

## Forces

### Questions

Q1.

A car with a mass of 1800 kg is accelerating at 1.2 m/s<sup>2</sup>.

Calculate the force used to accelerate the car.

Use the equation

$$\text{force} = \text{mass} \times \text{acceleration}$$

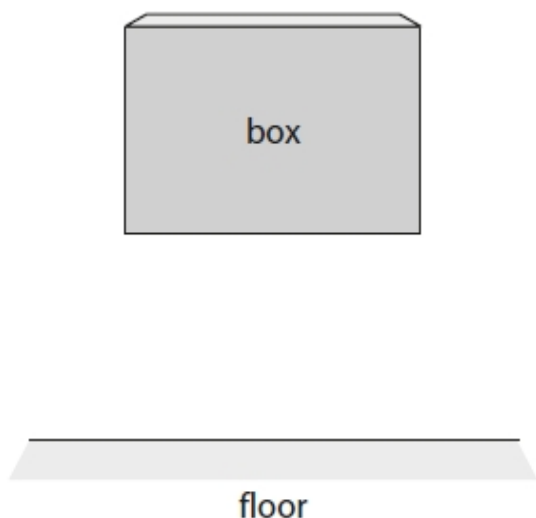
(2)

force = ..... N

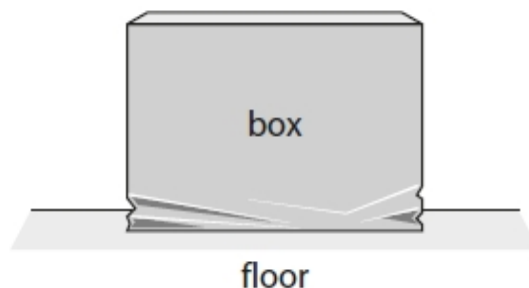
(Total for question = 2 marks)

Q2.

Figure 11a shows a box falling towards a hard floor.



**Figure 11a**



**Figure 11b**

The box hits the floor and crumples a little before it comes to rest as shown in Figure 11b.

The momentum of the box just before it hits the floor is 8.7 kg m/s.

The box comes to rest 0.35 s after it first hits the floor.

(i) Calculate the magnitude of the force exerted by the floor on the box.

Use an equation selected from the list of equations at the end of this paper.

(2)

force exerted by the floor on the box = ..... N

(ii) State the magnitude and direction of the force exerted by the box on the floor.

(2)

magnitude .....

direction .....

(Total for question = 4 marks)

Q3.

The gravitational field strength on the Moon is 1.6 N/kg.

The mass of a rock on the Moon is 6.0 kg.

Calculate the weight of this rock on the Moon.

State the unit of weight.

Use the equation

$$\text{weight} = \text{mass} \times \text{gravitational field strength}$$

(3)

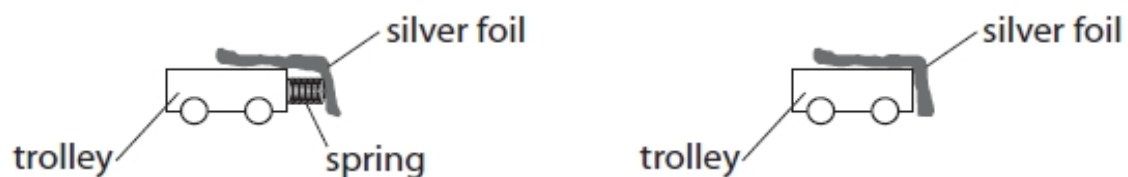
weight of rock = ..... unit

(Total for question = 3 marks)

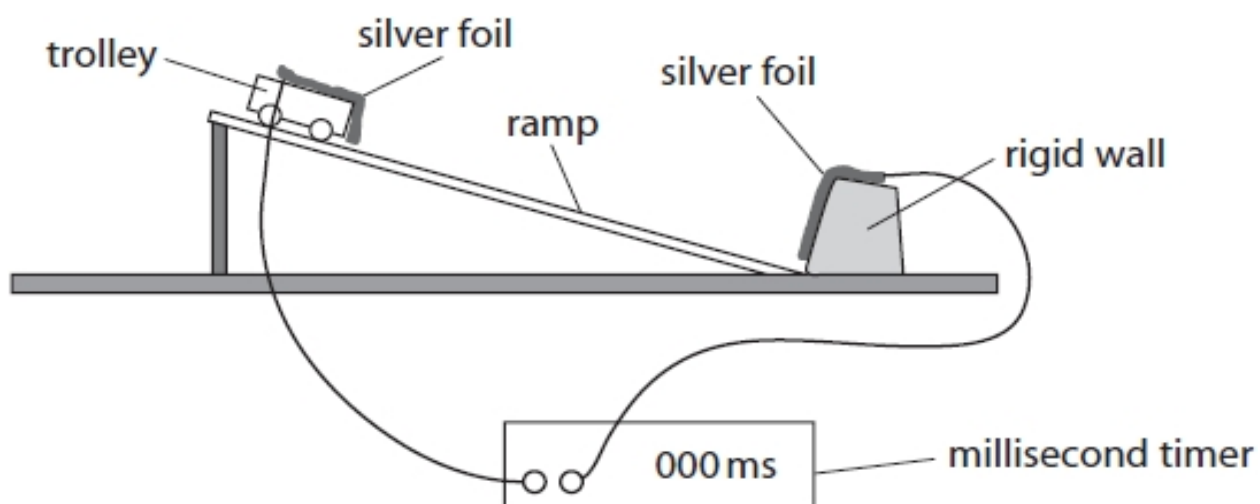
Q4.

A student investigates the effect of a crumple zone on the force exerted during a collision.

The student has one trolley with a spring at the front and another trolley without a spring.



The student uses the arrangement in Figure 13.



**Figure 13**

After a trolley is released, it accelerates down a slope and bounces off a rigid wall.

The speed of a trolley can be measured just before a collision with the wall and just after a collision with the wall.

The silver foils are connected to a millisecond timer.

The silver foils make contact with each other during the collision, so the time they are in contact can be read from the millisecond timer.

Explain how the student could investigate the effect of a crumple zone on the average force exerted during the collision.

Your explanation should include:

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- how to determine the force (you may wish to refer to an equation from the list of equations at the end of this paper)

- how the effect of crumple zones may be shown in the investigation
- precautions that may be necessary to achieve accurate results.



Q5.

A toy car has a mass of 0.10 kg.

The toy car accelerates at 2.0 m/s<sup>2</sup>.

Calculate the force producing this acceleration.

State the unit.

Use the equation

$$F = m \times a$$

(3)

force = ..... unit = .....

(Total for question = 3 marks)

Q6.

(i) Which of these is the correct equation that relates force, mass and acceleration?

(1)

- A  $F = m + a$   
 B  $F = m - a$   
 C  $F = m \times a$   
 D  $F = m \div a$

(ii) A cyclist has a mass of 70 kg.

Calculate the force needed to accelerate the cyclist at 2.0 m / s<sup>2</sup>.

State the unit.

(2)

force = ..... unit = .....

(Total for question = 3 marks)

Q7.

(i) Figure 14 shows the vertical forces on an aeroplane.

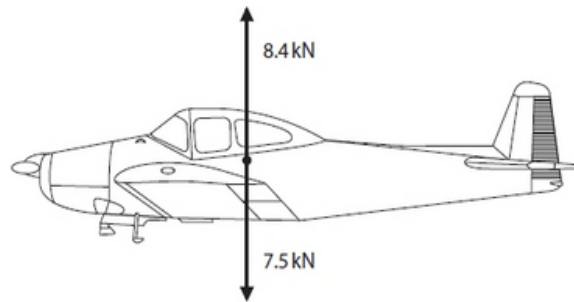


Figure 14

Use information from the diagram to determine the size and direction of the resultant vertical force on the aeroplane.

(2)

size = ..... kN, direction is .....

(ii) The aeroplane is descending.

Figure 15 shows a diagram of the resultant vertical and horizontal forces on the aeroplane as it is descending.

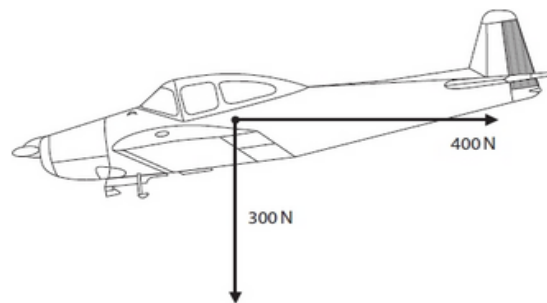


Figure 15

Complete the diagram to show the resultant of these two forces.

(1)

(iii) The mass of the aeroplane is 750 kg.

Calculate the change in gravitational potential energy of the aeroplane as it descends from 1300 m to the ground.

Gravitational field strength ( $g$ ) = 10 N/kg

(2)

energy = ..... J

(Total for question = 5 marks)

**Mark Scheme - Forces**

Q1.

Question Number	Answer	Additional guidance	Mark
	substitution (1) 1800 x 1.2  evaluation (1) 2200 (N)	accept $1800 \text{ kg} \times 1.2 \text{ m/s}^2$ reject $1800 \times 1.2^2$  2160  award full marks for the correct answer without working  allow 1 mark total for 2200 OR 2160 with any other power of ten	<b>(2)</b>

Q2.

Question number	Answer	Additional guidance	Mark
<b>(i)</b>	substitution (1)  (force =) $\frac{8.7}{0.35}$  evaluation (1)  25 (N)	use of force = $\frac{\text{change in momentum}}{\text{time}}$  allow numbers that round to 25 e.g 24 .8571  award full marks for correct answer without working.	<b>(2)</b> <b>AO2</b>

Question number	Answer	Additional guidance	Mark
<b>(ii)</b>	(magnitude) 25 (N) (1)  (direction) down(wards)/ towards floor (1)	ecf from 7bi  allow arrow drawn pointing down  "south"	<b>(2)</b> <b>AO3</b>



Q3.

Question number	Answer	Additional guidance	Mark
	substitution (1) $(W=) 6.0 \times 1.6$  evaluation (1) 9.6  unit (independent mark)(1)  newton	award full marks for correct answer without working.   accept N, n and/or Newton  9.6 N/n gains full marks	<b>(3)</b> <b>AO2(2)</b> <b>AO1(1)</b>

Q4.

Question number	Indicative content	Mark
	<p>Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme.</p> <p>The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant.</p> <p style="text-align: center;"><b>AO2 (strand 2) (6 marks)</b></p> <p><u>Determining force</u></p> <ul style="list-style-type: none"> <li>• Use of <math>F = (mv - mu)/t</math> or <math>F = ma</math></li> <li>• mass (of trolley(s)) needed</li> <li>• and times during impact (t)</li> </ul> <p><u>Showing effect of crumple zone</u></p> <ul style="list-style-type: none"> <li>• experiment repeated with and without the spring</li> <li>• (note) difference in contact times</li> <li>• use of spring as crumple zone</li> <li>• with spring, time for contact greater, less impact force</li> </ul> <p><u>Precautions or controls</u></p> <ul style="list-style-type: none"> <li>• times repeated and average taken</li> <li>• careful controls – same starting position / same angle of slope / release without pushing etc.</li> </ul>	<b>(6)Exp</b>

## 2.2 Forces

Level	Mark	Descriptor
	0	<ul style="list-style-type: none"> <li>No awardable content</li> </ul>
Level 1	1-2	<ul style="list-style-type: none"> <li>The explanation attempts to link and apply knowledge and understanding of scientific enquiry, techniques and procedures, flawed or simplistic connections made between elements in the context of the question.</li> <li>Lines of reasoning are unsupported or unclear. (AO2)</li> </ul>
Level 2	3-4	<ul style="list-style-type: none"> <li>The explanation is mostly supported through linkage and application of knowledge and understanding of scientific enquiry, techniques and procedures, some logical connections made between elements in the context of the question.</li> <li>Lines of reasoning mostly supported through the application of relevant evidence. (AO2)</li> </ul>
Level 3	5-6	<ul style="list-style-type: none"> <li>The explanation is supported throughout by linkage and application of knowledge and understanding of scientific enquiry, techniques and procedures, logical connections made between elements in the context of the question.</li> <li>Lines of reasoning are supported by sustained application of relevant evidence. (AO2)</li> </ul>

<b><u>SUMMARY, for guidance</u></b>			
Level	Mark	Additional Guidance	General additional guidance – the decision within levels e.g. - At each level, as well as content, the scientific coherency of what is stated will help place the answer at the top, or the bottom, of that level.
	0	No rewardable material.	
Level 1	1-2	<u>Additional guidance</u> Elements of physics present i.e. isolated knowledge of techniques and procedures – <b>two</b> unconnected statements from any section	<u>Possible candidate responses</u> Use $F = (mv - mu)/t$ Use $F = ma$ keep slope the same repeat and average use spring as crumple zone
Level 2	3-4	<u>Additional guidance</u> Some knowledge of techniques and procedures with a logical connection made in one section and statement from one more section	<u>Possible candidate responses</u> Measurements (difference in contact times) with and without the spring Use $F = ma$ in finding the force
Level 3	5-6	<u>Additional guidance</u> Detailed knowledge of techniques and procedures with logical connections made in two sections and statement from one more section	<u>Possible candidate responses</u> Measure the trolley mass(es)/ velocities/ impact time(s) and use $F = ma$ in finding the force Measurements (difference in contact times) with and without the spring Same starting place for trolley each time.

Q5.

Question Number	Answer	Additional guidance	Mark
	substitution (1) $(F =) 0.10 \times 2.0$  evaluation (1) $0.2(0)$  unit (1) N	$100 \times 2$ (using $0.10\text{kg} = 100\text{g}$ )  reject $0.10 \times 2.0^2$ and the follow up evaluation (equation given should be used)  correct answer without working gets 2 marks  allow 1 mark total for 2 with any other power of ten, so that includes 200 for example  separate unit mark  newtons / Newtons accept lowercase 'n'  for the abbreviated unit  accept $\text{kg ms}^{-2}$  accept $200 \text{ g ms}^{-2}$ for 3 marks	<b>(3)</b> AO 2 1

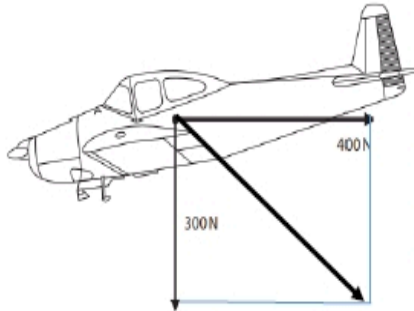
Q6.

Question number	Answer	Mark
(i)	<input checked="" type="checkbox"/> C $F = m \times a$ A, B and D have incorrect mathematical operator	<b>(1)</b>

Question number	Answer	Additional guidance	Mark
(ii)	140 (1) N (1)	no ecf from 2ai independent mark  allow newton(s) n  do <b>not</b> allow Ns ns	<b>(2)</b>

Q7.

Question Number:	Answer	Additional guidance	Mark
(i)	0.9 (k N) (1) up / upwards / ascending (1)	accept .9 or 0.90 north N ↑	(2) AO 3 2a AO 3 2b

Question Number:	Answer	Additional guidance	Mark
(ii)		<p>judge length and direction by eye</p> <p>construction lines need not be shown</p> <p>magnitude need not be stated</p> <p>allow missing arrowhead if direction and length are correct</p> <p>reject answers which have any additional vectors drawn</p>	(1) AO 3 2b

Question Number:	Answer	Additional Guidance	Mark
(iii)	<p>recall and substitution (1)</p> <p><math>GPE = 750 \times 10 \times 1300</math></p> <p>evaluation (1)</p> <p>(energy =) 9 800 000 (J)</p>	<p>no POT error (could have missed out <math>g</math>)</p> <p>allow answers in standard form <math>9.8 \times 10^6</math></p> <p>allow answers that round to 9 800 000 e.g. 9 750 000 J</p> <p>allow 9800 kJ or 9.8MJ</p> <p>allow 9 555 000 J</p> <p>allow negative values</p> <p>award full marks for correct answer without working</p>	(2) AO 2 1