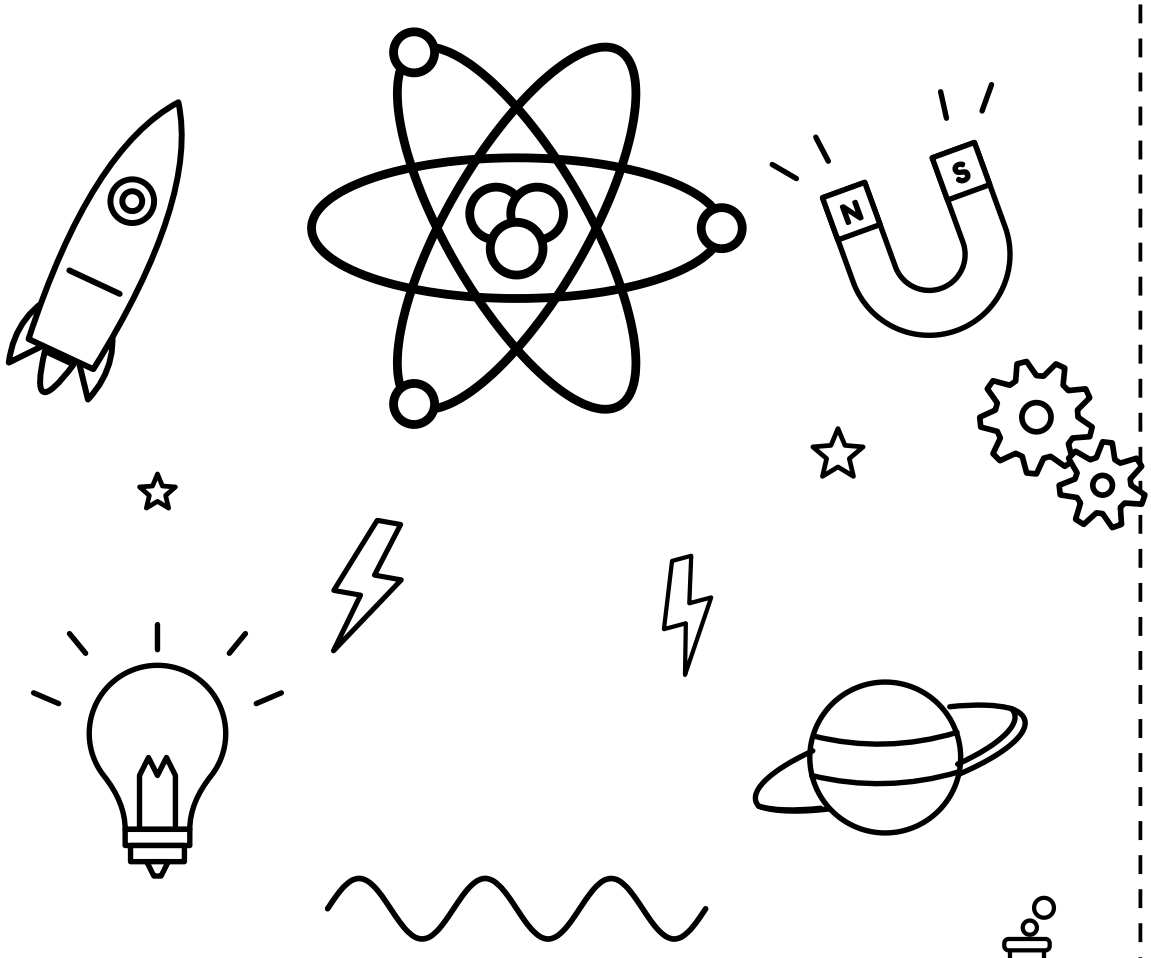
THE PHYSICS PUZZLE LAB

puzzles · games · colouring · challenges



Based on the AQA GCSE Physics (8463) specification

Foundation · Higher · Combined Science · Physics only

This lab belongs to:

Class:

START HERE

How to use

Read the badges!

Every activity has badges in its corner. A **circle** tells you the **tier**. A **square** tells you the **course**.

F	**Foundation**	Everyone needs this – Foundation *and* Higher tier.
H	**Higher only**	Only on the Higher tier papers. Foundation students can skip it or try it as a bonus!
C	**Combined Science**	This is in GCSE Combined Science: Trilogy *and* GCSE Physics.
P	**Physics only**	Only for separate (triple) GCSE Physics. Not on Combined Science papers.

How this booklet works

Puzzles – word searches, crosswords, mazes, code-breakers. **Colour it** – every drawing is ready to colour.
Games – board game, cut-out cards, dice and ruler-drop challenges. **Imagine it** – invent gadgets, aliens and rides.

Equation sheet – you get an equation sheet in the exam, so you don't need to learn equations off by heart. The skill is **picking the right one**, rearranging it and using the right units. Look for this sign: use your equation sheet

Answers are at the back. Have a go before you peek!

My Physics Passport

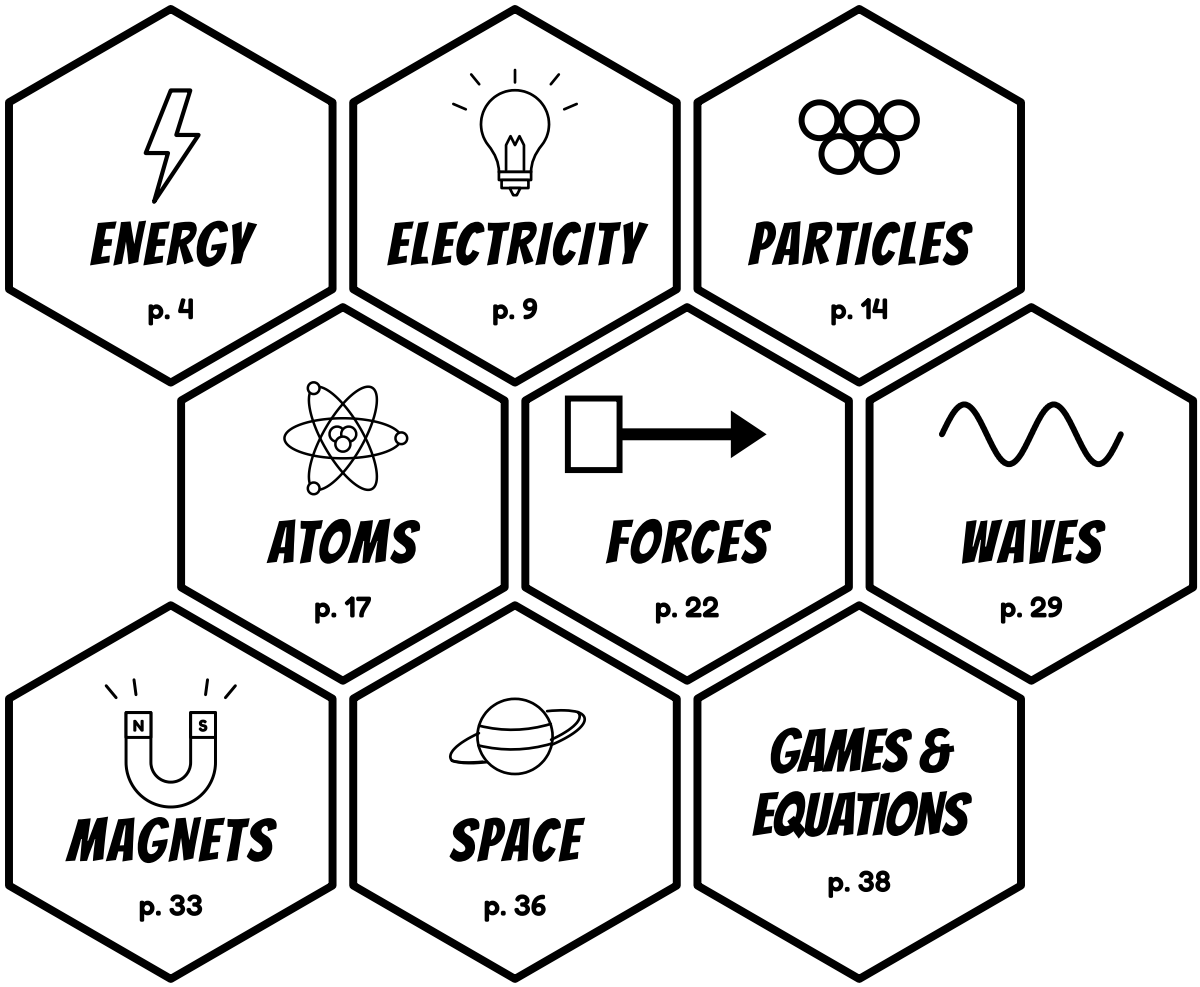
Colour **one star** when you start a topic, **two** when you've finished the activities, **three** when you could teach it to a friend.

Energy ☆☆☆	**Electricity** ☆☆☆
Particle model of matter ☆☆☆	**Atomic structure** ☆☆☆
Forces ☆☆☆	**Waves** ☆☆☆
Magnetism & electromagnetism ☆☆☆	**Space physics** ☆☆☆
Equation sheet skills ☆☆☆	**Required practicals** ☆☆☆
Games & challenges ☆☆☆	

MISSION MAP

Colour the zones

Welcome to the lab! Your mission: explore all nine zones. Colour in each zone when you finish it. Give every zone a different pattern – stripes, spots, zig-zags, stars…



Lab warm-up: what do you already know?

Write one physics fact you already know:

Write one physics question you want answered:

Energy store word search

F C

Find all 16 words. They go across, down, diagonally – and some go **backwards**!

G	F	E	C	M	G	F	C	K	J	P	D	A	L	V
R	U	F	I	I	I	B	H	I	W	J	K	G	W	M
A	T	F	T	N	T	N	F	T	H	E	R	M	A	L
V	S	I	A	C	O	E	S	M	R	P	V	G	Y	D
I	M	C	T	L	M	I	N	U	T	E	L	U	O	J
T	A	I	S	A	E	D	T	I	L	U	D	H	I	O
A	M	E	O	C	T	C	P	A	K	A	R	B	G	V
T	M	N	R	I	S	M	I	O	C	A	T	D	I	I
I	A	C	T	M	Y	I	K	T	W	I	S	I	S	R
O	G	Y	C	E	S	T	N	R	S	E	R	T	O	D
N	N	V	E	H	O	T	V	C	S	A	R	B	U	N
A	E	W	L	C	B	A	M	F	M	P	L	F	U	P
L	T	S	E	U	U	W	B	N	P	N	J	E	R	L
M	I	U	D	E	T	A	P	I	S	S	I	D	J	L
R	C	J	P	N	U	C	L	E	A	R	V	I	S	J

- ☐ kinetic
- ☐ gravitational
- ☐ elastic
- ☐ thermal
- ☐ chemical
- ☐ magnetic
- ☐ electrostatic
- ☐ nuclear
- ☐ dissipated
- ☐ efficiency
- ☐ power
- ☐ joule
- ☐ watt
- ☐ system
- ☐ insulation
- ☐ lubrication

Which store is it?

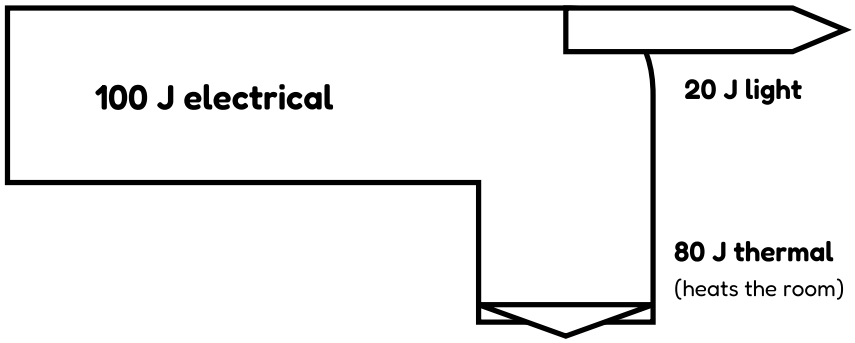
F C

Object	Energy store
A stretched catapult	
A hot cup of tea	
A battery	
A ball held high above the ground	
A speeding skateboard	
Two fridge magnets close together	

Remember: energy can't be made or destroyed – only moved between stores. That's **conservation of energy**.

Colour-code a Sankey diagram

F C



This Sankey diagram is for an old filament lamp. The **width** of each arrow shows how much energy.

Colour the **useful** arrow with stripes. Colour the **wasted** arrow with dots.

1. What is the useful output energy? _____ J
2. use your equation sheet Work out the efficiency of the lamp.

   _____
3. Where does the wasted energy go? _____

Draw your own Sankey diagram

F C

A kettle is supplied with **2000 J** of energy. **1800 J** heats the water. The rest heats the kettle and the air. Draw the Sankey diagram on the grid (1 square = 100 J), then work out the efficiency.

Efficiency = _____

Make it more efficient

H C

Give **two** ways to increase the efficiency of a machine or a house.

Renewable or non-renewable? Colour-sort

F C

Colour the **renewable** resources with **stripes** and the **non-renewable** ones with **dots**.


Coal


Oil


Gas

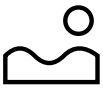

Nuclear


Bio-fuel

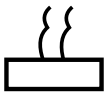

Wind


Solar


Hydro-electric


Tidal


Wave


Geothermal

Invent a new one!

A **renewable** resource is one that _____

_____

For and against

F C

Resource	One good thing	One problem
Wind		
Solar		
Coal		
Nuclear		

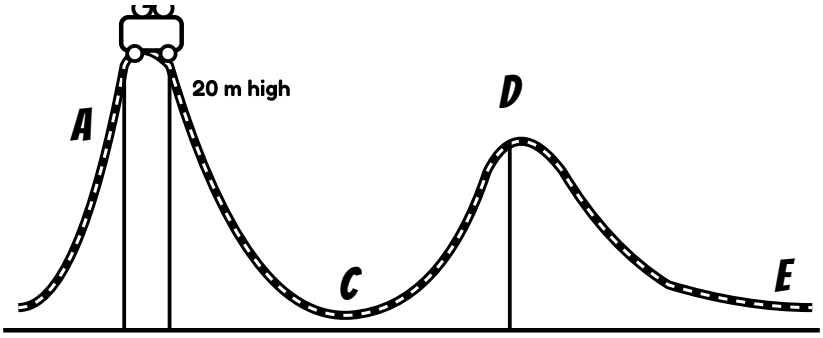
Imagine it: power up Puzzleton

F C

Puzzleton is a seaside town with a big hill, lots of wind and a river. Draw a map showing which energy resources you would use, and why. Remember: people use more electricity on cold winter evenings!

Theme park physics: the Thunder Coaster

F C



✎ Colour the coaster. Then fill in the table. Choose from: *gravitational potential, kinetic, both.*

Point	Main energy store(s)	Speeding up, slowing down or fastest?
B (top)		
C (bottom)		
D		

Number crunch

F C

use your equation sheet The car and riders have a mass of **500 kg**. Take g = 9.8 N/kg.

1. Calculate the gravitational potential energy gained when the car is lifted **20 m** to point B.
   _____ J
2. If no energy was wasted, how much kinetic energy would the car have at C?
   _____ J
3. In real life the car is slower at C. Where did some energy go?
   _____

Speed at the bottom

H C

Use your answer to Q2 to calculate the speed of the car at C (2 significant figures).

Design a ride

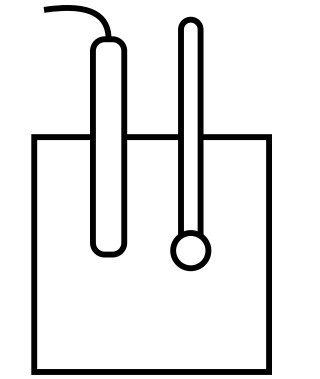
F C

Sketch a ride. Label three points with the energy store at each.

Lab notebook: specific heat capacity (Required practical)

F C

Kai heats a **1.0 kg** aluminium block with a heater. The joulemeter shows **15 000 J** transferred. The temperature rises from **20.0 °C** to **36.5 °C**.



heater · block · thermomete

1. Temperature change = _____ °C
2. equation sheet Calculate the specific heat capacity of aluminium. _____ J/kg °C
3. The real value is lower. Suggest one reason Kai's value is too high. _____
4. How could Kai reduce the energy wasted?

   _____

Keep it cosy: insulation challenge (Required practical)

F P

Ana wraps four identical beakers of hot water in different materials and measures the temperature after 10 minutes.

Material	Start (°C)	After 10 min (°C)	Drop (°C)
none	80	58	
bubble wrap	80	71	
newspaper	80	66	
cotton wool	80	69	

Best insulator: _____ Independent variable: _____

Name one control variable: _____

Power puzzles

F C

equation sheet Power is how fast energy is transferred. 1 watt = 1 joule per second.

1. A kettle transfers 360 000 J in 120 s. What is its power? _____
2. A crane lifts a 600 N load 12 m in 8 s. Work done = _____ J. Power = _____ W
3. Two motors lift the same box to the same height. Motor X takes 4 s, motor Y takes 10 s. Which is more powerful? _____

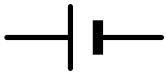
Symbol spotter

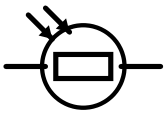
F C

Write the name under each circuit symbol. Word bank: **ammeter · battery · cell · diode · fuse · lamp · LDR · LED · resistor · switch · thermistor · variable resistor**

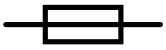
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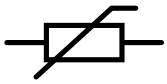
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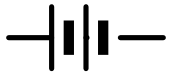
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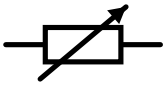
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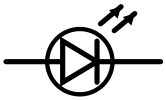
7 

8 

9 

10 

11 

12 

Draw the circuit

F C

Draw a circuit with a **battery**, a **switch**, a **lamp** and a **resistor** in series. Add an **ammeter** to measure the current and a **voltmeter** to measure the potential difference across the lamp.

Hint: ammeters go in **series**; voltmeters go in **parallel**.

Sensor detective

F C

LDR: as light gets brighter, its resistance _____

Used in: _____

Thermistor: as it gets hotter, its resistance _____

Used in: _____

Imagine it: invent a gadget that uses one of these sensors. What does it do?

Current maze: get the charge to the bulb!

F C

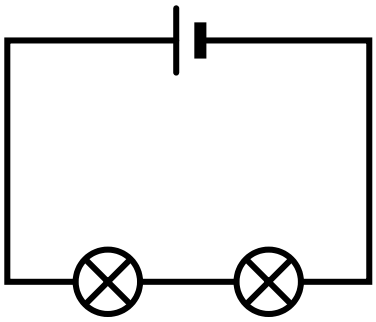
Start at START. Answer question 1 and shade the box with your answer – it must **touch the side** of the last box you shaded. Keep going until you light the BULB. equation sheet

START	12 V	2 V	27 A	120 C
0.33 Ω	3 A	48 Ω	1 A	24 C
115 W	30 C	3 Ω	240 C	0.6 J
16 J	4 Ω	36 V	460 W	18 Ω
3 C	90 W	0.25 A	60 J	BULB

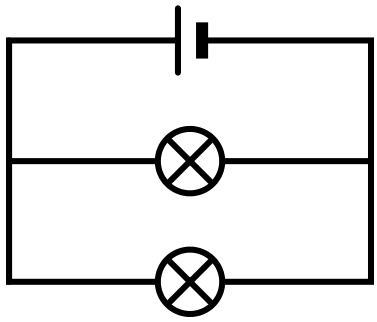
1. A current of 2 A flows through a 6 Ω resistor. What is the potential difference?
2. A 3 Ω resistor has a potential difference of 9 V across it. What is the current?
3. A current of 0.5 A flows for 60 s. How much charge flows?
4. A potential difference of 12 V drives a current of 4 A. What is the resistance?
5. A current of 2 A flows for 2 minutes. How much charge flows? (Careful with the time!)
6. A 230 V hairdryer takes a current of 2 A. What is its power?
7. 10 C of charge moves through a potential difference of 6 V. How much energy is transferred?

Series vs parallel

F C



SERIES



PARALLEL

✎ Colour the wires in each circuit a different pattern. Then complete the rules with: *same · shared · adds up · less than the smallest*

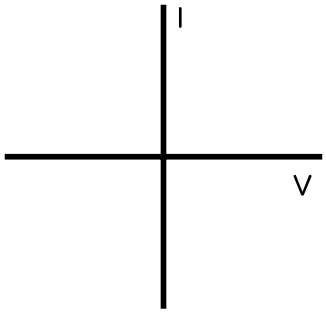
	Series	Parallel
Current	the ___ everywhere	___ between branches
Potential difference	___ between components	the ___ across each branch
Total resistance	$R_{total} = R_1 + R_2$ (it ___)	___ resistor

1. A 4 Ω and a 6 Ω resistor are in series. Total resistance = _____ Ω
2. One lamp breaks in each circuit. Which circuit's other lamp stays on? _____
3. Why are the lights in your house wired in parallel? _____

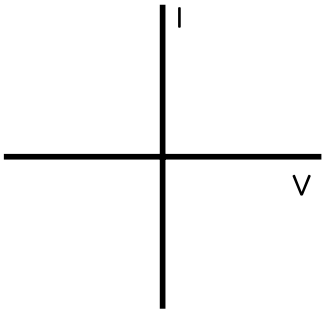
I–V graph sketch-off (Required practical)

F C

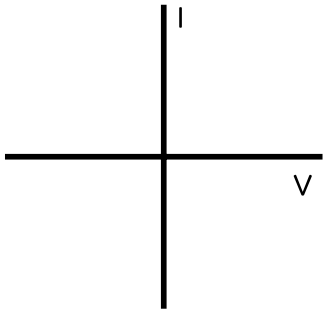
Sketch the current–potential difference graph for each component. The axes go through the middle so you can show negative values too.



Resistor (fixed temp.)



Filament lamp

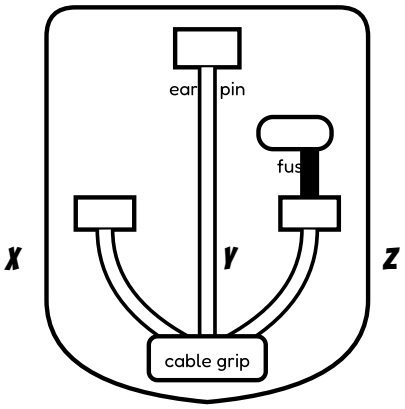


Diode

Which component has a resistance that goes **up** as it gets hotter? _____
Which only lets current flow one way? _____

Wire the plug

F C



✎ Colour the wires the real colours: **live = brown**, **neutral = blue**, **earth = green and yellow stripes**.

Wire	Name	Its job
X		
Y		
Z		

UK mains electricity is **a.c. / d.c.** (circle) with a frequency of _____ Hz and a potential difference of about _____ V.
Why can touching the live wire be dangerous even if the switch is off?

_____

The National Grid relay

F C

Fill in the boxes: *step-up transformer · step-down transformer · power station · homes · transmission cables*



Why is electricity sent at a very **high** potential difference? _____

_____

Bills, bulbs and toasters

F C

equation sheet

1. A toaster has a power of 800 W. How much energy does it transfer in 150 s?
   _____ J
2. A TV uses a current of 0.5 A from the 230 V mains. What is its power? _____ W
3. A current of 3 A flows through a 20 Ω heater. Power = _____ W
4. Name one everyday appliance that mainly transfers energy to a kinetic store:
   _____

Static comic strip

F P

Finish the comic! Draw what happens in each panel and complete the captions. Use the words *electrons, negative, positive, attract, repel*.

1

Rub a balloon on your jumper…

2

Electrons move from the ___ to the ___

3

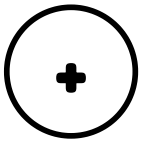
Hold the balloon near your hair…

4

Why does it stick to the wall?

Field lines

F P



Draw the **electric field** around this positively charged sphere. Add arrows to show the direction of the force on a small positive charge.

The field is strongest where the lines are _____.

Like charges _____. Unlike charges _____.

Why can a big build-up of static cause a spark?

_____

Particle party: draw the particles

F C

Draw about 12 particles in each box. Show how they are arranged. Add little motion lines to show how they move.

SOLID	LIQUID	GAS

Melting, boiling and freezing are **physical** changes. If you melt 100 g of ice, you get _____ g of water. This is because mass is _____.

Density code-breaker

F C

equation sheet Calculate each density in kg/m³. Find the answer in the code box and write its letter. The letters spell a secret word!

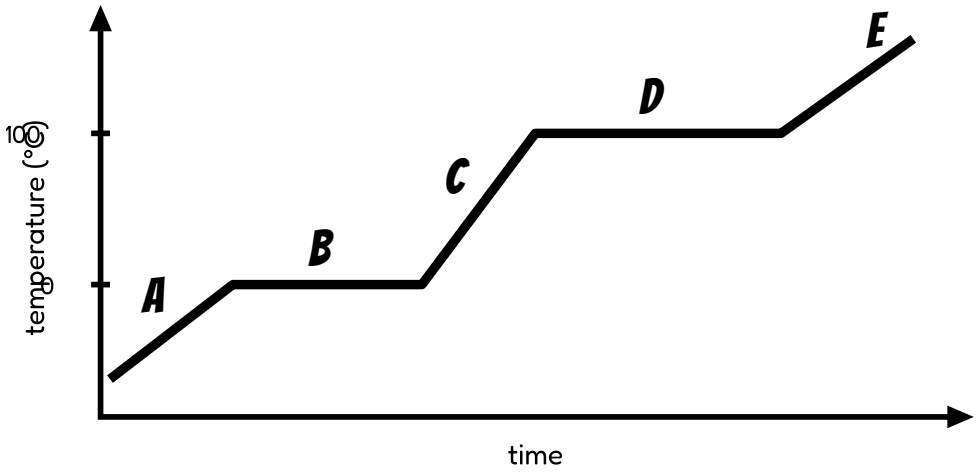
#	Object	Density (kg/m³)	Letter
1	A 50 kg block of water has a volume of 0.05 m³.		
2	A 5.4 kg piece of aluminium has a volume of 0.002 m³.		
3	A 0.9 kg block of ice has a volume of 0.001 m³.		
4	A 16 kg lump of brass has a volume of 0.002 m³.		
5	A 0.25 kg block of pine wood has a volume of 0.0005 m³.		
6	A 39 kg steel bar has a volume of 0.005 m³.		

250 E	500 T	900 O	1000 F	1200 R	2700 L	7800 S	8000 A	13600 M	19300 G

Secret word: ☐ ☐ ☐ ☐ ☐ ☐ **Which two objects would float in water?** _____

Label the heating curve

F C



Ice is heated steadily until it becomes steam.

Write the letter next to each label:

- ☐ water heating up
- ☐ ice melting
- ☐ steam heating up
- ☐ ice heating up
- ☐ water boiling

Why doesn't the temperature rise at B and D, even though the heater is still on?

_____

Internal energy: fill the gaps

F C

Internal energy is the total _____ energy and _____ energy of all the particles in a system. Heating a system increases its internal energy. This either raises the _____ or causes a change of _____.

Latent heat lab

F C

equation sheet Specific latent heat of fusion of ice = 334 000 J/kg. Specific latent heat of vaporisation of water = 2 260 000 J/kg.

1. How much energy is needed to melt 0.5 kg of ice? _____ J
2. How much energy is needed to boil away 0.2 kg of water? _____ J
3. What is the difference between specific **heat capacity** and specific **latent heat**?

_____

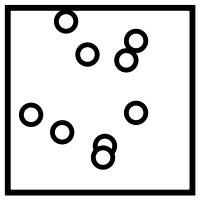
Imagine it: shrink yourself!

F C

You are shrunk to the size of a particle inside an ice cube that is slowly melting. Write a diary entry about what you see and feel.

Gas particles in a box

F C



cool gas

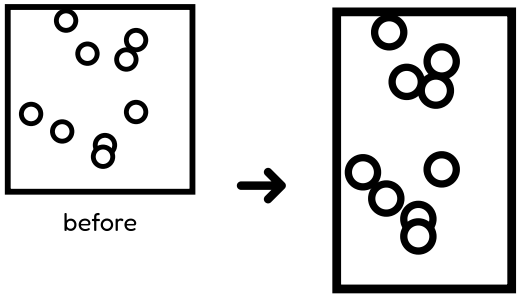
The gas in this sealed box is heated. The volume stays the same.

1. What happens to the speed of the particles? _____
2. What happens to the temperature of the gas? _____
3. Explain why the pressure goes **up**. _____

_____

Squeeze it! Pressure and volume

F P



before

after: squashe

Gas in a syringe at **100 kPa** has a volume of **2.0 m³**... well, a very big syringe! It is squashed slowly to **0.5 m³**. The temperature stays the same.

equation sheet

Calculate the new pressure. _____ kPa

Why is the pressure higher? (Think about how often particles hit the walls.)

_____

Pump it up!

H P

When you pump up a bike tyre quickly, the pump gets warm. Explain why, using the words *work, internal energy, particles, temperature.*

_____

_____

_____

Particle model speed-quiz

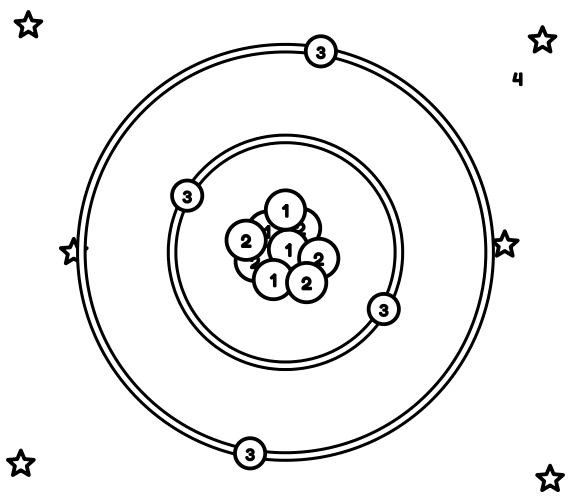
F C

Circle TRUE or FALSE.

Particles in a gas move in random directions at different speeds.	**TRUE / FALSE**
A change of state changes the mass of a substance.	**TRUE / FALSE**
Sublimation is when a solid turns straight into a gas.	**TRUE / FALSE**

Colour-by-number atom

F C



#	Colour	Particle
1	red	
2	grey	
3	blue	
4	yellow	energy levels (shells)

Fill in the names, then colour!

Protons: _____ Neutrons: _____ Electrons: _____

Atomic number = _____ Mass number = _____

This element is: _____ (look up atomic number 4 on a periodic table)

Particle profile cards

F C

Particle	Where is it?	Relative charge	Relative mass
proton			
neutron			
electron			

Why does an atom have no overall charge? _____

How tiny?!

F C

The radius of an atom is about **1×10^{-10} m**. The nucleus is less than **1/10 000** of that.

💡 If the nucleus were a pea on the centre spot, the atom would be about the size of a whole football _____! Draw it:

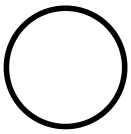
When an electron absorbs electromagnetic radiation it moves **further from / closer to** the nucleus. If an atom loses an electron it becomes a positive _____.

Atom time machine

F C

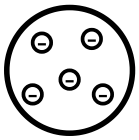
Scientists changed their model of the atom as new evidence came in. Draw the last model, and name the scientists if you know them: *Dalton, J.J. Thomson, Rutherford, Bohr, Chadwick.*

Tiny solid spheres
early 1800s



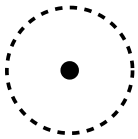
Scientist:
_____

Plum pudding
1897–1904



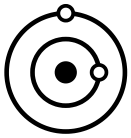
Scientist:
_____

Nuclear model
1911



Scientist:
_____

Electron shells
1913



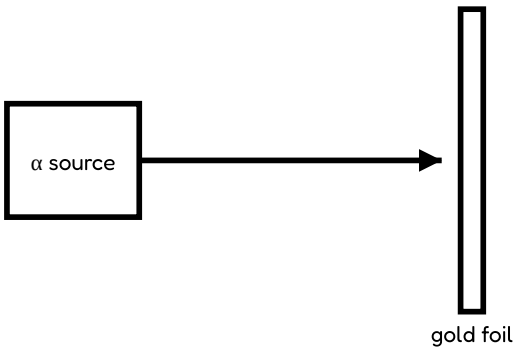
Scientist:
_____

Neutrons found
1932

Scientist:
_____

The gold foil experiment

F C



draw what happens next...

Alpha particles were fired at very thin gold foil. Draw three paths: one that goes **straight through**, one that is **deflected** a little and one that **bounces back**.

What they saw	What it told them
Most alpha particles went straight through.	
A few bounced back.	

Imagine it: atom news!

F C

It's 1911. Write a newspaper headline and a short report announcing that the plum pudding model is WRONG. Include a drawing!

Spot the isotopes

F C

$^{12}_{6}C$	$^{14}_{6}C$	$^{14}_{7}N$	$^{35}_{17}Cl$	$^{16}_{8}O$	$^{37}_{17}Cl$

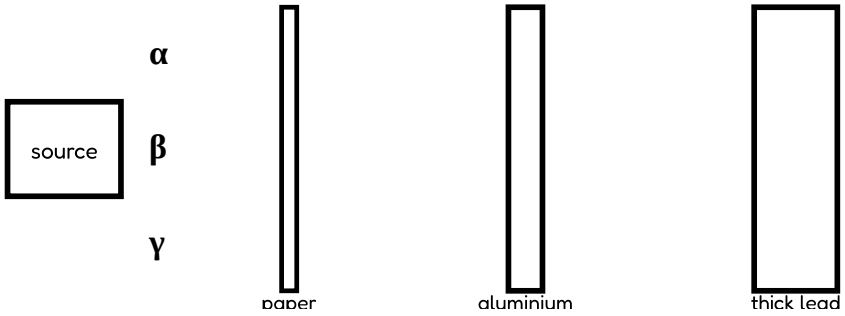
Isotopes are atoms of the same element with the same number of _____ but a different number of _____.

Draw rings around the **two pairs** of isotopes. How many neutrons in chlorine-37? _____

Stop that radiation!

F C

Draw an arrow for each type of radiation showing where it gets **stopped**. Then complete the table.



Type	What is it?	Ionising power (high / medium / low)
alpha α		
beta β		
gamma γ		

Decay equation detectives

F C

The top numbers must balance and the bottom numbers must balance. Fill in the missing numbers or particle.

1. $^{238}_{92}U \rightarrow {}^{\square}_{\square}Th + {}^{4}_{2}He$

2. $^{14}_{6}C \rightarrow {}^{14}_{\square}N + {}^{0}_{-1}e$

3. $^{226}_{88}Ra \rightarrow {}^{222}_{86}Rn +$ ————————

4. $^{90}_{38}Sr \rightarrow {}^{90}_{39}Y +$ ————————

What happens to the mass number and atomic number when a **gamma ray** is emitted?

_____

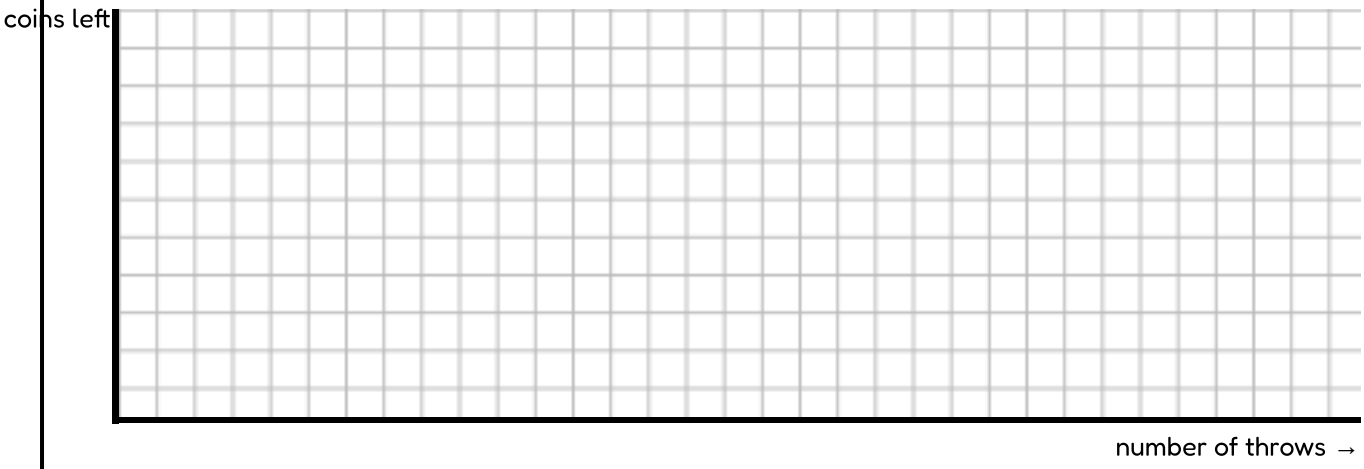
The half-life game

F C

You need: 50 coins (or 50 dice). Each coin is an unstable nucleus.
Play: Shake them all and tip them out. Every **head** has "decayed" – remove it. Count what's left. Repeat with the remaining coins until all have decayed.

Throw	0	1	2	3	4	5	6	7	8
Coins left	50								

Plot your results, then draw a smooth curve.



Your half-life (number of throws for the coins to halve) = _____ throws. Could you predict which coin decays next? Why not? _____

Half-life puzzles

F C

1. A sample's activity falls from 800 Bq to 400 Bq in 6 hours. What is its half-life?

   _____

2. What will the activity be after 24 hours? _____ Bq

Net decline

H C

What fraction of the original nuclei has decayed after **3** half-lives? Show the ratio.

_____

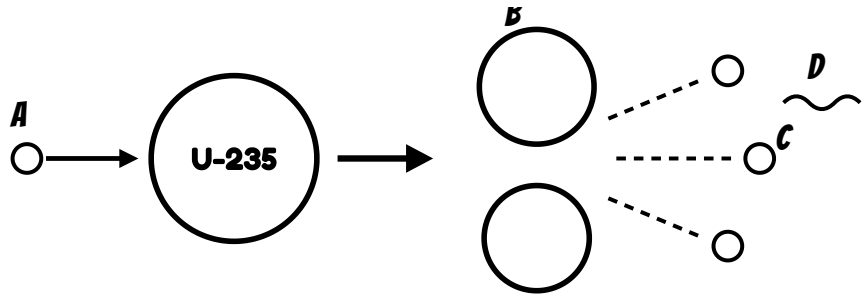
Contamination or irradiation?

F C

Write C or I. ☐ Radioactive dust lands on your skin. ☐ An X-ray passes through your arm. ☐ You breathe in radon gas. ☐ Food is zapped with gamma rays to kill bacteria.

Fission: split it!

F P



Label A–D: *neutron · gamma radiation · two smaller nuclei (daughter nuclei) · 2 or 3 more neutrons*

A: _____ B: _____ C: _____ D: _____

💡 If each neutron in C hits another U-235 nucleus, what happens? Name it: _____

How is a chain reaction controlled in a nuclear reactor? _____

Fusion: squash it!

F P

In **fusion**, two _____ nuclei join to make a _____ nucleus. Some of the mass is converted into energy. This is what powers the _____.

Draw two small nuclei fusing →

Radiation: friend or foe?

F P

Use	Which radiation? Why?
Medical tracer injected into the body (short half-life)	
Killing cancer cells (radiotherapy)	
Sterilising surgical instruments	

Name two sources of **background radiation**: _____ and _____

Why does a pilot get a higher dose of radiation than an office worker?

_____

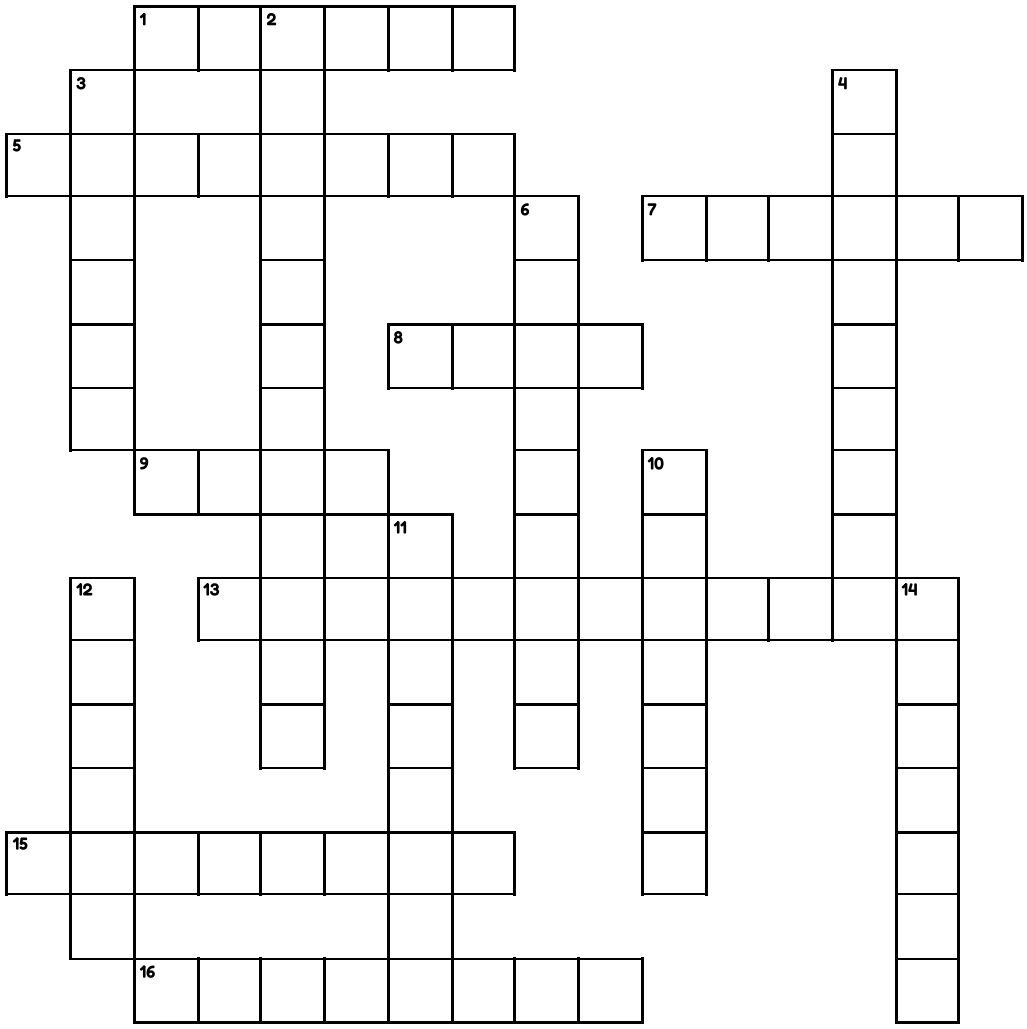
Peer review

F P

Why is it important that scientists share their findings about the effects of radiation on people and check each other's work?

The great forces crossword

F C



Across

1. A quantity with size only (6)
5. Speed in a given direction (8)
7. The unit of force (6)
8. The amount of matter in an object, measured in kg (4)
9. Friction from air or water on a moving object (4)
13. Distance in a given direction (12)
15. Mass × velocity (8)
16. A force that opposes motion when two surfaces rub (8)

Down

2. The rate of change of velocity (12)
3. The force on an object due to gravity (6)
4. How much longer a spring gets when stretched (9)
6. A single force with the same effect as all the forces acting (9)
10. The tendency of an object to keep doing what it is doing (7)
11. The upward force from a liquid that helps things float (8)
12. A quantity with size AND direction (6)
14. The force in a stretched rope or cable (7)

Bucket sort: scalar or vector?

F C

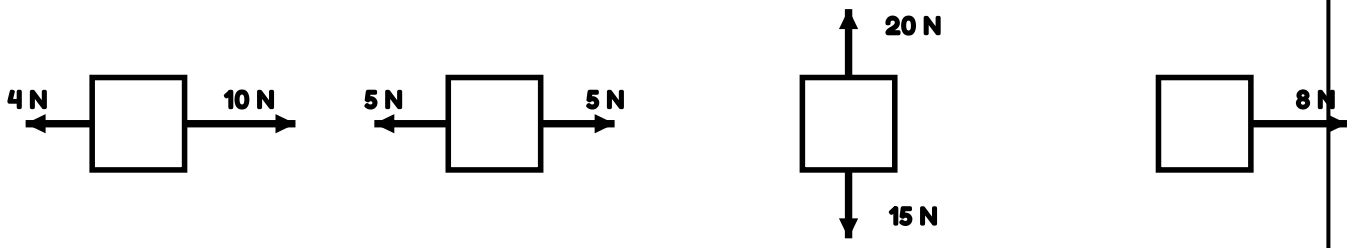
Write each word in the right bucket: **speed · velocity · distance · displacement · mass · force · time · acceleration · weight · temperature · momentum · energy**



Resultant force showdown

F C

Work out the size and direction of the resultant force on each box. Which box is balanced?



_____ N _____ _____ N _____ _____ N _____ _____ N _____

Vector diagram challenge

H C

A boat is pushed **3 N east** by its engine and **4 N north** by the wind. Draw a scale vector diagram (1 square = 1 N) to find the resultant force.

Resultant = _____ N

The interplanetary weighing machine

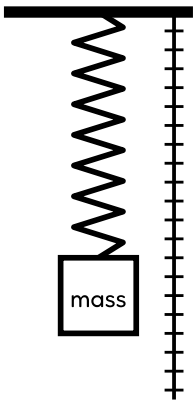
F C

equation sheet Your astronaut has a mass of **60 kg** everywhere. But their weight changes! Fill in the table.

Place	Earth	Moon	Mars	Jupiter (no landing!)
g (N/kg)	9.8	1.6	3.7	25
Weight (N)				

Spring lab (Required practical)

F C



Force (N)	0	1	2	3	4	5	6
Extension (cm)	0	4	8	12	16	22	31

Plot force (y-axis) against extension (x-axis) on graph paper or below. Up to which force is the spring **obeying Hooke's law**? _____ N

What is this point called? The limit of _____

Calculate the spring constant in N/m (careful – change cm to m!).

_____

Stretch and squash

F C

equation sheet

1. A spring has a spring constant of 25 N/m. It is stretched by 0.2 m. What force is needed? _____ N
2. A spring with k = 40 N/m is stretched by 0.1 m. How much elastic potential energy is stored? _____ J
3. What is the difference between **elastic** and **inelastic** deformation?

   _____
4. To change the shape of an object you need **more than one** force. Why?

   _____

Work it out

F C

Work is done when a force moves an object. 1 joule = 1 newton-metre.

1. You push a shopping trolley with 50 N for 3 m. Work done = _____ J
2. When you rub your hands together, work done against friction makes your hands _____

Imagine it: the bounciest invention

F C

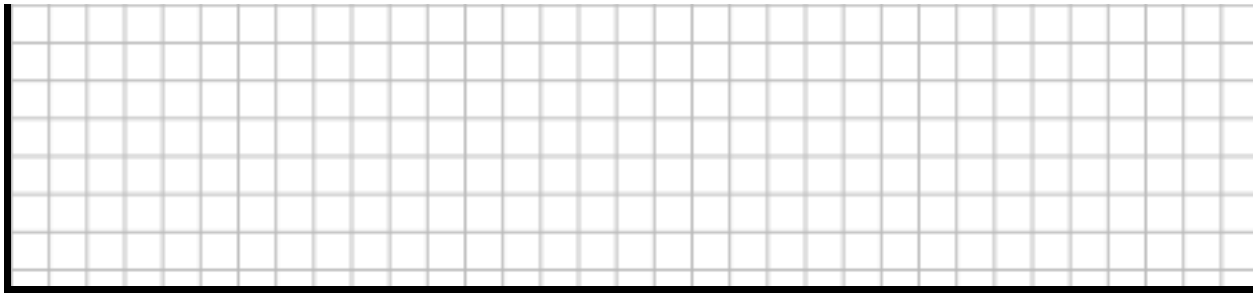
Invent something that uses springs (super-shoes? a pogo-bed? a cat launcher?). Label where elastic potential energy is stored and what it is transferred to.

Graph story time: distance–time

F C

Plot a distance-time graph for this story. Then label each part with how Zara was moving.

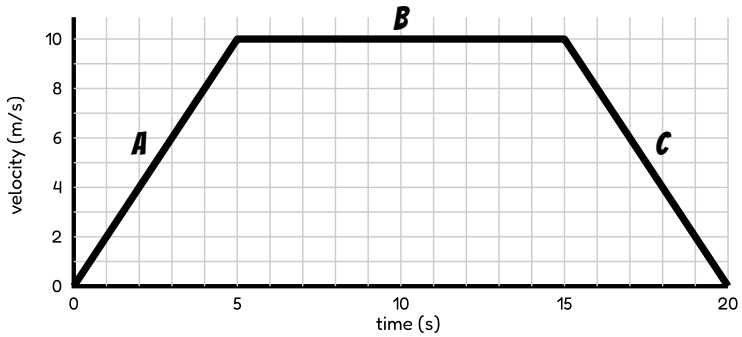
Zara walks 100 m to the bus stop in 50 s. She waits 30 s for her friend. Then they run 150 m in 50 s to catch the bus!



The **gradient** of a distance-time graph tells you the _____. Zara's walking speed = _____ m/s

Read the velocity–time graph

F C



Describe the motion in each part:

A: _____

B: _____

C: _____

1. Calculate the acceleration in part A. _____ m/s²

Area = distance

H C

Use the area under the graph to find the total distance travelled.

_____ m

Speed match-up

F C

walking	**about 6 m/s**
running	**about 330 m/s**
cycling	**about 1.5 m/s**
sound in air	**about 13 m/s**
car in a town	**about 3 m/s**

FORCES

Zone 5

Newton's laws comic

F C

Newton's 1st law
Draw something where the forces are balanced: it stays still or keeps moving at a steady speed.

Newton's 2nd law
Draw two people pushing the same trolley – one pushes harder. Who accelerates more?

Newton's 3rd law
Draw a skater pushing off a wall. Show the two equal and opposite forces.

F = m a power-up

F C

equation sheet

1. A 1200 kg car accelerates at 2 m/s². What resultant force is needed? _____ N
2. A 0.5 kg ball is kicked with a resultant force of 10 N. Acceleration = _____ m/s²
3. A car speeds up from 0 to 20 m/s over 100 m. Use $v^2 - u^2 = 2as$ to find its acceleration.

   _____
4. In the trolley practical, what do you change and what do you measure?

   _____

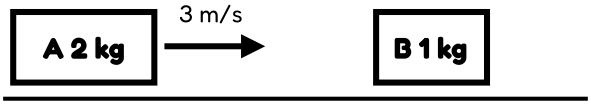
Inertia and mass

H C

Why is it harder to get a full shopping trolley moving than an empty one? Use the words *inertial mass*. _____

Momentum crash lab

H C



Trolley A crashes into stationary trolley B. They stick together.

1. Momentum of A before = _____ kg m/s
2. Speed of A and B together after = _____ m/s

Crumple zones & airbags

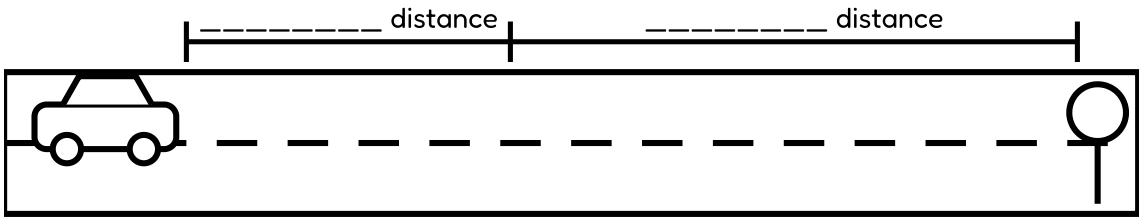
H P

equation sheet A 0.2 kg ball moving at 10 m/s is stopped in 0.05 s. Force = _____ N.

Explain how an airbag reduces the force on a driver. _____

Stop!

F C



Label the two parts of the stopping distance. Stopping distance = _____ + _____

Sort these factors: **tiredness · an icy road · drinking alcohol · worn tyres · using a phone · worn brakes · a wet road · some drugs · going faster**

Affects thinking distance	Affects braking distance

Which factor affects **both**? _____

Ruler-drop reaction game

F C

Your partner holds a 30 cm ruler. Put your finger and thumb at the 0 mark. When they drop it, catch it! Read where you caught it, then use the chart to find your reaction time.

5 cm **0.10 s**	10 cm **0.14 s**	15 cm **0.17 s**	20 cm **0.20 s**	25 cm **0.23 s**	30 cm **0.25 s**

Try	1	2	3	Mean
Distance (cm)				
Reaction time (s)				

Typical reaction times are 0.2 s to 0.9 s. A car travels at 20 m/s and the driver's reaction time is 0.7 s. Thinking distance = _____ m

Braking forces

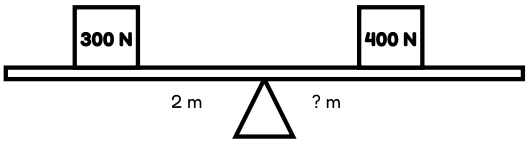
H C

A 1000 kg car slows from 20 m/s to 0 in 4 s. Calculate the deceleration and the braking force. Why is a large deceleration dangerous?

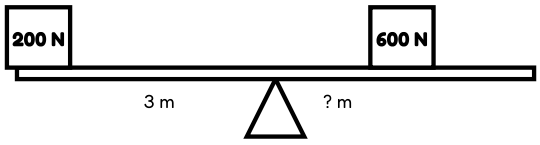
Balance the see-saws

F P

equation sheet moment = force × distance. For balance, clockwise moments = anticlockwise moments.



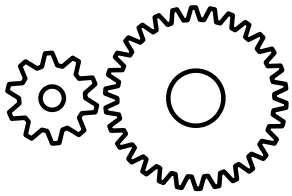
? = _____ m



? = _____ m

Gear up!

F P



The small gear (10 teeth) drives the big gear (30 teeth).

The big gear turns **faster / slower**. It turns once for every _____ turns of the small gear. Its turning effect (moment) is **bigger / smaller**.

Why is a long spanner easier to use than a short one?

_____

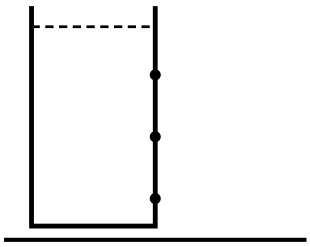
Pressure points

F P

equation sheet A 600 N person stands on snowshoes with an area of 0.2 m². Pressure = _____ Pa. Why don't they sink? _____

Leaky tank

F P



Draw the water jets coming out of the three holes. Which goes furthest, and why? _____

_____

Air pressure gets **bigger / smaller** as you climb a mountain.

Why does a boat float? (Hint: *upthrust*) _____

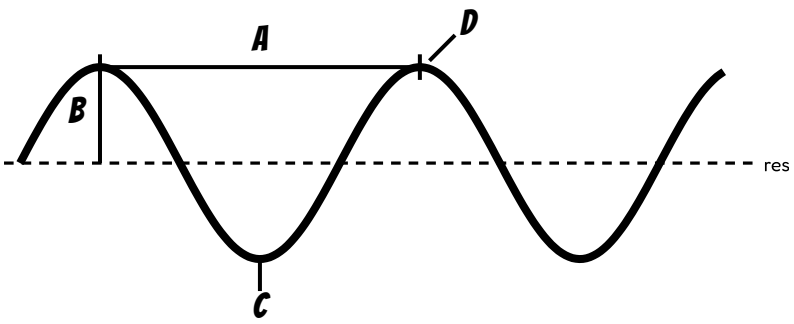
Deep-sea diver

H P

equation sheet Calculate the pressure due to the water on a diver 10 m deep. Density of water = 1000 kg/m³, g = 9.8 N/kg. _____ Pa

Wave anatomy

F C



Label A–D: *wavelength · amplitude · peak (crest) · trough*

A _____
B _____
C _____
D _____

Transverse or longitudinal?

F C

Transverse – draw a slinky wave. Oscillations are _____ to the direction of energy transfer.

Longitudinal – draw a slinky wave. Label a *compression* and a *rarefaction*.

Write T or L: ☐ ripples on water ☐ sound in air ☐ light ☐ a Mexican wave in a stadium 😉

When a wave travels, the **wave** moves forward – but does the water or air move along with it? _____

Ripple tank lab (Required practical)

F C

equation sheet In a ripple tank, 10 waves pass a point in 5 s. The wavelength is 0.03 m.

1. Frequency = _____ Hz
2. Wave speed = _____ m/s
3. Period of a wave with a frequency of 4 Hz = _____ s
4. Sound travels at 330 m/s. A note has a frequency of 660 Hz. What is its wavelength? _____ m

Imagine it: wave-surfing robot

F C

Design a robot that can measure the speed of waves at the beach. What would it measure, and how would it work out the speed?

Colour the electromagnetic spectrum

F C

Write the 7 groups in order, from **long wavelength** (left) to **short wavelength** (right). Then colour each section a different pattern.

_____	_____	_____	_____	_____	_____	_____

← **longer wavelength, lower frequency** **shorter wavelength, higher frequency** →

Make up your own funny sentence to remember the order (e.g. *Rabbits Mate In Very Unusual eXpensive Gardens*):

_____

_____

Uses match-up

F C

Draw lines from each wave to its use.

Radio waves	Cooking food and satellite signals
Microwaves	Sun tanning and energy-efficient lamps
Infrared	Medical imaging (seeing bones)
Visible light	TV and radio broadcasts
Ultraviolet	Fibre-optic communications
X-rays	Sterilising and treating cancer
Gamma rays	Electric heaters and thermal cameras

Danger zone

F C

Which **three** groups can harm body cells? _____ _____ _____ UV can cause skin to age early and increase the risk of _____.

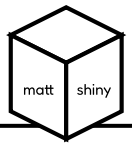
Making radio waves

H C

Radio waves can be produced by _____ in electrical circuits. When they are absorbed they can create an _____ current.

Infrared cube (Required practical)

F C



A cube of hot water has different coloured sides. Colour one face matt black and leave the other white/shiny. Which side emits the most infrared?

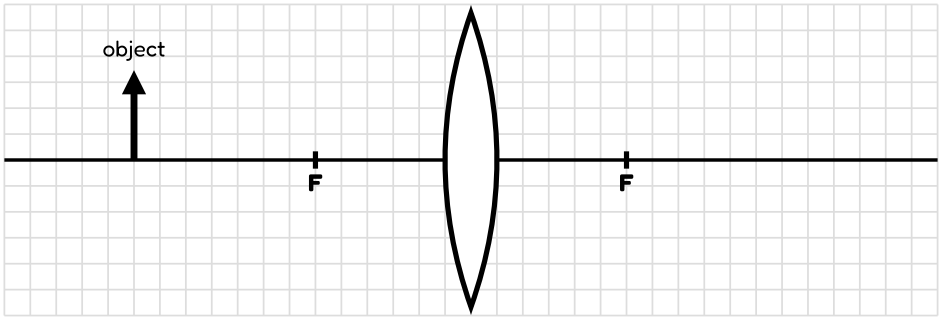
_____

What would you use to measure it? _____

Ray diagram challenge

F P

Draw two rays from the top of the object through the convex lens to find the image: one parallel to the axis, then through F; one straight through the centre of the lens.



The image is: **real / virtual** · **upright / inverted** · **bigger / smaller** than the object.

Magnify it

F P

equation sheet A magnifying glass makes a 2 cm ladybird look 6 cm long.

Magnification = _____ (it has no units!)

Draw the symbol for a convex lens [ ] and a concave lens [ ]

Colour puzzle

F P

Here's a colouring page with a twist! Colour each object the colour it would **look**.

Object	Lit with / seen through	Looks...	Colour it!
red apple	white light		
red apple	through a green filter		
white T-shirt	blue light		
green leaf	through a green filter		

An object looks red because it reflects red light and _____ all other colours.

Mirror, mirror (Required practical)

F P

Specular reflection – draw light hitting a smooth mirror.

Diffuse reflection – draw light hitting a rough surface like paper.

Echo hunter: ultrasound

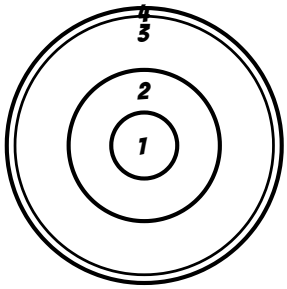
H P

Humans hear from about _____ Hz to _____ Hz. Ultrasound has a frequency **higher** than this.

An ultrasound pulse travels through the body at 1500 m/s. The echo from a baby's head returns after 0.0002 s. How far is the baby's head from the probe? (Careful – the pulse goes there **and back**!) _____ m

Earthquake detective

H P



✎ Colour and label Earth's layers: *inner core · outer core · mantle · crust.*

P-waves are _____ and travel through solids and liquids. **S-waves** are _____ and only travel through _____.

S-waves don't arrive on the far side of the Earth. What does this tell us about the outer core? _____

Glow-meter: black body radiation

F P

All objects emit and absorb infrared radiation. The **hotter** an object, the **more / less** radiation it emits each second and the **longer / shorter** the wavelengths.

A perfect black body absorbs _____ the radiation that hits it. It is also the best possible _____.

Earth's thermostat

H P

Earth absorbs radiation from the Sun and emits radiation into space. What happens to Earth's temperature if it absorbs more than it emits? Give one factor that affects this balance.

_____

_____

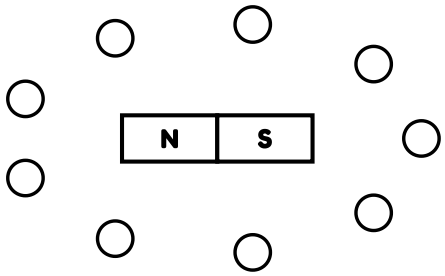
Imagine it: the infrared alien

F C

Zorb comes from a planet where everyone sees in infrared, not visible light. Draw what a street looks like to Zorb at night. What glows brightest?

Field line art

F C



Draw the magnetic field lines around the bar magnet. Draw an arrow in each compass to show which way it points.

Field lines go from _____ to _____.

The field is strongest at the _____ .

Attract or repel?

F C



_____ _____

Magnetic or not?

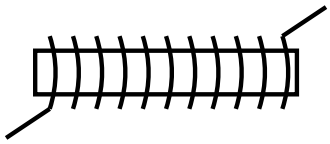
F C

Circle the **four** magnetic materials: **copper · iron · aluminium · nickel · wood · cobalt · gold · steel · plastic**

A **permanent** magnet makes its own field. An **induced** magnet only becomes a magnet when _____. Induced magnetism always causes **attraction / repulsion**.

Electromagnet power-up

F C



This coil of wire is a _____. Give **three** ways to make it a stronger electromagnet:

1. _____
2. _____
3. _____

Imagine it: the mega-magnet machine

F C

Design a machine that uses an electromagnet – a scrapyard crane, a door lock, a sorting robot for a recycling centre… Why is an electromagnet better than a permanent magnet for this job?

Fleming's left-hand rule

H C

Draw round your LEFT hand here, with your thumb, first finger and second finger all at right angles (like a gun shape with the middle finger pointing out).

Label each finger:

Thumb = _____

First finger = _____

Second finger = _____

Colour each finger a different pattern.

A wire carrying a current in a magnetic field feels a force. This is the _____ effect.

Force on a wire

H C

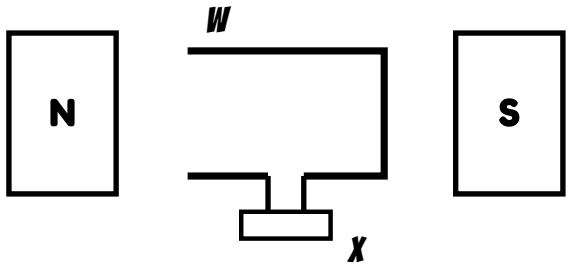
equation sheet

A 0.5 m wire carries 3 A at right angles to a 0.2 T magnetic field. Force = _____ N

Name two ways to make the force bigger: _____ and _____

Inside a motor

H C



W = _____

X = _____ (keeps it turning the same way)

Why does the coil rotate?

_____

_____

Loudspeaker secrets

H P

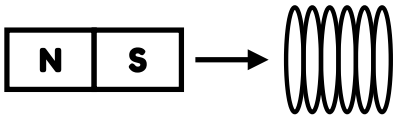
Put the steps in order (1–4):

☐ The cone vibrates and makes pressure variations in the air (sound). ☐ An alternating current flows through the coil.

☐ The coil moves backwards and forwards. ☐ The coil's field and the permanent magnet's field push on each other.

The generator effect

H P



Pushing a magnet into a coil **induces** a potential difference. Give two ways to make it bigger:

_____

_____

What happens if you pull the magnet **out**?

_____

Match the machine

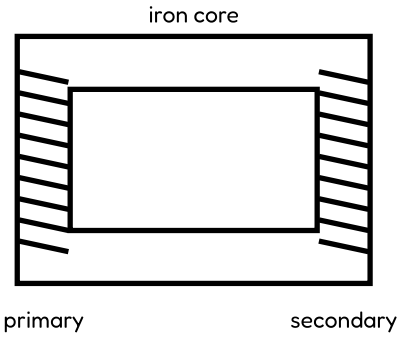
H P

Alternator	uses the generator effect to change sound waves into electrical signals
Dynamo	makes alternating current (a.c.)
Microphone	makes direct current (d.c.)

Hint: the descriptions are in the wrong order. Draw lines!

Transformer workshop

H P



equation sheet

1. A transformer has 1000 turns on the primary coil and 50 on the secondary. The input is 230 V. Output = _____ V
2. Is this a step-up or step-down transformer? _____
3. The primary current is 0.1 A. Assuming it is 100% efficient, the secondary current = _____ A

Why must a transformer use **alternating** current? _____

_____

Imagine it: bike-powered cinema

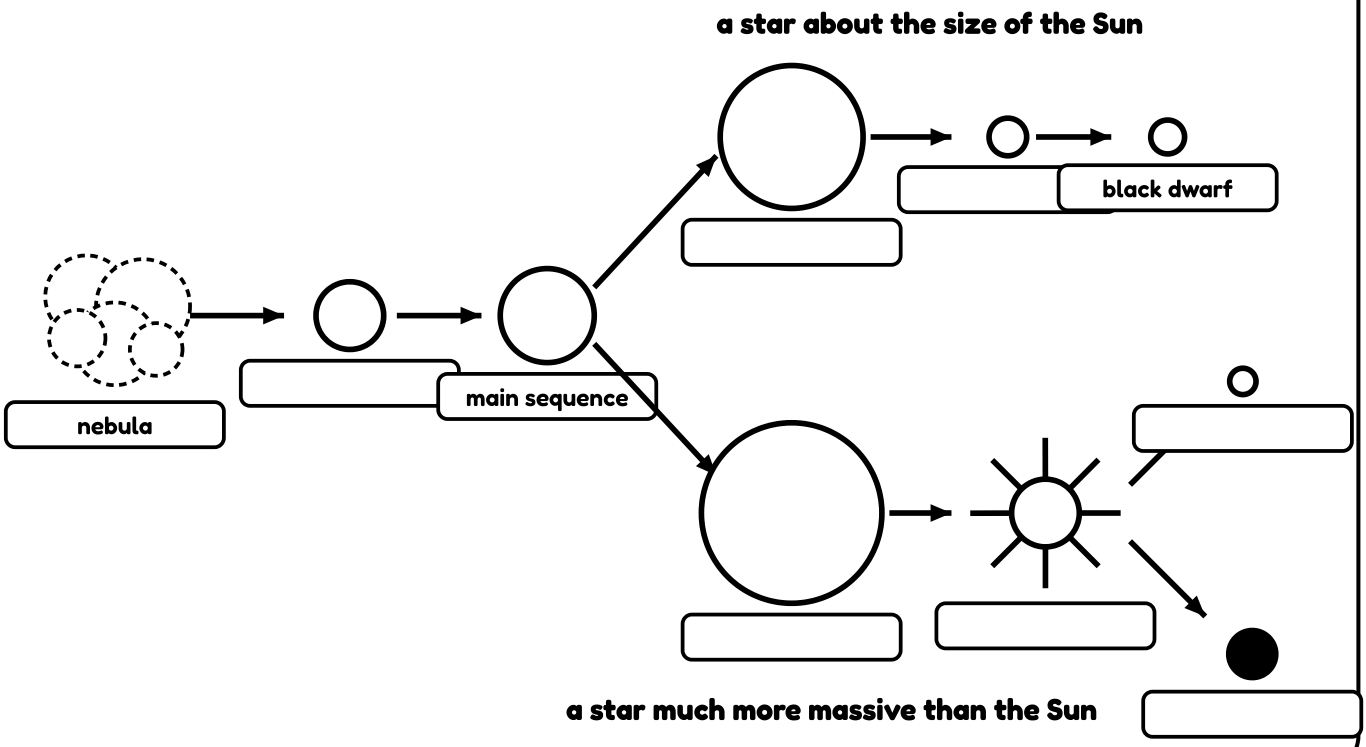
H P

Your school wants to power a film night using exercise bikes with dynamos. Draw and label how energy gets from the riders to the projector. Would the riders keep the film going?

Life of a star

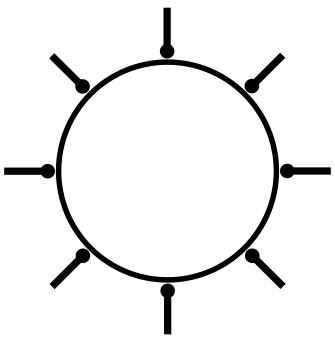
F P

Fill in the empty labels: *protostar · red giant · white dwarf · red super giant · supernova · neutron star · black hole*. Then ✎ colour the stars (red giants red, white dwarfs left white…).



Tug of war inside a star

F P



The arrows show a force pulling **inwards**. What is it?

_____

Draw arrows inside the star for the outward push caused by _____ energy.

A star is stable on the main sequence because these forces are _____.

Star-made elements

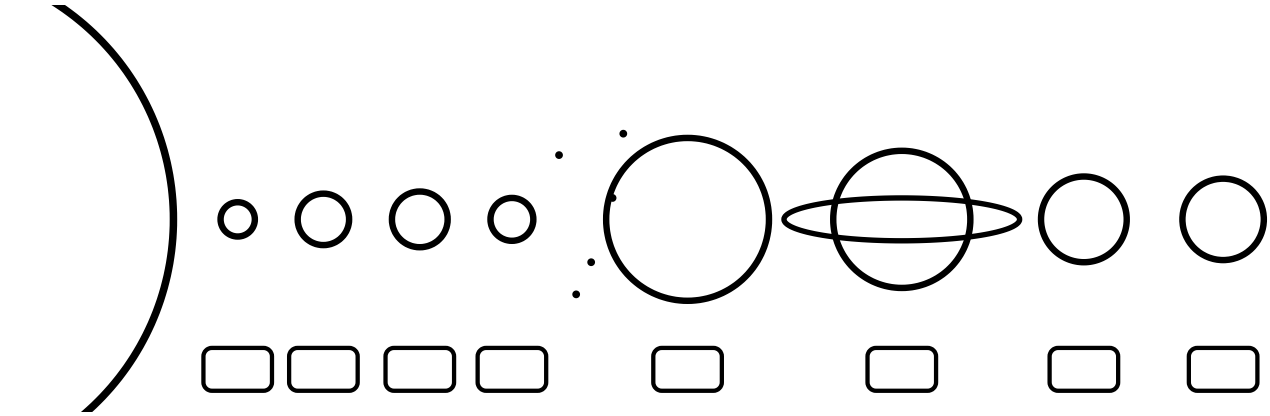
F P

Fusion in stars makes new elements. Elements heavier than _____ are made in a _____, which also spreads them throughout the universe.

💡 The iron in your blood was made inside a star! Write a short "thank-you note" to the star that made it:

Solar system colouring

F P



Write the first letter of each planet in the boxes, then colour them in. Make up a sentence to remember the order (My Very Easy Method…): _____

Our solar system is a small part of the _____ galaxy. The Moon is a natural _____.

Red-shift detective

F P

Dark lines in the spectrum of light from galaxies are shifted towards the red end (longer wavelength). The more shifted, the faster the galaxy is moving away. Shade each box so the left is violet and the right is red.

Lab (no shift)



Galaxy A



Galaxy B



Which galaxy is further away? _____ Red-shift is evidence that the universe is _____, which supports the _____ theory.

Two mysteries scientists still can't explain: dark _____ and dark _____

Orbit puzzler

H P

A satellite orbits at a steady speed. Why is its **velocity** changing? If it speeds up, what must happen to its orbit radius?

Launch a satellite

F P

Design a satellite. What is its job? High or low orbit?

EQUATION SHEET

Zone 9

Your equation sheet (practice copy)

You'll get an equation sheet in the exam, so you don't need to memorise these. Use this practice copy with the puzzles. Always check the equation sheet you're given in your actual exam. ✎ Highlight each equation when you've used it in a puzzle.

1	weight = mass × gravitational field strength	$W = m g$	F C
2	work done = force × distance	$W = F s$	F C
3	force = spring constant × extension	$F = k e$	F C
4	moment of a force = force × distance	$M = F d$	F P
5	pressure = force ÷ area	$p = F / A$	F P
6	distance = speed × time	$s = v t$	F C
7	acceleration = change in velocity ÷ time	$a = \Delta v / t$	F C
8	resultant force = mass × acceleration	$F = m a$	F C
9	momentum = mass × velocity	$p = m v$	H C
10	kinetic energy = 0.5 × mass × speed²	$E_k = ½ m v^2$	F C
11	gravitational potential energy = mass × g × height	$E_p = m g h$	F C
12	power = energy transferred ÷ time	$P = E / t$	F C
13	power = work done ÷ time	$P = W / t$	F C
14	efficiency = useful output energy ÷ total input energy		F C
15	efficiency = useful power output ÷ total power input		F C
16	wave speed = frequency × wavelength	$v = f \lambda$	F C
17	charge flow = current × time	$Q = I t$	F C
18	potential difference = current × resistance	$V = I R$	F C
19	power = potential difference × current	$P = V I$	F C
20	power = current² × resistance	$P = I^2 R$	F C
21	energy transferred = power × time	$E = P t$	F C
22	energy transferred = charge flow × potential difference	$E = Q V$	F C
23	density = mass ÷ volume	$\rho = m / V$	F C
24	pressure due to a column of liquid = height × density × g	$p = h \rho g$	H P
25	(final velocity)² − (initial velocity)² = 2 × acceleration × distance	$v^2 - u^2 = 2 a s$	F C
26	force = change in momentum ÷ time taken	$F = m \Delta v / \Delta t$	H P
27	elastic potential energy = 0.5 × spring constant × extension²	$E_e = ½ k e^2$	F C
28	change in thermal energy = mass × specific heat capacity × temperature change	$\Delta E = m c \Delta \theta$	F C
29	period = 1 ÷ frequency	$T = 1 / f$	F C
30	magnification = image height ÷ object height		F P
31	force on a wire = magnetic flux density × current × length	$F = B I l$	H C
32	thermal energy for a change of state = mass × specific latent heat	$E = m L$	F C
33	pd across primary ÷ pd across secondary = turns on primary ÷ turns on secondary	$V_p / V_s = n_p / n_s$	H P
34	pd across primary × current in primary = pd across secondary × current in secondary	$V_p I_p = V_s I_s$	H P
35	for gases: pressure × volume = constant	$pV = \text{constant}$	F P

EQUATION SHEET

Zone 9

Equation detective agency

F C

For each case: 1) find the right equation on the **practice sheet on the page before** and write its number (your real exam sheet may number them differently), 2) put the numbers in, 3) write the answer with its unit. equation sheet

1 A 2 kg rock is moving at 5 m/s. How much kinetic energy does it have?

Eq. no. ____ Answer: _____ J

2 A 2000 W heater is on for 60 s. How much energy does it transfer?

Eq. no. ____ Answer: _____ J

3 A sound wave has a frequency of 200 Hz and a wavelength of 1.5 m. How fast does it travel?

Eq. no. ____ Answer: _____ m/s

4 A cyclist rides 1200 m in 200 s. What is their average speed?

Eq. no. ____ Answer: _____ m/s

5 A car speeds up from 5 m/s to 25 m/s in 4 s. What is its acceleration?

Eq. no. ____ Answer: _____ m/s^2

6 2 kg of water (c = 4200 J/kg °C) is heated by 10 °C. How much energy was needed?

Eq. no. ____ Answer: _____ J

7 A 500 N force pushes a crate 4 m. How much work is done?

Eq. no. ____ Answer: _____ J

8 A 0.5 kg book is lifted 2 m onto a shelf (g = 9.8 N/kg). How much GPE does it gain?

Eq. no. ____ Answer: _____ J

9 A 6 kg brick has a volume of 0.003 m^3. What is its density?

Eq. no. ____ Answer: _____ kg/m^3

10 1.5 kg of ice melts (L = 334 000 J/kg). How much energy is needed?

Eq. no. ____ Answer: _____ J

Detective tips

F C

1. List what you know
Write each value with its symbol, e.g. m = 2 kg, v = 5 m/s.

2. Find the equation
Look for one with the thing you want AND the things you know.

3. Check units
Change g → kg, cm → m, minutes → seconds, kJ → J first!

EQUATION SKILLS

Zone 9

Unit hunt

F C

Fill in the missing unit names and symbols. The first two are done for you.

Quantity	Symbol	Unit	Unit symbol
current	I	ampere	A
potential difference	V	volt	V
resistance	R		
energy	E		
power	P		
force	F		
frequency	f		
charge	Q		
density	ρ		
acceleration	a		
momentum	p		

Equation flip!

F C

Rearrange each equation to make the **bold** letter the subject.

V = I R → **R** = _____

P = V I → **I** = _____

v = f λ → **λ** = _____

F = m a → **m** = _____

Q = I t → **t** = _____

ρ = m / V → **V** = _____

Flip it – the hard ones

H C

$E_k = \frac{1}{2} m v^2$ → **v** = _____

$\Delta E = m c \Delta\theta$ → **Δθ** = _____

Prefix ladder

F C

G = giga = 10^9 · M = mega = 10^6 · k = kilo = 10^3 · m = milli = 10^{-3} · μ = micro = 10^{-6} · n = nano = 10^{-9}

5 km = _____ m

3 kW = _____ W

250 mA = _____ A

2 MJ = _____ J

4 GW = _____ W

600 nm = _____ m

BOSS LEVEL

Grade 7–9 challenge

Boss level! Each problem needs **two or more** equations. Plan first: what do you know, and what do you need? equation sheet

H C

1 A 2 kW kettle heats 1.5 kg of water from 20 °C to 100 °C (c = 4200 J/kg °C). Assuming no energy is wasted, how long does it take?

Answer: 504 000 J ÷ 2000 W = 252 s

2 A 0.15 kg ball is dropped from 5.0 m. Ignoring air resistance, how fast is it going just before it hits the ground? (g = 9.8 N/kg)

Answer: E = 7.35 J → v = √(2 × 7.35 ÷ 0.15) = 9.9 m/s

3 A current of 1.5 A flows for 4 minutes through a 12 V motor. How much energy is transferred?

Answer: Q = 1.5 × 240 = 360 C → E = 360 × 12 = 4320 J

4 A 1200 kg car at 25 m/s brakes with a constant force of 6000 N. How far does it travel while braking?

Answer: a = 5 m/s² → s = 25² ÷ (2 × 5) = 62.5 m

5 A motor that is 75% efficient lifts a 50 kg load 4.0 m. How much energy must be supplied to the motor? (g = 9.8 N/kg)

Answer: useful = 1960 J → input = 1960 ÷ 0.75 ≈ 2600 J

6 A medical tracer has an activity of 160 MBq and a half-life of 6 hours. How long until its activity is 10 MBq?

Answer: 160 → 80 → 40 → 20 → 10 = 4 half-lives = 24 hours

Required practical passport

F

For each practical, write the main thing you **change** (independent variable) and the thing you **measure** (dependent variable). **C** = on Combined Science too, **P** = Physics only. *(Combined Science numbers these differently.)*

#	Practical		I change...	I measure...
1	Specific heat capacity	C		
2	Thermal insulation	P		
3	Resistance of a wire	C		
4	I–V characteristics	C		
5	Density	C		
6	Force and extension of a spring	C		
7	Force, mass and acceleration	C		
8	Waves in a ripple tank and on a string	C		
9	Reflection and refraction of light	P		
10	Infrared radiation from surfaces	C		

Spot the anomaly

F C

Leo timed a trolley rolling down a ramp three times.

Ramp height (cm)	Time 1 (s)	Time 2 (s)	Time 3 (s)	Mean (s)
10	2.4	2.5	2.3	
20	1.8	2.9	1.7	

Circle the anomaly. Calculate both means (ignore the anomaly). Why repeat readings?

Lab language

F C

accurate	a measurement close to the true value
precise	the variable you keep the same
control variable	the smallest change an instrument can show
resolution	repeat measurements that are close together

Oops! Only the first is matched correctly. Draw arrows to fix the rest.

BRAIN TEASERS

Mixed topics

Who am I?

F C

1. I'm the unit of power. One of me is one joule every second. Who am I? _____
2. I'm a component whose resistance falls when the light gets brighter. Who am I? _____
3. I'm the type of radiation stopped by a sheet of paper. Who am I? _____
4. I'm a wave that needs no medium. I travel at the same speed as all my family in a vacuum. Which family am I from? _____
5. I'm the force that keeps the Moon in orbit around the Earth. Who am I? _____
6. I'm the change of state from gas to liquid. Who am I? _____
7. I'm the point inside a magnet's field where it is strongest. Where am I? _____
8. I'm the stage a star like the Sun reaches after it runs out of hydrogen. Who am I? _____

Odd one out

F C

Find the odd one out and say why. The first is done for you: **newton**.

Set	Odd one	Why?
kinetic · thermal · newton · chemical		*unit, not a store*
ammeter · volt · ohm · watt		
alpha · beta · gamma · ultrasound		
speed · distance · time · velocity		
iron · nickel · cobalt · copper		
radio · sound · X-ray · microwave		

Write your own riddle

F C

Write a "Who am I?" riddle about any physics idea. Swap with a friend!

RACE ACROSS THE UNIVERSE

Game

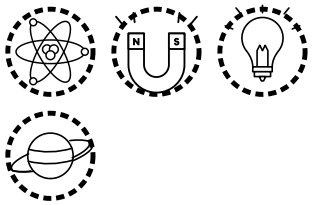
42 ★ FINISH! Edge of the universe	41	40 ◉ Black hole! Back to 30	39 ? Take a card	38	37 ? Take a card	36 ★ Gravity assist! Roll again
29 ★ Wormhole! Swap with any player	30	31 ? Take a card	32	33 ◉ Black hole! Back to 22	34 ? Take a card	35
28	27 ◉ Black hole! Back to 13	26 ? Take a card	25	24 🚀 Rocket! Zoom to 35	23 ? Take a card	22
15 ◉ Black hole! Back to 5	16	17 🚀 Rocket! Zoom to 28	18	19 ? Take a card	20	21 ★ Solar wind! Forward 2
14 ? Take a card	13	12	11 ? Take a card	10	9 🚀 Rocket! Zoom to 20	8 ? Take a card
1 ★ START The Big Bang	2 ? Take a card	3 🚀 Rocket! Zoom to 12	4	5	6 ? Take a card	7 ★ Supernova! Back 2

How to play

F H

2–4 players · one dice · the question cards on the next page. Take turns to roll and move. **Rocket**: zoom up! **Black hole**: get sucked back. On a **?** square, the player on your left reads you a card (Foundation players pick F cards, Higher players pick H cards). Right answer = move forward 2. First to square 42 wins! ✎ Colour the board before you play.

Cut-out counters



QUESTION CARDS

Cut out

✂ Cut out the cards along the dashed lines. The answer is upside down at the bottom – fold it under or cover it with your thumb!

F **CARD 1**

What is the unit of energy?

Answer: joule (J)

F **CARD 2**

Name the energy store in a stretched spring.

Answer: elastic potential

F **CARD 3**

What does an ammeter measure?

Answer: current

F **CARD 4**

What is the frequency of UK mains electricity?

Answer: 50 Hz

F **CARD 5**

Which radiation is stopped by a sheet of paper?

Answer: alpha

F **CARD 6**

Name the three states of matter.

Answer: solid, liquid, gas

F **CARD 7**

Name a renewable energy resource.

Answer: e.g. wind, solar, tidal

F **CARD 8**

Someone walks 100 m in 20 s. What is their speed?

Answer: 5 m/s

F **CARD 9**

Which EM wave has the longest wavelength?

Answer: radio waves

F **CARD 10**

What is the relative charge of a proton?

Answer: +1

F **CARD 11**

What colour is the earth wire in a plug?

Answer: green and yellow stripes

F **CARD 12**

Name a magnetic material.

Answer: iron, steel, nickel or cobalt

H **CARD 13**

What is the momentum of a 2 kg ball moving at 4 m/s?

Answer: 8 kg m/s

H **CARD 14**

In Fleming's left-hand rule, what does the thumb show?

Answer: the force (motion)

H **CARD 15**

What does the gradient of a velocity–time graph show?

Answer: acceleration

H **CARD 16**

What does the area under a velocity–time graph show?

Answer: distance travelled

H **CARD 17**

After 2 half-lives, what fraction of the nuclei is left?

Answer: one quarter (1/4)

H **CARD 18**

What is the name of the effect when a current-carrying wire in a magnetic field feels a force?

Answer: the motor effect

H **CARD 19**

B = 0.5 T, I = 2 A, l = 1 m. What is the force on the wire?

Answer: 1 N

H **CARD 20**

Why is a satellite's velocity changing in a circular orbit?

Answer: its direction keeps changing

H **CARD 21**

What is the resultant of 3 N east and 4 N north?

Answer: 5 N

H **CARD 22**

What is inertia?

Answer: the tendency to stay at rest or keep moving at a steady velocity

H **CARD 23**

How does an airbag reduce the force on a driver?

Answer: increases the time taken to change momentum

H **CARD 24**

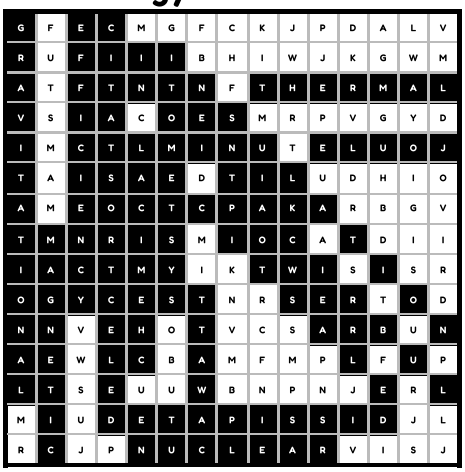
What happens to the temperature of a gas when work is done on it?

Answer: it increases

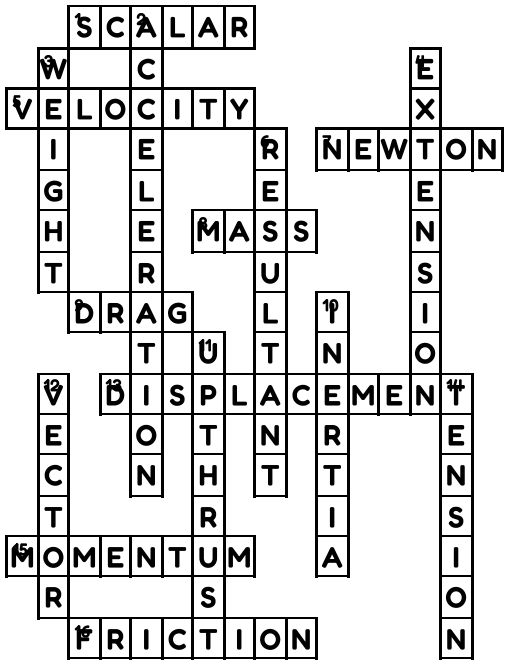
ANSWERS

No peeking!

Energy word search



Forces crossword



ENERGY

Which store?: elastic potential · thermal · chemical · gravitational potential · kinetic · magnetic

Sankey: Useful = 20 J. Efficiency = 20 ÷ 100 = 0.2 (20%). Wasted energy heats the surroundings (dissipated). Kettle: useful arrow 18 squares, wasted 2 squares; efficiency = 1800 ÷ 2000 = 0.9 (90%).

Make it efficient (H): e.g. lubricate moving parts to reduce friction; add thermal insulation (loft, cavity wall, double glazing); use thicker walls with lower thermal conductivity.

Resources: Renewable: bio-fuel, wind, solar, hydro-electric, tidal, wave, geothermal. Non-renewable: coal, oil, gas, nuclear. A renewable resource is one that is (or can be) replenished as it is used.

Coaster: B: gravitational potential – slowest/stopped. C: kinetic – fastest. D: both – slowing down as it climbs. GPE = 500 × 9.8 × 20 = 98 000 J. KE at C = 98 000 J. Energy lost to friction and air resistance → thermal store of surroundings (and sound).

Speed at bottom (H): $v = \sqrt{(2 \times 98\,000 \div 500)} = \sqrt{392} = 19.8 \rightarrow 20$ m/s

Specific heat capacity: $\Delta\theta = 16.5$ °C. $c = 15\,000 \div (1.0 \times 16.5) = 909 \approx 910$ J/kg °C. Too high because energy was lost to the surroundings, so the temperature rise was smaller. Insulate the block / put oil in the thermometer hole.

Insulation (P): Drops: 22, 9, 14, 11 °C. Best = bubble wrap. Independent variable = material. Control: starting temperature, volume of water, time, size of beaker.

Power: 360 000 ÷ 120 = 3000 W. Work = 600 × 12 = 7200 J; power = 7200 ÷ 8 = 900 W. Motor X.

ELECTRICITY

Symbol spotter: 1 lamp · 2 diode · 3 cell · 4 LDR · 5 ammeter · 6 fuse · 7 thermistor · 8 switch (open) · 9 battery · 10 variable resistor · 11 resistor · 12 LED

Sensors: LDR: resistance decreases as light increases – e.g. automatic night lights. Thermistor: resistance decreases as temperature increases – e.g. thermostats, fire alarms.

Current maze: 12 V → 3 A → 30 C → 3 Ω → 240 C → 460 W → 60 J. Path: right, down, down, right, right, down, down, then right to the BULB.

Series vs parallel: Series: current the same; pd shared; resistance adds up. Parallel: current shared; pd the same; total resistance less than the smallest resistor. 10 Ω. Parallel lamp stays on. Each light can be switched on/off separately and one failing doesn't stop the others.

I–V graphs: Resistor: straight line through the origin. Filament lamp: S-shaped curve (gets less steep). Diode: zero current for negative pd, then current rises steeply for positive pd. Lamp resistance rises when hot; the diode lets current flow one way.

Plug: X = neutral (blue) – completes the circuit. Y = earth (green/yellow) – safety wire that stops the case becoming live. Z = live (brown) – carries the alternating pd from the supply. a.c., 50 Hz, 230 V. The live wire is still at 230 V, so current can flow through you to earth.

National Grid: power station → step-up transformer → transmission cables → step-down transformer → homes. High pd means low current, so less energy is lost heating the cables (more efficient).

Bills: 800 × 150 = 120 000 J. 230 × 0.5 = 115 W. $3^2 \times 20 = 180$ W. e.g. fan, hairdryer, blender, washing machine.

Static (P): Electrons move from the jumper to the balloon, so the balloon becomes negative. The charged balloon attracts hair (unlike charges attract) and sticks to the wall by inducing a charge. Field lines point radially outwards; strongest where lines are closest. Like charges repel, unlike attract. Spark when the pd is high enough to ionise the air.

ANSWERS

No peeking!

PARTICLES

States: Solid: regular, touching, vibrate. Liquid: touching, random, move past each other. Gas: far apart, random, fast. 100 g – mass is conserved.

Density code: 1000 F · 2700 L · 900 O · 8000 A · 500 T · 7800 S → FLOATS. Ice and pine wood float (less dense than 1000 kg/m³).

Heating curve: A ice heating · B melting · C water heating · D boiling · E steam heating. During a change of state the energy breaks bonds (raises potential energy) rather than raising temperature.

Internal energy: kinetic · potential · temperature · state

Latent heat: 0.5 × 334 000 = 167 000 J. 0.2 × 2 260 000 = 452 000 J. SHC: energy to raise 1 kg by 1 °C. Latent heat: energy to change the state of 1 kg with no temperature change.

Gas in a box: Particles move faster; temperature increases; particles hit the walls more often and harder, so the force per area (pressure) increases.

Squeeze it (P): 100 × 2.0 = p × 0.5 → p = 400 kPa. Particles hit the walls more often.

Pump (H, P): Work is done on the gas, increasing its internal energy, so the particles move faster and the temperature rises.

Quiz: TRUE · FALSE · TRUE

ATOMS

Colour-by-number: 1 protons · 2 neutrons · 3 electrons. 4 protons, 5 neutrons, 4 electrons. Atomic number 4, mass number 9 = beryllium.

Particle cards: Proton: nucleus, +1, 1. Neutron: nucleus, 0, 1. Electron: shells, −1, very small. Equal numbers of protons and electrons. Size: about a stadium! Electron moves further from the nucleus. Positive ion.

Time machine: Dalton → J.J. Thomson → Rutherford (with Geiger & Marsden) → Bohr → Chadwick. Most went straight through: atom is mostly empty space. A few bounced back: mass and positive charge concentrated in a tiny nucleus.

Isotopes: Same protons, different neutrons. Pairs: carbon-12 & carbon-14; chlorine-35 & chlorine-37. Chlorine-37 has 20 neutrons.

Stop that radiation: α stopped by paper; β by aluminium; γ reduced by thick lead. α = 2 protons + 2 neutrons (helium nucleus), high ionising. β = fast electron from the nucleus, medium. γ = electromagnetic wave, low.

Decay equations: 1: $^{234}_{90}$Th. 2: atomic number 7. 3: alpha particle $^{4}_{2}$He. 4: beta particle $^{0}_{-1}$e. Gamma: no change to mass or atomic number.

Half-life: Coins: about 1 throw. Decay is random. 6 hours. 24 h = 4 half-lives → 50 Bq. (H) 7/8 decayed, 1/8 remains: net decline 7:8 of the original.

Contamination or irradiation: C · I · C · I

Fission & fusion (P): A neutron · B two smaller (daughter) nuclei · C 2–3 neutrons · D gamma radiation. Chain reaction – controlled by control rods absorbing neutrons. Fusion: two light nuclei join to make a heavier nucleus; powers the Sun / stars.

Uses (P): Tracer: gamma (passes out of the body, short half-life). Radiotherapy: gamma. Sterilising: gamma. Background: radon gas, rocks, cosmic rays, medical X-rays, fallout. Pilots are higher up so receive more cosmic rays.

FORCES

Buckets: Scalar: speed, distance, mass, time, temperature, energy. Vector: velocity, displacement, force, acceleration, weight, momentum.

Resultants: 6 N right · 0 N (balanced) · 5 N up · 8 N right. (H) Vector diagram: 5 N, about 53° north of east.

Weights: Earth 588 N · Moon 96 N · Mars 222 N · Jupiter 1500 N

Spring lab: Hooke's law obeyed up to 4 N – the limit of proportionality. k = 1 N ÷ 0.04 m = 25 N/m.

Stretch and squash: 25 × 0.2 = 5 N. 0.5 × 40 × 0.1² = 0.2 J. Elastic: returns to its original shape; inelastic: doesn't. One force would just make it move/accelerate. Work = 50 × 3 = 150 J; hands get warm.

Zara's graph: Straight line 0→100 m (0–50 s), flat line (50–80 s), steeper straight line 100→250 m (80–130 s). Gradient = speed. Walking speed = 2 m/s.

v–t graph: A: steady acceleration · B: constant velocity · C: steady deceleration. a = 10 ÷ 5 = 2 m/s². (H) distance = 25 + 100 + 25 = 150 m.

Speed match: walking 1.5 · running 3 · cycling 6 · sound 330 · car in town 13 m/s

F = ma: 2400 N · 20 m/s² · a = 20² ÷ (2 × 100) = 2 m/s² · change the force; measure the acceleration.

Inertia (H): The full trolley has a bigger inertial mass, so it needs a bigger force for the same acceleration.

Momentum (H): 2 × 3 = 6 kg m/s. 6 ÷ 3 = 2 m/s. (P) F = 0.2 × 10 ÷ 0.05 = 40 N. An airbag increases the time taken to stop, so the rate of change of momentum (force) is smaller.

Stopping: thinking + braking. Thinking: tiredness, alcohol, phone, drugs. Braking: icy road, worn tyres, worn brakes, wet road. Both: speed. Thinking distance = 20 × 0.7 = 14 m. (H) a = 5 m/s², F = 1000 × 5 = 5000 N; large forces can injure people and make brakes overheat or skid.

Moments (P): 1.5 m · 1 m. Big gear turns slower, once every 3 turns, bigger moment. Longer spanner = bigger distance so bigger moment for the same force.

Pressure (P): 600 ÷ 0.2 = 3000 Pa – force spread over a big area. Bottom jet goes furthest (more pressure deeper). Smaller. Upthrust balances weight. (H) 10 × 1000 × 9.8 = 98 000 Pa.

ANSWERS

No peeking!

WAVES

Wave anatomy: A wavelength · B amplitude · C trough · D peak

T or L: Transverse: perpendicular. Ripples T · sound L · light T · Mexican wave T. Only the wave (energy) travels, not the water or air.

Ripple tank: f = 2 Hz · v = 2 × 0.03 = 0.06 m/s · T = 0.25 s · λ = 330 ÷ 660 = 0.5 m

EM spectrum: radio · microwaves · infrared · visible · ultraviolet · X-rays · gamma

Uses: radio – TV and radio · microwaves – cooking and satellites · infrared – heaters and thermal cameras · visible – fibre optics · UV – sun tanning and lamps · X-rays – medical imaging · gamma – sterilising and treating cancer

Danger: UV, X-rays, gamma. Skin cancer. (H) oscillations; alternating current. IR cube: matt black; infrared detector or thermometer.

Lenses (P): Real, inverted, smaller (object is beyond 2F). Magnification = 6 ÷ 2 = 3.

Colour (P): red · black · blue · green. Absorbs. Specular: parallel rays reflect together. Diffuse: rays scatter in all directions.

Ultrasound (P, H): 20 Hz to 20 000 Hz. 1500 × 0.0002 = 0.3 m there and back → 0.15 m.

Earthquakes (P, H): 1 inner core · 2 outer core · 3 mantle · 4 crust. P: longitudinal. S: transverse, solids only. The outer core is liquid.

Black body (P): more · shorter · all · emitter. (H) Earth warms up. Factors: greenhouse gases, clouds, ice/snow cover.

MAGNETS

Field lines: From N to S. Strongest at the poles.

Attract or repel: Left pair (S faces S): repel. Right pair (S faces N): attract.

Magnetic: iron · nickel · cobalt · steel. Induced: when placed in a magnetic field. Always attraction.

Electromagnet: Solenoid. More turns, bigger current, add an iron core.

Fleming (H): thumb = force (motion) · first finger = field · second finger = current. Motor effect. F = 0.2 × 3 × 0.5 = 0.3 N. Bigger current, stronger magnet, longer wire in the field.

Motor (H): W = coil · X = split-ring commutator. Forces on the two sides of the coil act in opposite directions.

Loudspeaker (H, P): Order of statements as printed: 4, 1, 3, 2.

Generator (H, P): Move the magnet faster, use a stronger magnet, more turns. Pulling out reverses the pd. Alternator → a.c. · dynamo → d.c. · microphone → sound to electrical signals.

Transformer (H, P): 230 × 50 ÷ 1000 = 11.5 V · step-down · Is = 230 × 0.1 ÷ 11.5 = 2 A. A.c. makes a changing magnetic field, which induces a pd in the secondary coil.

SPACE

Life of a star: nebula → protostar → main sequence. Sun-sized: red giant → white dwarf → black dwarf. Massive: red super giant → supernova → neutron star (small circle) or black hole (black dot).

Tug of war: gravity · fusion · balanced (equilibrium)

Elements: iron · supernova

Solar system: M, V, E, M, J, S, U, N. Milky Way. Satellite.

Orbits (H): The direction keeps changing, so velocity changes. Faster → smaller orbit radius.

Red-shift: Galaxy B · expanding · Big Bang · dark matter (mass) and dark energy

SKILLS

Detective cases: 1: eq. 10, 25 J · 2: eq. 21, 120 000 J · 3: eq. 16, 300 m/s · 4: eq. 6, 6 m/s · 5: eq. 7, 5 m/s² · 6: eq. 28, 84 000 J · 7: eq. 2, 2000 J · 8: eq. 11, 9.8 J · 9: eq. 23, 2000 kg/m³ · 10: eq. 32, 501 000 J

Units: resistance ohm Ω · energy joule J · power watt W · force newton N · frequency hertz Hz · charge coulomb C · density kg/m³ · acceleration m/s² · momentum kg m/s

Flips: R = V/I · I = P/V · λ = v/f · m = F/a · t = Q/I · V = m/ρ · (H) $v = \sqrt{(2E_k/m)}$ · $\Delta\theta = \Delta E/(m\,c)$

Prefixes: 5000 m · 3000 W · 0.25 A · 2 000 000 J · 4×10^9 W · 6×10^{-7} m

Practicals: 1 energy supplied (time) / temperature · 2 material / temperature fall · 3 length of wire / resistance · 4 pd / current · 5 – / mass and volume → density · 6 force / extension · 7 force (or mass) / acceleration · 8 frequency / wavelength and speed · 9 angle of incidence / angle of reflection or refraction · 10 type of surface / infrared emitted

Anomaly: 2.9 s. Means 2.4 s and 1.75 ≈ 1.8 s. Repeats help spot anomalies and give a more accurate mean.

Lab language: precise → repeat measurements close together · control variable → the variable you keep the same · resolution → the smallest change an instrument can show

Who am I?: watt · LDR · alpha · electromagnetic waves · gravity · condensation · the poles · red giant

Odd one out: newton (unit) · ammeter (instrument, others are units) · ultrasound (not nuclear radiation) · velocity (vector) · copper (not magnetic) · sound (not electromagnetic)

WHAT DID YOU THINK?

Your feedback

Rate the zones

F

Colour in up to 5 stars for each part of the booklet.

Energy	☆☆☆☆☆	Electricity	☆☆☆☆☆
Particles	☆☆☆☆☆	Atoms	☆☆☆☆☆
Forces	☆☆☆☆☆	Waves	☆☆☆☆☆
Magnets	☆☆☆☆☆	Space	☆☆☆☆☆
Equation skills	☆☆☆☆☆	Board game	☆☆☆☆☆

How hard was it?

F

Circle the face that matches how you found it overall.



Too hard



Bit tricky



Just right



Too easy

Your verdict

F

My favourite activity was...

Something that confused me was...

I'd love the next booklet to include...

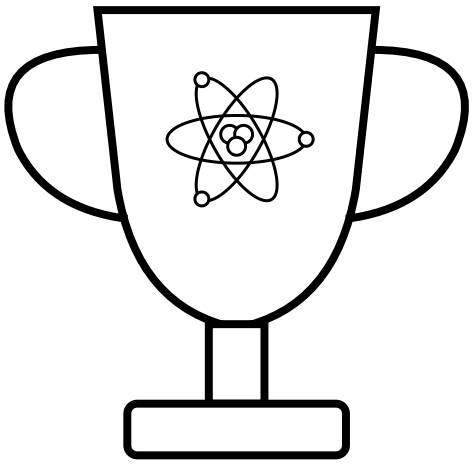
Draw it!

F

Draw your favourite thing you learned, or design a new puzzle for the next booklet.

CERTIFICATE

of Outstanding Physics



This is to certify that

_____

has explored every zone of

THE PHYSICS PUZZLE LAB

_____ _____

Signed (teacher) Date