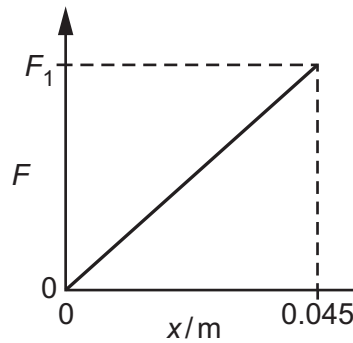


- 3 (a) A spring is fixed at one end and is compressed by applying a force to the other end. The variation of the force  $F$  acting on the spring with its compression  $x$  is shown in Fig. 3.1.



**Fig. 3.1**

A compression of 0.045 m is produced when a force  $F_1$  acts on the spring. The spring has a spring constant of  $800 \text{ N m}^{-1}$ .

- (i) Determine  $F_1$ .

$$F_1 = \dots\dots\dots \text{ N [2]}$$

- (ii) Use Fig. 3.1 to show that, for a compression of 0.045 m, the elastic potential energy of the spring is 0.81 J.

[2]

- (b) A child's toy uses the spring in (a) to launch a ball of mass 0.020 kg vertically into the air. The ball is initially held against one end of the spring which has a compression of 0.045 m. The spring is then released to launch the ball. The kinetic energy of the ball as it leaves the toy is 0.72 J.

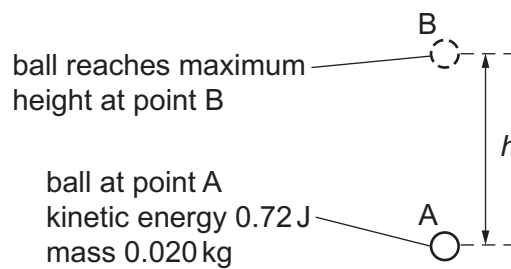
- (i) The toy converts the elastic potential energy of the spring into the kinetic energy of the ball. Use the information in (a)(ii) to calculate the percentage efficiency of this conversion.

$$\text{efficiency} = \dots\dots\dots \% [1]$$

- (ii) Determine the initial momentum of the ball as it leaves the toy.

momentum = ..... N s [3]

- (c) The ball in (b) leaves the toy at point A and moves vertically upwards through the air. Point B is the position of the ball when it is at maximum height  $h$  above point A, as illustrated in Fig. 3.2.



**Fig. 3.2** (not to scale)

The gravitational potential energy of the ball increases by 0.60 J as it moves from A to B.

- (i) Calculate  $h$ .

$h =$  ..... m [2]

- (ii) Determine the average force due to air resistance acting on the ball for its movement from A to B.

average force = ..... N [2]

- (iii) When there is air resistance, the ball takes time  $T$  to move from A to B.

State and explain whether the time taken for the ball to move from A to its maximum height will be more than, less than or equal to time  $T$  if there is **no** air resistance.

.....

..... [1]