time = ... s [1]

(ii) Calculate the vertical component of the velocity of the ball as it hits the ground.

velocity = ... m s^{-1} [2]

(iii) Determine the magnitude and the angle to the horizontal of the velocity of the ball as it hits the ground.

magnitude of velocity = ... $m\,s^{-1}$

angle to the horizontal = ... °

[3]

(b) The ball is projected by means of a compressed spring which is attached to a fixed block as shown in Fig. 2.2.

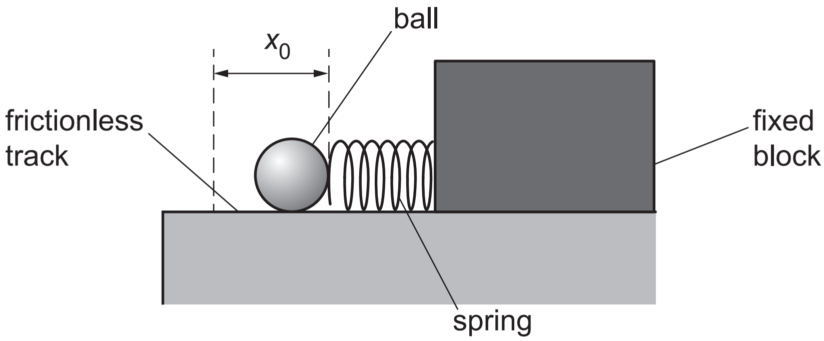

Fig. 2.2

The ball is placed on a frictionless track in front of the spring. The ball is then pulled back so that the spring has compression x_0.

When the spring is released, the ball is projected horizontally as shown in Fig. 2.3.

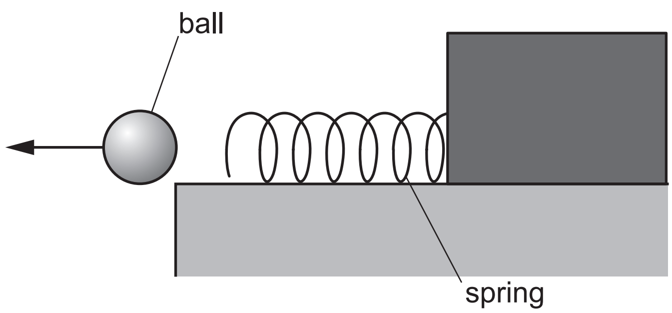

Fig. 2.3

The variation with compression x of the applied force F for the spring is shown in Fig. 2.4.

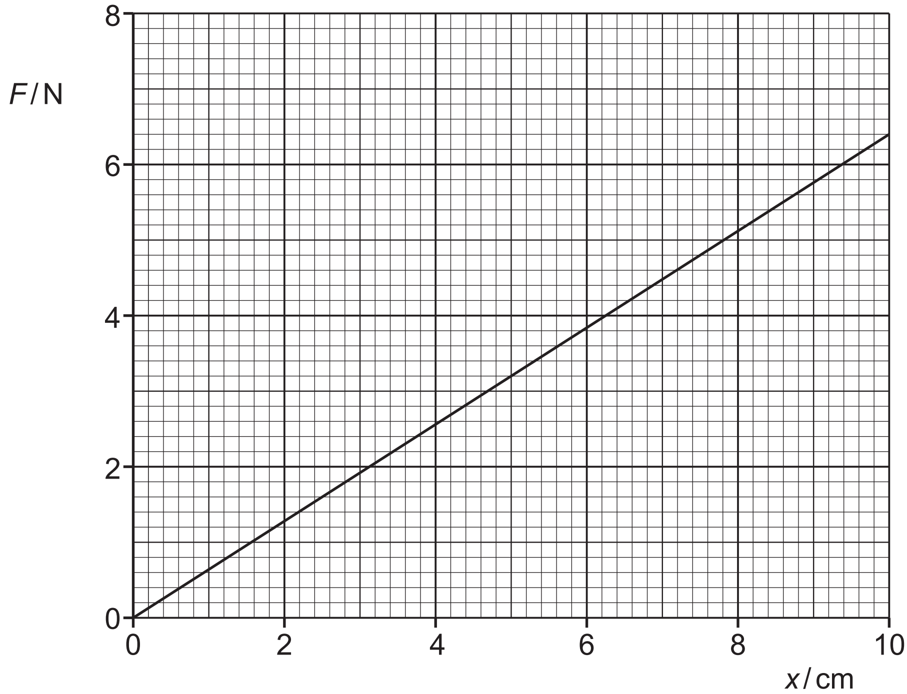

Fig. 2.4

The ball is a uniform sphere of steel of diameter 0.016 m and mass 0.017 kg.

(i) Calculate the density of the steel.

density = ... kg m^{-3} [3]

(ii) All of the elastic potential energy in the spring is converted into kinetic energy of the ball. The speed of the ball as it leaves the spring is 4.9 m s^{-1}.

Show that the maximum elastic potential energy of the spring is 0.20 J.

[2]

(iii) Use Fig. 2.4 to determine the spring constant k of the spring.

k = ... $N\,m^{-1}$ [2]

(iv) Use your answer in **(b)(iii)** and the value of energy given in **(b)(ii)** to determine the compression x_0 of the spring.

x_0 = ... m [2]

(c) The steel ball is replaced by a polystyrene ball of the same diameter but of much lower mass. The spring is given compression x_0 and is then released.

Air resistance on this ball is **not** negligible after it leaves the spring.

Explain:

(i) why this ball leaves the spring with a greater speed than that of the steel ball

....

....

.... [1]

(ii) why this ball takes a longer time to reach the ground than the steel ball.

....

....

.... [1]

[Total: 17]