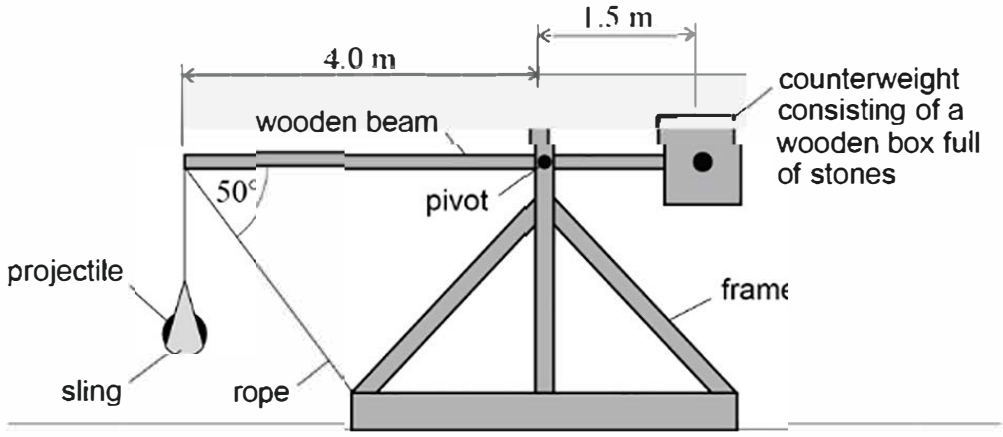
Do not write outside the box

**0 4** **Figure 5** shows a simplified catapult used to hurl projectiles a long way.

**Figure 5**




The counterweight is a wooden box full of stones attached to one end of the beam.
The projectile, usually a large rock, is in a sling hanging vertically from the other end of the beam. The weight of the sling is negligible.
The beam is held horizontal by a rope attached to the frame.

**0 4 . 1** The catapult is designed so that the weight of the beam and the weight of the **empty** wooden box have no effect on the tension in the rope.

Suggest how the pivot position achieves this.

**[2 marks]**

**Question 4 continues on the next page**

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**0 4 . 2** The stones in the counterweight have a total mass of 610 kg and the projectile weighs 250 N.

Calculate the tension in the rope.

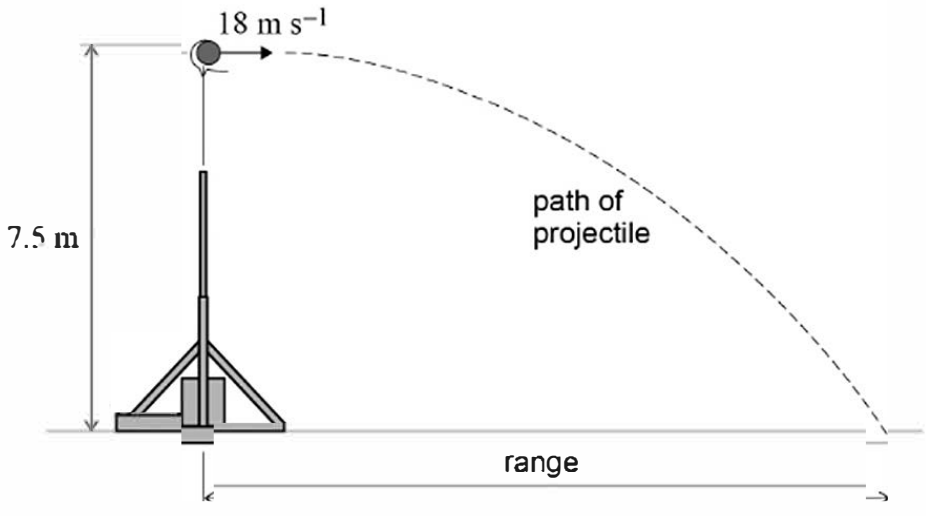
**[5 marks]**

tension = _____ N

**0 4 . 3** When the rope is cut, the counterweight rotates clockwise. When the beam is vertical it is prevented from rotating further. The projectile is then released horizontally with a velocity of 18 m $s^{-1}$, as shown in **Figure 6**.

The projectile is released at a height of 7.5 m above ground level.

**Figure 6**



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The range of the catapult is the horizontal distance between the point where the projectile is released to the point where it lands.

Calculate the range.
Ignore air resistance.

**[2 marks]**

range = _____ m

**0 4 . 4** In another release, the sling is adjusted so that a projectile of the same mass is released just before the wooden beam is vertical. The projectile is not released horizontally.

Discuss the effect this change has on the range of the catapult.

**[3 marks]**

12

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**0 5** Safety barriers are used on UK motorways to prevent vehicles crossing from one carriageway to the other carriageway. The barriers also absorb some of the kinetic energy of a vehicle and deflect vehicles along the barrier.

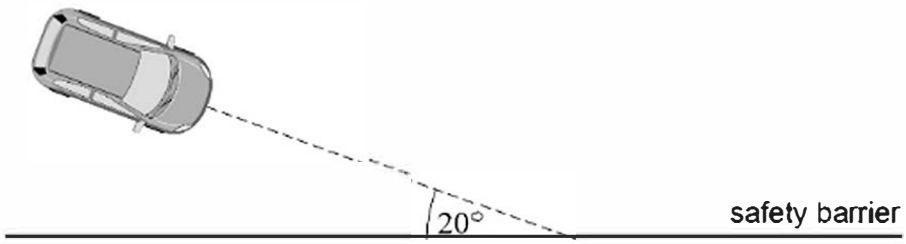
The standard test of a safety barrier uses a vehicle that contains dummies. The total mass of the vehicle and its contents is $1.5 \times 10^3$ kg and its initial speed is 110 km $h^{-1}$.

**0 5 . 1** Show that the initial kinetic energy of the test vehicle is 700 kJ.

**[2 marks]**

**0 5 . 2** The test vehicle hits a steel safety barrier at an angle of 20°, as shown in **Figure 7**.

**Figure 7**




Calculate the component of the momentum of the test vehicle in a direction along the line of the safety barrier.
Give an appropriate unit for your answer.

**[3 marks]**

momentum = _____ unit _____

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**0 5 . 3** Immediately after the collision, the test vehicle moves along the safety barrier with no change in its momentum in this direction.

Show that the kinetic energy lost in the collision is about 80 kJ.

**[3 marks]**

**0 5 . 4** The steel safety barrier deforms during the collision. For the barrier to pass the test, the test vehicle should not move more than 1.5 m towards the other carriageway.

The barrier can apply an average force of 60 kN at right angles to the carriageway.

Deduce whether the safety barrier will pass the test.

**[3 marks]**

**Question 5 continues on the next page**

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**0 5 . 5** A different safety barrier uses a solid concrete wall which does not deform. The same standard test is carried out on a concrete wall.

Discuss which type of barrier would cause less damage to the dummies in the test.

**[2 marks]**

13

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**1 2** Which statement about a couple is **not** true?

**[1 mark]**

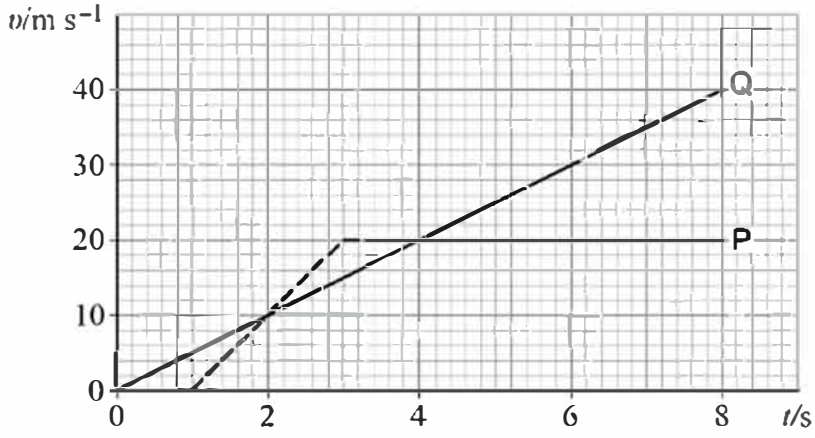
**A** It must consist of coplanar forces. ○

**B** It can produce rotational motion. ○

**C** It can produce translational motion. ○

**D** It has a moment with units $\mathrm{N\,m}$. ○

**1 3** Two cars **P** and **Q** leave from the same point and travel in the same direction.
**Q** leaves at time $t = 0$ and **P** leaves one second later.
The figure shows the velocity–time graph for **P** and **Q**.




What is the distance between **Q** and **P** when $t = 8$ s?

**[1 mark]**

**A** 40 m ○

**B** 80 m ○

**C** 160 m ○

**D** 180 m ○

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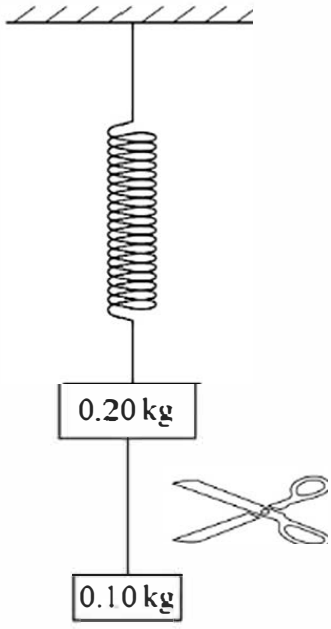
**1 4** A 0.20 kg mass is suspended from a spring. A 0.10 kg mass is suspended from the 0.20 kg mass using a thread of negligible mass.
The system is in equilibrium and the thread is then cut.




What is the upward acceleration of the 0.20 kg mass at the instant that the thread is cut?

**[1 mark]**

**A** 3.3 m s$^{-2}$ ○

**B** 4.9 m s$^{-2}$ ○

**C** 6.5 m s$^{-2}$ ○

**D** 9.8 m s$^{-2}$ ○

**1 5** A lift of mass $M$ is suspended from a cable. The lift descends with a downward acceleration, $a$. A frictional force $F$ acts on the lift.

What is the tension $T$ in the cable?

**[1 mark]**

**A** $T = Ma + F$ ○

**B** $T = Ma - F$ ○

**C** $T = M(g + a) - F$ ○

**D** $T = M(g - a) - F$ ○

Do not write outside the box

**1 6** A body of constant mass falls freely due to gravity.

The rate of change of momentum of the body is equal to its

**[1 mark]**

**A** kinetic energy. ○

**B** mass. ○

**C** gravitational potential energy. ○

**D** weight. ○

**1 7** An electric vehicle is driven by a motor which produces a constant driving force.
The vehicle travels from rest along a straight horizontal road.
Friction and air resistance are negligible.

Which statement describes the variation with time of the power developed by the motor?

**[1 mark]**

**A** It stays constant. ○

**B** It increases linearly from zero. ○

**C** It increases non-linearly from zero. ○

**D** It increases from zero to a maximum and then decreases. ○

**1 8** Which is a correct statement about mechanical power?

**[1 mark]**

**A** It is a vector quantity. ○

**B** It is measured in J. ○

**C** In fundamental units, its unit is $kg\ m^2\ s^{-3}$ ○

**D** It can be calculated from force × distance moved. ○