Changing the subject of a formula

With Physics formulae you can change the subject of the formula as long as you do the same to both sides of the equation, as the formula represents a mathematical relationship between the physical quantities represented.

Example

$$\text{Pressure (p)} = \frac{\text{force (F)}}{\text{area (A)}}$$

$$p \times A = \frac{F}{A} \times A$$

a. To change the subject to F (force), multiply both sides by A and then cancel.

$$\text{Therefore,} \quad F = A \times p$$

b. To change the subject to A (area) multiply both sides by A and then cancel.

$$p \times A = \frac{F}{A} \times A$$

Then divide both sides by p and then cancel.

$$\frac{p \times A}{p} = \frac{F}{p}$$

$$\text{Therefore,} \quad A = \frac{F}{p}$$

Physical quantity	Relationship	Simple calculation
Distance (s) travelled	$= \text{speed (v)} \times \text{time (t)}$	A jogger ran at a constant speed of 3 m/s for half an hour. How many kilometres did the jogger run?
Speed (v) (velocity)	$= \frac{\text{distance (s)}}{\text{time (t)}}$	A car covers a distance of 200 m in 8 seconds. What is its speed?
Acceleration (a)	$= \frac{\text{change in velocity } (\Delta v)}{\text{time (t)}}$	A bus starts from rest and after 10 seconds its velocity is 20 m/s. What is its acceleration?
Weight (W)	$= \text{mass (m)} \times \text{gravitational field strength(g)}$	What is the weight of a mass of 1 tonne (1 000 kg) on Earth (g = 10 N/kg)?
Force (F)	$= \text{mass (m)} \times \text{accleration (a)}$	What size force causes a 5 kg mass to have an acceleration of 4 m/s^2?
Force applied to spring (F)	$= \text{spring constant (k)} \times \text{extension (e)}$	Oscar catches a fish and uses a spring balance to weigh it. The spring extends 6 cm. Oscar knows the spring constant is 200 N/m. How much does his fish weigh?
Moment of a force (M)	$= \text{force (F)} \times \text{distance from turning point (s)}$	What is the moment of a 6 N force acting 50 cm from its turning point?
Work done (W)	$= \text{force (F)} \times \text{distance (s)}$	How much work is done when a 20 N bag of sugar is pushed 50 cm across the counter at a checkout?
Pressure (p)	$= \frac{\text{force (F)}}{\text{area (A)}}$	What is the pressure of a 50 N force acting on an area of 0.05 m^2?
Density (ρ)	$= \frac{\text{mass (m)}}{\text{volume (V)}}$	What is the density of a 24 carat gold ring which has a mass of 96.5 g and a volume of 5.0 cm^3?
Momentum (p)	$= \text{mass (m)} \times \text{velocity (v)}$	A 4 kg rock is rolling down a hill with a velocity of 5 m/s. What is the momentum of the rock?
Kinetic energy (E_k)	$= \frac{1}{2}\text{mass (m)} \times \text{speed}^2 (v^2)$	A 5 g bullet has a velocity of 100 m/s. What is the kinetic energy of the bullet?

Physical quantity	Relationship	Simple calculation
Gravitational potential energy (E_p)	$= \text{mass(m)} \times \text{gravitational field strength(g)} \times \text{height(h)}$	What is the gravitational potential energy of a 50 kg object which is stationary on a shelf 1.5 m above the ground? (g = 10 N/kg)
Power (P)	$= \frac{\text{work done (w)}}{\text{time taken (t)}}$	A 200 N block is lifted by a crane 20 metres in 5 seconds. What is the power of this crane?
Energy transferred (E)	$= \text{power (P)} \times \text{time (t)}$	How much energy is transferred by a 0.5 kW machine which runs for half an hour?
Efficiency (E)	$= \frac{\text{useful energy out}}{\text{total energy in}}$	What is the efficiency of a diesel engine if 200 J of chemical energy produces 70 J of mechanical energy?
Wave speed (v)	$= \text{frequency(f)} \times \text{wavelength}(\lambda)$	A sound of frequency 10 kHz has a wavelength of 0.033 m. What is the speed of sound?
Potential difference (V)	$= \text{current(I)} \times \text{resistance(R)}$	What is the potential difference across a 5 Ω resistor if 0.2 A of current flows through it?
Current (I)	$= \frac{\text{voltage (V)}}{\text{resistance (R)}}$	What is the current through a 10 Ω resistor across which there is a potential difference of 15 V?
Resistance (R)	$= \frac{\text{voltage (V)}}{\text{current (I)}}$	A wire has a voltage of 12 V with a current of 3 A flowing through. What is the wire's electrical resistance?
Power (P)	$= \text{current}^2 (I^2) \times \text{resistance(R)}$	What is the power of a heating element which has a current of 5 A and an electrical resistance of 40 Ω?
Charge flow (Q)	$= \text{current(I)} \times \text{time(t)}$	How much charge has passed if 5 A flows for 2 minutes?
Energy transferred (E)	$= \text{power (P)} \times \text{time(t)}$	How much energy is transferred by a 1 200 W hairdryer in 5 minutes?

Answers

Physical quantity	Relationship	Simple calculation
Distance (s) travelled	= speed (v) × time (t)	A jogger ran at a constant speed of 3 m/s for half an hour. How many kilometres did the jogger run? Distance (m) = 3 m/s x (30 x 60) s = 5 400 m = 5.4 km
Speed (v) (velocity)	$= \frac{\text{distance (s)}}{\text{time (t)}}$	A car covers a distance of 200 m in 8 seconds. What is its speed? Speed (m/s) = $\frac{200m}{8s}$ = 25 m/s
Acceleration (a)	$= \frac{\text{change in velocity } (\Delta v)}{\text{time (t)}}$	A bus starts from rest and after 10 seconds its velocity is 20 m/s. What is its acceleration? Acceleration (m/s^2) = $\frac{(20-0)\ m/s}{10s}$ = 2 m/s^2
Weight (W)	= mass (m) × gravitational field strength(g)	What is the weight of a mass of 1 tonne (1 000 kg) on Earth (g = 10 N/kg)? Weight (N) = 1 000 kg × 10 N/kg = 10 000 N
Force (F)	= mass (m) × accleration (a)	What size force causes a 5 kg mass to have an acceleration of 4 m/s^2? Force = 5 kg × 4 m/s^2 = 20 N
Force applied to spring (F)	= spring constant (k) × extension (e)	Oscar catches a fish and uses a spring balance to weigh it. The spring extends 6 cm. Oscar knows the spring constant is 200 N/m. How much does his fish weigh? Force = 200 N/m × 0.06 m = 12 N
Moment of a force (M)	= force (F) × distance from turning point (s)	What is the moment of a 6 N force acting 50 cm from its turning point? Moment = 6 N × 0.5 m = 3 Nm
Work done (W)	= force (F) × distance (s)	How much work is done when a 20 N bag of sugar is pushed 50 cm across the counter at a checkout? Work done = 20 N × 0.5 m = 10 N

Pressure (p)	$= \frac{\text{force (F)}}{\text{area (A)}}$	What is the pressure of a 50 N force acting on an area of 0.05 m^2? **Pressure** $= \frac{50\ \text{N}}{0.05\ \text{m}^2}$ **= 1 000 N/m^2**
Density (ρ)	$= \frac{\text{mass (m)}}{\text{volume (V)}}$	What is the density of a 24 carat gold ring which has a mass of 96.5 g and a volume of 5.0 cm^3? **Density** $= \frac{96.5\ \text{g}}{5.0\ cm^3}$ **= 19.3 g/cm^3**
Momentum (p)	$=$ mass (m) $\times$ velocity (v)	A 4 kg rock is rolling down a hill with a velocity of 5 m/s. What is the momentum of the rock? **Momentum = 4 kg × 5 m/s** **= 20 kg m/s**
Kinetic energy (E_k)	$= \frac{1}{2}$ mass (m) $\times$ speed^2(v^2)	A 5 g bullet has a velocity of 100 m/s. What is the kinetic energy of the bullet? **Kinetic energy** $= \frac{1}{2}$ **(0.005) kg × (100 m/s)^2** **= 25 J**
Gravitational potential energy (E_p)	$=$ mass(m) $\times$ gravitational field strength(g) $\times$ height(h)	What is the gravitational potential energy of a 50 kg object which is stationary on a shelf 1.5 m above the ground? (g = 10 N/kg) **E_P = 50 kg × 10 N/kg × 1.5 m** **= 750 J**
Power (P)	$= \frac{\text{work done (w)}}{\text{time taken (t)}}$	A 200 N block is lifted by a crane 20 metres in 5 seconds. What is the power of this crane? **Work done = force x distance** **= 200 N × 20 m = 4 000 J (Nm)** **Power** $= \frac{4\,000\ \text{J}}{5\ \text{s}}$ **= 800 W (J/s)**
Energy transferred (E)	$=$ power (P) $\times$ time (t)	How much energy is transferred by a 0.5 kW machine which runs for half an hour? **Energy = 500 W × (30 x 60) s** **= 900 000 J (Ws)** **= 900 kJ**
Efficiency (E)	$= \frac{\text{useful energy out}}{\text{total energy in}}$	What is the efficiency of a diesel engine if 200 J of chemical energy produces 70 J of mechanical energy? **Efficiency** $= \frac{70\ \text{J}}{200\ \text{J}} \times 100$ **= 35%**

Physical quantity	Relationship	Simple calculation
Wave speed (v)	$= \text{frequency(f)} \times \text{wavelength } (\lambda)$	A sound of frequency 10 Hz has a wavelength of 33 m. What is the speed of sound? **Wave speed = 10 Hz × 33 m** **= 330 m/s**
Potential difference (V)	$= \text{current(I)} \times \text{resistance(R)}$	What is the potential difference across a 5 Ω resistor if 0.2 A of current flows through it? **Potential difference = 0.2 A × 5 Ω** **= 1.0 V**
Current (I)	$= \frac{\text{voltage (V)}}{\text{resistance (R)}}$	What is the current through a 10 Ω resistor across which there is a potential difference of 15 V? **Current =** $\frac{15\text{ V}}{10\ \Omega}$ **= 1.5 A**
Resistance (R)	$= \frac{\text{voltage (V)}}{\text{current (I)}}$	A wire has a voltage of 12 V with a current of 3 A flowing through. What is the wire's electrical resistance? **Resistance =** $\frac{12\text{ V}}{3\text{A}}$ **= 4 Ω**
Power (P)	$= \text{potential difference(V)} \times \text{current(I)}$	What is the power of an electric light bulb connected to 240 V mains, with 0.25 A of current passing through the filament? **Power = 240 V × 0.25 A** **= 60 W**
Power (P)	$= \text{current}^2\ (\text{I}^2) \times \text{resistance(R)}$	What is the power of a heating element which has a current of 5 A and an electrical resistance of 40 Ω? **Power =** $(5\text{A})^2 \times 40\ \Omega$ **= 1 000 W** **= 1 kW**
Charge flow (Q)	$= \text{current(I)} \times \text{time(t)}$	How much charge has passed if 5 A flows for 2 minutes? **Charge flow = 5 A × (2 x 60) s** **= 600 C**
Energy transferred (E)	$= \text{power (P)} \times \text{time (t)}$	How much energy is transferred by a 1 200 W hairdryer in 5 minutes? **Energy = 1 200 W x (5 x 60)** **= 360 000 J** **= 360 kJ**

Teaching notes – suggested activities

- These could be given to students as examples of how each equation is used.
- As an alternative give students the sheets to practice using the equations.
- The sheets could be printed out and cut up for students to match up to complete the equations.
- Read out the questions and ask the class to decide what equation will be needed to work out the answer.