Exercise 2.2 Newton's laws of motion

The questions in this section will help you to learn and use Newton's three laws of motion.

TIP
Try to learn formal definitions, such as Newton's laws of motion, word for word. They are often required in exams.

1　a　State Newton's first law of motion.

　　b　State what is meant by the term equilibrium.

　　c　Is it possible for a body to be in equilibrium if it is moving?

2　In which of the following situations is the body in equilibrium?

　　a　A helicopter is hovering 10 m above a landing site.

　　b　A car is travelling along a straight road at a constant speed.

　　c　A cyclist is riding around a bend in the road with a constant speed.

　　d　A skydiver is free-falling from an aeroplane at their terminal velocity.

3　a　State Newton's second law of motion.

　　b　Use Newton's second law to define the unit of force, the Newton.

　　c　Use Newton's second law to complete the following table.

Net force / N	Mass / kg	Acceleration / ms^{-2}
120	50	
900		4.5
	6	0.25

Table 2.2.1

4　A bullet accelerates along the barrel of a rifle. Its speed changes from 0 ms^{-1} to 1500 ms^{-1} in a time of 0.1 s. The mass of the bullet is 0.05 kg. Calculate the average force acting on the bullet.

5 Figure 2.5 shows the free-body force diagram for a 12 g paper cone falling through the air.
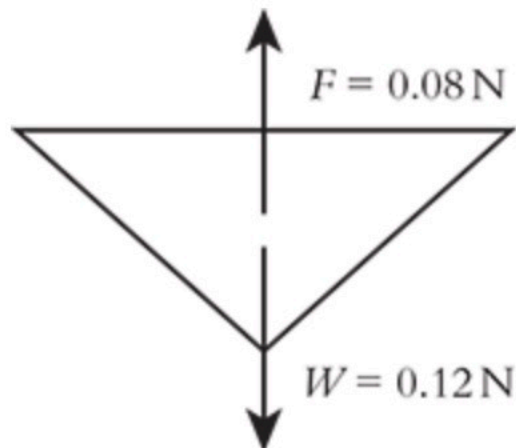

$F = 0.08\,\text{N}$

$W = 0.12\,\text{N}$

Figure 2.5

a Calculate the acceleration of the paper cone.

b Sketch a graph of *acceleration of the cone* against *time* for the next few seconds of its fall.

c Explain the shape of your graph using Newton's laws of motion.

6 a State Newton's third law of motion.

b Comment on whether the following pairs of forces are examples of Newton's third law pairs.

i The gravitational force of the Moon on the Earth and the gravitational force of the Earth on the Moon

ii The weight of a book resting on a table and the normal contact force of the table on the book

iii The electrical force exerted by a proton on an electron in a hydrogen atom and the electrical force exerted by the electron on the proton

iv The force exerted by a raindrop as it hits the ground and the force of the ground on the raindrop

7 Consider a person of mass 60 kg standing on a set of weighing scales in an elevator.

a If the elevator is moving at a constant speed, determine the reading on the weighing scales.

b i If the elevator is accelerating downwards with an acceleration of $0.25g$, determine the reading on the weighing scales. ($g = 9.81\ \text{ms}^{-2}$)

ii How does this make the person feel?

c i If the elevator is accelerating upwards with an acceleration of $0.2g$, determine the reading on the weighing scales. ($g = 9.81\ \text{ms}^{-2}$)

ii How does this make the person feel?

8 **a** Outline the way in which we are able to *know* things in the natural sciences.

b Outline what is meant by the term *law* in the natural sciences.

c Is it ever possible to *prove* a law in the natural sciences?

d How has our understanding of Newton's laws of motion changed as a result of Einstein's ideas about relativity?