# Forces part 8 AQA Triple Physics

Name: _____

Class: _____

Date: _____

Time: **82 minutes**

Marks: **78 marks**

Comments:

**1.** **Figure 1** shows a young child using a baby walker.

**Figure 1**

(a) The child is standing still.

What is the resultant **vertical** force on the child?

Give a reason for your answer.

Resultant vertical force = _____ N

Reason _____

_____

**(2)**

Use the Physics Equations Sheet to answer parts (b) and (c).

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

_____

**(1)**

(c) The child pushed the baby walker 2.8 m across a horizontal floor.

The work done by the child was 35 J.

Calculate the horizontal force the child applied to the baby walker.

Horizontal force = _____ N

**(3)**

(d) The child pushed the baby walker from a carpet onto a hard floor.

The child applied the same horizontal force to the baby walker.

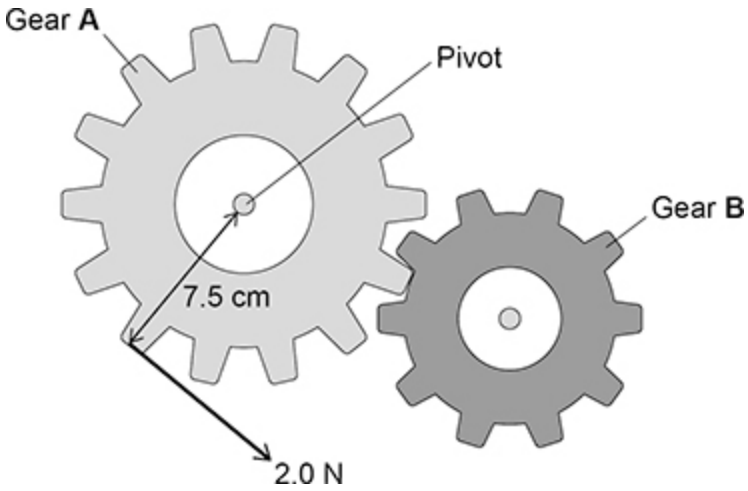
Explain why the speed of the baby walker increased.

**(2)**

There are some toy gears on the front of the baby walker.

**Figure 2** shows the gears.

**Figure 2**




The child applies a force to gear **A**.

This causes a moment about the pivot, so gear **A** rotates.

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

(e) Write down the equation which links distance (*d*), force (*F*) and moment of a force (*M*).

_____

**(1)**

(f) The child applies a force of 2.0 N on gear **A**.

The perpendicular distance between the force and the pivot is 7.5 cm.

Calculate the moment of the force about the pivot.

_____

_____

_____

_____

_____

Moment of force = _____ N m

**(3)**

(g) Explain what happens to gear **B** when the child applies the force to gear **A**.

_____

_____

_____

_____

**(2)**

**(Total 14 marks)**

**2.** The Universe contains many stars.

(a) The Sun is the star at the centre of our solar system.

Give **three** other types of object that form our solar system.

1 _____

2 _____

3 _____

**(3)**

Some main sequence stars will eventually form black holes.

The table below gives the mass of four stars.

| **Star** | **Mass in kg** |
|---|---|
| Arcturus | $2.2 \times 10^{30}$ |
| Betelgeuse | $2.2 \times 10^{31}$ |
| Cygni A | $1.4 \times 10^{30}$ |
| The Sun | $2.0 \times 10^{30}$ |

(b) Which star in the table above is most likely to form a black hole?

_____

**(1)**

(c) The distance from Cygni A to the Earth is $1.1 \times 10^8$ gigametres.

Which distance is the same as $1.1 \times 10^8$ gigametres?

Tick (✓) **one** box.

$1.1 \times 10^{11}$ m ☐

$1.1 \times 10^{14}$ m ☐

$1.1 \times 10^{17}$ m ☐

$1.1 \times 10^{20}$ m ☐

**(1)**

(d) The light spectrum from every galaxy includes dark lines.

The lines have the same pattern.

The figure below shows the position of dark lines in the visible spectra of light from the Sun and from two distant galaxies.

Explain what these light spectra tell us about the velocities of galaxy **A** and galaxy **B**.

**(3)**

(e) The distance between Arcturus and the Earth is $3.6 \times 10^{14}$ km.

speed of light = $3.0 \times 10^{8}$ m/s

Calculate the time taken for light from Arcturus to reach the Earth.

Use the Physics Equations Sheet.

Time taken = _____ s

**(4)**

(f) When stars are formed, they contain mostly hydrogen.

Describe how stars produce all other naturally occurring elements.

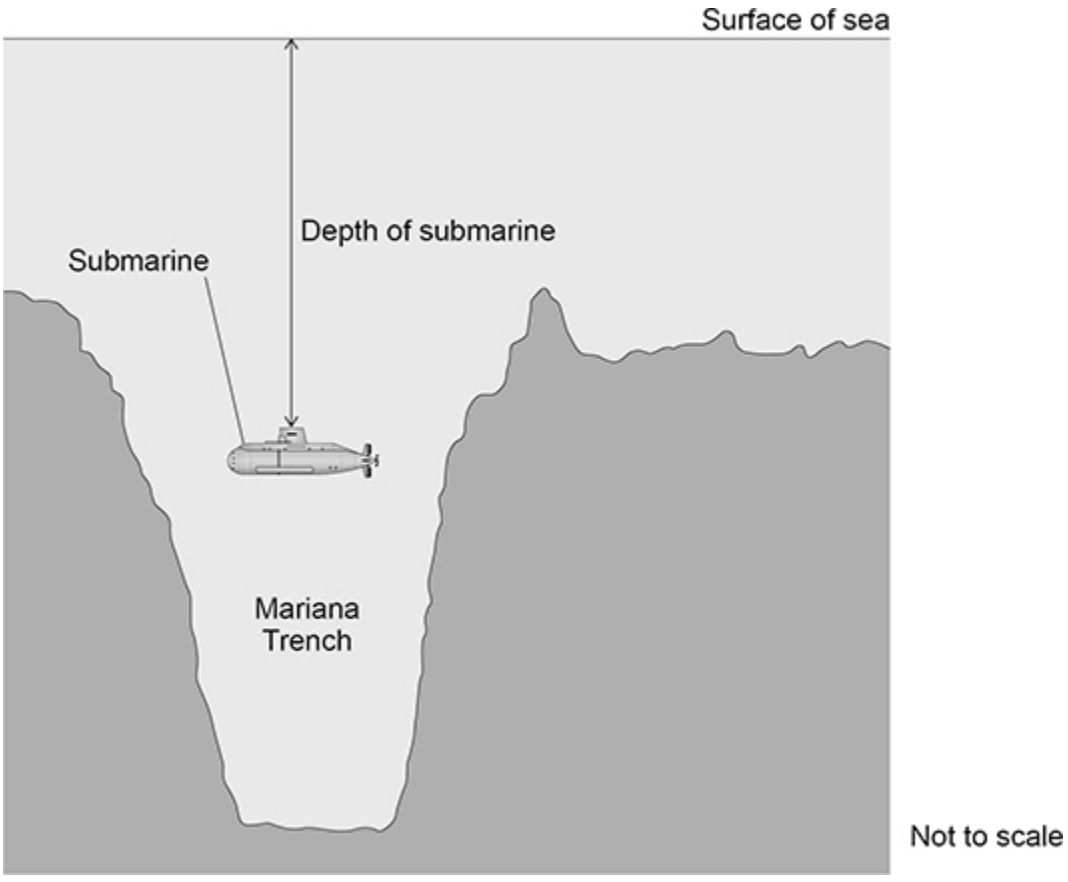
**(4)**

**(Total 16 marks)**

**3.** The Mariana Trench is the deepest part of the Pacific Ocean.

**Figure 1** shows a submarine going to the bottom of the Mariana Trench.

**Figure 1**



(a) The depth of the submarine increases.

Explain what happens to the pressure on the submarine.

_____

_____

_____

_____

**(2)**

(b) The submarine moved from the surface of the water to the bottom of the Mariana Trench.

The change in pressure was 110 000 kPa.

mean density of sea water = 1026 kg/$m^3$

gravitational field strength = 9.8 N/kg

Calculate the depth of the Mariana Trench.

Use the Physics Equations Sheet.

_____

_____

_____

_____

_____

_____

_____

Depth = _____ m

**(4)**

Earthquakes often occur at the Mariana Trench.

P-waves and S-waves are produced by earthquakes.

(c) Which statement describes P-waves and S-waves?

Tick (✓) **one** box.

Both P-waves and S-waves are longitudinal. ☐

Both P-waves and S-waves are transverse. ☐

P-waves are longitudinal and S-waves are transverse. ☐

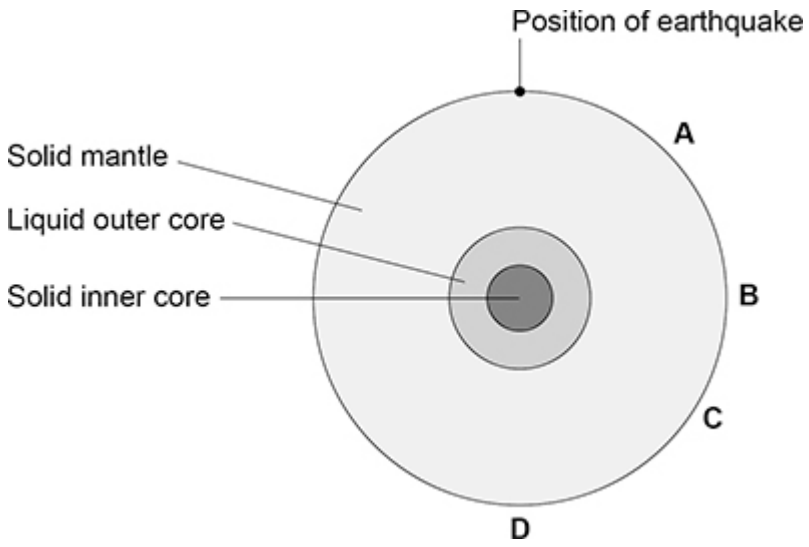
P-waves are transverse and S-waves are longitudinal. ☐

**(1)**

(d) **Figure 2** shows the layers inside the Earth.

An earthquake occurs at the position shown.

**Figure 2**



Which letter shows the position where **only** P-waves will be detected?

Give a reason for your answer.

Tick (✓) **one** box.

**A** ☐ **B** ☐ **C** ☐ **D** ☐

Reason _____

_____

**(2)**

(e) An S-wave has a frequency of 3.6 Hz.

The S-wave has a speed of 4.5 km/s.

Calculate the wavelength of this S-wave.

Use the Physics Equations Sheet.

_____

_____

_____

_____

_____

Wavelength = _____ m

**(3)**

(f) A seismometer is a device that detects earthquakes.

P-waves travel at a known speed between an earthquake and a seismometer.

S-waves travel at a slower speed than P-waves.

A P-wave and an S-wave from the earthquake arrive at the seismometer at different times.

Describe the relationship between the distance from the earthquake to the seismometer and the time between the P-wave and the S-wave arriving.

_____

_____

_____

_____

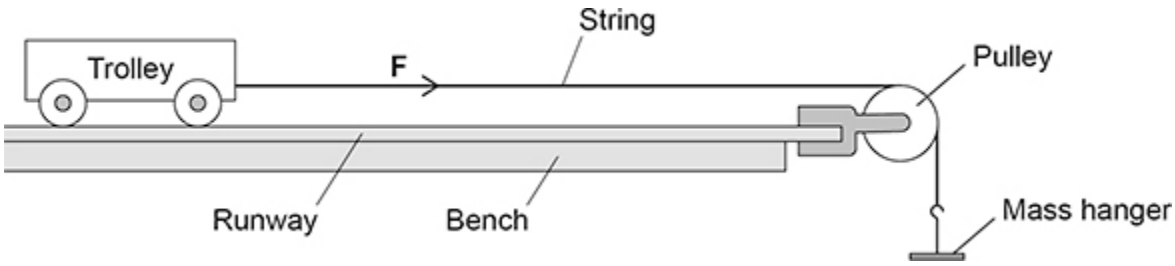
**(2)**

**(Total 14 marks)**

**4.** A student investigated how the acceleration of a trolley varies with the resultant force on the trolley.

**Figure 1** shows some of the equipment used.

**Figure 1**




(a) **Figure 1** shows the force **F** which acts through the string.

What name is given to force **F**?

_____

**(1)**

(b) Give **one** variable that should have been a control variable in this investigation.

_____

**(1)**

(c) The student held the trolley stationary and then released it.

The trolley moved along the runway with a constant acceleration.

The student recorded the time taken for the trolley to travel a measured distance along the runway.

Describe how the acceleration of the trolley can be calculated using the time taken and distance travelled by the trolley.

**(3)**

For one set of results, the force acting through the string was 2.0 N.

(d) The student released the trolley three times and determined the following values for acceleration:

1.36 $m/s^2$ 1.39 $m/s^2$ 1.33 $m/s^2$

Calculate the uncertainty in the values of acceleration.

Uncertainty = ± _____ $m/s^2$

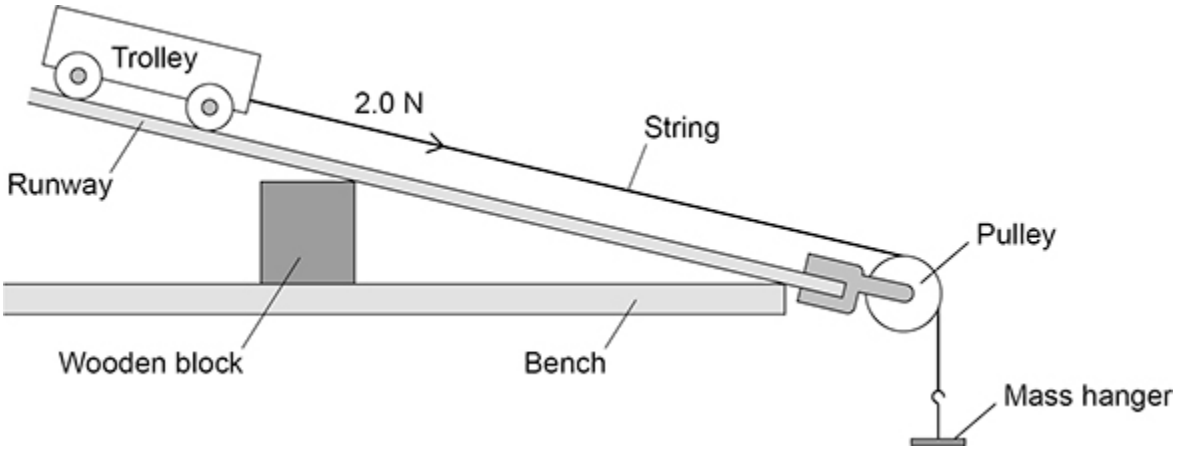
**(2)**

(e) The runway was then raised at one end.

The force acting through the string remained the same.

**Figure 2** shows this.

**Figure 2**




Explain how the acceleration was affected by raising the end of the runway.

_____

_____

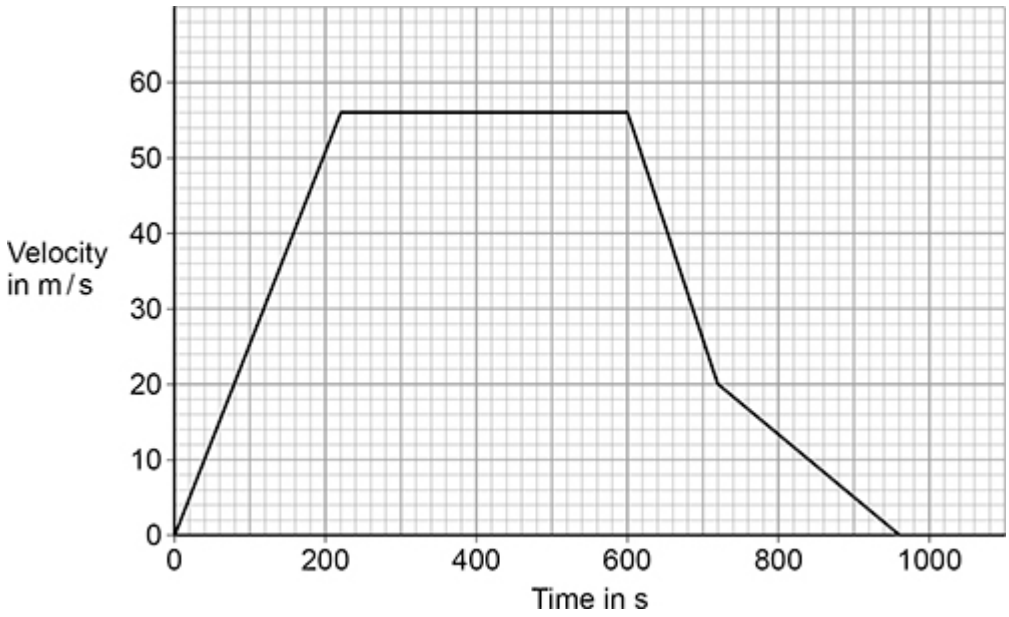
_____

_____

**(2)**

**(Total 9 marks)**

**5.** The figure below shows a velocity–time graph for a train travelling between two stations.



(a) Determine the distance travelled by the train in the first 600 s of the journey.

Distance = _____ m

**(3)**

(b) Explain what happens to the braking force as the train decelerates.

Use information from the figure above.

**(3)**

(c) Determine the maximum deceleration of the train.

Deceleration = _____ $m/s^2$

**(3)**

(d) Another train travels at a speed of 60 m/s.

A constant braking force of 270 000 N causes the train to decelerate and stop.

mass of train = 240 000 kg

Calculate the distance travelled while the braking force is applied.

Use the Physics Equations Sheet.

Distance travelled = _____ m

**(6)**

(e) It is illegal for train drivers to drink alcohol before driving a train.

Explain how drinking alcohol would affect the stopping distance of a train.

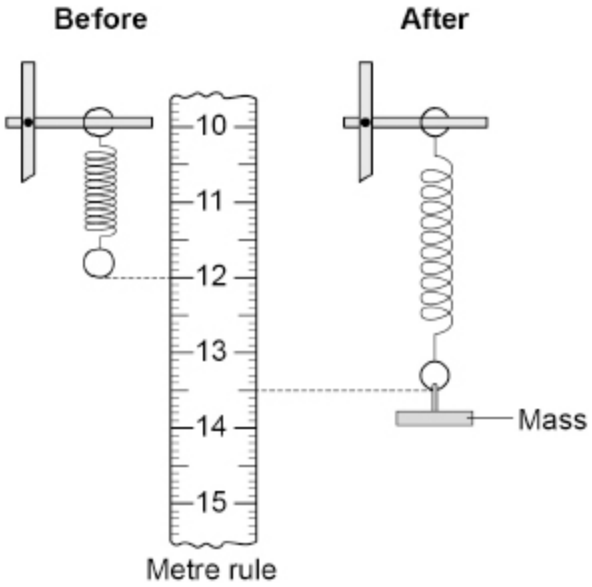
**(3)**

**(Total 18 marks)**

**6.** A student carried out an investigation to determine the spring constant of a spring.

**Figure 1** shows the spring before and after a mass was hung from the end of the spring.

**Figure 1**




(a) What is the extension of the spring in **Figure 1**?

Tick (✓) **one** box.

1.5 cm ☐

3.5 cm ☐

13.5 cm ☐

**(1)**

(b) Give **one** safety precaution the student should have taken during this investigation.

_____

_____

**(1)**

(c) The student hung a mass of 0.050 kg from the spring.

gravitational field strength = 9.8 N/kg

Calculate the weight of the 0.050 kg mass.

Use the equation:

weight = mass × gravitational field strength

_____

_____

Weight = _____ N

**(2)**

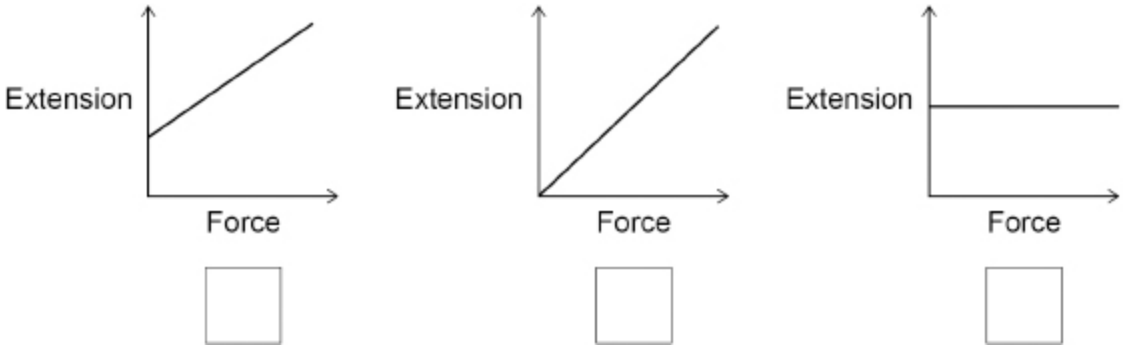
(d) The weight of the mass applies a force to the spring.

The student added more masses and recorded the extension of the spring.

Which graph in **Figure 2** shows the relationship between the force applied to the spring and the extension of the spring?

Tick (✓) **one** box.

**Figure 2**




**(1)**

(e) A force of 2.0 N was applied to a different spring.

The extension of the spring was 0.080 m.

Calculate the spring constant of the spring.

Use the equation:

$$\text{spring constant} = \frac{\text{force}}{\text{extension}}$$

Spring constant = _____ N/m

**(2)**

**(Total 7 marks)**

**1.** (a) 0 (N)

1

the child isn't accelerating (vertically)

*MP2 dependent on MP1*

**or**

upwards forces are equal to the downwards forces

*allow forces are balanced*

1

(b) work done = force × distance

**or**

$W = F \times s$

1

(c) $35 = F \times 2.8$

1

$$F = \frac{35}{2.8}$$

1

$F = 12.5$ (N)

*allow 13 (N)*

1

(d) the resistive force has decreased

*allow friction (between the wheels and the floor) has decreased*

1

so the resultant force increases

1

(e) moment = force × distance

**or**

$M = F \times d$

1

(f) 7.5 cm = 0.075 m

1

$M = 2.0 \times 0.075$

*allow a correct substitution of an incorrectly / not converted value of d*

1

$M = 0.15$ (Nm)

*allow an answer consistent with an incorrectly / not converted value of d*

1

(g) gear B rotates in the opposite direction (to gear A)
**or**
gear B rotates clockwise
**or**
gear B rotates faster than gear A

1

(because) gear A exerts a force on gear B
**or**
(because) gear A causes a moment about the pivot of gear B

1

**[14]**

**2.** (a) planets

1

dwarf planets

1

moons
**or**
natural satellites

*allow asteroids / meteors / meteoroids / meteorites*

*allow comets*

1

(b) Betelgeuse

1

(c) $1.1 \times 10^{17}$ m

1

(d) both show red-shift so both are moving away from us

**or**

the wavelength of the (absorption) lines has increased so both are moving away from us

**1**

A shows a greater red-shift (than B)

**1**

so A is travelling faster (than B)

**1**

(e) $s = 3.6 \times 10^{17}$ (m)

**1**

$3.6 \times 10^{17} = 3.0 \times 10^{8} \times t$

*allow a correct substitution of an incorrectly / not converted value for s*

**1**

$$\frac{3.6 \times 10^{17}}{3.0 \times 10^{8}} = t$$

*allow a correct re-arrangement using an incorrectly / not converted value for s*

**1**

$t = 1.2 \times 10^{9}$ (s)

**or**

$t = 1\ 200\ 000\ 000$ (s)

*allow a correct calculation using an incorrectly / not converted value for s 1*

**1**

(f) **Level 2:** Scientifically relevant facts, events or processes are identified and given in detail to form an accurate account.

**3–4**

**Level 1:** Facts, events or processes are identified and simply stated but their relevance is not clear.

**1–2**

**No relevant content**

**0**

**Indicative content**

- fusion occurs at high temperatures
- fusion produces new elements
- hydrogen nuclei fuse to form helium nuclei
- hydrogen (in the core) begins to run out
- helium nuclei fuse to make heavier elements
- up to iron
- some massive stars become supernovae
- creating elements heavier than iron

**[16]**

**3.** (a) the height of the (column of) water above the submarine increases

*allow volume / mass for height*

**1**

which increases the force / weight (of the water) acting on the submarine so pressure increases

*allow p = ρgh and ρ and g remain constant so pressure increases*

**1**

(b) $p$ = 110 000 000 Pa

**1**

110 000 000 = 1026 × 9.8 × $\Delta h$

*allow a correct substitution of an incorrectly / not converted value for p*

**1**

$$\Delta h = \frac{110\,000\,000}{1026 \times 9.8}$$

*allow a correct re-arrangement using an incorrectly / not converted value for p*

**1**

$\Delta h$ = 10 940 (m)

*allow a correct calculation from using an incorrectly / not converted value for p*

*allow 11 000 (m) if correct working shown*

**1**

(c) P-waves are longitudinal and S-waves are transverse

**1**

(d) D

**1**

only P-waves can travel through liquids

*allow only P-waves can travel through the outer core*

*allow S waves cannot travel through liquids*

*allow S waves cannot travel through the outer core*

*MP2 dependent on MP1*

**1**

(e) $4500 = 3.6 \times \lambda$

*allow a correct substitution of an incorrectly / not converted value for v*

**1**

$$\lambda = \frac{4500}{3.6}$$

*allow a correct re-arrangement using an incorrectly / not converted value for v*

**1**

$\lambda = 1250$ (m)

*allow 1300 (m)*

*only allow an answer consistent with a correctly converted value for v*

**1**

(f) the distance is (directly) proportional to the time between the two waves arriving (at the seismometer)

*allow they are (directly) proportional*

*allow a greater distance means a greater time for **1** mark*

*allow there is a positive correlation for **1** mark*

**2**

**[14]**

**4.** (a) tension

**1**

(b) (combined) mass of trolley and mass hanger

*allow mass / weight of trolley / hanger*

**1**

(c) divide distance travelled by time taken to give (average / mean) velocity

*allow speed for velocity throughout*

**1**

double mean velocity (to give maximum velocity)

**1**

divide change in velocity by time taken (to give acceleration)

*allow divide maximum velocity by time (to give acceleration) allow use of* $v^2 = u^2 + 2as$

*allow correct use of*

$$s = ut + \frac{1}{2}at^2$$

**1**

(d) (range =) 0.06 ($m/s^2$)
**or**
(mean =) 1.36 ($m/s^2$)

**1**

uncertainty = ±0.03 ($m/s^2$)

**1**

(e) a component of the weight of the trolley acts parallel to runway

**1**

(so) resultant force increases so acceleration increases

*allow work is done (by raising the trolley) so the trolley gains gravitational potential energy (1)*

*gravitational potential energy is transferred to kinetic energy increasing the final velocity and the acceleration (1)*

**1**

**[9]**

**5.** (a)

$(\frac{1}{2} \times 56 \times 220) = 6160$

**1**

(56 × 380) = 21280

**1**

(6160 + 21280) = 27 440 (m)

*allow a correctly calculated total distance from an incorrectly calculated area of the rectangle and / or the triangle*

**1**

(b) the gradient is less after 720 s

*allow the gradient is less after (velocity decreases to) 20 m/s*

**1**

so the deceleration is smaller

**1**

so the braking force is smaller

**1**

(c) correct section of line identified

*judge by values used*

**1**

attempt to calculate a gradient using values from the correct section of the graph
eg

gradient = $\frac{(-)36}{120}$

*allow use of correct values obtained from the section of the graph after 720 s*

**1**

correct calculation using their correct values
eg $a = (-)0.3\ (m/s^2)$

*allow a correct calculation using correct values obtained from the section of the graph after 720 s*

*if no other marks scored, an answer that rounds to 0.16 ($m/s^2$) scores 1 mark*

**1**

(d) (–)270 000 = 240 000 × *a*

1

$$a = \frac{(-)270\,000}{240\,000}$$

1

*a* = (–) 1.125 (m/s$^2$)

*the equation F = ma must have been used to score subsequent marks*

1

0 = 60$^2$ + (2 × (–1.125) × *s*)

*allow a correct substitution using their value of deceleration*

1

$$s = \frac{3600}{2.25}$$

*allow a correct re-arrangement using their value of deceleration*

1

*s* = 1600 (m)

*allow a correct calculation using their value of deceleration*

**OR**

$E_k = \frac{1}{2} \times 240\,000 \times 60^2$ (1)

= 432 000 000 (1)

Δ $E_k$ = work done (1)

*the equation $E_k = \frac{1}{2}mv^2$ must have been used to score subsequent marks*

432 000 000 = 270 000 × *s* (1)

*allow a correct substitution using their value of $E_k$*

$s = \frac{432\,000\,000}{270\,000}$ (1)

*allow a correct re-arrangement using their value of $E_k$*

*s* = 1600 (m) (1)

*allow a correct calculation using their value of $E_k$*

1

**OR**

*p* = 240 000 × 60 (= 14 400 000) (1)

$270\,000 = \frac{14\,400\,000}{t}$ (1)

*t* = 53.333…(s) (1)

*allow t = 53 (s)*

*the equation* $F = \frac{\text{change in momentum}}{\text{time taken}}$ *must have been used to score subsequent marks*

$\text{mean speed} = \frac{60}{2} = 30$ (1)

$s = 30 \times 53.333\ldots$ (1)

*allow a correct substitution using their value of t*

$s = 1600$ (m) (1)

*allow a correct calculation using their value of t*

(e) stopping distance includes both braking distance and thinking distance

**1**

alcohol increases driver's reaction time

**1**

which will increase the thinking distance so stopping distance increases

**1**

**[18]**

**6.** (a) 1.5 cm

**1**

(b) any **one** from:

- clamp the stand to the desk
- wear safety goggles / glasses
- stand up / away from apparatus
- limit the total mass used
- have masses over the base of the stand

**1**

(c) $W = 0.050 \times 9.8$

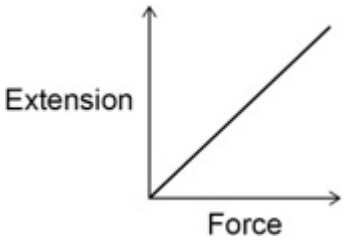
**1**

$W = 0.49$ (N)

*do **not** accept 0.50 (N) alone*

**1**

(d)




**1**

(e) $k = \frac{2.0}{0.080}$

1

$k$ = 25 (N/m)

1

**[7]**