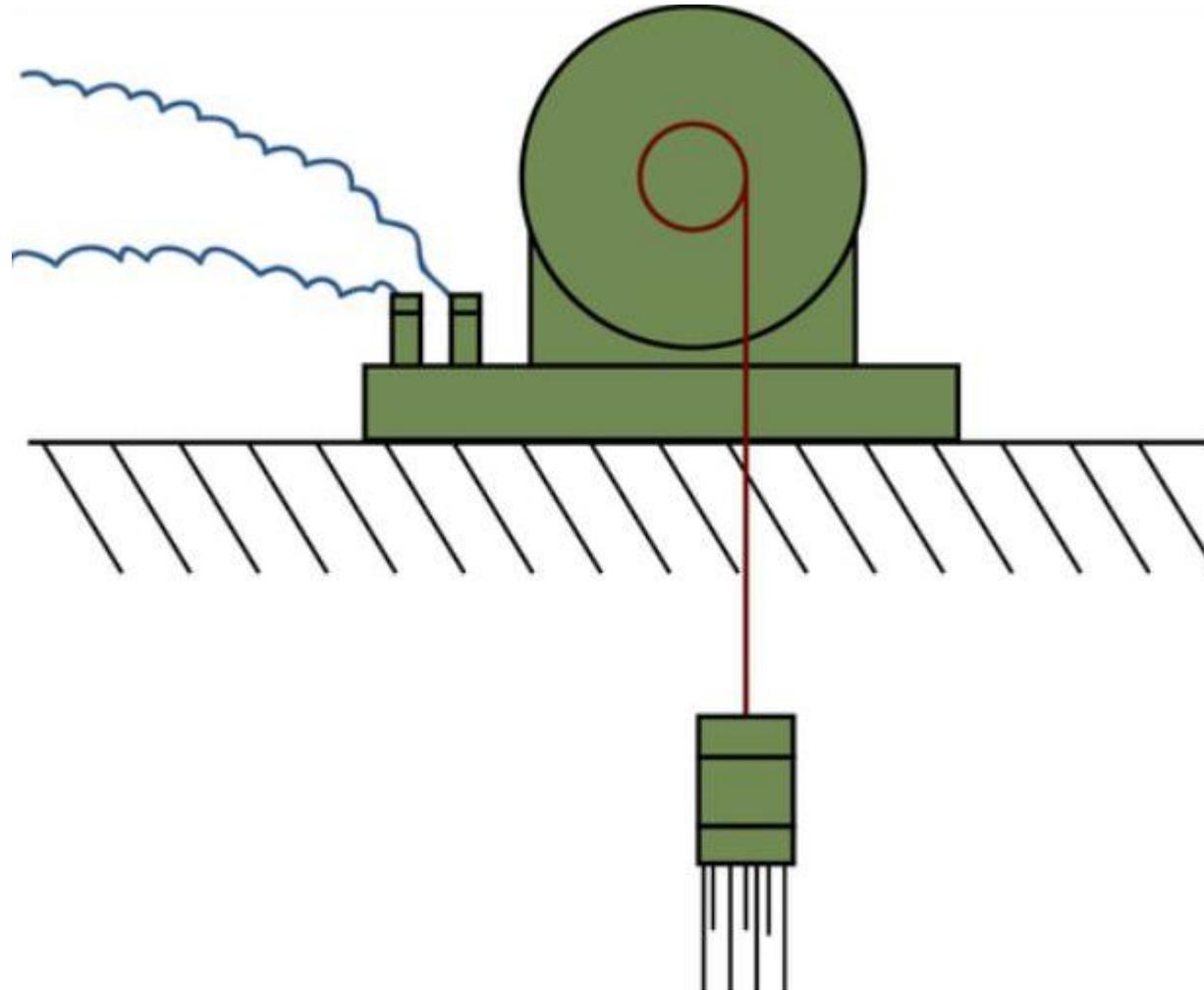


Kinematics, Work & Energy



Material Covered

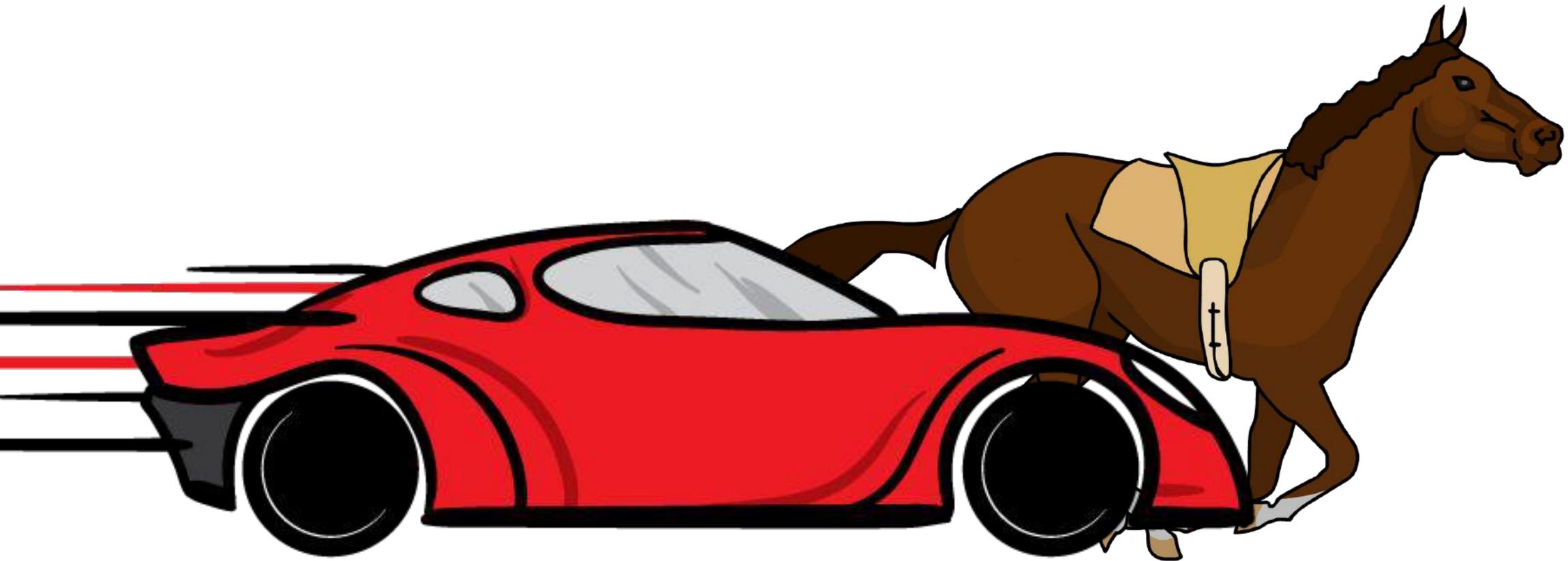
Motion

1. Motion Graphs.
2. Kinematics Equations.
3. Projectile Motion.

Work, Energy and Power

1. Work Done and Power.
2. Kinetic Energy and Gravitational Potential Energy.
3. Conservation of Energy.

Motion



Specification Points - AQA

3.4.1.3 Motion along a straight line

Content	Opportunities for skills development
<p>Displacement, speed, velocity, acceleration.</p> $v = \frac{\Delta s}{\Delta t}$ $a = \frac{\Delta v}{\Delta t}$ <p>Calculations may include average and instantaneous speeds and velocities.</p> <p>Representation by graphical methods of uniform and non-uniform acceleration.</p> <p>Significance of areas of velocity–time and acceleration–time graphs and gradients of displacement–time and velocity–time graphs for uniform and non-uniform acceleration eg graphs for motion of bouncing ball.</p> <p>Equations for uniform acceleration:</p> $v = u + at$ $s = \left(\frac{u+v}{2}\right)t$ $s = ut + \frac{at^2}{2}$ $v^2 = u^2 + 2as$ <p>Acceleration due to gravity, g.</p>	<p>MS 3.6, 3.7 / PS 1.1, 3.1</p> <p>Distinguish between instantaneous velocity and average velocity.</p> <p>MS 3.5, 3.6</p> <p>Measurements and calculations from displacement–time, velocity–time and acceleration–time graphs.</p> <p>MS 0.5, 2.2, 2.3, 2.4</p> <p>Calculations involving motion in a straight line.</p>

3.4.1.4 Projectile motion

Content
<p>Independent effect of motion in horizontal and vertical directions of a uniform gravitational field. Problems will be solvable using the equations of uniform acceleration.</p>

Specification Points – OCR A

3.1.1 Kinematics

Learning outcomes

Learners should be able to demonstrate and apply their knowledge and understanding of:

- (a) displacement, instantaneous speed, average speed, velocity and acceleration
- (b) graphical representations of displacement, speed, velocity and acceleration
- (c) Displacement–time graphs; velocity is gradient
- (d) Velocity–time graphs; acceleration is gradient; displacement is area under graph.

3.1.2 Linear motion

Learning outcomes

Learners should be able to demonstrate and apply their knowledge and understanding of:

- (a) (i) the equations of motion for constant acceleration in a straight line, including motion of bodies falling in a uniform gravitational field without air resistance

$$v = u + at \quad s = \frac{1}{2}(u + v)t$$

$$s = ut + \frac{1}{2}at^2 \quad v^2 = u^2 + 2as$$
- (ii) techniques and procedures used to investigate the motion and collisions of objects

3.1.3 Projectile motion

Learning outcomes

Learners should be able to demonstrate and apply their knowledge and understanding of:

- (a) independence of the vertical and horizontal motion of a projectile
- (b) two-dimensional motion of a projectile with constant velocity in one direction and constant acceleration in a perpendicular direction.

Specification Points – OCR B

Learning outcomes

- (a)** *Describe and explain:*
- (i)** the use of vectors to represent displacement, velocity and acceleration
 - (ii)** the trajectory of a body moving under constant acceleration, in one or two dimensions
 - (vii)** measurement of displacement, velocity and acceleration
- (b)** *Make appropriate use of:*
- (i)** the terms: displacement, speed, velocity, acceleration, force, mass, vector, scalar, work, energy, power, momentum, impulse
- by sketching and interpreting:*
- (ii)** graphs of accelerated motion; slope of displacement–time and velocity–time graphs; area underneath the line of a velocity–time graph
- (c)** *Make calculations and estimates involving:*
- (i)** the resolution of a vector into two components at right angles to each other
 - (ii)** the addition of two vectors, graphically and algebraically
 - (iii)** the kinematic equations for constant acceleration derivable from:

$$a = \frac{v - u}{t}$$
and average velocity = $\frac{v + u}{2}$:

$$v = u + at, s = ut + \frac{1}{2}at^2, v^2 = u^2 + 2as$$

Specification Points - Edexcel

9. be able to use the equations for uniformly accelerated motion in one dimension:

$$s = \frac{(u + v)t}{2}$$

$$v = u + at$$

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

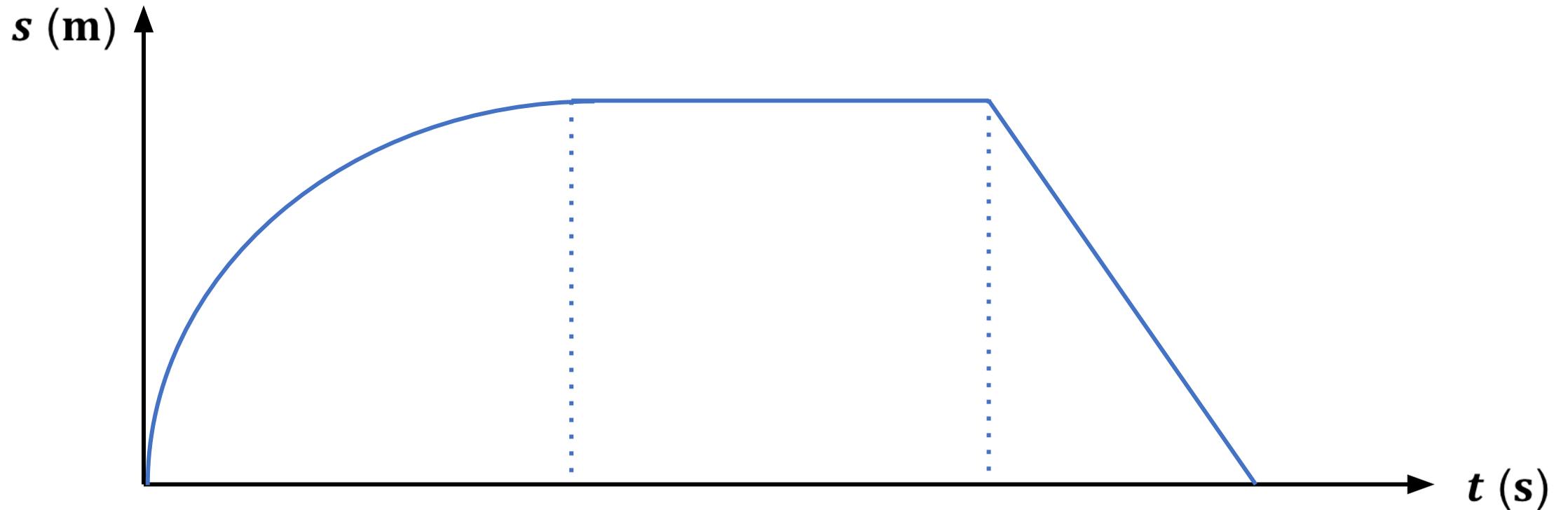
$$v^2 = u^2 + 2as$$

10. be able to draw and interpret displacement-time, velocity-time and acceleration-time graphs
11. know the physical quantities derived from the slopes and areas of displacement-time, velocity-time and acceleration-time graphs, including cases of non-uniform acceleration and understand how to use the quantities
15. understand how to make use of the independence of vertical and horizontal motion of a projectile moving freely under gravity

Motion Graphs

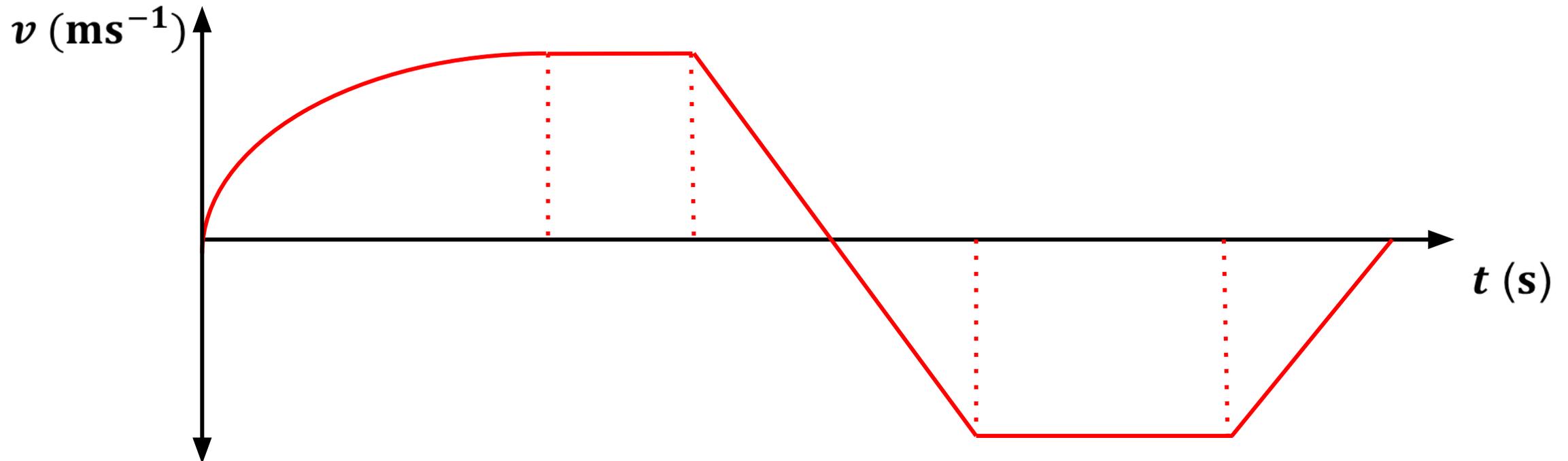
Displacement-time graphs plot an object's displacement against time.

- The **gradient** of the **graph** gives the **instantaneous velocity** at that **time**.



Velocity-time graphs plot an object's velocity against time.

- The **gradient** of the **graph** gives the **instantaneous acceleration** at that **time**.
- The **area** between the **graph** and the **time-axis** gives the **total distance travelled**.



Exemplar Plot/Sketch Exam Question

Context: Velocity-time graph. Keep track of the **key numerical data** for the **journey**.

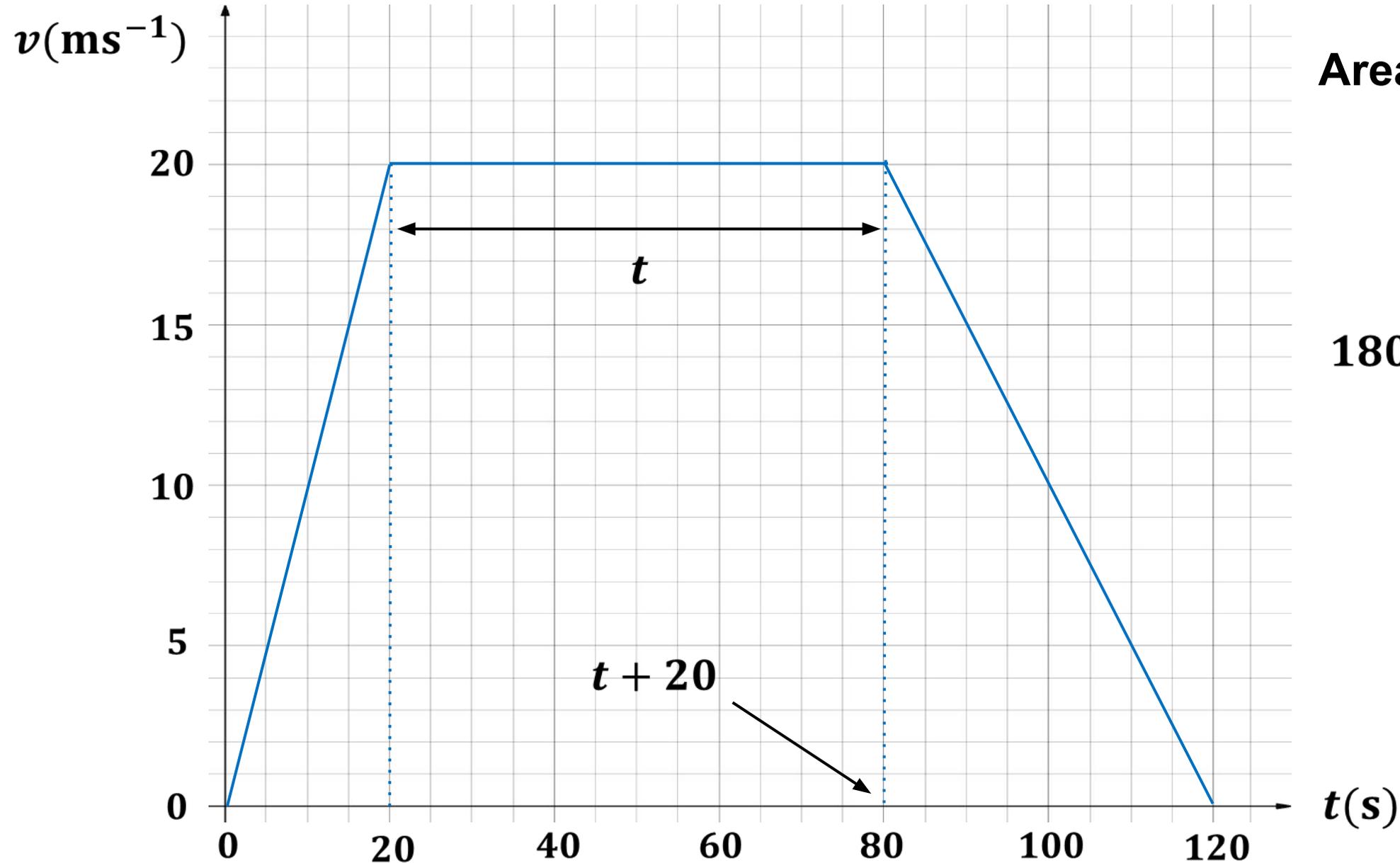
Pick out important values for **velocity-time graph**.

- 1) A car travels along a straight road. It takes **120 s** to travel between two sets of traffic lights **1800 m** apart. The car starts at rest and moves with constant acceleration for **20 s** until it reaches a speed of **20ms^{-1}** which it maintains for t seconds. It then decelerates uniformly to reach the next set of traffic lights. Plot the velocity-time graph for this journey on the axes below and find the value of t .

Plot/Sketch Question: Make **graph neat** and **easy** for the examiner to **interpret**.

[3 marks]

1 mark for finding t . **1 mark** for correct graph and **1 mark** for correct axes values.



Area of Trapezium:

$$A = \frac{a + b}{2} h$$

$$1800 = \frac{120 + t}{2} \times 20$$

$$t = 60 \text{ s}$$

Kinematics Equations

The **SUVAT** equations for constant acceleration relate the 5 variables:

- **s** - Displacement
- **u** – Initial Velocity
- **v** – Final Velocity
- **a** – Acceleration
- **t** – Time

$$v = u + at$$

$$s = \frac{(u + v)}{2} t$$

$$v^2 = u^2 + 2as$$

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

Each **equation** contains 4 of the 5 **variables**. If you know 3 of the **variables** you can use the right **SUVAT equations** to find the others.

Write down the variables you know and the variable you need to calculate. Then select the equation which contains these variables.

- If the **object** begins at rest, $u = 0$. This can **simplify** some of the **equations**.

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

$$v^2 = u^2 + 2as$$

- For **motion** under **gravity**, the **acceleration** a equals the **constant** $g = 9.81\text{ms}^{-2}$.
- If the **object** is **thrown** up in the air, $v = 0$ at its **highest point**. Also the **time of ascent** equals the **time of descent**.

Exemplar Calculation Exam Question

Use the fact that $a = g$ and **time of ascent = time of descent**.

Context: Kinematics. We will need to apply the **SUVAT equations**.

- 1) A tennis ball is thrown vertically up in the air with velocity of 4 ms^{-1} and is caught at the same height it is thrown from. Calculate the total distance it travels and the total time that it is in the air for.

[4 marks]

Calculation Question:

Mathematical question – we need to show our working.

Answer requires a distance with **units** of **metres (m)** and a time with **units** of **seconds (s)**.

Indicates that there will be about **4 steps** to our **calculation**. Any less and we may have missed something.

Exemplar Calculation Question Answer

Write out variables that are known

$$s = ? \quad u = 4 \text{ ms}^{-1} \quad v = 0 \quad a = -9.81 \text{ ms}^{-2}$$

Select the required SUVAT equation and rearrange to calculate s

$$v^2 = u^2 + 2as \Rightarrow u^2 + 2as = 0$$

$$s = \frac{-u^2}{2a} = \frac{-4^2}{2 \times -9.81} = 0.8154 \dots \text{ m} \quad [1 \text{ Mark}]$$

$$\text{Total Distance} = 2 \times 0.8154 \dots \text{ m} = 1.63 \text{ m} \quad [1 \text{ Mark}]$$

Exemplar Calculation Question Answer

Select the required **SUVAT** equation and rearrange to calculate t

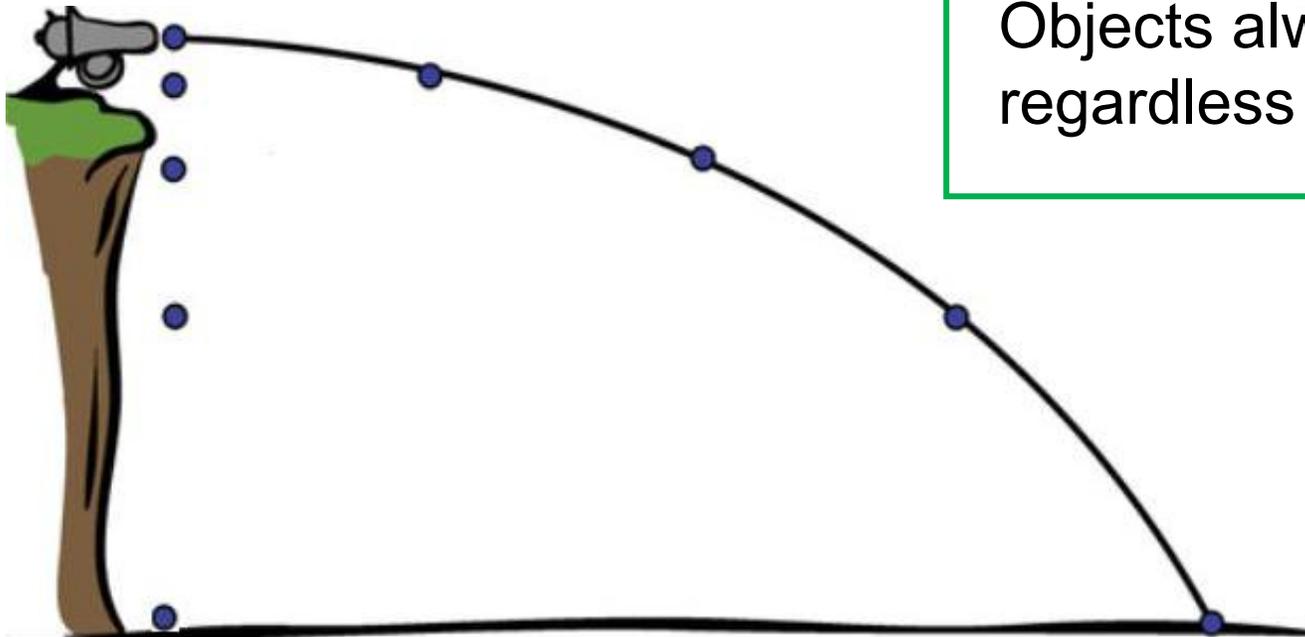
$$v = u + at$$

$$t = \frac{v - u}{a} = \frac{0 - 4}{-9.81} = 0.4077 \dots \text{s} \quad [1 \text{ Mark}]$$

$$\text{Total Time} = 2 \times 0.4077 \dots \text{s} = 0.815 \text{ s} \quad [1 \text{ Mark}]$$

Projectile Motion

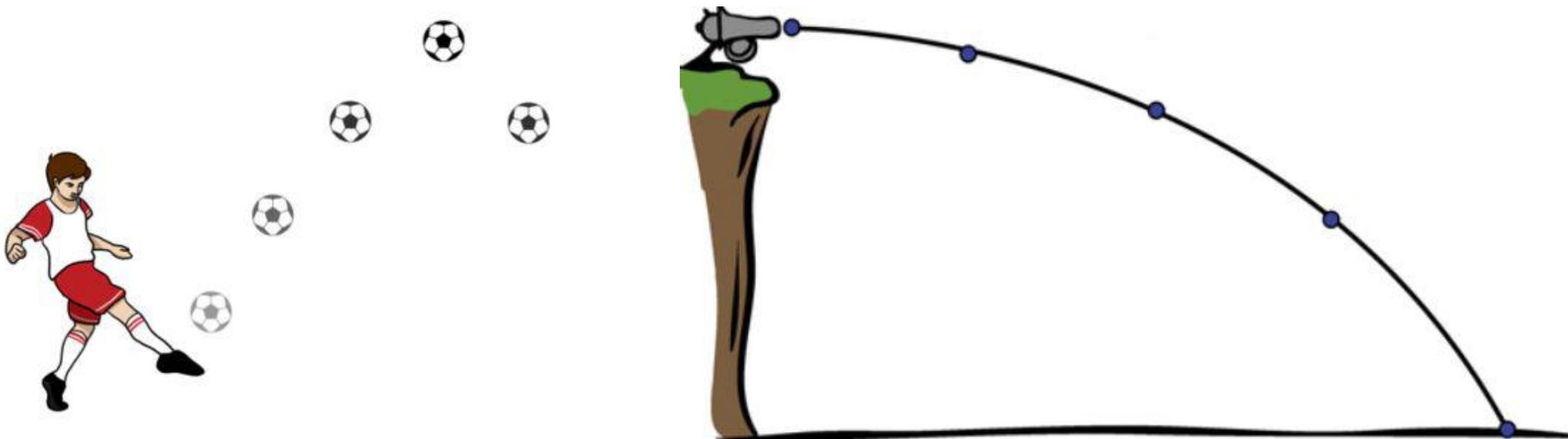
- **Projectiles**, such as a kicked football or a fired cannonball, follow **curved paths**.
- This is because they have a **horizontal velocity component** while **accelerating vertically** due to **gravity**.



Objects always **fall** at the same **rate vertically** regardless of their **horizontal motion**.

- To solve problems involving **projectile motion**, resolve the **horizontal** and **vertical components** of velocity **separately**.

- The **horizontal component** undergoes **uniform motion** (no **acceleration**) so we can use **Distance = Speed \times Time**.
- The **vertical component** undergoes **uniform acceleration** with $a = g$ so we use the **SUVAT equations**.



Exemplar Calculation Exam Question

Context: Projectile motion.

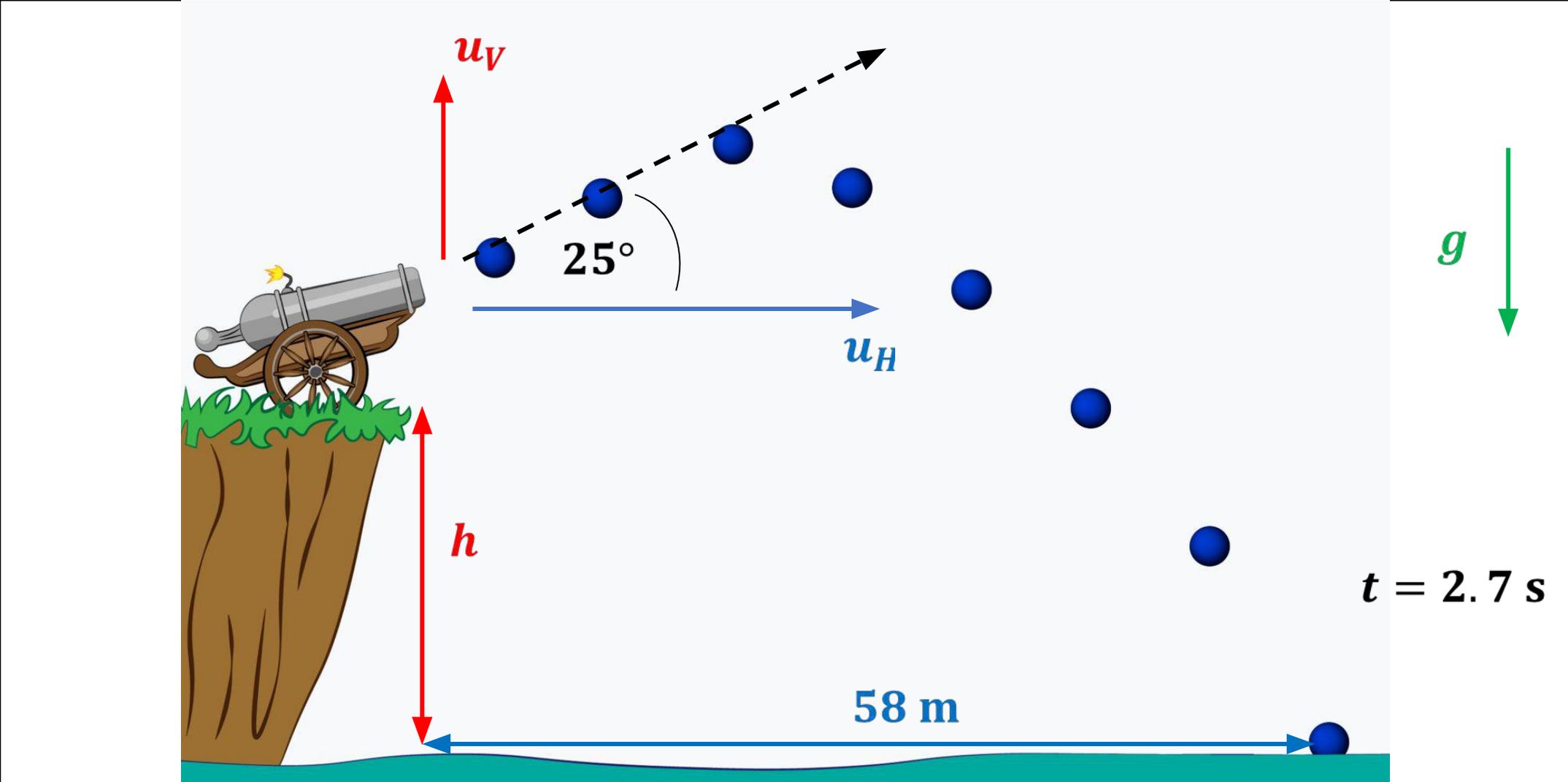
Calculation Question: Show working and give units.

- 1) A cannonball is fired from the top of a cliff at an angle of elevation of 25° . The ball hits the sea 2.7 s later at a distance 58 m away from the foot of the cliff. Calculate the initial velocity of the ball, the height of the cliff and the speed of the ball when it impacts the sea.

Hints at order of our calculation.

[5 marks]

Multi-stage question.



Exemplar Calculation Question Answer

Determine horizontal speed of cannonball

Cannonball doesn't experience air resistance, so horizontal speed is constant

Hence horizontal speed is given by

$$u_H = \frac{s}{t}$$

Using time and distance for when cannonball hits water

$$u_H = \frac{58}{2.7} = 21.48.. \text{ms}^{-1}$$

[1 Mark]

Exemplar Calculation Question Answer

Determine initial vertical speed of cannonball

Initial speed of cannonball u given by

$$u = \frac{u_H}{\cos 25} = \frac{21.48\dots}{\cos 25} = 23.70 \dots \text{ms}^{-1}$$

Vertical component of speed then given by

$$u_V = u \sin 25 = 23.70 \dots \sin 25 = 10.01\dots \text{ms}^{-1}$$

[1 Mark]

Exemplar Calculation Question Answer

Determine height of cliff

Using suvat in vertical direction (take ↓ as positive)

$$s = h \quad u = -10.01 \text{ ms}^{-1} \quad t = 2.7 \text{ s} \quad a = 9.81 \text{ ms}^{-2}$$

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

$$h = (-10.01 \dots \times 2.7) + \frac{1}{2}(9.81 \times 2.7^2)$$

$$h = 8.71 \text{ m}$$

[1 Mark]

Exemplar Calculation Question Answer

Determine speed v of cannonball at water

Horizontal speed is constant, so $v_H = u_H$

Using suvat in vertical direction (take \downarrow as positive)

$$v = v_V \quad u = -10.01 \dots \text{ms}^{-1} \quad t = 2.7\text{s} \quad a = 9.81 \text{ms}^{-2}$$

$$v = u + at$$

$$v_V = -10.01 \dots + (9.81 \times 2.7)$$

$$v_V = 16.47 \dots \text{ms}^{-1}$$

[1 Mark]

Exemplar Calculation Question Answer

Use Pythagoras to determine speed

$$v = \sqrt{v_H^2 + v_V^2}$$

$$v = \sqrt{21.48^2 + 16.47^2}$$

$$v = 27.1 \text{ ms}^{-1}$$

[1 Mark]

Work, Energy and Power



Specification Points - AQA

3.4.1.7 Work, energy and power

Content	Opportunities for skills development
<p>Energy transferred, $W = Fscos\theta$</p> <p>rate of doing work = rate of energy transfer, $P = \frac{\Delta W}{\Delta t} = Fv$</p> <p>Quantitative questions may be set on variable forces.</p> <p>Significance of the area under a force–displacement graph.</p> <p>$efficiency = \frac{useful\ output\ power}{input\ power}$</p> <p>Efficiency can be expressed as a percentage.</p>	<p>MS 0.3 / PS 3.3, 4.1 / AT a, b, f.</p> <p>Investigate the efficiency of an electric motor being used to raise a mass through a measured height. Students should be able to identify random and systematic errors in the experiment and suggest ways to remove them.</p>

3.4.1.8 Conservation of energy

Content	Opportunities for skills development
<p>Principle of conservation of energy.</p> <p>$\Delta E_p = mg\Delta h$ and $E_k = \frac{1}{2}mv^2$</p> <p>Quantitative and qualitative application of energy conservation to examples involving gravitational potential energy, kinetic energy, and work done against resistive forces.</p>	<p>MS 0.4, 2.2</p> <p>Estimate the energy that can be derived from food consumption.</p>

Specification Points – OCR A

3.3.1 Work and conservation of energy

Learning outcomes

Learners should be able to demonstrate and apply their knowledge and understanding of:

- (a) work done by a force; the unit joule
- (b) $W = Fx \cos \theta$ for work done by a force
- (c) the principle of conservation of energy
- (d) energy in different forms; transfer and conservation
- (e) transfer of energy is equal to work done.

3.3.2 Kinetic and potential energies

Learning outcomes

Learners should be able to demonstrate and apply their knowledge and understanding of:

- (a) kinetic energy of an object; $E_k = \frac{1}{2}mv^2$
- (b) gravitational potential energy of an object in a uniform gravitational field; $E_p = mgh$
- (c) the exchange between gravitational potential energy and kinetic energy.

Additional guidance

Learners will also be expected to recall this equation and derive it from first principles.
M0.5

Learners will also be expected to recall this equation and derive it from first principles.
HSW5, 6

3.3.3 Power

Learning outcomes

Learners should be able to demonstrate and apply their knowledge and understanding of:

- (a) power; the unit watt; $P = \frac{W}{t}$
- (b) $P = Fv$
- (c) efficiency of a mechanical system;

$$\text{efficiency} = \frac{\text{useful output energy}}{\text{total input energy}} \times 100\%$$

Additional guidance

Learners will also be expected to derive this equation from first principles.
M0.3
HSW9, 10, 12

Specification Points – OCR B

Learning outcomes

(a) *Describe and explain:*

(iv) calculation of work done, including cases where the force is not parallel to the displacement

(v) the principle of conservation of energy

(vi) power as rate of transfer of energy

(b) *Make appropriate use of:*

(i) the terms: displacement, speed, velocity, acceleration, force, mass, vector, scalar, work, energy, power, momentum, impulse

(c) *Make calculations and estimates involving:*

(vi) the principle of conservation of momentum

(vii) work done $\Delta E = F\Delta s$

(viii) kinetic energy $= \frac{1}{2}mv^2$

(ix) gravitational potential energy $= mgh$

(x) force, energy and power:

$$\text{power} = \frac{\Delta E}{t}, \quad \text{power} = Fv$$

Specification Points - Edexcel

25. be able to use the equation for work $\Delta W = F\Delta s$, including calculations when the force is not along the line of motion

26. be able to use the equation $E_k = \frac{1}{2}mv^2$ for the kinetic energy of a body

27. be able to use the equation $\Delta E_{grav} = mg\Delta h$ for the difference in gravitational potential energy near the Earth's surface

28. know, and understand how to apply, the principle of conservation of energy including use of work done, gravitational potential energy and kinetic energy

29. be able to use the equations relating power, time and energy transferred or work done $P = \frac{E}{t}$ and $P = \frac{W}{t}$

30. be able to use the equations

$$\text{efficiency} = \frac{\text{useful energy output}}{\text{total energy input}}$$

and

$$\text{efficiency} = \frac{\text{useful power output}}{\text{total power input}}$$

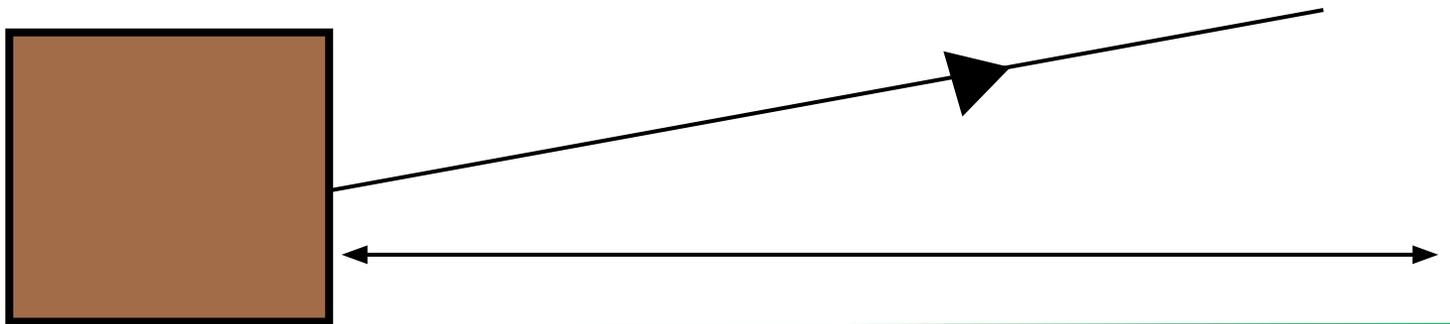
Work Done and Power

Work is done when **energy** is **transferred** from one **body** to another.

- We say that **work** is being **done on** the **body** the **energy** is **transferred** to.
- A **force** must always be **applied** in order to **do work**.

Work done is equal to **force** multiplied by the **distance** moved in the **direction** of the **force**.

$$W = F \cos \theta \times s$$



Work done is equal to the **area** under a **force-displacement graph**.

Work Done and Power

Power is the **rate of transfer of energy**, or in other words, the **rate of doing work**.

$$P = \frac{\Delta E}{\Delta t} = \frac{\Delta W}{\Delta t}$$

Power is measured in units of **Watts (W)** where **1 Watt** equals **1 Joule per second**.

We can also form an **equation** for **power** in terms of **velocity** (v):

\Rightarrow

$$P = F \times v$$

Exemplar Explanation Exam Question

Numbers from the **question** can **support** our **answer** but **explanation questions** first require **qualitative reasoning**.

Context: Work done. Recall what we know from the **definition of work done**.

- 1) The International Space Station (I.S.S) has a mass of approximately **420,000 kg** and orbits the Earth at **7.66 kms⁻¹**. State and explain the work done by the Earth's gravitational force acting on the I.S.S.

[2 marks]

Explanation Question:
Here we need to **explain** our own **statement**.

1 mark for statement and **1 mark for explanation**.
Only require one simple **reason** for **justification**.

-
- During orbit, gravitational force acts perpendicular to instantaneous velocity.
-

[1 Mark]

-
- Therefore $\theta = 90^\circ$ and $W = F \cos \theta \times x = F \times 0 \times x = 0$.
-

No work is done on the satellite by the Earth's gravitational field.

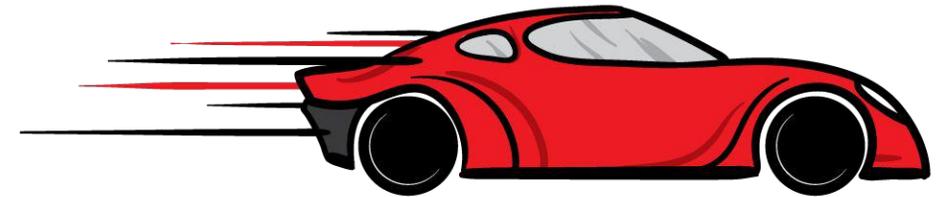
[1 Mark]

Kinetic Energy

Kinetic energy ($K.E$) is the energy due to the movement of an object.

- To **derive** the **equation** for $K.E$ we require the **equations**:

$$s = \frac{(u + v)}{2}t \quad F = ma \quad \Delta W = F\Delta s$$



- **Consider an object moving from rest.**

$$K.E = \frac{1}{2}mv^2$$

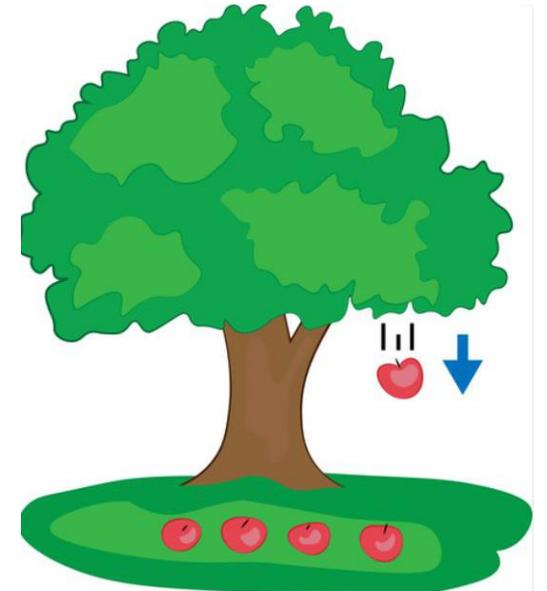
Gravitational Potential Energy

Gravitational potential energy is the **stored energy** an **object** at a **point** in a **gravitational field** possesses.

- To **derive** the **equation** for *GPE* we require the **equations**:

$$F = mg \quad \Delta W = F\Delta h$$

$$G.P.E = mg\Delta h$$



When calculating *GPE* we must **define** a **zero-point** h_0 from which we **measure** Δh .

Exemplar Calculation Exam Question

We will need to use this **equation**.

Context: Power and work. Recall the equations for these variables.

- 1) The equation for the power output of a wind turbine is given by $P = \frac{1}{2}\rho Av^3$ where ρ is the density of the air, A is the circular area swept out by the wind turbine blades and v is the wind speed. The power output of the wind turbine is used by a winch on a crane to raise a block of mass **14000 kg** over the course of one minute. Calculate the height the block can be raised by if the density of air is **1.3 kgm⁻³**, the length of the turbine blades are **10 m** and the wind speed is **22 ms⁻¹**. You may assume no energy is lost by the turbine or the winch.

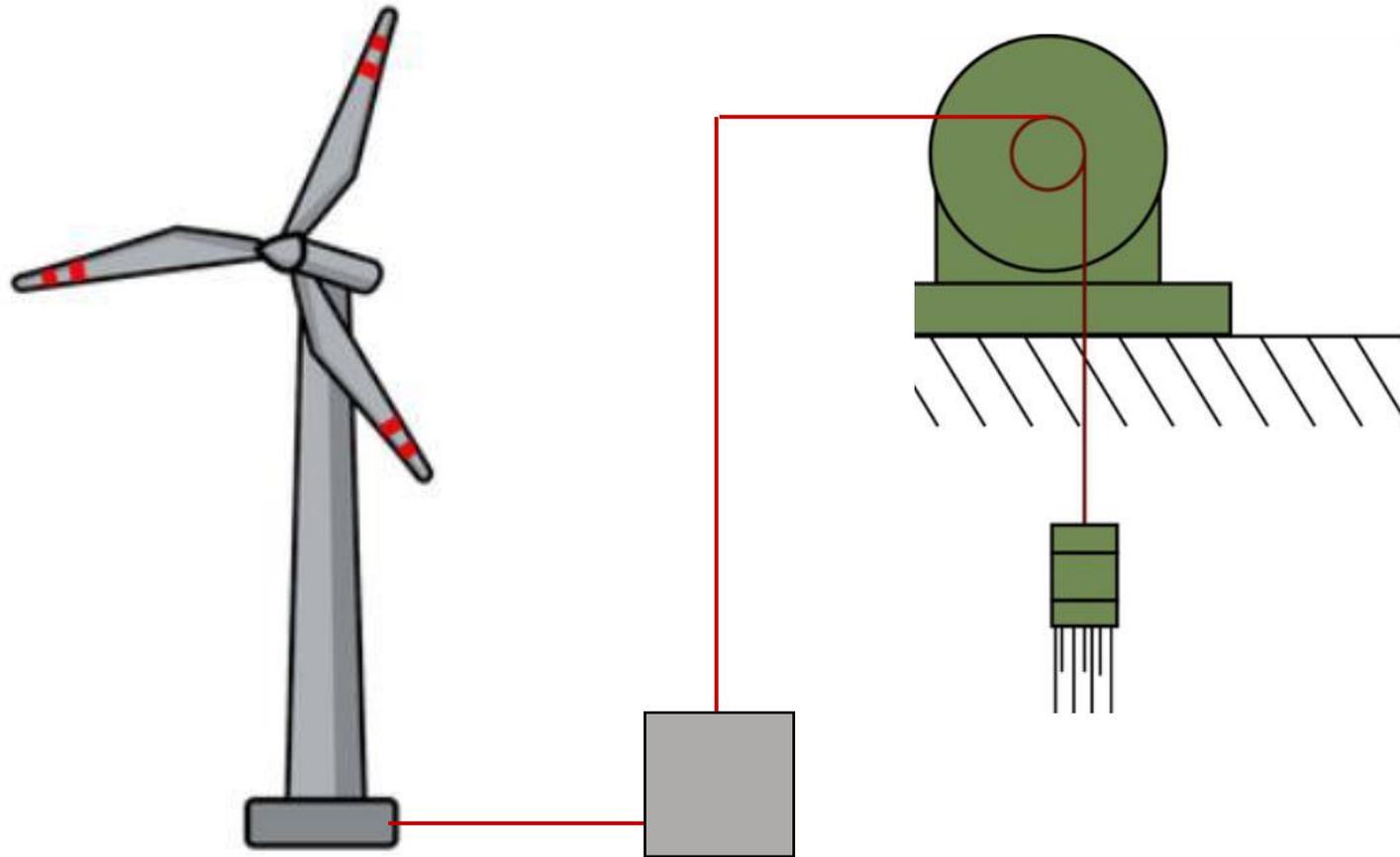
[5 marks]

Values for these **variables** will need to be determined.

Calculation Question:

Mathematical question – we need to show our working.

Indicates that there will be about **5 steps** to our **calculation**. Any less and we may have missed something.



Exemplar Calculation Question Answer

Calculate the power output of the wind turbine

$$P = \frac{1}{2} \rho A v^3$$

$$\rho = 1.3 \text{ kgm}^{-3} \quad v = 22 \text{ ms}^{-1}$$

$$A = \pi r^2 = \pi \times 10^2 = 100\pi \text{ m}^2$$

[1 Mark]

$$P = \frac{1}{2} \times 1.3 \times 100\pi \times 22^3 = 692120\pi \text{ W}$$

[1 Mark]

Exemplar Calculation Question Answer

Calculate the energy available to the winch

$$E = Pt = 692120\pi \times (1 \times 60) = 41527200\pi \text{ J} \quad [1 \text{ Mark}]$$

Equate to change in GPE

$$\Delta \text{G. P. E} = mg\Delta h = 41527200\pi \text{ J}$$

$$14000 \times 9.81 \times \Delta h = 41527200\pi \text{ J}$$

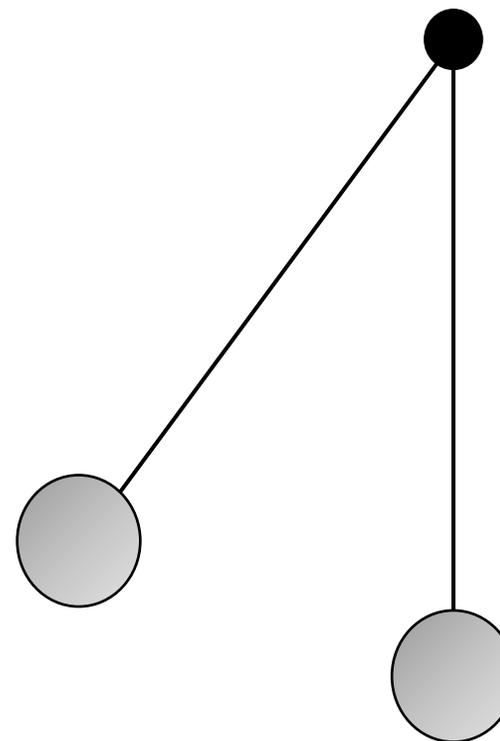
$$\Delta h = 950 \text{ m} \quad [1 \text{ Mark}]$$

Conservation of Energy

The **principle of conservation of energy** states that the **total energy** of a **closed system** is constant, only **converted** from one **form** to another.

- Often, ignoring the effects of **friction**, it is the case that the **total energy** of the **system** is **equal** to the **sum** of ***K.E*** and ***G.P.E***.
- As $E_{TOT} = \text{Constant}$:

$$\Delta K.E = -\Delta G.P.E$$

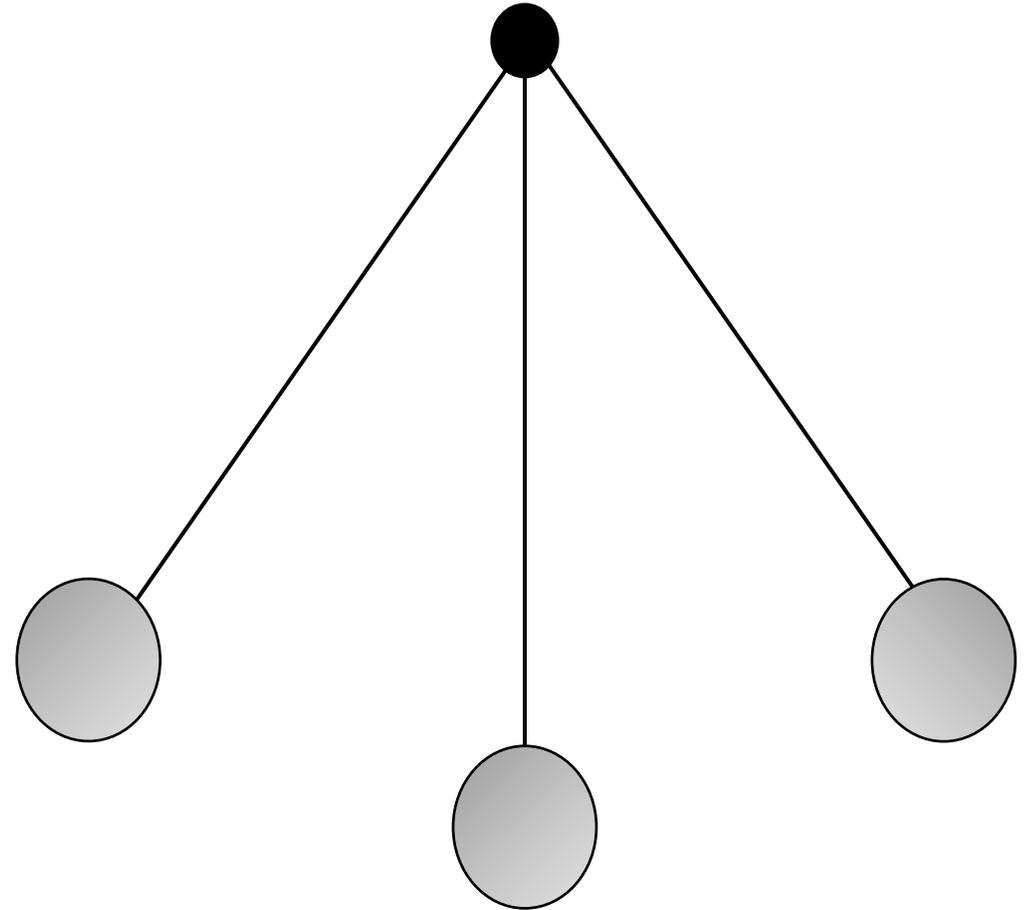


Conservation of Energy

Consider a **pendulum** released from **rest**.

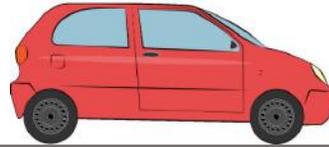
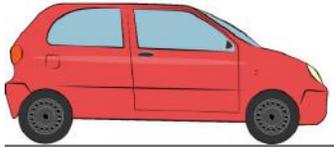
- As the **pendulum falls**:
- As the **pendulum rises**:
- **Pendulum** stops when reaches **initial height** from which it was **released**.

$$\Delta K.E = -\Delta G.P.E$$



Any **energy lost** by the **system** other than that **transferred** between *K.E* and *G.P.E* is **equal** to the **work done** by the **system**.

$$W = \Delta E = \Delta K.E$$



Work done by the **system** can be **exerted** by its **driving force** or to overcome **friction**.

$$W = \Delta E = \Delta G.P.E - \Delta K.E$$

Exemplar Calculation Exam Question

Key values we will need.

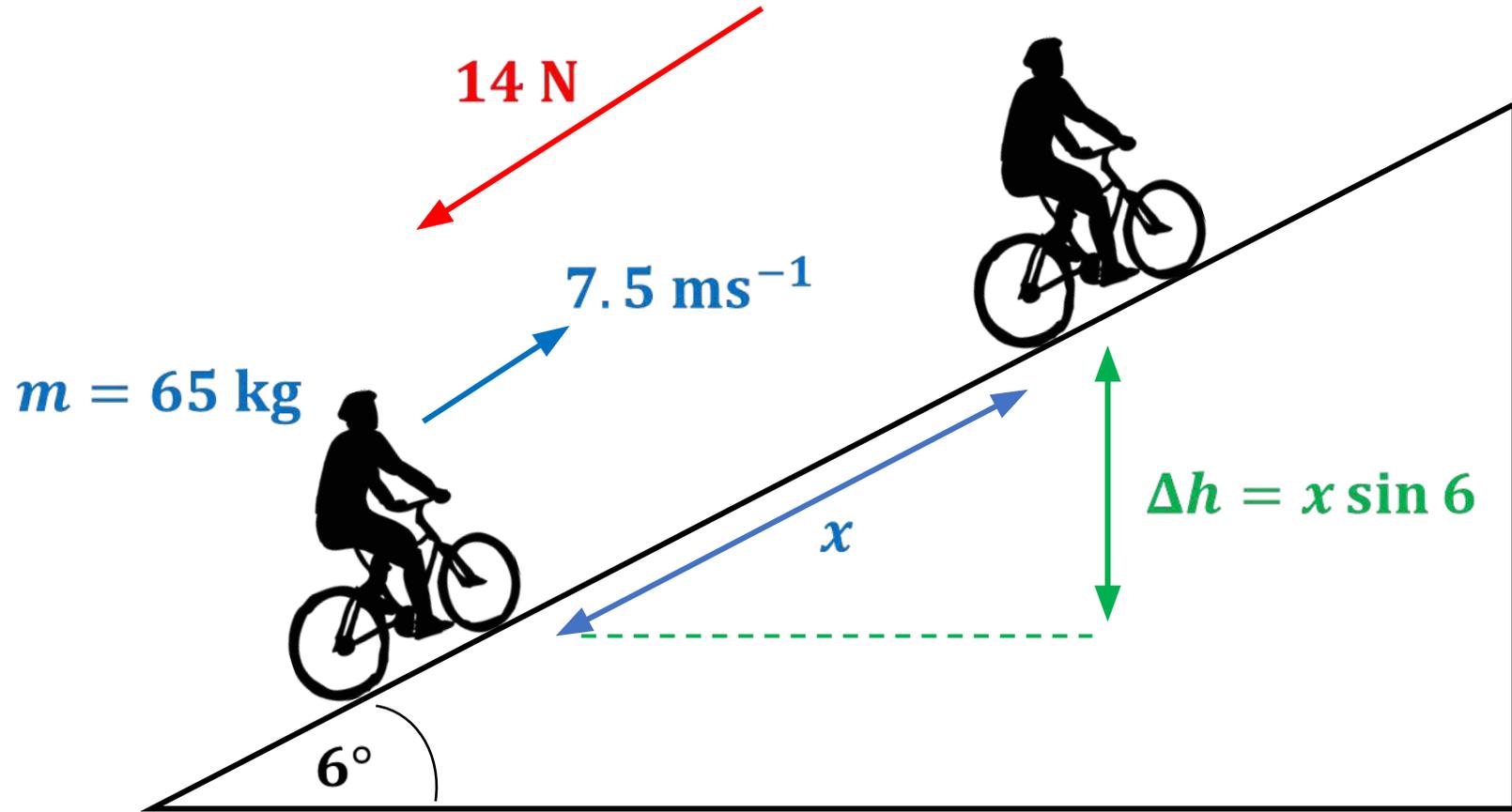
- 1) A cyclist of mass **65 kg** is travelling up a hill which has an angle of inclination of 6° . They have a velocity of **7.5 ms^{-1}** when they stop pedalling. The frictional force acting against the cyclist is **14 N**. Using the principle of the conservation of energy, determine the distance that the cyclist travels up the hill once they stop pedalling and calculate the cyclist's change in gravitational potential energy.

Calculation Question:
Show **working** and give **units**.

Context: Solve by energy conservation. Likely **simplest method**, others will **lose marks**

[3 marks]

At least **3 steps** required.



Exemplar Calculation Question Answer

Find change in gravitational energy in terms of x

Cyclist ascends height of $\Delta h = x \sin 6$

So change in gravitational energy is

$$\Delta GPE = mg\Delta h$$

$$\Delta GPE = 65 \times 9.81 \times x \sin 6$$

$$\Delta GPE = 66.65..x$$

[1 Mark]

Exemplar Calculation Question Answer

Use Conservation of Energy

Kinetic energy is lost through work against friction, given by $W = Fx$, as well as to be converted to Gravitational Potential Energy

By conservation of energy, the kinetic energy lost is equal to sum of the work done and gravitational potential energy gained

$$\Delta KE = \Delta GPE + W$$

$$\frac{1}{2}m(\Delta v)^2 = mg\Delta h + Fx$$

$$\left(\frac{1}{2} \times 65 \times 7.5^2\right) = 66.65..x + 14x$$

Exemplar Calculation Question Answer

$$1828.. = 66.65..x + 14x$$

$$1828.. = 80.65..x$$

$$x = \frac{1828..}{80.65..}$$

$$x = 22.7\text{m}$$

[1 Mark]

Find change in gravitational energy x

$$\Delta\text{GPE} = 66.65.. \times 22.7$$

$$\Delta\text{GPE} = 1510 \text{ J}$$

[1 Mark]

MINI MOCK PAPER



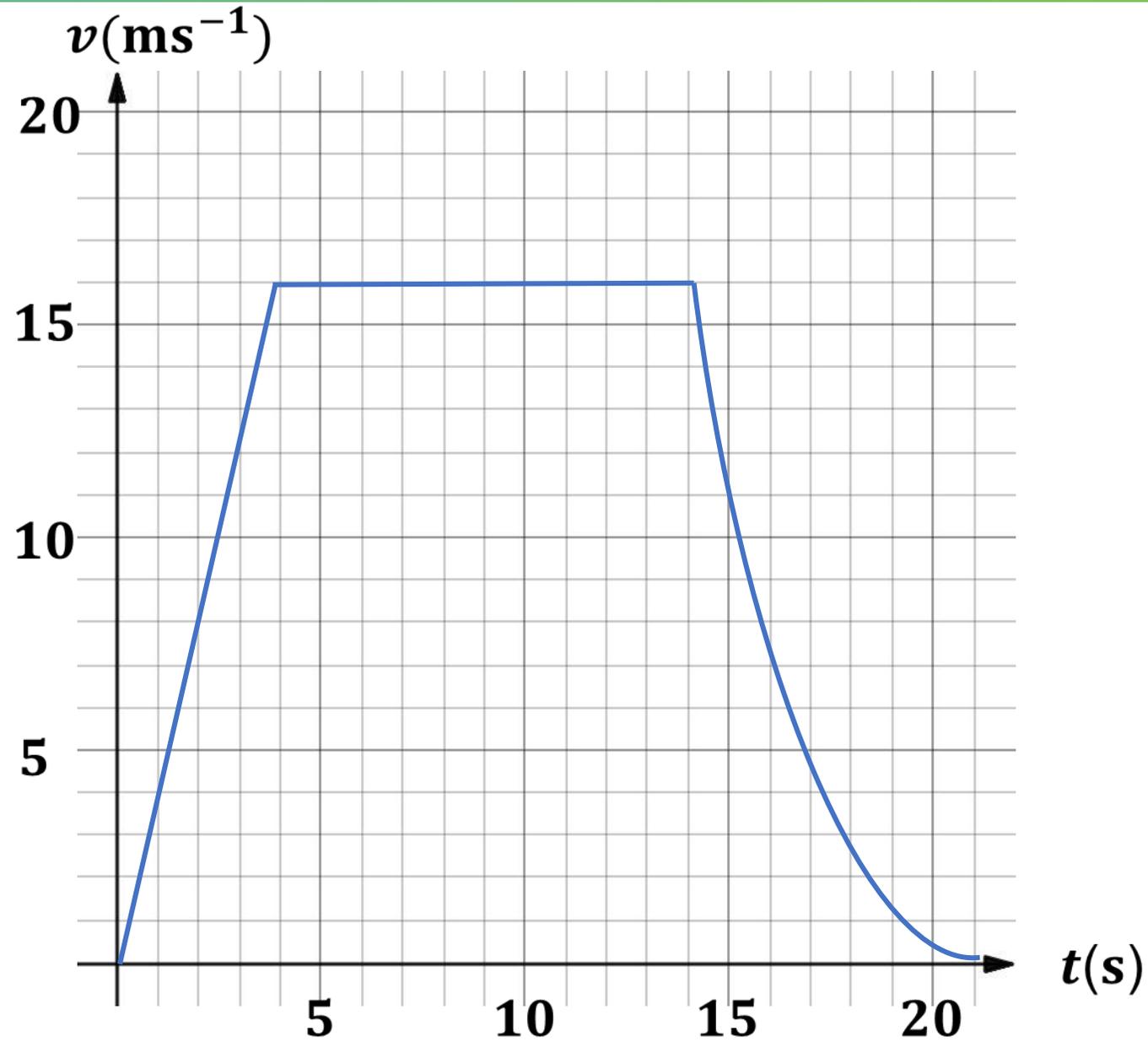
- 1) a) Define the principle of conservation of energy. [1
mark]
- b) A student sits on a skateboard and rolls down a hill. They calculate that their loss in gravitational potential energy is not equal to their gain in kinetic energy at the bottom of the hill. Give a reason why. [1
mark]

a) The principle of conservation of energy states that the total energy of a closed system is constant, energy is only converted from one form to another. **[1 Mark]**

b) Gravitational potential energy is converted to heat in friction between the skateboard and hill and air resistance. **[1 Mark]**

- 2) Consider the following velocity-time graph for a motorcycle travelling in a straight line. Describe the car's motion between $t = 0$ and $t = 21$ s.

[3 marks]



-
- Between $t = 0$ and $t = 4$ s the motorcycle accelerates from rest at a constant rate of 4 ms^{-2} .
-

[1 Mark]

-
- Between $t = 4$ s and $t = 14$ s the motorcycle travels at a velocity of 16 ms^{-1} .
-

[1 Mark]

-
- Between $t = 14$ s and $t = 21$ s the motorcycle undergoes deceleration at a decreasing rate until it comes to rest.
-

[1 Mark]

- 3) An archer shoots an arrow at a speed of 48 ms^{-1} at an angle of 30° above the horizontal. Calculate its maximum height and how long it takes the arrow to return to the same level as it started.

[4 marks]

Exam Question Answer

Use SUVAT vertically to find greatest height

$$u = 48 \sin 30, \quad v = 0, \quad a = -9.81, \quad s = ?$$

$$v^2 = u^2 + 2as$$

[1 Mark]

$$s = \frac{v^2 - u^2}{2a} = \frac{0^2 - (48 \sin 30)^2}{2 \times -9.81}$$

$$= 29.357798 \dots \text{ m} = 29\text{m (to 2 s. f.)}$$

[1 Mark]

Exam Question Answer

Use SUVAT vertically to find time of flight

$$u = 48 \sin 30, \quad s = 0, \quad a = -9.81, \quad t = ?$$

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

[1 Mark]

$$0 = 48t \sin 30 - \frac{9.81}{2}t^2$$

$$0 = t \left(48 \sin 30 - \frac{9.81}{2}t \right)$$

$$t = \frac{2 \times 48 \sin 30}{9.81} = 4.892966 \dots \text{ s} = 4.9 \text{ s (to 2 s. f.)}$$

[1 Mark]

- 4) a) A car exerting a driving force of 800 N travels at a constant speed of 30 ms^{-1} for 10 seconds. What is the power output of the car during this 10 seconds?

[1 mark]

- b) What is the work done during this 10 seconds?

2 marks]

[

Exam Question Answer

a) Use power-velocity relation to calculate the power

[1 Mark]

Exam Question Answer

b) Use work-power relation to calculate work done

[1 Mark]

[1 Mark]