

Q1. When a gun is fired, a very large force acts on the bullet for a very short time.

The change in momentum of the bullet is given by the following relationship:

$$\text{force (N)} \times \text{time(s)} = \text{change in momentum (kg m/s)}$$

- (a) An average force of 4000 newton acts for 0.01 seconds on a bullet of mass 50g.

Calculate the speed of the bullet. (*Show your working.*)

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Answer m/s

(4)

- (b) The bullet is fired horizontally. In the short time it takes for the bullet to reach its target, its horizontal speed has fallen to 80% of its initial speed.

- (i) Explain why the speed of the bullet decreases so quickly.

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(2)

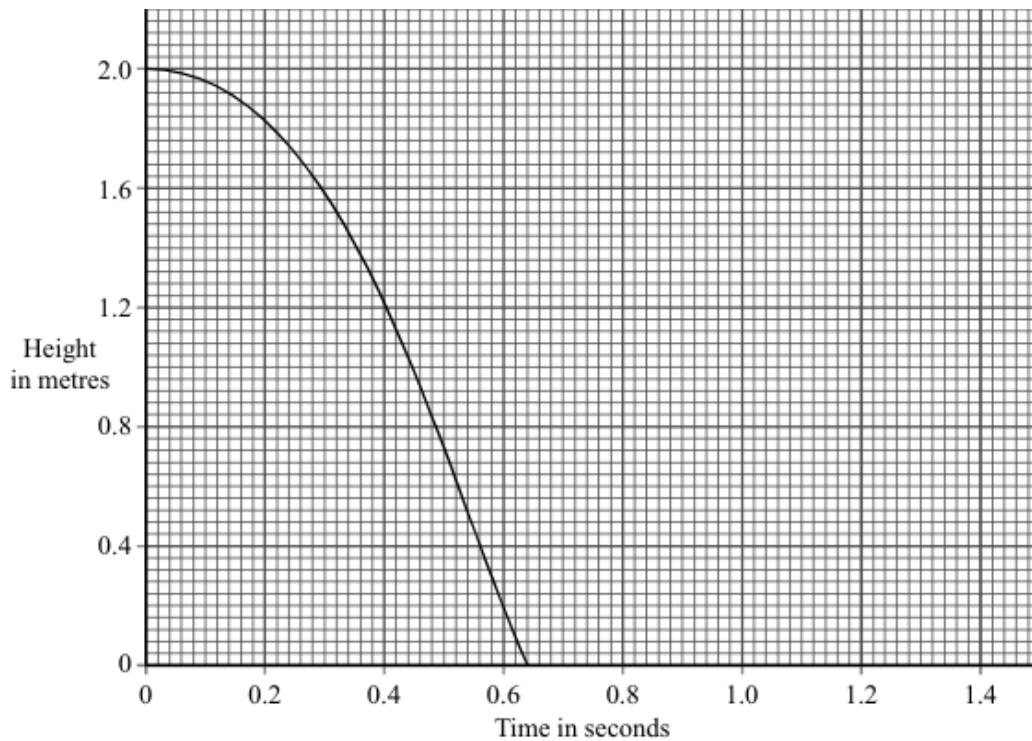
- (ii) Calculate the percentage of its original kinetic energy the bullet still has when it reaches its target.

(*Show your working.*)

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(4)
(Total 10 marks)

- Q2.** A bouncy ball is dropped vertically from a height of 2.00 m onto the floor. The graph shows the height of the ball above the floor at different times during its fall until it hits the floor after 0.64 s.



- (a) What is the average speed of the ball over the first 0.64 s? Show clearly how you work out your answer.

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$$\text{Average speed} = \dots \text{ m/s}$$

(1)

- (b) After it hits the floor the ball bounces back to a height of 1.25 m. It reaches this height 1.16 s after it was dropped. Plot this point on the grid above and sketch a graph to show the height of the ball above the floor between 0.64 s and 1.16 s.

(3)

- (c) (i) The ball bounces on the floor 0.64 s after being dropped. How long after being dropped will it be before it bounces a second time?

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(1)

- (ii) What distance will the ball travel between its first and second bounce?

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(1)

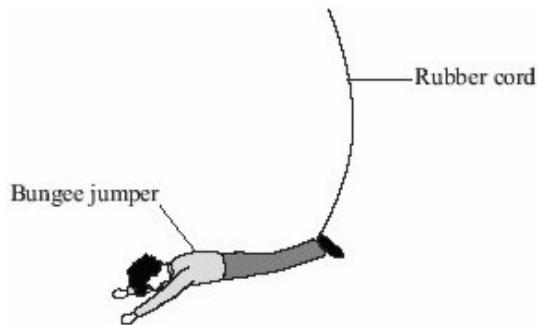
- (d) The ball was held stationary before being dropped. On the graph and your sketch mark **two** other points X_1 and X_2 , where the ball is stationary, and in each case explain why the ball is not moving.

X_1

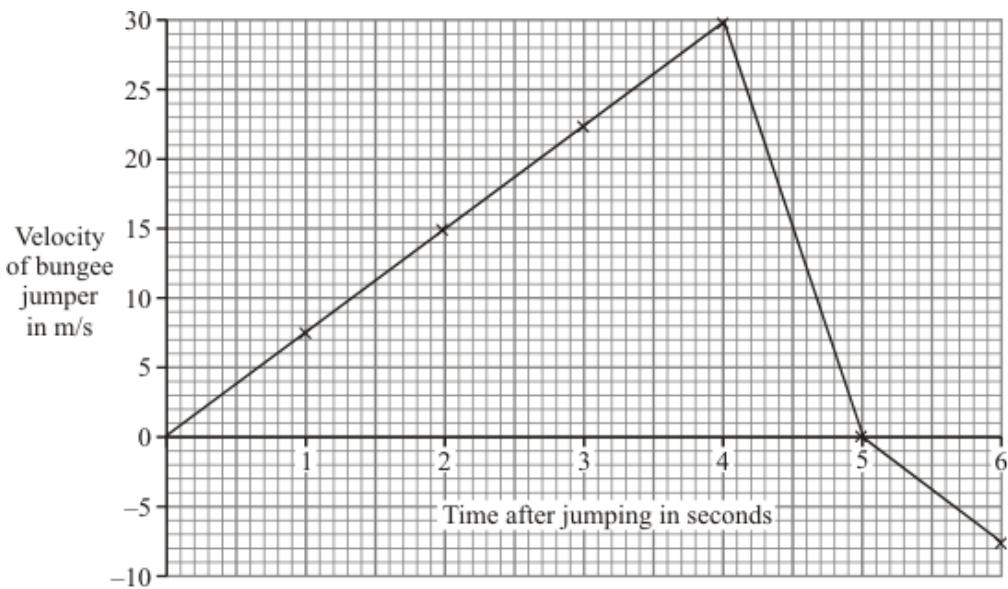
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 X_2

(2)
(Total 8 marks)

- Q3.** In bungee jumping, a fixed rubber cord is fastened to the jumper's ankles.



The graph shows how the bungee jumper's velocity changes during part of the jump.



- (a) Calculate the acceleration of the bungee jumper between 2 and 4 seconds. Show your working.

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$$\text{Acceleration} = \dots \text{ m/s}^2$$

(3)

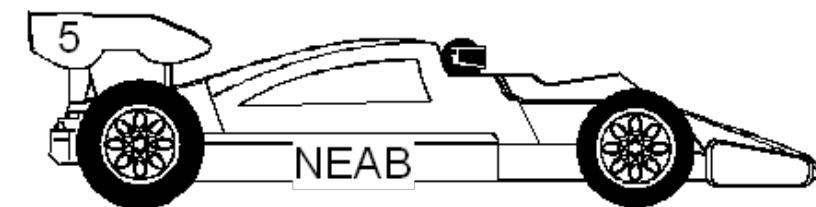
- (b) Describe, in as much detail as you can, what happens to the bungee jumper after 4 seconds.

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(3)

(Total 6 marks)

- Q4.** A racing driver is driving his car along a **straight** and **level** road as shown in the diagram below.



- (a) The driver pushes the accelerator pedal as far down as possible. The car does not accelerate above a certain maximum speed. Explain the reasons for this in terms of the forces acting on the car.

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(4)

- (b) The racing car has a mass of 1250 kg. When the brake pedal is pushed down a constant braking force of 10 000 N is exerted on the car.

- (i) Calculate the acceleration of the car.

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- (ii) Calculate the kinetic energy of the car when it is travelling at a speed of 48 m/s.

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- (iii) When the brakes are applied with a constant force of 10 000 N the car travels a distance of 144 m before it stops. Calculate the work done in stopping the car.

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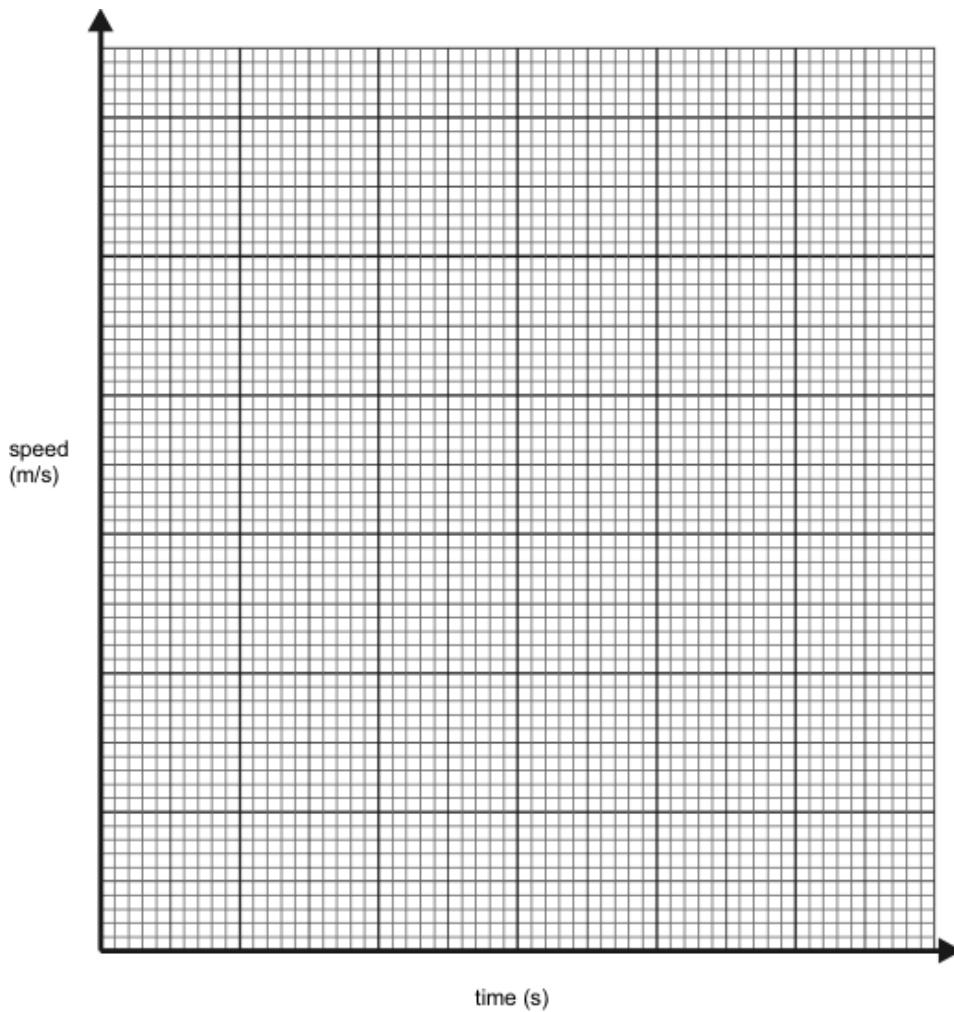
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(12)
(Total 16 marks)

Q5. A driver is driving along a road at 30 m/s. The driver suddenly sees a large truck parked across the road and reacts to the situation by applying the brakes so that a constant braking force stops the car. The reaction time of the driver is 0.67 seconds, it then takes another 5 seconds for the brakes to bring the car to rest.

- (a) Using the data above, draw a speed-time graph to show the speed of the car from the instant the truck was seen by the driver until the car stopped.



(5)

- (b) Calculate the acceleration of the car whilst the brakes are applied.

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Answer = m/s²

(3)

- (c) The mass of the car is 1500 kg. Calculate the braking force applied to the car.

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Answer = N

(3)

- (d) The diagrams below show what would happen to a driver in a car crash.



- (i) Explain why the driver tends to be thrown towards the windscreen.

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- (ii) During the collision the front end of the car becomes crumpled and buckled. Use this information to explain why such a collision is described as "inelastic".

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- (iii) The car was travelling at 30 m/s immediately before the crash. Calculate the energy which has to be dissipated as the front of the car crumples.

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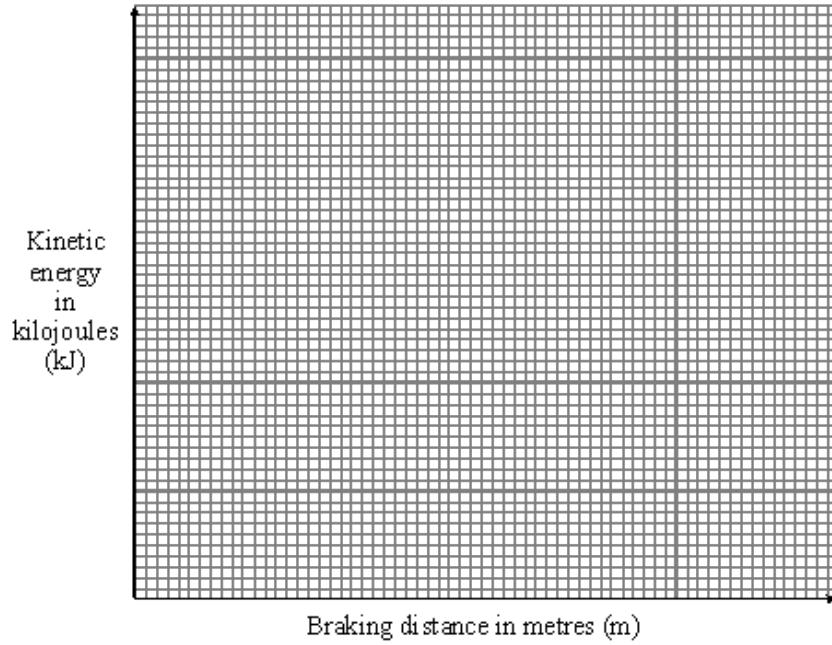
(8)
(Total 19 marks)

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The table shows the braking distances for a car at different speeds and kinetic energy. The braking distance is how far the car travels once the brakes have been applied.

Braking distance in m	Speed of car in m/s	Kinetic energy of car in kJ
5	10	40
12	15	90
20	20	160
33	25	250
45	30	360

- (a) A student suggests, "the braking distance is directly proportional to the kinetic energy."
(i) Draw a line graph to test this suggestion.



(3)

- (ii) Does the graph show that the student's suggestion was correct or incorrect? Give a reason for your answer.

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(1)

- (iii) Use your graph and the following equation to predict a braking distance for a speed of 35 metres per second (m/s). The mass of the car is 800 kilograms (kg). Show clearly how you obtain your answer.

$$\text{kinetic energy} = \frac{1}{2} mv^2$$

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Braking distance = m

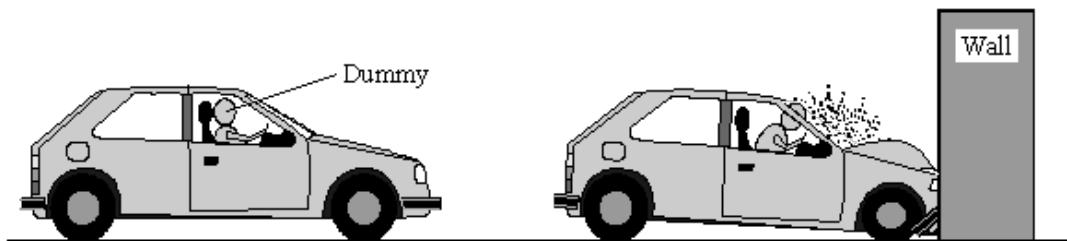
(2)

- (iv) State **one** factor, apart from speed, which would increase the car's braking distance.

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(1)

- (b) The diagram shows a car before and during a crash test. The car hits the wall at 14 metres per second (m/s) and takes 0.25 seconds (s) to stop.



- (i) Write down the equation which links acceleration, change in velocity and time taken.

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(1)

- (ii) Calculate the deceleration of the car.

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$$\text{Deceleration} = \text{ m/s}^2$$

(1)

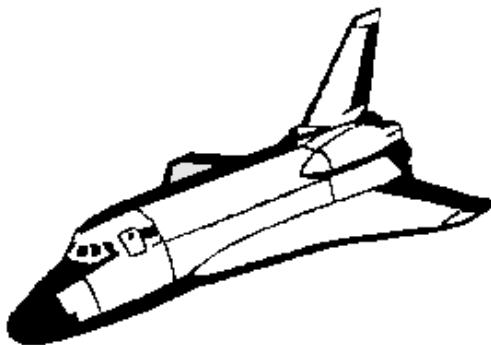
- (iii) In an accident the crumple zone at the front of a car collapses progressively. This increases the time it takes the car to stop. In a front end collision the injury to the car passengers should be reduced. Explain why. The answer has been started for you.

By increasing the time it takes for the car to stop, the

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(2)
(Total 11 marks)

- Q7.** The diagram shows an orbiter, the reusable part of a space shuttle. The data refers to a typical flight.



Orbiter data	
Mass	78 000 kg
Orbital speed	7.5 km/s
Orbital altitude	200 km
Landing speed	100 m/s
Flight time	7 days

- (a) (i) What name is given to the force which keeps the orbiter in orbit around the Earth?

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(1)

- (ii) Use the following equation to calculate the kinetic energy, in joules, of the orbiter while it is in orbit.

$$\text{kinetic energy} = \frac{1}{2} mv^2$$

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Kinetic energy = joules

(2)

- (iii) What happens to most of this kinetic energy as the orbiter re-enters the Earth's atmosphere?

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(1)

- (b) After touchdown the orbiter decelerates uniformly coming to a halt in 50 s.

- (i) Give the equation that links acceleration, time and velocity.

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(1)

- (ii) Calculate the deceleration of the orbiter. Show clearly how you work out your answer and give the unit.

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Deceleration =

(2)

- (c) (i) Give the equation that links acceleration, force and mass.

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(1)

- (ii) Calculate, in newtons, the force needed to bring the orbiter to a halt. Show clearly how you work out your answer.

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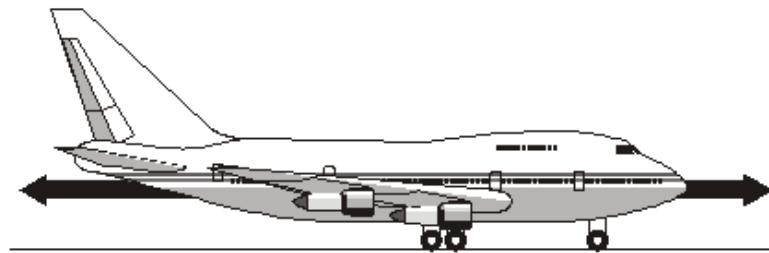
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Force = newtons

(1)

(Total 9 marks)

- Q8.** (a) The diagram shows an aircraft and the horizontal forces acting on it as it moves along a runway. The *resultant force* on the aircraft is zero.



- (i) What is meant by the term *resultant force*?

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(1)

- (ii) Describe the movement of the aircraft when the resultant force is zero.

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(1)

- (b) The aircraft has a take-off mass of 320 000 kg. Each of the 4 engines can produce a maximum force of 240 kN.

Use the equation in the box to calculate the maximum acceleration of the aircraft.

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

Show clearly how you work out your answer and give the unit.

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$$\text{Acceleration} = \dots$$

(3)

- (c) As the aircraft moves along the runway to take off, its acceleration decreases even though the force from the engines is constant.

Explain why.

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(2)

(Total 7 marks)

- Q9.** The diagram shows the horizontal forces acting on a car of mass 1200 kg.



- (a) Calculate the acceleration of the car at the instant shown in the diagram.

Write down the equation you use, and then show clearly how you work out your answer and give the unit.

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Acceleration =

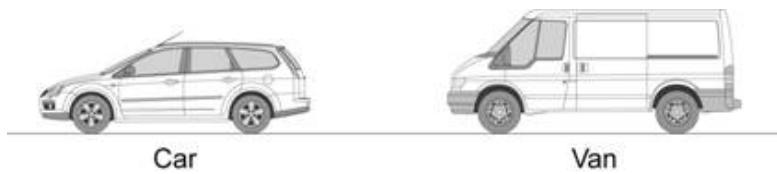
(4)

- (b) Explain why the car reaches a top speed even though the thrust force remains constant at 3500 N.

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(3)

- (c) The diagram shows a car and a van.



The two vehicles have the same mass and identical engines.

Explain why the top speed of the car is higher than the top speed of the van.

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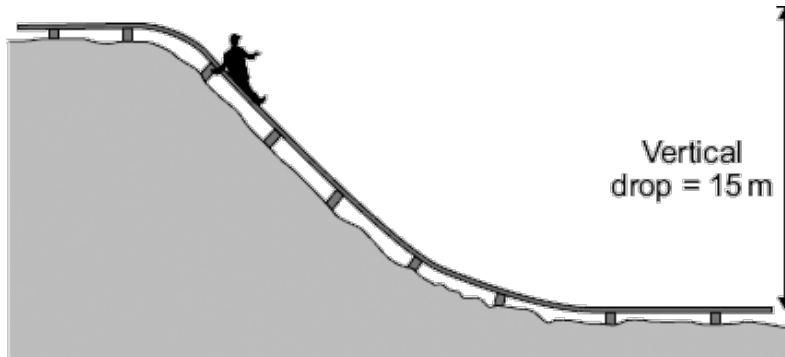
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(4)
(Total 11 marks)

- Q10.** The miners working in a salt mine use smooth wooden slides to move quickly from one level to another.



- (a) A miner of mass 90 kg travels down the slide.

Calculate the change in gravitational potential energy of the miner when he moves 15 m vertically downwards.

$$\text{gravitational field strength} = 10 \text{ N/kg}$$

Use the correct equation from the Physics Equations Sheet.

Show clearly how you work out your answer.

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$$\text{Change in gravitational potential energy} = \dots \text{ J}$$

(2)

- (b) Calculate the **maximum** possible speed that the miner could reach at the bottom of the slide.

Use the correct equation from the Physics Equations Sheet.

Show clearly how you work out your answer.

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Give your answer to an appropriate number of significant figures.

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$$\text{Maximum possible speed} = \dots \text{ m/s}$$

(3)

- (c) The speed of the miner at the bottom of the slide is much less than the calculated maximum possible speed.

Explain why.

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(3)
(Total 8 marks)

