Forces 3

Name: _____

Class: _____

Date: _____

Time: **70 minutes**

Marks: **64 marks**

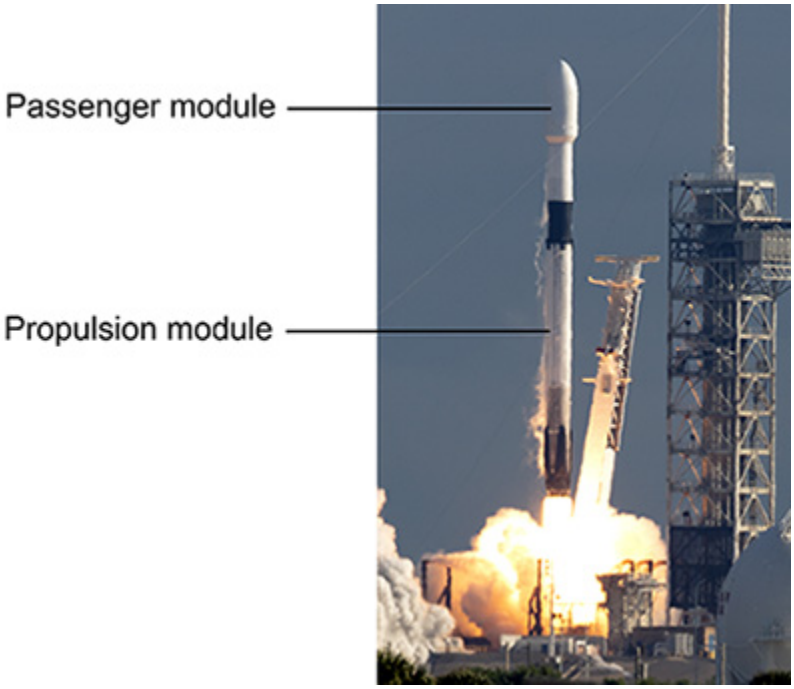
Comments:

1. Rockets have been developed so that people who are not trained astronauts can pay to travel to space.

Figure 1 shows the passenger module and the propulsion module of a rocket.

The propulsion module burns a large volume of fuel.

Figure 1



(a) The rocket was initially stationary on the ground.

Then the rocket accelerated upwards until it reached a height of 40 km.

The constant acceleration of the rocket was 6.48 m/s^2.

Calculate the velocity of the rocket at a height of 40 km.

Use the Physics Equations Sheet.

Velocity = _____ m/s

(4)

(b) Explain how the weight of the rocket changed as it accelerated upwards.

(3)

(c) At a height of 40 km, the rocket stopped burning fuel.

The rocket continued upwards to its maximum height of 60 km.

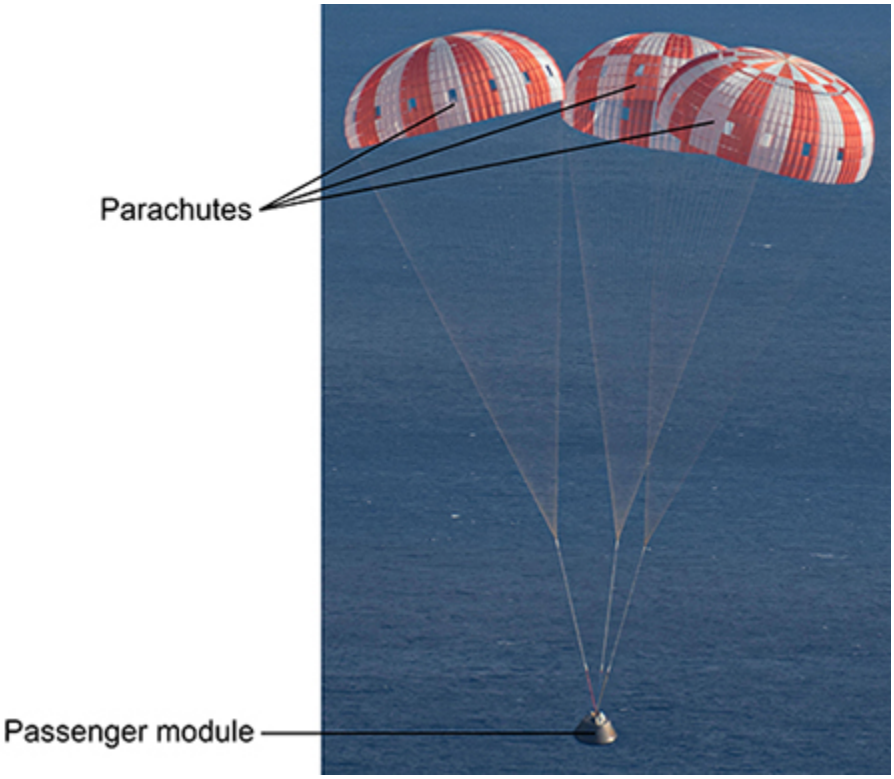
Explain why the velocity of the rocket decreased between a height of 40 km and a height of 60 km.

(3)

(d) At a height of 60 km the two modules of the rocket separated and the passenger module fell back to Earth.

Figure 2 shows the passenger module falling towards the Earth's surface.

Figure 2



Using parachutes causes the passenger module to fall with a lower terminal velocity than if parachutes were not used.

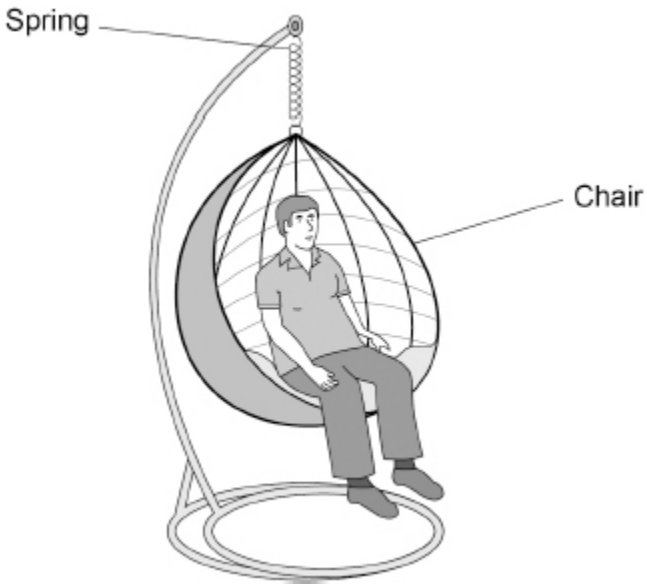
Explain why the parachutes allow the passenger module to fall with a lower terminal velocity.

(3)

(Total 13 marks)

2. **Figure 1** shows a garden chair hanging from a spring.

Figure 1



The weight of the person causes the spring to extend.

(a) Why does the weight of the person cause the spring to extend?

Tick (✓) **one** box.

Weight acts downwards ☐

Weight acts in all directions ☐

Weight acts upwards ☐

(1)

(b) Complete the sentence.

Choose the answer from the box.

a gravitational	**a frictional**	**an electrostatic**

The weight of the person in **Figure 1** is _____ force.

(1)

The weight of the person causes an extension in the spring of 0.070 m.

The spring constant of the spring is 12 000 N/m.

(c) Calculate the weight of the person.

Use the equation:

weight = spring constant × extension

_____

_____

_____

Weight = _____ N

(2)

(d) Calculate the elastic potential energy stored in the extended spring.

Use the equation:

elastic potential energy = 0.5 × spring constant × (extension)^2

_____

_____

_____

Elastic potential energy = _____ J

(2)

(e) If there is more than one person on the chair, the spring could become inelastically deformed.

What is meant by 'inelastically deformed'?

Tick (✓) **one** box.

The spring extends more when two or more forces act on it. ☐

The spring will not go back to its original length when the force is removed. ☐

The spring extends so that it is twice as long as its original length. ☐

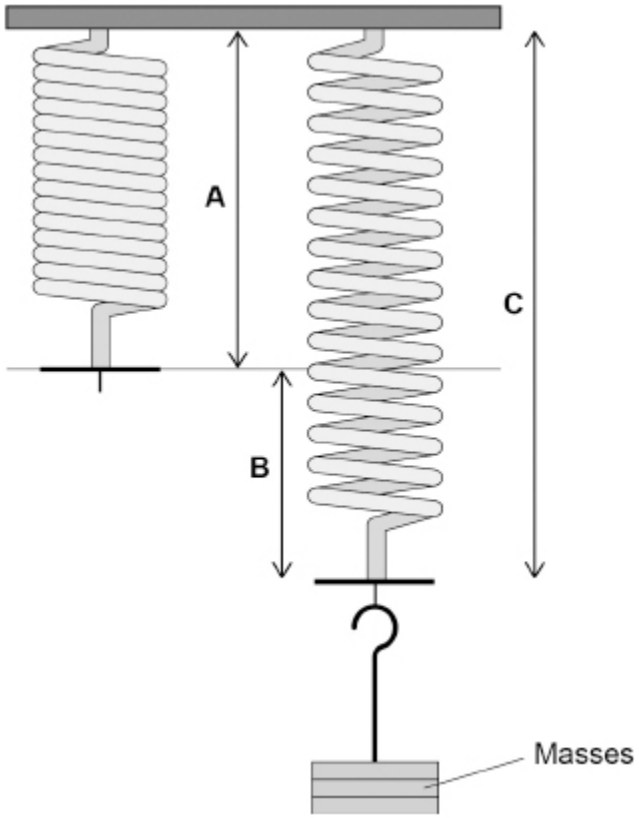
(1)

The manufacturer of the chair investigated the extension of a new spring.

(f) **Figure 2** shows slotted masses hanging from the spring.

The weight of the masses extends the spring.

Figure 2



Which length in **Figure 2** represents the extension of the spring?

Tick (✓) **one** box.

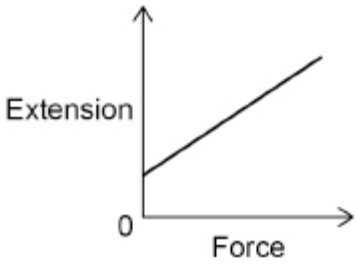
A ☐ **B** ☐ **C** ☐

(1)

(g) Which graph shows that the extension of the spring is directly proportional to the force applied to the spring?

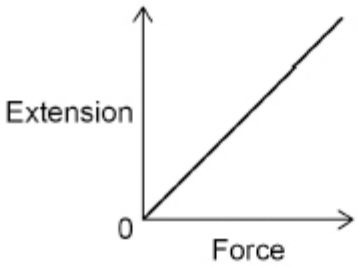
Tick (✓) **one** box.

A



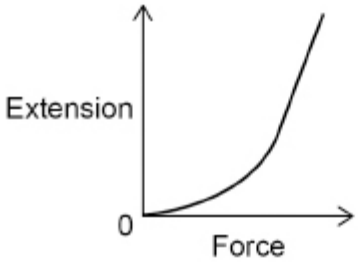
☐

B



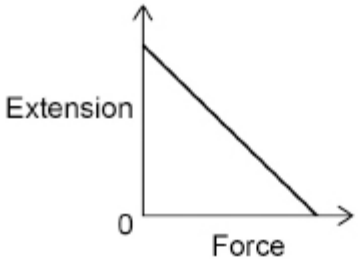
☐

C



☐

D



☐

(1)

(h) The table below shows the results of the manufacturer's investigation.

Force in newtons	Extension in metres
100	0.008
200	0.016

Suggest **two** improvements to the investigation.

1 _____

_____

2 _____

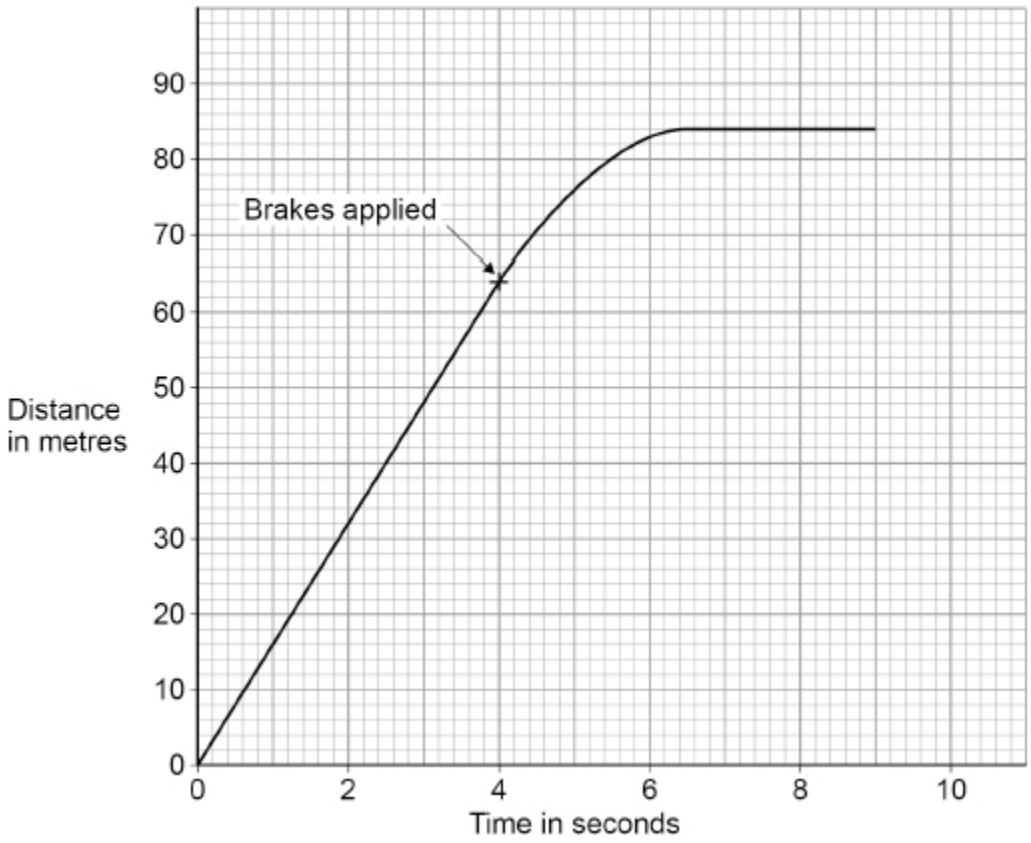
_____

(2)

(Total 11 marks)

3. A car contains a device called a black box. The black box records the distance travelled and the time taken for each journey.

The figure below shows the distance–time graph for part of a journey.



(a) Which feature of **Figure 1** shows that the car travels at a constant speed for the first 4 seconds?

Tick (✓) **one** box.

The line becomes horizontal. ☐

The line goes through the origin. ☐

The line is straight. ☐

(1)

(b) After 4 seconds the driver applied the brakes and the car slowed down and stopped.

The distance the car travelled after the brakes were applied is called the braking distance.

Determine the braking distance of the car.

Use **Figure 1**.

_____

_____

_____

Braking distance = _____ m

(2)

The black box also records the deceleration of the car.

(c) As the car decelerates, the velocity of the car changes by 16 m/s.

The car decelerates for 2.5 seconds.

Calculate the deceleration of the car.

Use the equation:

$$\text{deceleration} = \frac{\text{change in velocity}}{\text{time taken}}$$

_____

_____

Deceleration = _____ m/s^2

(2)

(d) If the black box records large decelerations, it identifies that the driving may be dangerous.

Why can large decelerations be dangerous?

Tick (✓) **two** boxes.

- The brakes on the car can overheat. ☐
- The driver may lose control of the car. ☐
- The force applied by the brakes is very small. ☐
- The reaction time of the driver increases. ☐
- The thinking distance is very short. ☐

(2)

(e) The black box monitors the speed of the car.

Describe how speed affects braking distance.

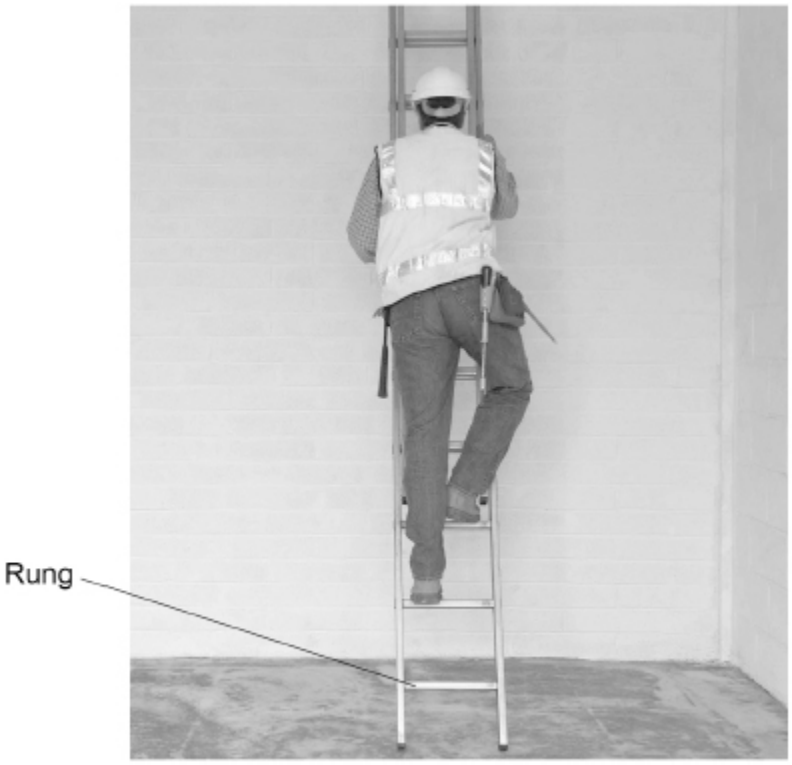
_____

_____

(1)

(Total 8 marks)

4. The figure below shows an engineer climbing up a ladder.



The distance between each rung on the ladder is 30 cm.

(a) What is 30 cm in metres?

Tick (✓) **one** box.

0.030 m	☐	0.30 m	☐	3.0 m	☐	30 m	☐

(1)

(b) The engineer has a weight of 710 N.

Calculate the work done when climbing up one rung of the ladder.

Use your answer to part (a) and the equation:

work done = force × distance

_____

_____

_____

Work done = _____ Nm

(2)

(c) The engineer climbs the ladder carrying some equipment.

Give the reason why carrying equipment increases the work done by the engineer when climbing the ladder.

_____

_____

(1)

(d) The engineer is stationary at the top of the ladder.

Which energy stores of the engineer increase due to the engineer climbing the ladder?

Tick (✓) **two** boxes.

Chemical ☐

Elastic potential ☐

Gravitational potential ☐

Kinetic ☐

Thermal ☐

(2)

Use the Physics Equations Sheet to answer parts (e) and (f).

(e) Write down the equation that links gravitational field strength (*g*), mass (*m*) and weight (*W*).

_____

_____

(1)

(f) The engineer has a weight of 710 N.

gravitational field strength = 9.8 N/kg

Calculate the mass of the engineer.

Give your answer to 2 significant figures.

_____

_____

_____

_____

_____

_____

_____

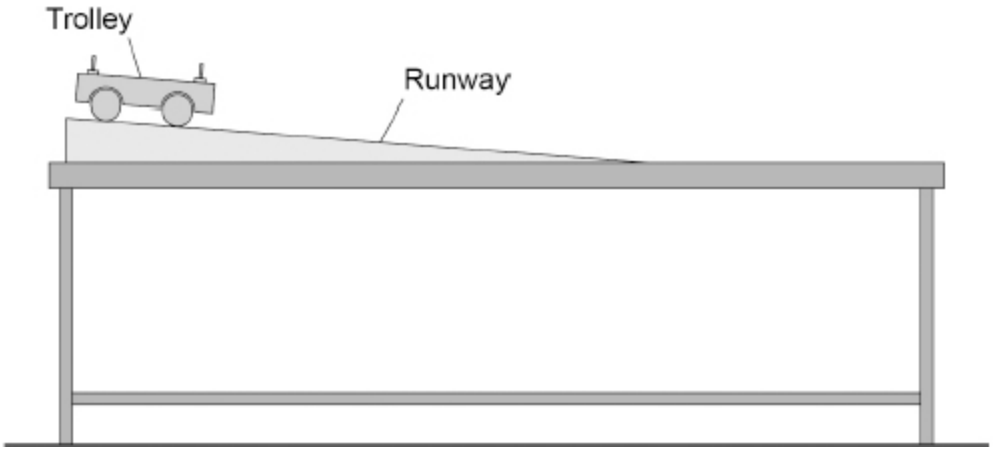
Mass (2 significant figures) = _____ kg

(4)

(Total 11 marks)

5. A student investigated how the acceleration of a trolley is affected by the force acting on the trolley.

The figure below shows some of the equipment used.



(a) Describe a method the student could use.

Your answer should include any extra equipment needed.

(6)

The table below shows one set of results for a similar investigation.

Resultant force in newtons	**Acceleration in m/s^2**
1.2	1.6

(d) Which of Newton's laws predicts that the acceleration of the trolley is proportional to the resultant force on the trolley?

Tick (✓) **one** box.

First law ☐

Second law ☐

Third law ☐

(1)

(c) Determine the acceleration of the trolley when the resultant force is 3.6 N.

Use the table above.

Acceleration = _____ m/s^2

(2)

Use the Physics Equations Sheet to answer parts (d) and (e).

(d) Write down the equation that links acceleration (*a*), mass (*m*) and resultant force (*F*).

(1)

(e) A resultant force of 0.42 N acts on a different trolley.

The acceleration of the trolley is 1.2 m/s^2.

Calculate the mass of the trolley.

Mass of trolley = _____ kg

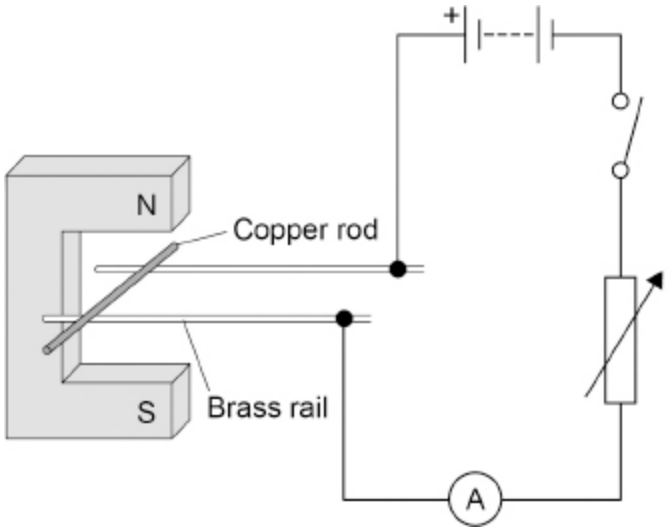
(3)

(Total 13 marks)

6. A teacher demonstrated the motor effect.

Figure 1 shows the equipment used. The equipment includes a permanent magnet.

Figure 1



(a) The copper rod remains stationary while the switch is open.

Complete the sentence.

The tendency for an object to remain stationary is

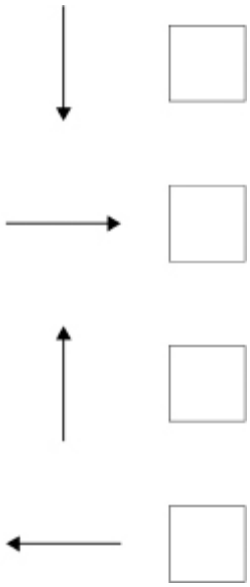
called _____.

(1)

When the switch is closed the copper rod accelerates.

(b) In which direction will the copper rod accelerate?

Tick (✓) **one** box.



(1)

(c) Explain **one** way the teacher could increase the acceleration of the copper rod.

_____

_____

_____

_____

(2)

(d) The magnet used in the demonstration was a permanent magnet.

Figure 2 shows an iron bar and a permanent magnet.

Figure 2

Describe how the permanent magnet could be used to test if the iron bar is also a permanent magnet.

_____

_____

_____

_____

(2)

(e) **Figure 3** shows a magnetic compass used by walkers.

Figure 3

Explain how a magnetic compass provides evidence that the Earth has a magnetic field.

_____

_____

_____

_____

(2)

(Total 8 marks)

1. (a) s = 40 000

1

v^2 (- 0^2) = 2 × 6.48 × 40 000

allow v^2 = 518 400

allow a correct substitution using an incorrectly / not converted value of height

1

$v = \sqrt{(2 \times 6.48 \times 40\,000)}$

allow a correct rearrangement using an incorrectly / not converted value of height

1

v = 720 (m/s)

allow a correct calculation using an incorrectly / not converted value of height

1

(b) weight depends on mass and gravitational field strength

allow weight = mass × gravitational field strength
allow W = mg

1

mass decreases (as fuel is burned)
or
gravitational field strength decreases

1

therefore the weight decreases

dependent on MP2

if no other marks are awarded
*allow **1** mark for the weight decreases because the fuel is used*

1

(c) gravitational force acts on the rocket (in the opposite direction to the motion of the rocket)

allow air resistance acts on the rocket (in the opposite direction to the motion of the rocket)

1

(and) there are no forces in the direction that the rocket is moving

1

(so) resultant force is towards the Earth

allow so the rocket decelerates if MP1 or MP2 awarded

1

(d) parachutes increase the effective area

1

(so) there is the same air resistance at a lower speed

1

(so) resultant force is zero at a lower speed (with the parachutes open)

allow air resistance is equal to weight at a lower speed (with the parachutes open)

1

[13]

2. (a) weight acts downwards

1

(b) a gravitational

1

(c) $W = 12\ 000 \times 0.070$

1

$W = 840$ (N)

1

(d) $E_e = 0.5 \times 12\ 000 \times (0.070)^2$

1

$E_e = 29.4$ (J)

allow 29 (J)

1

(e) the spring will not go back to its original length when the force is removed

1

(f) B

1

(g) B

1

(h) any **two** from:

- use a greater range of forces

  allow test more forces
- use forces that are similar to the weight of a person
- test more (identical) springs
- find the limit of proportionality

  allow elastic limit
- repeat (discard anomalous results) and calculate a mean

2

[11]

3. (a) the line is straight

1

(b) 64 **and** 84 read from graph

1

braking distance = 20 (m)

do not accept if readings from the graph are incorrect

1

(c) $a = \frac{16}{2.5}$

1

a = 6.4 (m/s^2)

ignore negative signs

1

(d) the brakes on the car can overheat

1

the driver may lose control of the car

1

(e) the greater the speed the greater the braking distance

1

[8]

4. (a) 0.30 (m)

1

(b) W = 710 × 0.30

1

W = 213 Nm

allow ecf from part (a)

1

(c) force / weight is greater

1

(d) gravitational potential

1

thermal

1

(e) weight = mass × gravitational field strength

or

$W = mg$

1

(f) $710 = m \times 9.8$

1

$$m = \frac{710}{9.8}$$

1

$m = 72.4...$

1

$m = 72$ (kg)

this mark can only be awarded if the correct equation is used and a value of m is calculated

1

[11]

5. (a) **Level 3:** The plan would lead to the production of a valid outcome. All key steps are identified and logically sequenced.

5-6

Level 2: The plan would not necessarily lead to a valid outcome. Most steps are identified, but the plan is not fully logically sequenced.

3-4

Level 1: The plan would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.

1-2

No relevant content

0

Indicative content

method of varying force

- clamp a pulley onto the edge of the desk
- attach a string to the trolley and place the string over the pulley
- attach a mass holder to the string

or

- vary the height of the runway
- use wooden blocks

measurements

- place a slotted mass on the mass holder
- use $W = mg$ to calculate the force
- mark the starting and finishing points of the trolley on the runway
- measure the distance between the two marks with a metre rule
- time how long it takes to travel between the two marks with a stopclock / timer
- use $v = \frac{s}{t}$ and $a = \frac{\Delta v}{t}$

or

- use light gate(s) to determine time and / or speed
- computer calculates acceleration

- repeat for different numbers of slotted masses

allow a description of a method using a ticker timer

(b) second law

1

(c) $\frac{3.6}{1.2} = 3$

1

$1.6 \times 3 = 4.8$ (m/s^2)

OR

(use of $F = ma$)

$m = \frac{1.2}{1.6} = 0.75$ (1)

$a = \frac{3.6}{0.75} = 4.8$ (m/s^2) (1)

1

(d) resultant force = mass × acceleration

or

$F = ma$

1

(e) $0.42 = m \times 1.2$

1

$m = \frac{0.42}{1.2}$

1

$m = 0.35$ kg

1

[13]

6. (a) inertia

1

(b)

1

(c) increase the current

allow use a stronger magnet

1

so that the (resultant) force increases

1

(d) bring the (same end of the) iron bar close to each pole / end of the permanent magnet

allow bring each end of the iron bar to the same pole of the magnet

1

any repulsion shows the iron bar is a permanent magnet

or

if one end of the iron bar is attracted to both poles it is not a permanent magnet

1

(e) the compass (needle always) points in the same direction

allow the compass (needle always) points north

1

because it aligns itself with the Earth's magnetic field

dependent on MP1

1

[8]