Forces 5

Name: _____

Class: _____

Date: _____

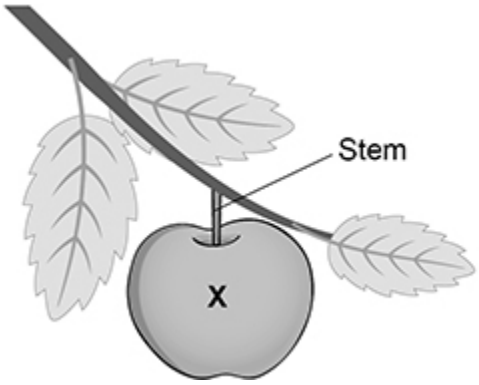
Time: **82 minutes**

Marks: **75 marks**

Comments:

1. The figure below shows a stationary apple hanging from a tree.

The **X** marks the centre of mass of the apple.



(a) Draw **two** arrows on the figure above to show the forces acting on the apple.

(2)

(b) It takes 0.50 s for the apple to fall to the ground.

The initial velocity of the apple is 0 m/s

acceleration due to gravity = 9.8 m/s^2

Calculate the distance fallen by the apple.

Use the Physics Equations Sheet.

Distance = _____ m

(6)

(c) In part (b) it was assumed that the acceleration was a constant 9.8 m/s^2

Evaluate this assumption.

(4)

(Total 12 marks)

2. The stopping distance of a car is the sum of the thinking distance and the braking distance.

(a) The thinking distance is affected by the reaction time of the driver.

Which **two** of the following can affect the reaction time of the driver?

Tick (✓) **two** boxes.

Damaged brakes	☐
Taking drugs	☐
Tiredness	☐
Wet roads	☐
Worn tyres	☐

(2)

Scientists measured the reaction time for drivers of different ages.

The graph below shows the results.

(b) At what age did the drivers have the lowest mean reaction time?

Age = _____ years

(1)

(c) What was the lowest mean reaction time?

Time = _____ seconds

(1)

The braking distance of a car is the distance travelled between the driver applying the brakes and the car stopping.

(d) Complete the sentences.

Choose answers from the box.

Each answer may be used once, more than once or not at all.

decreases	**stays the same**	**increases**

When the brakes are applied, the kinetic energy of the car _____.

The temperature of the brakes _____.

(2)

(e) A car is travelling at a speed of 12 m/s.

The driver applies the brakes and the car decelerates at a constant 3.0 m/s^2.

Calculate the braking distance of the car.

Use the equation:

$$\text{braking distance} = \frac{(\text{speed})^2}{2 \times \text{deceleration}}$$

Choose the unit from the box.

m	**kg**	**s**

_____

_____

_____

_____

_____

Braking distance = _____ Unit _____

(3)

(f) To pass the UK driving test, people must know the typical stopping distance of a car at certain speeds.

Suggest **one** reason why.

_____

_____

(1)

(Total 10 marks)

3. Forces are either contact forces or non-contact forces.

(a) Which of the following is a non-contact force?

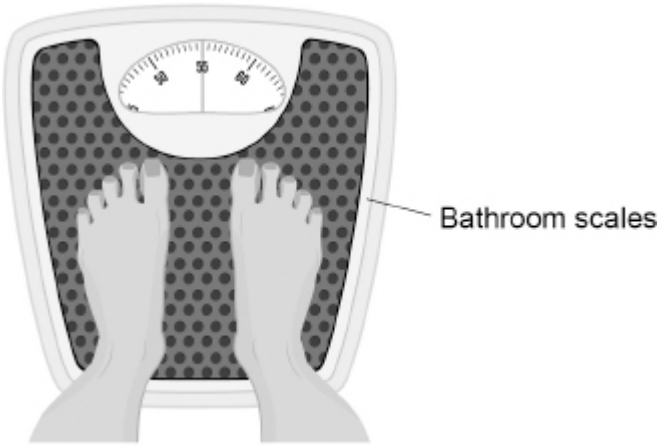
Tick (✓) **one** box.

Electrostatic force	☐
Friction force	☐
Tension force	☐

(1)

Figure 1 shows a person standing on some bathroom scales.

Figure 1



The person exerts a downward force on the scales and the scales exert an upward force on the person.

(b) Which sentence about the forces is true?

Tick (✓) **one** box.

The downward force is less than the upward force.	☐
The downward force is the same size as the upward force.	☐
The downward force is greater than the upward force.	☐

(1)

(c) What is the name of the upward force on the person?

Tick (✓) **one** box.

Air resistance	☐
Normal contact force	☐
Weight	☐

(1)

(d) The person on the scales has a mass of 55 kg.

gravitational field strength = 9.8 N/kg

Calculate the weight of the person.

Use the equation:

weight = mass × gravitational field strength

_____

_____

_____

Weight = _____ N

(2)

(e) The gravitational field strength is **not** the same at all points on the surface of the Earth.

The gravitational field strength is weakest at the equator.

A person travelled from the UK to the equator.

What happened to the weight of the person?

Tick (✓) **one** box.

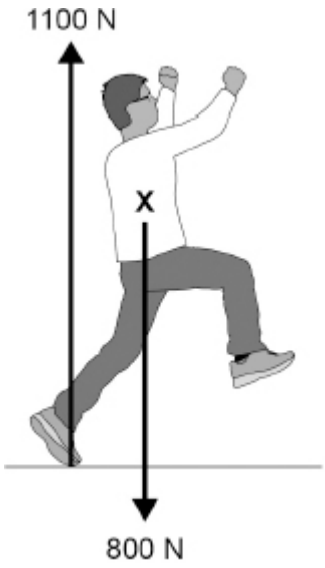
The weight decreased.	☐
The weight remained the same.	☐
The weight increased.	☐

(1)

Figure 2 shows the forces acting on a person.

The person is about to jump.

Figure 2



(f) The arrow representing the weight of the person is drawn from point **X**.

What is the name given to point **X**?

Tick (✓) **one** box.

Centre of force ☐

Centre of mass ☐

Centre of weight ☐

(1)

(g) Determine the size of the resultant force on the person in **Figure 2**.

_____

_____

Resultant force = _____ N

(1)

(Total 8 marks)

4. Scientists are developing a rocket aeroplane designed to travel much faster than jet aeroplanes.

(a) The rocket aeroplane must accelerate along a runway to take off.

What would happen to the air resistance acting on the rocket aeroplane as it accelerates?

_____

_____

(1)

(b) An upward force called lift will act on the wings of the rocket aeroplane when it moves.

Complete the sentence.

Choose the answer from the box.

less than	**denatured**	**the same as**

As the rocket aeroplane starts to accelerate along the runway, the lift force on the wings will be _____ the weight of the rocket aeroplane.

(1)

(c) During the first 14 seconds the average speed of the rocket aeroplane on the runway will be 35 m/s.

Calculate the distance that the rocket aeroplane will travel during the first 14 seconds.

Use the equation:

distance travelled = average speed × time

_____

_____

_____

Distance travelled = _____ m

(2)

(d) Write down the equation which links distance (*s*), force (*F*) and work done (*W*).

_____

(1)

(e) When the rocket aeroplane travels a distance of 270 m on the runway the engines will do 54 000 000 J of work.

Calculate the average force exerted by the engines.

_____

_____

_____

_____

_____

Average force = _____ N

(3)

(f) The rocket aeroplane will fly at a greater height than a jet aeroplane.

The height that an aeroplane flies at affects the radiation dose a passenger will receive each hour.

The table below shows the speed of each aeroplane and the radiation dose a passenger will receive each hour.

Aeroplane	**Speed in metres per second**	**Radiation dose each hour in millisieverts**
Rocket aeroplane	8000	0.006
Jet aeroplane	250	0.003

Exposure to ionising radiation has risks and possible consequences.

Evaluate the risks and possible consequences of flying in a rocket aeroplane and in a jet aeroplane.

Assume the same journey is made in each aeroplane.

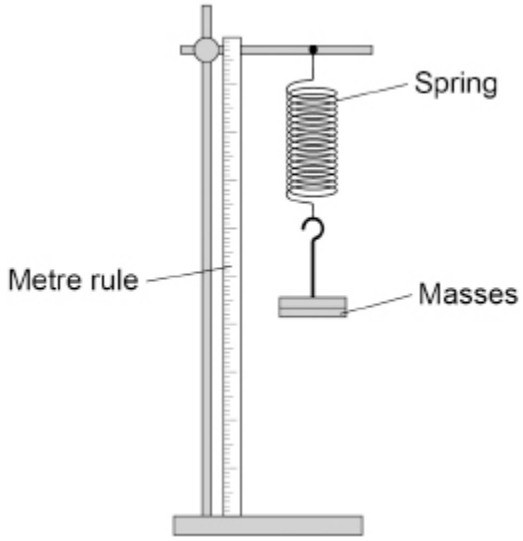
Use values from the table above.

(6)

(Total 14 marks)

5. The figure below shows a stretched spring.

The spring is elastically deformed.



(a) What is meant by 'elastically deformed'?

Tick (✓) **one** box.

As the force on the spring increases the length of the spring increases. ☐

Only a very small force is needed to stretch the spring. ☐

The force on the spring causes it to change shape. ☐

The spring will return to its original length when the force is removed. ☐

(1)

(b) Describe a method to determine the extension of the spring.

_____

_____

_____

_____

(2)

(c) The extension of the spring is 80 mm.

spring constant = 40 N/m

Calculate the elastic potential energy of the spring.

Use the Physics Equations Sheet.

Elastic potential energy = _____ J

(3)

(d) Write down the equation which links extension (*e*), force (*F*) and spring constant (*k*).

(1)

(e) A force of 300 N acts on a different spring.

The force causes the spring to extend by 0.40 m.

Calculate the spring constant of the spring.

Spring constant = _____ N/m

(3)

(Total 10 marks)

6. Professional rugby players wear a tracking device that measures their velocity and acceleration.

Figure 1 shows a player wearing a tracking device.

The player is tackling another player who is running with the ball.

Figure 1

(a) Velocity and acceleration are both vector quantities.

What is a vector quantity?

Tick (✓) **one** box.

A quantity with both magnitude and direction ☐

A quantity with direction only ☐

A quantity with magnitude only ☐

(1)

(b) Which of the following is a vector quantity?

Tick (✓) **one** box.

Displacement ☐

Distance ☐

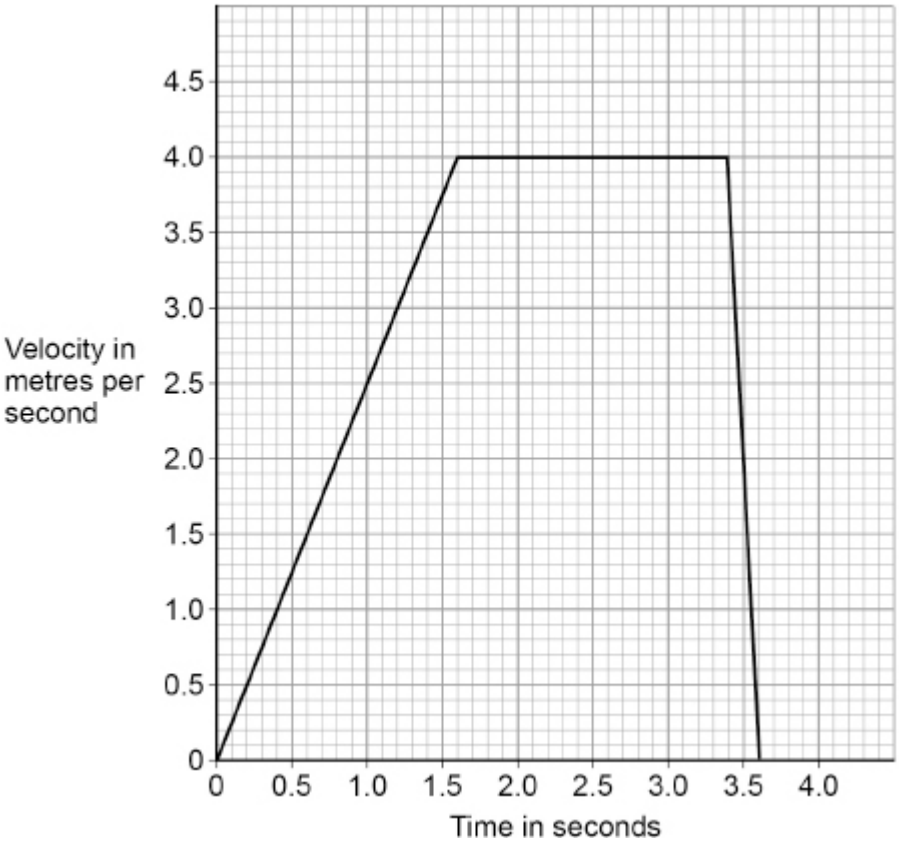
Time ☐

Work done ☐

(1)

Figure 2 shows a velocity–time graph for the player running with the ball.

Figure 2



(c) Determine the acceleration of the player between 0 and 1.6 s.

Acceleration = _____ m/s^2

(2)

(d) Describe the motion of the player between 3.4 s and 3.6 s.

(1)

The force exerted on the player when she is tackled causes her to accelerate.

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

(1)

(f) The player accelerates at 25 m/s^2 when a resultant force of 1800 N acts on her.

Calculate the mass of the player.

Mass = _____ kg

(3)

(g) The tracking device sends data to a computer during the game.

Suggest **one** advantage of the data being sent during the game.

(1)

(Total 10 marks)

7. Scientists are developing a hypersonic aeroplane that will travel much faster than normal aeroplanes.

(a) An aeroplane accelerates from a low speed to a high speed with the engines at maximum power.

Explain why the acceleration is **not** constant.

(5)

(b) The hypersonic aeroplane will have jet engines and a rocket engine.

The speed of aeroplanes can be measured on a uniform scale called the Mach scale.

Mach 1 = 330 m/s

The jet engines will accelerate the aeroplane to Mach 5.5.

The rocket engine will accelerate the aeroplane from Mach 5.5 to Mach 25.5 in 300 s.

The average resultant force on the aeroplane when the rocket engine is used will be 630 000 N.

Calculate the mass of the hypersonic aeroplane.

Give your answer to 2 significant figures.

Mass (2 significant figures) = _____ kg

(6)

(Total 11 marks)

1.

(a) two vertical arrows in opposite directions away from point **X**

allow if the upwards arrow starts from the stem

ignore any labels

1

both arrows the same length

dependent on MP1

1

(b) $9.8 = \frac{\Delta v}{0.5}$

1

$\Delta v = 9.8 \times 0.5$

1

final velocity = Δv = 4.9 (m/s)

1

$4.9^2 - 0^2 = 2 \times 9.8 \times s$

allow a correct substitution of an incorrectly calculated value of final velocity

1

$s = \frac{4.9^2}{2 \times 9.8}$

allow a correct rearrangement of an incorrectly calculated value of final velocity

1

s = 1.2 m

allow 1.23 or 1.225

*do **not** accept 1.22*

allow a correct calculation using an incorrectly calculated value of final velocity

1

(c) as the apple falls / accelerates air resistance increases

allow there is air resistance acting on the apple as it falls

1

so resultant force decreases

1

so acceleration will decrease

MP3 dependent on MP1 or MP2 being awarded

1

acceleration will not be constant, so not a good assumption

MP4 dependent on MP1 or MP2 being awarded

1

OR

the apple only falls for a short time/distance (1)

air resistance is negligible (1)

so resultant force is constant (1)

MP3 dependent on MP1 or MP2 being awarded

therefore acceleration is constant, so good assumption (1)

MP4 dependent on MP1 or MP2 being awarded

[12]

2. (a) taking drugs

1

tiredness

1

(b) 24 (years)

1

(c) 0.55 (s)

allow answer in range 0.54 to 0.56

1

(d) decreases

this order only

1

increases

1

(e) braking distance = $\frac{(12)^2}{(2 \times 3)}$

1

braking distance = 24

1

unit = m

1

(f) so they know how far behind another car they should drive

or

so they can stop safely if the car in front stops

1

[10]

3. (a) electrostatic force

1

(b) the downward force is the same size as the upward force

1

(c) normal contact force

1

(d) W = 55 × 9.8

1

539 (N)

allow 540 (N)

1

(e) the weight decreased

1

(f) centre of mass

1

(g) 300 (N)

1

[8]

4. (a) (air resistance) increases

1

(b) less than

1

(c) s = 35 × 14

1

s = 490 (m)

1

(d) work done = force × distance

or

W = Fs

1

(e) 54 000 000 = F × 270

1

$$F = \frac{54\,000\,000}{270}$$

1

F = 200 000 (N)

1

(f) **Level 2:** Scientifically relevant features are identified; the way(s) in which they are similar/different is made clear and (where appropriate) the magnitude of the similarity/difference is noted.

4–6

Level 1: Relevant features are identified and differences noted.

1–3

No relevant content

0

Indicative content

- distance travelled is the same for each aeroplane
- time in the air is much greater for jet aeroplane
- speed of rocket plane is much greater
- speed of rocket plane is 32 times greater
- radiation dose each hour greater for rocket aeroplane
- radiation dose each hour is 2 times greater for rocket aeroplane
- overall radiation dose is less for rocket plane
- dose in jet aeroplane is 16 times greater overall
- much higher risk in jet aeroplane
- increased risk of skin cancer
- increased risk of gene mutation and cancer

To access level 2, there must be a relevant calculation.

[14]

5. (a) the spring will return to its original length when the force is removed

1

(b) measure the original length of the spring **and** the extended length of the spring (with the metre rule)

1

extension = extended length – original length

1

(c) e = 0.080 m

1

$E_e = 0.5 \times 40 \times (0.080)^2$

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

1

$E_e = 0.128$ (J)

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

1

(d) force = spring constant × extension
or
F = k e

1

(e) $300 = k \times 0.40$

1

$$k = \frac{300}{0.40}$$

1

$k = 750$ (N/m)

1

[10]

6. (a) a quantity with both magnitude and direction

1

(b) displacement

1

(c) gradient = $\frac{(4 - 0)}{(1.6 - 0)}$

1

acceleration = 2.5 m/s^2

allow use of $a = \Delta v / t$

1

(d) constant deceleration

allow large deceleration allow decelerates to a stop

1

(e) resultant force = mass × acceleration

or

$F = ma$

allow force = mass × acceleration

1

(f) $1800 = m \times 25$

1

$$m = \frac{1800}{25}$$

1

$m = 72$ (kg)

1

(g) performance can be monitored during the game

allow do not have to wait until the end of the game to download data

1

[10]

7. (a) at maximum power the forward force of the engines is constant

1

as it accelerates the air resistance increases

1

resultant force = force from engines – air resistance

1

therefore resultant force decreases

1

acceleration is directly proportional to resultant force

1

(b) $\Delta v = (25.5 - 5.5) \times 330$

allow 6600 m/s

1

$$a = \frac{((25.5 \times 330) - (5.5 \times 330))}{300}$$

allow a correct substitution using incorrectly / not converted values of u and v

1

$a = 22\ m/s^2$

allow a correct calculation using incorrectly / not converted values of u and v

a = Δv / t must have been used to score subsequent marks

1

m = 630 000 / 22

allow a correct substitution using an incorrectly calculated value of a

1

m = 28636.36 (kg)

allow a correct calculation using an incorrectly calculated value of a

1

m = 29000 (kg)

this mark can only be awarded for a calculation using the correct equations

1

[11]