Name _____

Physics – Year 11 into 12 Summer Work

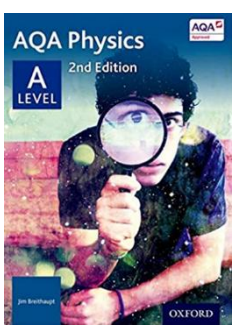
Physics is one of the most academically rewarding A-levels you can choose to do and an excellent grade in it is held in high regard by employers and top universities. It is however also one of the most challenging. It is therefore vital that you 'hit the ground running' in terms of your skills and understanding of high-end Physics and Maths material from your GCSEs. Your summer task is split in to four sections, all of which need to be completed and brought with you to the first lesson in September.

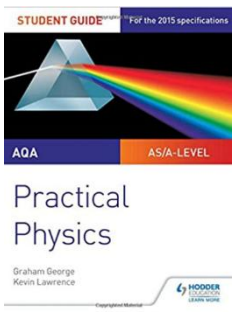
1. Familiarise yourself with the AQA course structure

Use the QR code to familiarise yourself with the course content and how it is assessed. Click on the topics to get a deeper understanding of the content within each one.

2. For your first lesson, purchase and bring in…

- A **lever arch file** and at least **30 dividers**
- The **AQA Practical Physics book**
- Optional: You will have access to your textbook through Kerboodle from September onwards, however if you wish to buy a paper copy, then the link is here





3. Complete the questions spanning the rest of this booklet

Once you have finished, you will also need to self-mark and correct your answers in a different colour using the link at the end of the booklet. Use AMCR to get the most from this task:

Answer – answer the questions to the best of your ability, without looking at the answers. Do look at your GCSE notes, you AQA Practical Physics book or either of the books below if you get stuck.

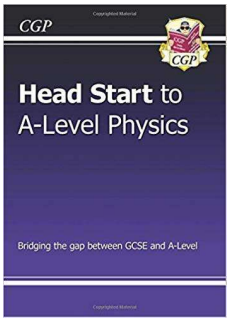
Mark – get a red pen and mark yourself rigorously using the mark scheme. Err on the harsher side to learn from your mistakes.

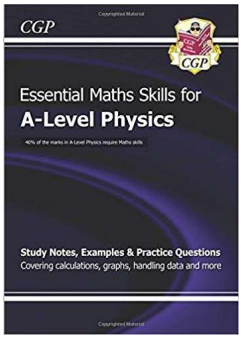
Correct – correct yourself in red. Make sure you understand every correction – copying from the mark scheme is no good!

Reflect - You should come away having learnt something new about the topic or concept. Note down what this is.

Bring your completed, self-marked and corrected booklet with you to your first lesson in September. Marking and corrections MUST be in a different colour.

These books are also excellent resources for bridging the considerable gap between GCSE and A Level. It is not compulsory, but I would recommend working through them over the summer if you think you would benefit from it… especially if you find any of the questions in this booklet at all unclear.





4. Wider reading

Follow this QR code to view the Physics A Level super curricular slide. First open the reading lists link about half way down the slide – there should be something that catches your eye in either the Physics or Engineering lists. Then explore some of the other enrichment resources… you have 2 months off after all!

Problems with any links or not sure what you need to do? Email powellj@mysandstorm.org

Vocabulary in practical physics

You need to be confident about the definitions of terms that describe measurements and results in A Level Physics.

Complete the three activities below. If you get really stuck, pages 57-59 from the AQA A Level practical handbook should help: https://filestore.aqa.org.uk/resources/physics/AQA-7407-7408-PHBK.PDF

Activity 1 Scientific vocabulary: Designing an investigation

Link each term on the left to the correct definition on the right.

Hypothesis	The maximum and minimum values of the independent or dependent variable
Dependent variable	A variable that is kept constant during an experiment
Independent variable	The quantity between readings, eg a set of 11 readings equally spaced over a distance of 1 metre would give an interval of 10 centimetres
Control variable	A proposal intended to explain certain facts or observations
Range	A variable that is measured as the outcome of an experiment
Interval	A variable selected by the investigator and whose values are changed during the investigation

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Activity 2 Scientific vocabulary: Making measurements

Link each term on the left to the correct definition on the right. Then write a definition for the two terms at the bottom.

True value	The range within which you would expect the true value to lie
Accurate	A measurement that is close to the true value
Resolution	Repeated measurements that are very similar to the calculated mean value
Precise	The value that would be obtained in an ideal measurement where there were no errors of any kind
Uncertainty	The smallest change that can be measured using the measuring instrument that gives a readable change in the reading

Repeatability:

Reproducibility:

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Activity 3 Scientific vocabulary: Errors

Link each term on the left to the correct definition on the right.

Random error	Causes readings to differ from the true value by a consistent amount each time a measurement is made
Systematic error	When there is an indication that a measuring system gives a false reading when the true value of a measured quantity is zero
Zero error	Causes readings to be spread about the true value, due to results varying in an unpredictable way from one measurement to the next

Once you have completed and self-marked the three sections above, commit these definitions to memory by learning, covering, self-testing.

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Maths skills

1 Measurements

1.1 Base and derived SI units

Units are defined so that, for example, every scientist who measures a mass in kilograms uses the same size for the kilogram and gets the same value for the mass. Scientific measurement depends on standard units – most are *Système International* (SI) units. Every measurement must give the unit to have any meaning. You should know the correct unit for physical quantities.

Base units

Physical quantity	Unit	Symbol
length	metre	m
mass	kilogram	kg
time	second	s

Physical quantity	Unit	Symbol
electric current	ampere	A
temperature difference	Kelvin	K
amount of substance	mole	mol

Derived units

Example:

$$\text{speed} = \frac{\text{distance travelled}}{\text{time taken}}$$

If a car travels 2 metres in 2 seconds:

$$\text{speed} = \frac{2\,\text{metres}}{2\,\text{seconds}} = 1\frac{\text{m}}{\text{s}} = 1\text{m/s}$$

This defines the SI unit of speed to be 1 metre per second (m/s), or 1 m s^{-1} ($s^{-1} = \frac{1}{s}$).

Practice questions

1 Complete this table by filling in the missing units and symbols.

Physical quantity	*Equation used to derive unit*	*Unit*	*Symbol and name (if there is one)*
frequency	*period*$^{-1}$	s^{-1}	*Hz, hertz*
volume	*length*^{3}		–
density	*mass ÷ volume*		–
acceleration	*velocity ÷ time*		–
force	*mass × acceleration*		
work and energy	*force × distance*		

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1.2 Significant figures

When you use a calculator to work out a numerical answer, you know that this often results in a large number of decimal places and, in most cases, the final few digits are 'not significant'. It is important to record your data and your answers to calculations to a reasonable number of significant figures. Too many and your answer is claiming an accuracy that it does not have, too few and you are not showing the precision and care required in scientific analysis.

Numbers to 3 significant figures (3 s.f.):

3.62 25.4 271 0.0147 0.245 39 400

(notice that the zeros before the figures and after the figures are *not* significant – they just show you how large the number is by the position of the decimal point).

Numbers to 3 significant figures where the zeros *are* significant:

207 4050 1.01 (any zeros between the other significant figures *are* significant).

Standard form numbers with 3 significant figures:

9.42×10^{-5} 1.56×10^{8}

If the value you wanted to write to 3.s.f. was 590, then to show the zero was significant you would have to write:

590 (to 3.s.f.) or 5.90×10^{2}

Practice questions

2 *Give these measurements to 2 significant figures:*

a *19.47 m*

b *21.0 s*

c *1.673×10^{-27} kg*

d *5 s*

3 *Use the equation:*

$$\text{resistance} = \frac{\text{potential difference}}{\text{current}}$$

to calculate the resistance of a circuit when the potential difference is 12 V and the current is 1.8 mA. Write your answer in kΩ to 3 s.f.

1.3 Uncertainties

When a physical quantity is measured there will always be a small difference between the measured value and the true value. How important the difference is depends on the size of the measurement and the size of the uncertainty, so it is important to know this information when using data.

There are several possible reasons for uncertainty in measurements, including the difficulty of taking the measurement and the resolution of the measuring instrument (i.e. the size of the scale divisions).

For example, a length of 6.5 m measured with great care using a 10 m tape measure marked in mm would have an uncertainty of 2 mm and would be recorded as 6.500 ± 0.002 m.

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It is useful to quote these uncertainties as percentages.

For the above length, for example,

$$\text{percentage uncertainty} = \frac{\text{uncertainty}}{\text{measurement}} \times 100$$

$$\text{percentage uncertainty} = \frac{0.002}{6.500} \times 100\% = 0.03\%.$$ The measurement is 6.500 m ± 0.03%.

Values may also be quoted with absolute error rather than percentage uncertainty, for example, if the 6.5 m length is measured with a 5% error,

the absolute error = 5/100 × 6.5 m = ±0.325 m.

Practice questions

4 *Give these measurements with the uncertainty shown as a percentage (to 1 significant figure):*

a *5.7 ± 0.1 cm*

b *450 ± 2 kg*

c *10.60 ± 0.05 s*

d *366 000 ± 1000 J*

5 *Give these measurements with the error shown as an absolute value:*

a *1200 W ± 10%*

b *330 000 Ω ± 0.5%*

6 *Identify the measurement with the smallest percentage error. Show your working.*

A *9 ± 5 mm*

B *26 ± 5 mm*

C *516 ± 5 mm*

D *1400 ± 5 mm*

2 Standard form and prefixes

When describing the structure of the Universe you have to use very large numbers. There are billions of galaxies and their average separation is about a million light years (ly). The Big Bang theory says that the Universe began expanding about 14 billion years ago. The Sun formed about 5 billion years ago. These numbers and larger numbers can be expressed in standard form and by using prefixes.

2.1 Standard form for large numbers

In standard form, the number is written with one digit in front of the decimal point and multiplied by the appropriate power of 10. For example:

- The diameter of the Earth, for example, is 13 000 km.
  13 000 km = 1.3 × 10 000 km = 1.3×10^4 km.
- The distance to the Andromeda galaxy is 2 200 000 light years = 2.2 × 1 000 000 ly = 2.2×10^6 ly.

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2.2 Prefixes for large numbers

Prefixes are used with SI units (see Topic 1.1) when the value is very large or very small. They can be used instead of writing the number in standard form. For example:

- A kilowatt (1 kW) is a thousand watts, that is 1000 W or 10^3 W.
- A megawatt (1 MW) is a million watts, that is 1 000 000 W or 10^6 W.
- A gigawatt (1 GW) is a billion watts, that is 1 000 000 000 W or 10^9 W.

Prefix	Symbol	Value
kilo	k	10^3
mega	M	10^6

Prefix	Symbol	Value
giga	G	10^9
tera	T	10^{12}

For example, Gansu Wind Farm in China has an output of 6.8×10^9 W. This can be written as 6800 MW or 6.8 GW.

Practice questions

1 *Give these measurements in standard form:*

a *1350 W*

b *130 000 Pa*

c *696×10^6 s*

d *0.176×10^{12} C kg^{-1}*

2 *The latent heat of vaporisation of water is 2 260 000 J/kg. Write this in:*

a *J/g*

b *kJ/kg*

c *MJ/kg*

2.3 Standard form and prefixes for small numbers

At the other end of the scale, the diameter of an atom is about a tenth of a billionth of a metre. The particles that make up an atomic nucleus are much smaller. These measurements are represented using negative powers of ten and more prefixes. For example:

- The charge on an electron = 1.6×10^{-19} C.
- The mass of a neutron = $0.016\,75 \times 10^{-25}$ kg = 1.675×10^{-27} kg (the decimal point has moved 2 places to the right).
- There are a billion nanometres in a metre, that is 1 000 000 000 nm = 1 m.
- There are a million micrometres in a metre, that is 1 000 000 µm = 1 m.

Prefix	Symbol	Value
centi	c	10^{-2}
milli	m	10^{-3}
micro	µ	10^{-6}

Prefix	Symbol	Value
nano	n	10^{-9}
pico	p	10^{-12}
femto	f	10^{-15}

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Practice questions

3 *Give these measurements in standard form:*
a *0.0025 m*

b *160 × 10^{-17} m*

c *0.01 × 10^{-6} J*

d *0.005 × 10^{6} m*

e *0.00062 × 10^{3} N*

4 *Write the measurements for question 3a, c, and d above using suitable prefixes.*

5 *Write the following measurements using suitable prefixes.*
a *a microwave wavelength = 0.009 m*

b *a wavelength of infrared = 1×10^{-5} m*

c *a wavelength of blue light = 4.7×10^{-7} m*

6 *Re-write the following quantities…*

a. *1.5 kilometres in metres*

b. *450 milligrams in kilograms*

c. *96.7 megahertz in hertz*

d. *5 nanometers in metres*

e. *3.9 gigawatts in watts*

2.4 Powers of ten

When multiplying powers of ten, you must *add* the indices.

So 100 × 1000 = 100 000 is the same as $10^2 \times 10^3 = 10^{2+3} = 10^5$

When dividing powers of ten, you must *subtract* the indices.

So $\frac{100}{1000} = \frac{1}{10} = 10^{-1}$ is the same as $\frac{10^2}{10^3} = 10^{2-3} = 10^{-1}$

But you can only do this when the numbers with the indices are the same.

So $10^2 \times 2^3 = 100 \times 8 = 800$

And you can't do this when adding or subtracting.

$10^2 + 10^3 = 100 + 1000 = 1100$

$10^2 - 10^3 = 100 - 1000 = -900$

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Remember: You can only add and subtract the indices when you are multiplying or dividing the numbers, not adding or subtracting them.

Practice questions

7 *Calculate the following values – read the questions very carefully!*

a $20^6 + 10^{-3}$

b $10^2 - 10^{-2}$

c $2^3 \times 10^2$

d $10^5 \div 10^2$

8 *The speed of light is 3.0×10^8 m s^{-1}. Use the equation $v = f\lambda$ (where λ is wavelength) to calculate the frequency of:*

a *ultraviolet, wavelength 3.0×10^{-7} m*

b *radio waves, wavelength 1000 m*

c *X-rays, wavelength 1.0×10^{-10} m.*

3 Resolving vectors

3.1 Vectors and scalars

Vectors have a magnitude (size) and a direction. Directions can be given as points of the compass, angles or words such as forwards, left or right. For example, 30 mph east and 50 km/h north-west are velocities.

Scalars have a magnitude, but no direction. For example, 10 m/s is a speed.

Practice questions

1 *State whether each of these terms is a vector quantity or a scalar quantity:*

Density
Temperature
electrical resistance
energy
field strength
force
friction
frequency
mass
momentum
power
voltage
volume
weight
work done

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2 *For the following data, state whether each is a vector or a scalar:*

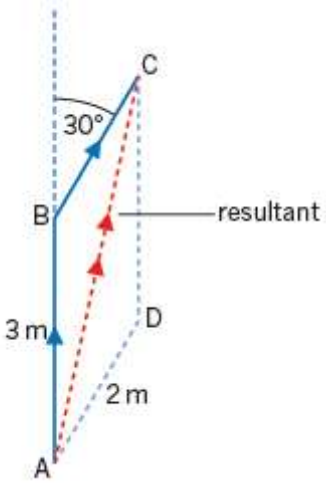
3 ms^{-1}
+20 ms^{-1}
100 m NE
50 km
−5 cm
10 km S 30° W
3 × 10^8 ms^{-1} upwards
273 °C
50 kg
3 A.

3.2 Drawing vectors

Vectors are shown on drawings by a straight arrow. The arrow starts from the point where the vector is acting and shows its direction. The length of the vector represents the magnitude.

When you add vectors, for example two velocities or three forces, you must take the direction into account.

The combined effect of the vectors is called the resultant.



This diagram shows that walking 3 m from A to B and then turning through 30° and walking 2 m to C has the same effect as walking directly from A to C. $\overrightarrow{AC}$ is the resultant vector, denoted by the double arrowhead.

A careful drawing of a scale diagram allows us to measure these. Notice that if the vectors are combined by drawing them in the opposite order, $\overrightarrow{AD}$ and $\overrightarrow{DC}$, these are the other two sides of the parallelogram and give the same resultant.

Practice question

3 *Two tractors are pulling a log across a field. Tractor 1 is pulling north with force 1 = 5 kN and tractor 2 is pulling east with force 2 = 12 kN. By scale drawing, determine the resultant force.*

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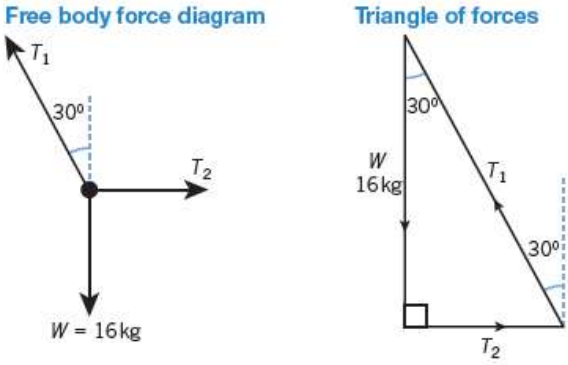
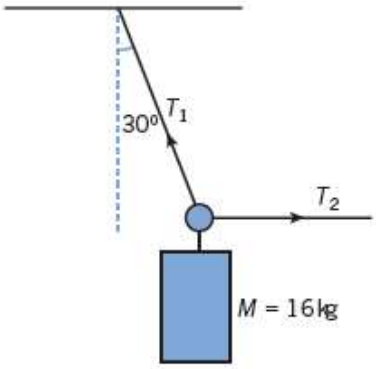
3.3 Free body force diagrams

To combine forces, you can draw a similar diagram to the one above, where the lengths of the sides represent the magnitude of the force (e.g., 30 N and 20 N). The third side of the triangle shows us the magnitude and direction of the resultant force.

When solving problems, start by drawing a free body force diagram. The object is a small dot and the forces are shown as arrows that start on the dot and are drawn in the direction of the force. They don't have to be to scale, but it helps if the larger forces are shown to be larger. Look at this example.

A 16 kg mass is suspended from a hook in the ceiling and pulled to one side with a rope, as shown on the right. Sketch a free body force diagram for the mass and draw a triangle of forces.

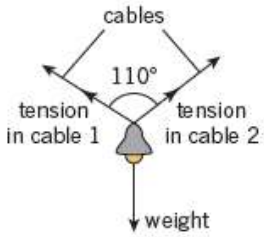




Notice that each force starts from where the previous one ended and they join up to form a triangle with no resultant because the mass is in equilibrium (there is no resultant force, i.e. they are balanced).

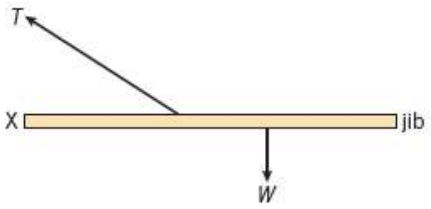
Practice questions

4 *Sketch a free body force diagram for the lamp (below) and draw a triangle of forces.*



5 *There are three forces on the jib of a tower crane (below). The tension in the cable T, the weight W, and a third force P acting at X.*

The crane is in equilibrium. Sketch the triangle of forces.



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3.4 Calculating resultants

When two forces are acting at right angles, the resultant can be calculated using Pythagoras's theorem and the trig functions: sine, cosine, and tangent.

For a right-angled triangle as shown:

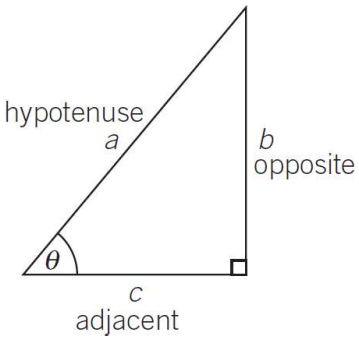
$h^2 = o^2 + a^2$

$\sin\theta = \frac{o}{h}$

$\cos\theta = \frac{a}{h}$

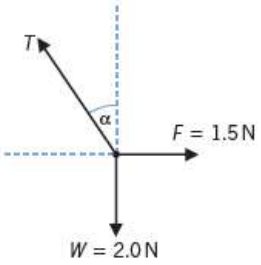
$\tan\theta = \frac{o}{a}$

(soh-cah-toa).



Practice questions

6 *The diagram below shows three forces in equilibrium.*
Draw a triangle of forces to find T and α.



7 *Find the resultant force for the following pairs of forces at right angles to each other:*
a *3.0 N and 4.0 N*

b *5.0 N and 12.0 N*

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4 Rearranging equations

Sometimes you will need to rearrange an equation to calculate the answer to a question. For example, if you want to calculate the resistance *R*, the equation:

potential difference (*V*) = current (*A*) × resistance (Ω) or $V = I R$

must be rearranged to make *R* the subject of the equation:

$$R = \frac{V}{I}$$

Practice questions

1. Rearrange $c = f \lambda$ to make *f* the subject.
2. Rearrange $\rho = \frac{m}{V}$ to make *m* the subject.
3. Rearrange $w = \frac{\lambda D}{s}$ to make *s* the subject
4. Rearrange $P = I^2 R$ to make *I* the subject
5. Rearrange $E = ½ m v^2$ to make *v* the subject.
6. Rearrange $h f = \varphi + E_k$ to make φ the subject
7. Rearrange $v = u + a t$ to make *a* the subject.
8. Rearrange $s = u t + ½ a t^2$ to make *a* the subject.
9. Rearrange $\varepsilon = I(R + r)$ to make *r* the subject.
10. Rearrange $f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$ to make *T* the subject.

4.1 Rearrange and substitute I

When you are solving a problem:

- Write down the values you know and the ones you want to calculate.
- Identify the appropriate equation(s) and combine them if necessary
- Rearrange the equation first, and then substitute the values

For example… *A student throws a ball vertically upwards at 5 m s^{-1}. When it comes down, she catches it at the same point. Calculate how high it goes.*

step 1: Known values are:

- initial velocity $u = 5.0$ m s^{-1}
- final velocity $v = 0$ (you know this because as it rises it will slow down, until it comes to a stop, and then it will start falling downwards)
- acceleration $a = g = -9.81$ m s^{-2}
- distance s = ?

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Step 2: Equation:

(final velocity)^2 − (initial velocity)^2 = 2 × acceleration × distance

or $v^2 - u^2 = 2 \times g \times s$

Step 3: Rearrange the equation, making the unknown value the subject.

$s = (v^2 - u^2) / 2g$

Step 4: Substitute into the equation:

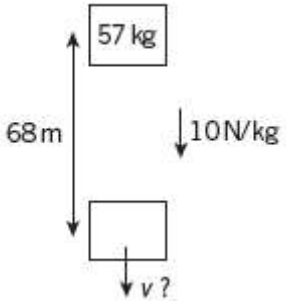
$s = (0^2 - 5.0^2) / (2 \times -9.81) = -25 / -19.62 = 1.27\ m = 1.3\ m$ (2 s.f.)

4.2 Rearrange and substitute II

A 57 kg block falls from a height of 68 m. By considering the energy transferred, calculate its speed when it reaches the ground.

(Gravitational field strength = 10 N kg^{-1})

Step 1: m = 57 kg h = 68 m g = 10 N kg^{-1} v = ?



Step 2: There are three equations:

PE = $m\,g\,h$ KE gained = PE lost KE = 0.5 $m\,v^2$

Step 3: Rearrange the equations before substituting into it.

As KE gained = PE lost, $m\,g\,h = 0.5\,m\,v^2$

You want to find v. Divide both sides of the equation by 0.5 m:

$$\frac{mgh}{0.5m} = \frac{0.5mv^2}{0.5m}$$

$2\,g\,h = v^2$

To get v, take the square root of both sides: $v = \sqrt{2gh}$

Step 4: Substitute into the equation:

$v = \sqrt{2 \times 10 \times 68}$

$v = \sqrt{1360} = 37$ m s^{-1}

Practice questions

11 *The potential difference across a resistor is 12 V and the current through it is 0.25 A. Calculate its resistance.*

12 *Red light has a wavelength of 650 nm. Calculate its frequency. Write your answer in standard form.*

(Speed of light = 3.0 × 10^8 m s^{-1})

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13 *Calculate the specific latent heat of fusion for water from this data:*
4.03×10^4 J of energy melted 120 g of ice.
Use the equation:
thermal energy for a change in state (J) = mass (kg) × specific latent heat (J kg^{-1})
Give your answer in J kg^{-1} in standard form.

5 Work done, power, and efficiency

5.1 Work done

Work is done when energy is transferred. Work is done when a force makes something move. If work is done *by* an object its energy decreases and if work is done *on* an object its energy increases.

work done = energy transferred = force × distance

Work and energy are measured in joules (J) and are scalar quantities (see Topic 3.1).

Practice question

1 *Calculate the work done when the resultant force on a car is 22 kN and it travels 2.0 km.*

2 *Calculate the distance travelled when 62.5 kJ of work is done applying a force of 500 N to an object.*

5.2 Power

Power is the rate of work done.

It is measured in watts (W) where 1 watt = 1 joule per second.

$$\text{power} = \frac{\text{energy transferred}}{\text{time taken}} \quad \textit{or} \quad \text{power} = \frac{\text{work done}}{\text{time taken}}$$

$P = \Delta W/\Delta t$ *Δ is the symbol 'delta' and is used to mean a 'change in'*

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Look at this worked example, which uses the equation for potential energy gained.

A motor lifts a mass *m* of 12 kg through a height Δ*h* of 25 m in 6.0 s.

Gravitational potential energy gained:

$\Delta PE = mg\Delta h = (12\text{ kg}) \times (9.81\text{ m s}^{-2}) \times (25\text{ m}) = 2943\text{ J}$

$$\text{Power} = \frac{2943\text{ J}}{6.0\text{ s}} = 490\text{ W (2 s.f.)}$$

Practice questions

3 *Calculate the power of a crane motor that lifts a weight of 260 000 N through 25 m in 48 s.*

4 *A motor rated at 8.0 kW lifts a 2500 N load 15 m in 5.0 s. Calculate the output power.*

5.3 Efficiency

Whenever work is done, energy is transferred and some energy is transferred to other forms, for example, heat or sound. The efficiency is a measure of how much of the energy is transferred usefully.

Efficiency is a ratio and is given as a decimal fraction between 0 (all the energy is wasted) and 1 (all the energy is usefully transferred) or as a percentage between 0 and 100%. It is not possible for anything to be 100% efficient: some energy is always lost to the surroundings.

$$\text{Efficiency} = \frac{\text{useful energy output}}{\text{total energy input}} \text{ or Efficiency} = \frac{\text{useful power output}}{\text{total power input}}$$

(multiply by 100% for a percentage)

Look at this worked example.

A thermal power station uses 11 600 kWh of energy from fuel to generate electricity. A total of 4500 kWh of energy is output as electricity. Calculate the percentage of energy 'wasted' (dissipated in heating the surroundings).

You must calculate the energy wasted using the value for useful energy output:

$$\text{percentage energy wasted} = \frac{(\text{total energy input} - \text{energy output as electricity})}{\text{total energy input}} \times 100$$

$$\text{percentage energy wasted} = \frac{(11600 - 4500)}{11600} \times 100 = 61.2\% = 61\%\text{ (2 s.f.)}$$

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Practice questions

5 *Calculate the percentage efficiency of a motor that does 8400 J of work to lift a load. The electrical energy supplied is 11 200 J.*

6 *An 850 W microwave oven has a power consumption of 1.2 kW. Calculate the efficiency, as a percentage.*

7 *Use your answer to question 4 above to calculate the percentage efficiency of the motor. (The motor, rated at 8.0 kW, lifts a 2500 N load 15 m in 5.0 s.)*

8 *Determine the time it takes for a 92% efficient 55 W electric motor take to lift a 15 N weight 2.5 m.*

! Now get a red pen, and self-mark and correct your work !

Re-read the AMCR guidance on the second page of this booklet and use the answers here:

https://docs.google.com/document/d/1QJKJzIcwUwGJysf8qn9Ky17UF1jAd2Cn/edit?usp=sharing&ouid=107116085343793190046&rtpof=true&sd=true

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