Exercise 4.2 Impulse and force–time graphs

In this section the questions will help you become more familiar with the identity $J = Ft$ and to use force−time graphs to solve problems involving impulses.

1 **a** State what is meant by the term *impulse*.

b State the units of impulse.

TIP

Since momentum is a vector quantity, drawing a vector diagram may help to visualise the problem—and hence solve it.

2 Table 4.1 shows the momentum of a body before and after an interaction. For each example, determine the impulse.

	Momentum before interaction	Momentum after interaction
a	4.0 $kgms^{-1}$ vertically upwards	6.5 $kgms^{-1}$ vertically upwards
b	3.0 $kgms^{-1}$ vertically upwards	2 $kgms^{-1}$ vertically downwards
c	12.0 $kgms^{-1}$ horizontally	9.0 $kgms^{-1}$ vertically upwards

Table 4.1

3 A stationary pool ball, of mass 200 g, is struck by a cue with an average horizontal force of 60 N. If the contact time between the cue and the ball is 12 ms, calculate:

a the impulse felt by the ball.

b the speed of the ball immediately after impact.

4 A 60 kg woman jumps off a 3 m high wall onto the hard ground. Taking $g = 10\ Nkg^{-1}$,

a calculate the impulse felt by the woman as she lands on the ground.

b when the woman lands, her body moves a distance of 1.5 cm. Calculate the average force exerted on the woman's feet and legs by the hard ground.

c if the woman had bent her legs whilst landing, her body would have moved a distance of 50 cm. Compare the force she would have experienced whilst bending her legs to the force you calculated in **part b**.

d Comment on why it is sensible to bend one's legs when landing on the ground from a jump.

5 Explain, with reference to the terms *impulse*, *force* and *time*, how crumple zones on a modern car reduce the chance of injury to its passengers.

6 A force of 3.2 N acting on a mass of 600 g decreases uniformly over a period of 8.0 s until it becomes zero.

a Sketch a graph of the force acting on the 600 g mass.

b Use your graph to determine the impulse felt by the mass.

7 Figure 4.1 shows how the unbalanced force on an initially stationary object of mass 3 kg varies with time.

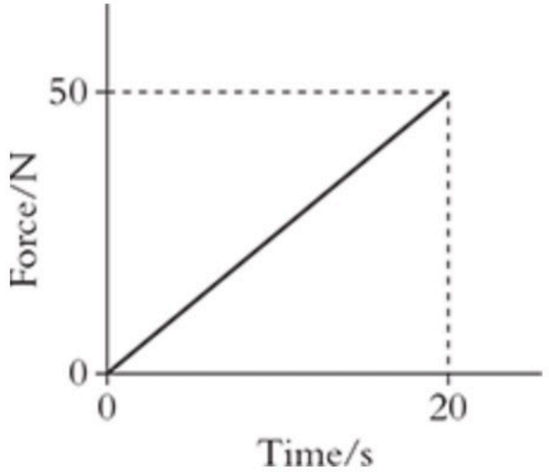

Figure 4.1

a Use the graph to determine the impulse experienced by the object.

b Sketch a graph of how the velocity of the object may be changing.

c Calculate the final velocity of the object.