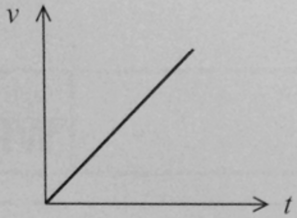
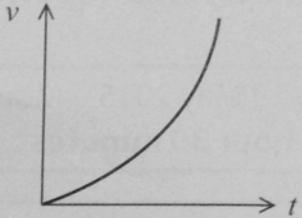
1 A moving object has uniform, non-zero acceleration.

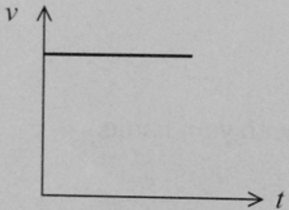
Which velocity-time graph correctly shows this?



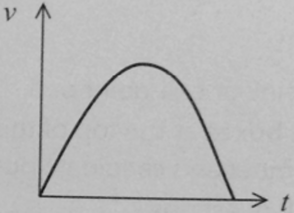
A



B



C



D

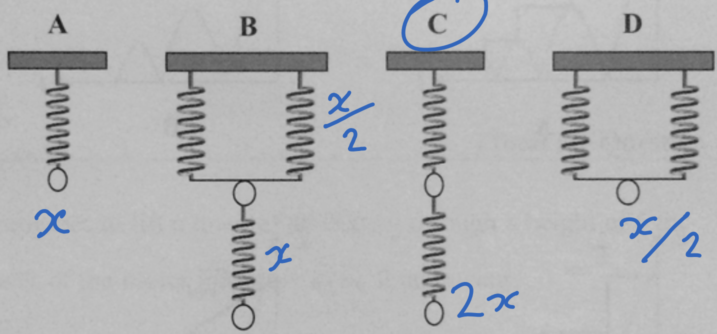
2 Physical quantities are either vectors or scalars.

Select the row of the table which correctly identifies vector and scalar quantities.

	Mass	Velocity	Displacement
☒ **A**	scalar	vector	scalar
☒ **B**	vector	scalar	vector
☒ **C**	vector	scalar	scalar
☒ **D**	scalar	vector	vector

(Total for Question 2 = 1 mark

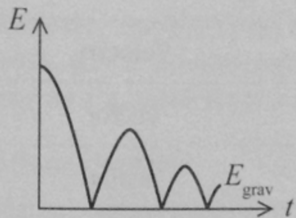
3 The following arrangements all contain identical springs, shown unextended.



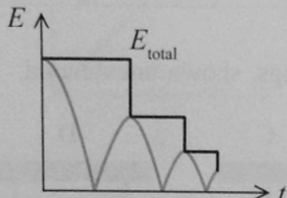
A mass m is added to the bottom of each arrangement. Which arrangement will produce the greatest total extension?

4 A ball is dropped and bounces three times before being caught. The following graph shows how the gravitational potential energy E_{grav} of the ball varies with time t.

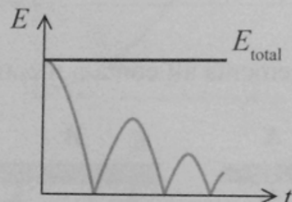
KE lost in each collision



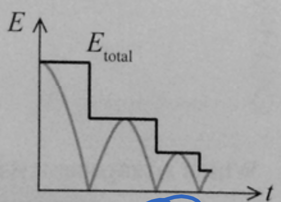
Ignore the effects of air resistance. Select the graph that correctly shows how the total kinetic and potential energy E_{total} of the ball varies with time.



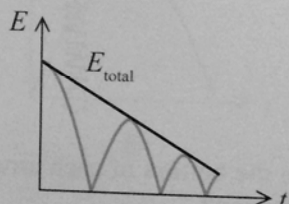
A



B



C



D

5 A force is applied to a length of wire.

Which of the following statements is **not** correct for small deformations of the wire?

☒ **A** As the force applied increases, the extension increases. $F = kx$ ✓

☒ **B** The force applied is directly proportional to the extension. ✓

☒ **C** The force applied is directly proportional to the original length.

☒ **D** The stress is directly proportional to the strain. ✓

(Total for Question 5 = 1 ma

---

6 Aluminium can be used to produce thin sheets of food wrapping because it is

☒ **A** brittle.

☒ **B** ductile.

☒ **C** hard.

☒ **D** malleable.

(Total for Question 6 = 1 ma

---

7 A motor takes 10 minutes to lift a mass of 40 000 kg through a height of 5 m.

The minimum power of the motor in watts can be found using

☒ **A** $\dfrac{40\,000 \times 9.81 \times 5 \times 60}{10}$ $P = \dfrac{\Delta E}{\Delta t} = \dfrac{mgh}{\Delta t}$

☒ **B** $\dfrac{40\,000 \times 9.81 \times 5}{10 \times 60}$

☒ **C** $\dfrac{40\,000 \times 5 \times 60}{10}$

☒ **D** $\dfrac{40\,000 \times 5}{10 \times 60}$

8 A stone dropped into a well takes 1.5 seconds to reach the water.

Ignoring the effects of air resistance, what distance did the stone fall through?

☒ **A** 7 m

☒ **B** 11 m

☒ **C** 14 m

☒ **D** 22 m

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

$= 0 + \frac{9.81}{2} \times 1.5^2$

$= 11\text{m}$

(Total for Question 8 =

9 A swimmer jumps from a diving platform into a swimming pool. The swimmer is slowed to a stop by friction with the water.

The total work done by the water on the swimmer does **not** depend on

☒ **A** the mass of the swimmer. x

☒ **B** the speed of the swimmer on entering the water.

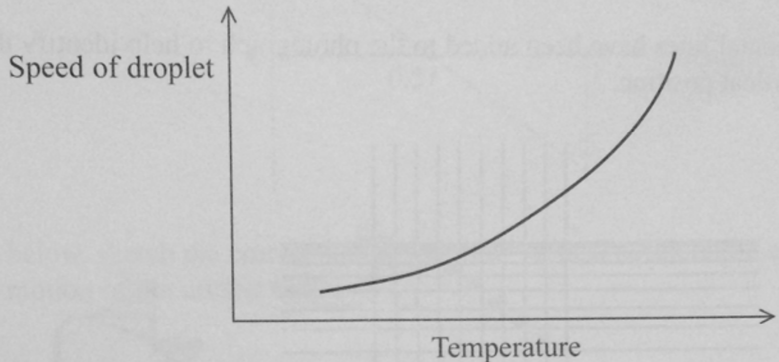
☒ **C** the depth of the swimming pool.

☒ **D** the height of the diving platform. x

$mgh \rightarrow \frac{1}{2}mv^2$

0 A glue dispenser produces small droplets of glue. The glue dispenser contains a small heater.

The graph shows how the speed of a droplet leaving the dispenser varies with the temperature of the glue.



A higher temperature of glue is preferred because

☒ **A** the viscosity will be greater and the glue will flow at a greater speed.

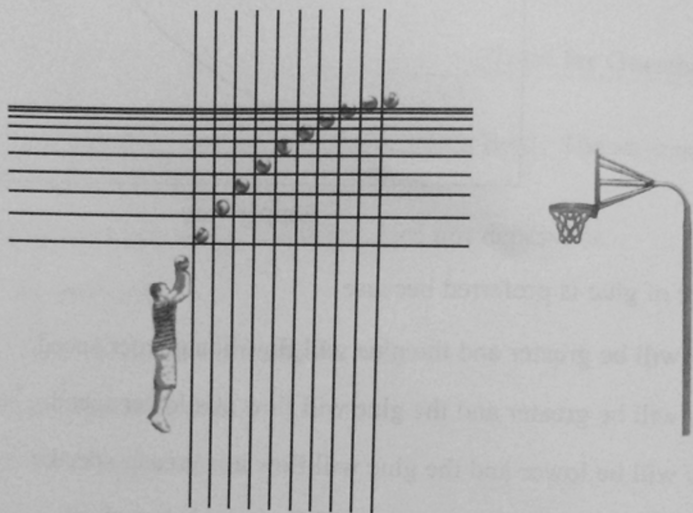
☒ **B** the viscosity will be greater and the glue will flow at a lower speed.

☒ **C** the viscosity will be lower and the glue will flow at a greater speed.

☒ **D** the viscosity will be lower and the glue will flow at a lower speed.

11 A basketball is thrown towards a basket. The position of the ball at equal time intervals is shown in the photograph.

Vertical and horizontal lines have been added to the photograph to help identify the ball's horizontal and vertical position.



Suggest a reason for each of the following observations:

(a) the vertical lines are evenly spaced,

constant horizontal velocity

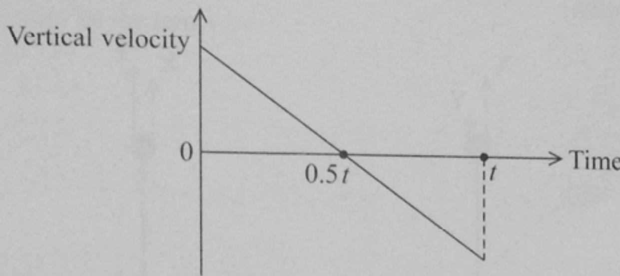
(1)

(b) the horizontal lines become closer together.

ball decelerates in the vertical direction due to gravity

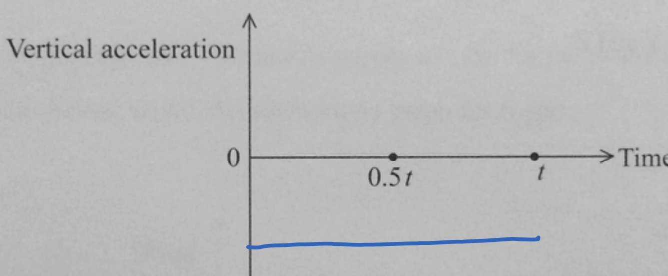
(1)

12 A cricket ball is hit and travels across a field where it is caught at a time t. A graph of vertical velocity against time is shown.



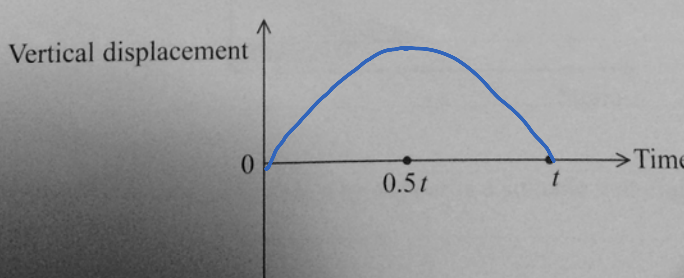
(a) On the axes below, sketch the corresponding graph of vertical acceleration against time for the motion of the cricket ball.

(2)

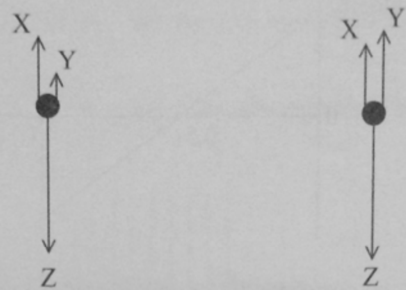


(b) On the axes below, sketch the corresponding graph of vertical displacement against time for the motion of the cricket ball.

(2)



13 A small steel ball is released at the surface of some oil of known viscosity and begins to sink. The diagrams show the forces acting on the ball shortly after its release and when it has reached terminal velocity.



Steel ball shortly after release

Steel ball at terminal velocity

(a) Identify forces X, Y and Z.

(3)

X is upthrust

Y is viscous drag

Z is weight

(b) A student uses Stokes' law to calculate force Y.

State the measurements the student should make to calculate force Y acting on the ball when it is moving at terminal velocity.

(2)

$F = 6\pi r \eta v$

Measure diameter of ball and terminal velocity

14 (a) A force is applied across the ends of a sample of wire. For small forces the deformation of the wire is elastic and for large forces the deformation is plastic.

Explain what is meant by the terms

(3)

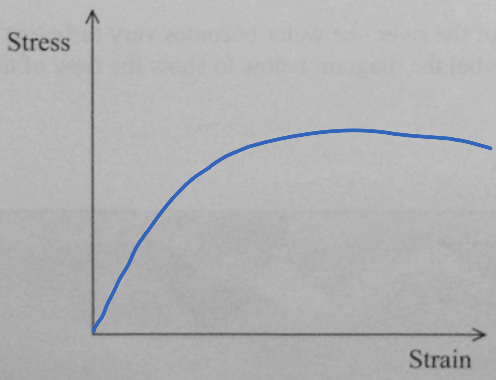
elastic deformation material returns to original length once force is removed

plastic deformation there's a permanent extension after the force is removed

(b) Copper is a ductile material. This makes copper suitable for the production of wires.

(i) On the axes below, sketch the stress-strain graph for copper.

(2)



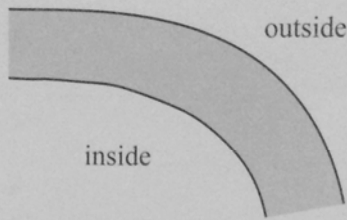
(ii) With reference to your graph, state why copper is a suitable material for the production of wires.

(1)

There's a large strain before it breaks

15 Along a river there are changes in the speed of the water due to natural obstacles such as bends and rocks.

(a) At a bend, the water on the inside of the bend is shallower than the water on the outside of the bend.



Suggest why the speed of the water is lower at the inside of the bend than at the outside of the bend.

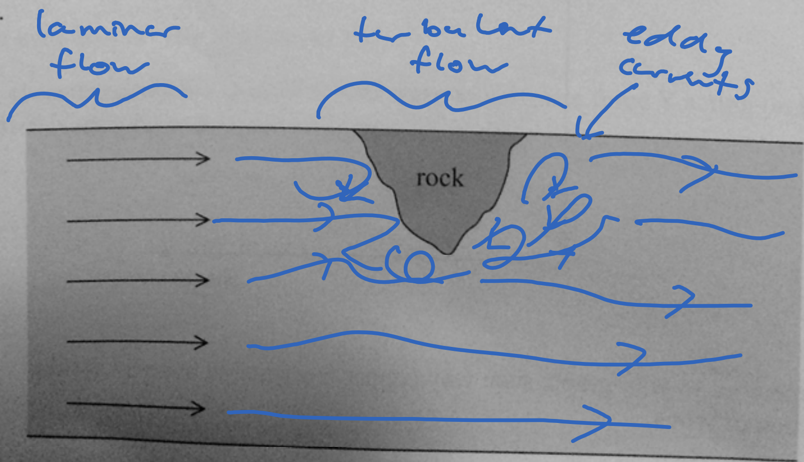
(1)

• Smaller radius of curvature inside so distance travelled is less

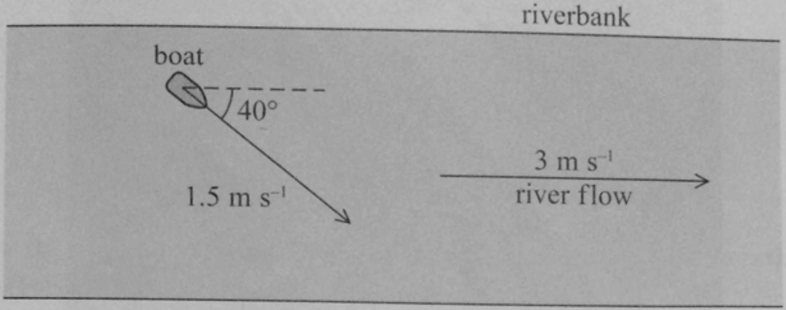
• Shallow water so there's more friction

(b) On a straight section of the river, the water becomes very turbulent around a large rock. Complete and label the diagram below to show the flow of the water around the rock.

(2)

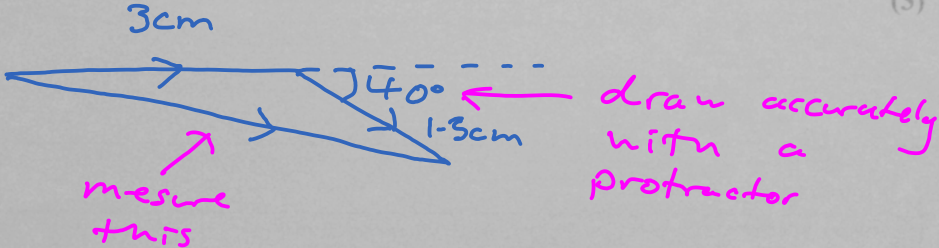


(c) The river is flowing at a speed of 3 m s^{-1}. A boat is pointed at an angle of 40° to the riverbank and paddled at a speed of 1.5 m s^{-1}, as shown in the diagram.



In the space below, draw a vector diagram to scale and use it to determine the magnitude of the actual velocity of the boat.

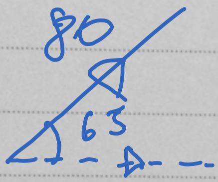
(3)



16 A passenger in an airport pulls a suitcase at a constant speed with a force of 80 N at an angle of 65° to the horizontal.

(a) (i) Show that the horizontal component of the applied force is about 30 N.

(2)



$80\cos 65 = 34\text{ N}$

(ii) Hence calculate the work done on the suitcase in pulling it a distance of 320 m.

(2)

$W = Fd = 34 \times 320$

$= 11\text{ kJ}$

Work done = ...

(iii) Show that the vertical component of the applied force is about 70 N.

(2)

$80\sin 65 = 73\text{ N}$

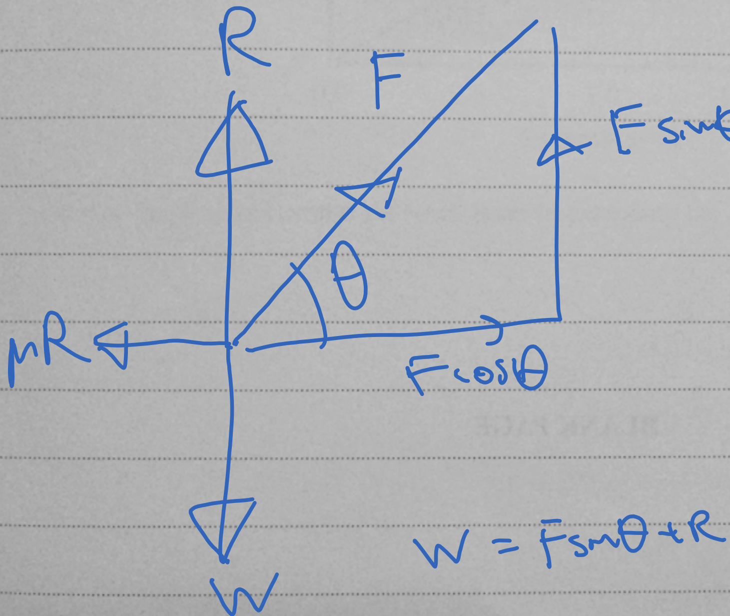
(iv) State why no work is done in a vertical direction even though there is a component of the applied force in the vertical direction.

(1)

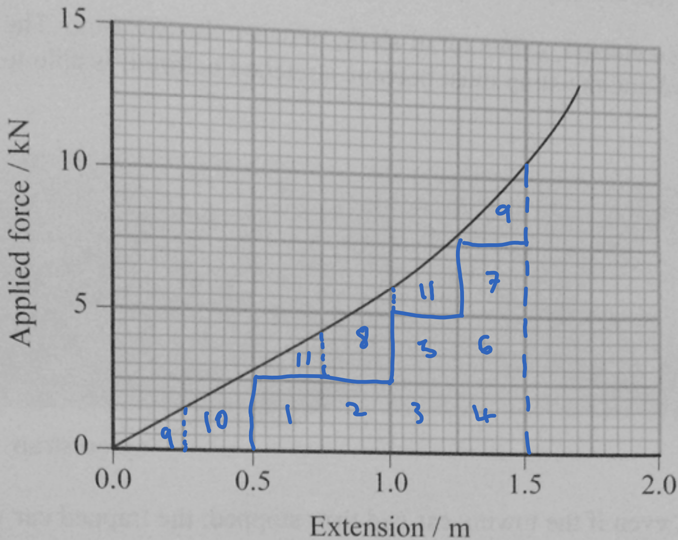
No movement in the vertical direction

*(b) Explain how the magnitude and angle of the applied force must change in order to make the suitcase accelerate horizontally.

(4)



17 (a) The force-extension graph obtained when stretching a nylon rope is shown below.



Use the graph to determine the work done in extending the rope by 1.5 m.

(3)

$W = 11 \times 2.5 \times 10^3 \times 0.25$

$= 6875 J$

(b) Kinetic towing of cars is a method that can be used when it is difficult for a towing car to achieve sufficient grip, such as in snow or sand.

A nylon strap is connected, with a lot of slack, between the two cars. The towing car drives forward and the strap must become stretched before it is able to pull the trapped car free.

*(i) Explain why, even if the towing car had then stopped, the trapped car would still begin to move.

(2)

Extended nylon strap exerts a force on trapped car.
Stored electric potential energy turns into kinetic energy of trapped car

(ii) The nylon strap used for kinetic towing typically has a breaking strain of 25%. Steel cables, often used for towing cars along roads, typically have a breaking strain of 0.02%.

It can be assumed that the nylon strap and the steel cable both obey Hooke's law. Show that, for the same pulling force and just before breaking, a nylon strap can store over 1000 times more energy than a steel cable of identical initial length and cross sectional area.

(3)

strain = $\frac{\text{ext. } (x)}{\text{org. length} (l)}$

$x_s = 0.25l$

$x_N = 0.0002l$

$E = \frac{1}{2}Fx$

$E_s = \frac{1}{2}F(0.0002l) = 0.0001Fl$

$E_N = \frac{1}{2}F(0.25l) = 0.125Fl$

$\frac{E_N}{E_s} = \frac{0.125Fl}{0.0001Fl} = 1250$

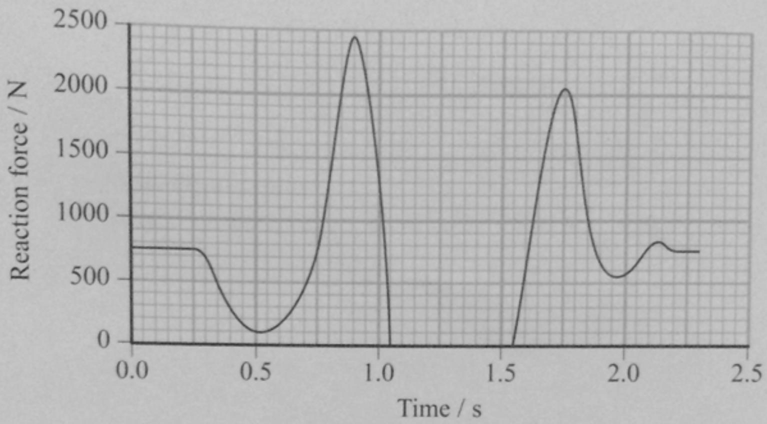
(iii) Suggest why steel cables are **not** suitable for kinetic towing of cars.

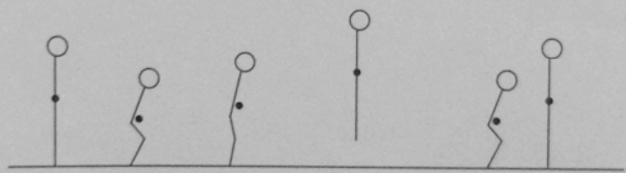
(1)

Breaks without extending much

18 An athlete bends his knees and then springs up into a vertical jump. The graph below shows how the reaction force from the ground on the athlete varies with time.

The diagram below the graph shows the position of the athlete at the corresponding times as he completes his jump.





(a) Show that the mass of the athlete is about 80 kg.

(2)

$R = mg$

$750 = 9.81m$

$m = 76.5$ kg

(b) The small dot on each diagram of the athlete represents his centre of gravity.

(i) State what is meant by centre of gravity.

(1)

The point which weight acts through

(ii) Between 0.25 s and 0.75 s the athlete bends his knees. As a result of this, his centre of gravity moves lower.

Explain how the graph shows that an acceleration is produced as the athlete bends his knees.

(2)

$F = ma$

$F = R - mg > 0$

$\Rightarrow a > 0$

*(c) In order to jump, the athlete pushes down on the ground between 0.75 s and 1.05 s.

With reference to Newton's laws, explain why the athlete must push down on the ground.

(3)

- $R > mg$ for jumping
- Normally, $R = mg$ so extra R is required.
- Newton's third law: athlete pushes down, ground (R) pushes back

(d) The maximum reaction force was reached at $t = 0.9$ s. Calculate the acceleration of the athlete at this point.

(3)

$F = ma$

$2450 - 750 = 76.5a$

$a = 22.2\ m\,s^{-2}$

(e) The athlete was in the air for 0.50 s.

(i) Calculate the height jumped by the athlete.

(2)

$s = ?$

$u = x$

$v = 0$

$a = -9.81$

$t = 0.25\,s$

$[s = vt - \frac{1}{2}at^2]$

$s = 0 - \frac{1}{2}(-9.81)(0.25)^2$

$= 0.31\,m$

Height = ...

(ii) Calculate the speed of the athlete on leaving the ground.

(2)

$v = u + at$

$0 = u - 9.81(0.25)$

$u = 2.45\,ms^{-1}$

19 During the 17th century, the physicist Galileo carried out a series of experiments to investigate how gravity affected acceleration.

There were no accurate methods to measure short times, so Galileo used an object on a smooth inclined plane to increase the time taken for the object's motion.

(a) An object is released from rest and slides a distance s down a smooth inclined plane, as shown in diagram 1. This will take longer than releasing the object from rest and allowing it to fall freely through the same distance s, as shown in diagram 2.

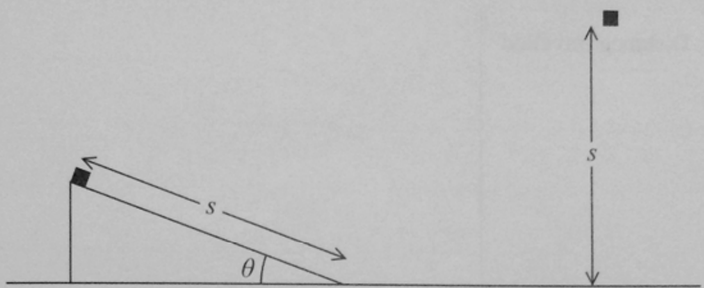
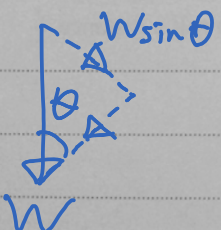


Diagram 1 Diagram 2

(i) Assuming that the frictional forces between the plane and the object are negligible, explain why the object in diagram 1 takes longer to travel distance s than the object in diagram 2.

(3)



The resultant force on object is only a component of the weight so acceleration is less than g.

(ii) Calculate the acceleration of the object in diagram 1 when $\theta = 35°$.

(2)

$F = ma$

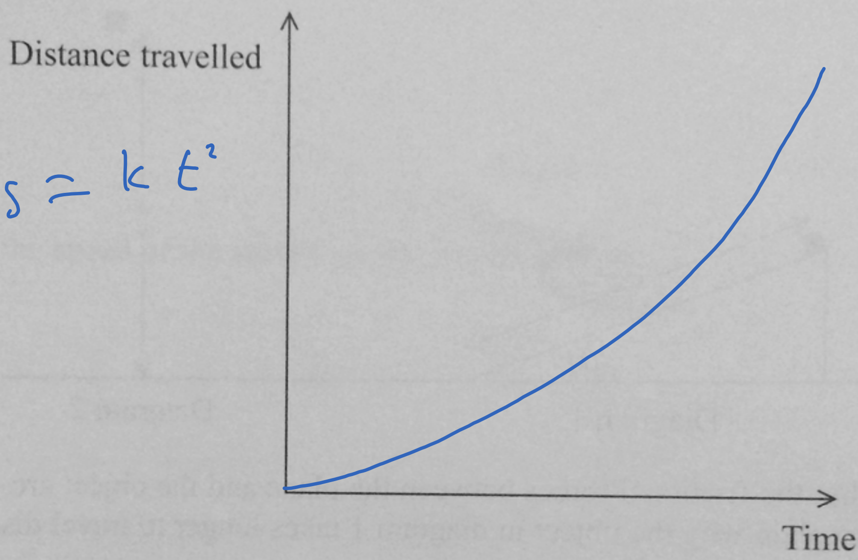
$mg \sin 35 = ma$

$a = 5.6\ \text{ms}^{-2}$

(b) Galileo released a metal ball from rest so that it could roll down a smooth inclined plane. The time t taken to roll a distance s was measured. He repeated the experiment, each time recording the time taken to travel a different fraction of the distance s.

(i) On the axes below, sketch the distance-time graph that would be expected from these readings.

(2)



$s = k t^2$

(ii) Write an expression for the time taken, in terms of t, for the ball to roll a distance $\frac{s}{2}$ from the top of the plane.

$s \propto t^2$

(1)

$T = \frac{t}{\sqrt{2}}$

(c) Galileo repeated his measurements many times and obtained similar results on each occasion. He did not have a stopwatch and had to measure times using his pulse. A human pulse is about one beat per second.

Comment on Galileo's method.

(2)

Time only measured to nearest second

Using an inclined plane makes the time longer so the uncertainty becomes less significant

(d) Today, the acceleration of free fall can be found accurately by dropping a metal ball vertically and using ICT to collect data.

Suggest the apparatus required to take the measurements needed to calculate a value for the acceleration of free fall.

(2)

Electromagnet holding the ball

Timer connected to electromagnet

Trap door to stop timer