A-level Physics Bridging Work

Name: ....

Please complete this booklet, including the self-assessment below.

YOU MAY USE A CALCULATOR THROUGHOUT

Confidence: ***1 = fully understood*** ***3 = mostly understood*** ***5 = poorly understood***	**Confidence (1-5)**	**Issues or Comments**
1. Unit Prefixes – complete table + questions		
2. SI system of units		
3. Maths-powers of ten and standard form – complete calculations		
4. Significant figures – read + complete calculations		
5. Rearranging equations		
6. Showing your working		
7. Bringing it all together – How many of these challenging questions did you crack?		
8. Revise and Extend: Energy and Power		
9. Revise and Extend: Speed and Acceleration		

Part 1 - Unit Prefixes

You will have encountered most of these at GCSE, but A-level will require you to fluently communicate and understand measurements and calculations involving prefixes.

1. Complete the following table. Research required!

Symbol		Meaning	Standard Form	Multiplier
	Tera			
			x10^{9}	
M		Million		x1 000 000
k				x1000
	Centi		x10^{-2}	
m		Thousandth		
	Micro			/1 000 000
n		Billionth		
			x10^{-12}	
f				

2. Expand each of these quantities to write out the answer in full (i.e. without the prefixes)

a. 900 mV =
b. 12 MJ =
c. 1.67 mm =
d. 3.456 kg =
e. 700 nm =
f. 0.72 pA =

3. Write each of the following using an appropriate prefix:

g. 0.005 A =
h. 30000 s =
i. 5 × 105 m =
j. 1001 m =
k. 0.006 V =
l. 2,100,000 N =

4. Convert each of the following to the indicated units:

a. 34 nm = ... mm

b. 0.012 s = ... μs

c. 4.5 MJ = ... kJ

Part 2 – The SI Units

Science is all about making and comparing measurements.

This course uses the International System of Units, or SI Units. There are 7. Fill in the table below. You do not need to know the definitions; those are just included so that you understand how these are agreed.

Quantity	Unit	Symbol	Definition
Length	Metre		The distance travelled by light in a vacuum in 1/299 792 458 seconds.
Time		s	
Mass			
Current			
Temperature			
Amount of Substance			
Luminous Intensity			

Non-base quantities are called 'derived quantities' and are defined by equations. For example, the equation for speed is: *speed = distance / time*.

The unit of speed = unit of distance / unit of time = m/s or $m \cdot s^{-1}$

The unit $m \cdot s^{-1}$ is *derived* from the units for distance and time.

Similarly, since *charge flow = current x time*, the unit of charge = the unit of current × the unit of time = $A \cdot s$ ('amp second')

When we refer to a coulomb of charge, we are using the name 'coulomb' as a stand-in for 'amp second.'

Any SI unit can be expressed in terms of base units by looking at the equations defining those quantities. For example, to find the base units of a joule requires two steps:

Work done = Force × distance moved, therefore one joule = one newton metre ($J = N \cdot m$)

Now we need to define the newton in base units. Force is defined from F = m a, so one newton = one kilogram metre per second squared (or $N = kg \cdot m \cdot s^{-2}$)

Therefore, a joule = N m = ($kg \cdot m \cdot s^{-2}$) m = $kg \cdot m^2 \cdot s^{-2}$

Find the equivalent bast units for the following quantities:

Quantity	Equation	Base Unit
Speed	Speed = distance / time v = s/t	$m \cdot s^{-1}$
Momentum	Momentum = mass x velocity p = mv	
Acceleration	Acceleration = change in velocity/time a = (v-u) / t	
Force	Force = mass x acceleration F = ma	
Power	Power = work done/time P = W / t	
Frequency	Frequency = 1/period f = 1 / T	
Charge	Charge = current x time Q = It	
Potential Difference	p.d. = work done/charge V = W / Q	
Resistance	Resistance = p.d./current R = V / I	
Specific Heat Capacity	$c = Q / (m \times \Delta\Theta)$	

Part 3 – Powers of 10 and Standard Form

Rewrite these numbers in standard form, removing any unit prefixes:

a) 3141	b) .00055	c) 2.0002
....	....	....
d) 120000 *(2sf)*	e) 120000 *(6sf)*	f) 843 × 104
....	....	....
g) 1.5 µm	h) 12.0 × 10-2 nm	i) 999 MJ
....	....	....
j) 245 mg	k) 16 pF	l) 97.237 GN
....	....	....

The equations we use require prefixes to be removed.

For example, to calculate resistance in ohms (Ω) if current = 8.0 mA (milliamps) and the voltage = 12 kV (kilovolts) the correct calculation would be:

$R = V/I = 12 \times 10^{3} / 8.0 \times 10^{-3} = 1.5 \times 10^{6}\ \Omega$

Try the above on your calculator before you continue.

2. Calculate the following, giving the answers in appropriate units

a) Area (m^2) = 120 mm × 250 mm

b) Area (m^2) = 2.4 m × 60 cm

c) Density ($kg \cdot m^{-3}$) = 48 g / 12 cm^3

d) Charge in coulombs, if a current of 3.0 kA flows for 20 ms

e) Speed squared, $v^2 = (16\ m \cdot s^{-1})^2$

f) Force, F = m a = 923000g × 9.8 $m \cdot s^{-2}$

Part 4 – Significant Figures

Read from the left and start counting sig figs when you encounter the first non-zero digit

1. All non-zero numbers are *significant* (meaning they count as sig figs)

- 613 has three sig figs
- 123456 has six sig figs

2. Zeros located between non-zero digits are *significant* (they count)

- 5004 has four sig figs
- 602 has three sig figs
- 6000000000000002 has 16 sig figs

3. Trailing zeros (those at the end) are *significant* only if the number contains a decimal point; otherwise they are insignificant (they **don't** count)

- 5.640 has four sig figs
- 120000.0 has seven sig figs
- 120000 has two sig figs – unless you're given additional information in the problem

4. Zeros to left of the first nonzero digit are *insignificant* (they **don't** count); they are only placeholders!

- 0.000456 has three sig figs
- 0.052 has two sig figs
- 0.0000000000000000000000000000000052 also has two sig figs

Rules for calculations

When you perform a calculation, the answer should be given to the same number of significant figures as the weakest piece of data that was used in the calculation. For example, if a piece of card is 11.3 cm long and 2.4 cm wide then the area = 27.12 cm^2 (on the calculator), but should be written as **27 cm^2** (i.e. 2 sig fig) because the width (2.4) was only given to 2 sig fig.

C. Practice Questions

1. State the number of sig figs in each of the following numbers:

(a) 0.0000055 g .... (b) 1.6402 g .... (c) 3.40×10^3 mL ....

2. Compare the following numbers:

370 000 versus 3.70×10^6 (standard form)

Explain the advantage of giving an answer in standard form

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3. Complete each of the following calculations using your calculator, giving your answer in standard form with the correct number of significant figures, with your answer in the units indicated.

(a) $\rho = m / V = 0.542 \text{ g} / 0.027 \text{ cm}^3 =$ ....$\text{g} \cdot \text{cm}^{-3}$

(b) $E = m c^2 = 231.5 \times 10^{-3} \times (3.00 \times 10^8)^2 =$ ....J

(c) Mean time = (23 + 20 + 21 + 22 + 25) / 5 = ...s

(d) Height difference = 2.32 m – 2.07 m = ...m

Part 5 – Rearranging Equations

Rearrange these equations to express them in the terms that follow:

1. $v = x / t$ **a.** $x = ?$ **b.** $t = ?$

2. $F = m\ a$ **a.** $m = ?$ **b.** $a = ?$

3. $a = (v - u) / t$ **a.** $t = ?$ **b.** $v = ?$ **c.** $u = ?$

4. $v^2 = u^2 + 2as$ **a.** $v = ?$ **b.** $a = ?$ **c.** $u = ?$

5. $s = ut + \frac{1}{2} a\ t^2$ **a.** $u = ?$ **b.** $a = ?$ **c.** $t = ?$

6. $\frac{1}{R_{Total}} = \frac{1}{R_1} + \frac{1}{R_2}$ **a.** $R_{Total} = ?$ **b.** $R_1 = ?$

Part 6 – Showing your working clearly

When completing calculations all steps should be shown, working left to right and top to bottom. Your final answer should be found to the bottom right of your working and should be underlined. Below is an example for you to base your own answer style on.

Ch6, Q4: A white snooker ball with a kinetic energy of 15 J collides with a red ball. On impact the white ball stops, transferring all its kinetic energy to the red ball. The mass of the red ball is 120 g. What would be the velocity of the red ball immediately following the collision?

1. Equation	$E_k = \frac{1}{2}mv^2$
2. Substitution	$15 = \frac{1}{2}0.120v^2$
3. Rearrangement (you can do this in multiple steps if necessary!)	$v = \sqrt{\frac{2 \times 15}{0.120}}$
4. Calculated answer	$v = 15.8\ ms^{-1}$
5. Units 6. Significant figures	$v = 16\ ms^{-1}\ (2sf)$

Your turn: A tennis ball with a mass of 60 g is served with 30 J of kinetic energy. Calculate its velocity.

1. Equation	
2. Substitution	
3. Rearrangement (you can do this in multiple steps if necessary!)	
4. Calculated answer	
5. Units 6. Significant figures	

EIGHT STEPS TO IMPROVE THE QUALITY OF YOUR WORKING

- Show all steps.
- Work left to right and top to bottom.
- Rearrange equations before substituting values.
- If a calculation is two-step, underline the answer to the first step before proceeding as this may get marks.
- Your writing should be small and neat. Don’t scrawl.
- You should be able to easily check over your working to find mistakes.
- Plan to use the available answer space wisely.
- Try to leave space for correcting mistakes if you go wrong.

Part 7 – Bringing it all together

These problems will challenge you to work with powers and units, rearrange equations and use your calculator carefully. Helpful formulae for volume and surface area are given on the last page, as are the answers.

Lay out your working clearly, work step by step, and check your answers. If you get one wrong, go back and try again. Do not be disheartened if they seem difficult to start with, persevere and seek help – you will improve. Importantly, have fun!

1. How many mm^2 are there in (a) $1cm^2$? ....

(b) $1\ m^2$? ....

(c) $1\ km^2$? ....

2. How many cm^3 are there in:

(a) $1mm^3$? ....

(b) $1\ m^3$? ....

3. A piece of A4 paper is 210 × 297 mm. All measurements are to the nearest mm. Calculate its area in (a) mm^2, (b) cm^2, (c) m^2. Give answers to the correct number of significant figures.

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a) Area = ... mm^2

b) Area = ...cm^2

c) Area = ... m^2

4. A plastic toy is supplied in a cubic box, 4.0 cm each side. How many of them pack into a carton 80 × 52 × 70 cm? (Students often get the wrong answer and can't see why. Visualise the actual problem don't just rely on maths!)

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5. A copper atom has a diameter of 217 pm (pico-meters). How many of them would fit inside 1mm^3 of copper to 3 sig. fig? (Tip: for simplicity, treat them as cubes of side 217 pm)

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6. Water has a density of 1.0 g cm^{-3}. Express this in (a) kg cm^{-3}, (b) kg m^{-3}, (c) kg mm^{-3}

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a) Density = ... kg cm^{-3}

b) Density = ... kg m^{-3}

c) Density = ... kg mm^{-3}

7. A regular block of metal has sides 12.2 × 3.7 × 0.95 cm, and a mass of 107 g. Find its density in kg m^{-3} to a suitable number of significant figures.

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8. A measuring cylinder is filled with 1.00 litres of water. The column of water inside forms a regular cylinder 32.0 cm high. What is (a) the area of the surface of the water (in mm^2)? (b) the internal diameter of the cylinder (in mm)? *(TIP: Visualise the problem clearly. Draw a diagram if it helps. Use the equation or the volume of a cylinder)*

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9. The diameter of the sun is 1.4×10^6 km. Its average density is 1.4 g cm^{-3}. What is its mass in kg? *(TIP: The trick here is to convert the units carefully before you start)*

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10. The total energy arriving in the Earth's upper atmosphere from the sun is 174×10^{15} Watts. Given that the Earth's diameter is 12.8×10^3 km, what is the average intensity of this radiation in W m^{-2}? *(TIP: Think about the units carefully. What does W m^{-2} mean?)*

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GEOMETRICAL EQUATIONS

arc length	$= r\theta$
circumference of circle	$= 2\pi r$
area of circle	$= \pi r^2$
surface area of cylinder	$= 2\pi rh$
volume of cylinder	$= \pi r^2 h$
area of sphere	$= 4\pi r^2$
volume of sphere	$= \frac{4}{3}\pi r^3$

Part 8 - Energy and Power

Look up definitions for each of the following quantities and write down the equations and any notes you think are helpful

Work

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Kinetic Energy

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Gravitational Energy

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Elastic Potential Energy

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Efficiency

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Power (including electrical power)

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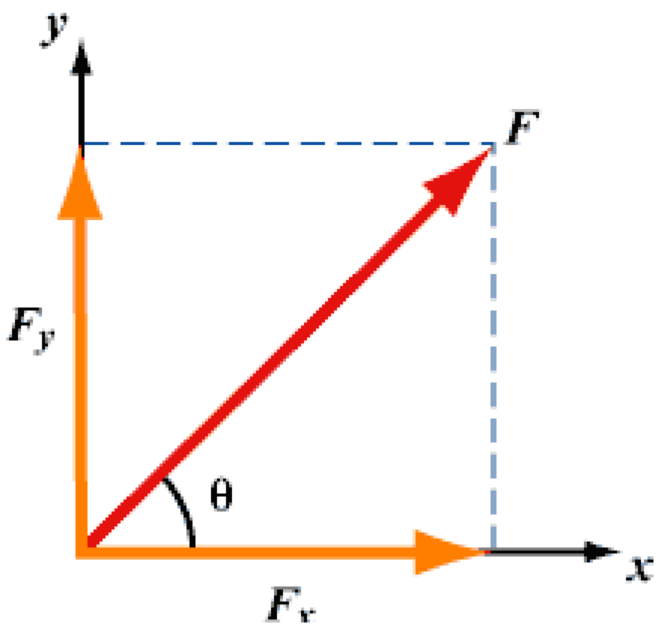

Resolving vectors

In A level Physics you will need to work with vectors that act at odd angles. Often the easiest way to deal with this is to convert the diagonal vector into horizontal and vertical components.

For example, in the case of a force F acting at an angle Θ, can be treated as two forces acting horizontally (Fx) and vertically (Fy). These can be calculated with trigonometry: $\mathbf{F_y = F \sin(\Theta)}$ *and* $\mathbf{F_x = F \cos(\Theta)}$

You may need to use this in the following questions.

Work

What is the definition of work?

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.... (2)

In the following calculations take g = 9.8 N kg^{-1}

1) Calculate the work done in each of the following situations, stating the final form of the transferred energy:

i) A box is pushed 3 m along the floor by a horizontal force of 500 N

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Work = ... J of energy is transferred into .... (2)

ii) An electric lift raises 540 kg load through a height of 18.3 metres

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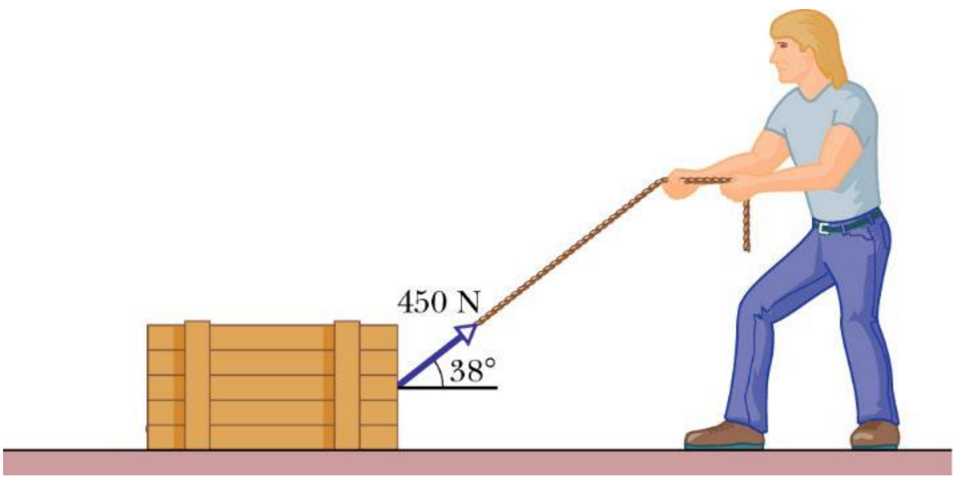
Work = ... J of energy is transferred into .... (3)

iii) A man uses a rope to pull a box along a floor, as shown below. He drags the box 3.0 km. (Hint: first find the *horizontal component* of the force then use this to calculate the work done horizontally).



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Work = ... J of energy is transferred into .... (4)

iv) A student adds three 100 g masses to a spring of spring constant, $k = 6.0\ Nm^{-1}$. It extends by 14.0 cm.

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Work = ... J of energy is transferred into .... (4)

Power

What is the definition of power?

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.... (1)

2) Which of the following are units of power? (circle all of the correct units)

a) joule second
b) watt
c) joule $second^{-1}$

d) newton metre second^{-1}

e) amp volt

(2)

Explain why power is equal to force × velocity

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.... (2)

Explain why power is equal to current × potential difference

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.... (2)

3) In two minutes, a rocket gained 370 MJ of kinetic energy and 1300 MJ of gravitational potential energy. i) Find the useful power produced by the rocket engines.

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Power = ... W (2)

ii) In the following 30 seconds the rocket travels at a steady speed of 320 ms^{-1}. Assuming the power of the engines to be constant, calculate the thrust force produced by the engines.

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Force = ... N (2)

4) A 12V electric motor is used to lift a 50 g mass through 1.0 m. The overall efficiency of this system is 10%. Whilst in operation it draws a current of 0.25 A.

i) Find the useful power output of the electric motor.

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Power = ... W (2)

ii) How long does it take the motor to raise the mass 1.0m?

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Time = ... s (2)

Part 9 – speed and acceleration

SPEED QUESTIONS

1. A bullet travels 300 m in 2.60 seconds what is its velocity in:

(a) m s^{-1}?

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(b) km h^{-1}?

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2. An alpha particle covers 2.0 cm travelling at 5 % the speed of light (speed of light=3.0 x10^8 m s^{-1}). How long does it take to cover this distance?

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3. A cyclist is racing on a circular track at an average speed of 8.35 m s^{-1}. She completes three laps in 2 minutes 24.36 seconds. What is the radius of the track?

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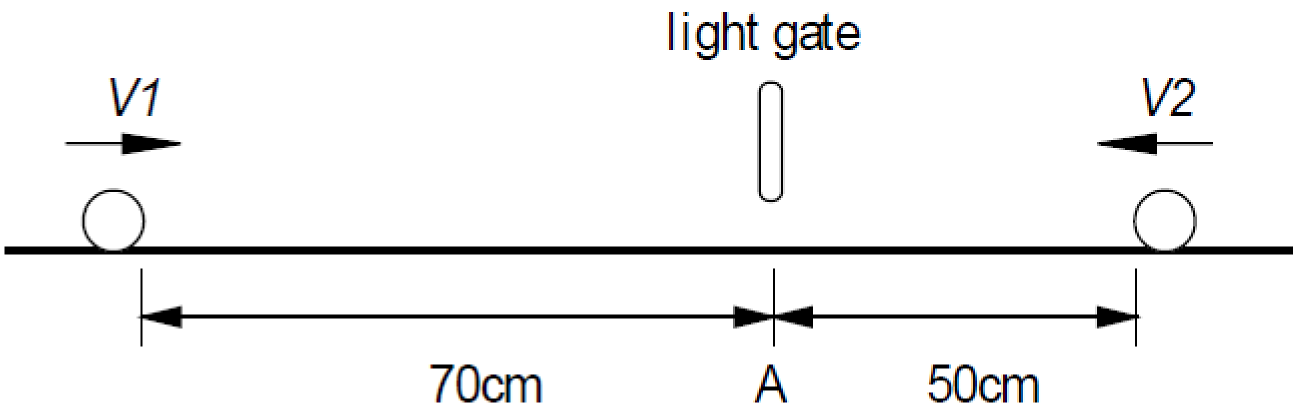
4. Two pool balls are moving towards each other as in the diagram below. At position A is a light gate.



If *V1* = 0.60 m s^{-1} and *V2* = 0.20 m s^{-1} then (a) which ball passes through the light gate first and (b) at what time and (c) at what position do they collide and (d) at what time?

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5. A light-year is the distance light travels in one year. Calculate this distance in metres to 3 significant figures, given that the speed of light is 3.00×10^8 m s^{-1}.

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ACCELERATION QUESTIONS

6. A horse is cantering at 3.1 m s^{-1} and breaks into a gallop reaching a speed of 5.6 m s^{-1} in 3.5 seconds. Calculate its acceleration.

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7. A car travelling at 16.0 m s^{-1}, brakes for 3.20 s, decelerating at a rate of 3.125 m s^{-2}. What is its final speed?

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8. An Olympic diver strikes the water at a speed of 7.2 m s^{-1}, and comes to rest in 1.2 seconds. What is his acceleration?

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9. A falling ball strikes a floor with a velocity of 4.2 m s^{-1} and rebounds with a velocity of -3.8 m s^{-1}. It is in contact with the floor for 0.12 seconds. What was its acceleration?

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10. A Porsche is quoted as having a *"0-60 time of 4.2 seconds"*. This means it accelerates from zero to 60 miles per hour in 4.2 seconds. Given that 1 mile = 1.55 km, calculate its acceleration in ms^{-2}

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11. At the University of Errors Science Tower, a brick is observed falling past the window of the physics laboratory. A quick-thinking physics student records its speed as 4.59 m s^{-1}. A moment later it passes the ground floor windows of the engineering faculty and an alert engineer records its speed as 12.91 m s^{-1}.

(a) Assuming acceleration due to gravity to be 9.81 m s^{-1} and assuming air resistance to be negligible, how long was the 'moment' between these observations?

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(b) By considering its average speed calculate the height between the Physics and the Engineering labs.

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