6 This question is about waves in the electromagnetic (e.m.) spectrum.

(a) The potential danger associated with the waves of the e.m. spectrum increases as

(1)

- ☒ **A** frequency decreases
- ☒ **B** frequency increases
- ☒ **C** velocity decreases
- ☒ **D** velocity increases

(b) (i) A microwave oven uses waves of frequency 2.45 GHz.

Calculate the wavelength of the microwaves.

The velocity of light is 3.00×10^8 m/s.

(3)

wavelength = ... m

(ii) The microwave oven is 55% efficient and transfers 42 000 J of energy to some food when it is heated.

Calculate the total amount of energy that must be supplied to the oven.

(3)

energy supplied to oven = ... J

*(c) X-rays and radio waves are part of the electromagnetic spectrum and have different uses.

These radiations are produced in different ways.

X-rays are emitted when electrons within an atom go through energy changes.

Radiowaves are produced by electrons in circuits.

Compare X-rays with radio waves.

Your answer should refer to

- the uses of both types of radiation
- the different ways that electrons are involved in producing X-rays and radio waves.

(6)

(Total for Question 6 = 13 marks)

TOTAL FOR PAPER = 60 MARKS

Answer ALL questions. Write your answers in the spaces provided.

Some questions must be answered with a cross in a box ☒.
If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 (a) Figure 1 shows part of a wave.

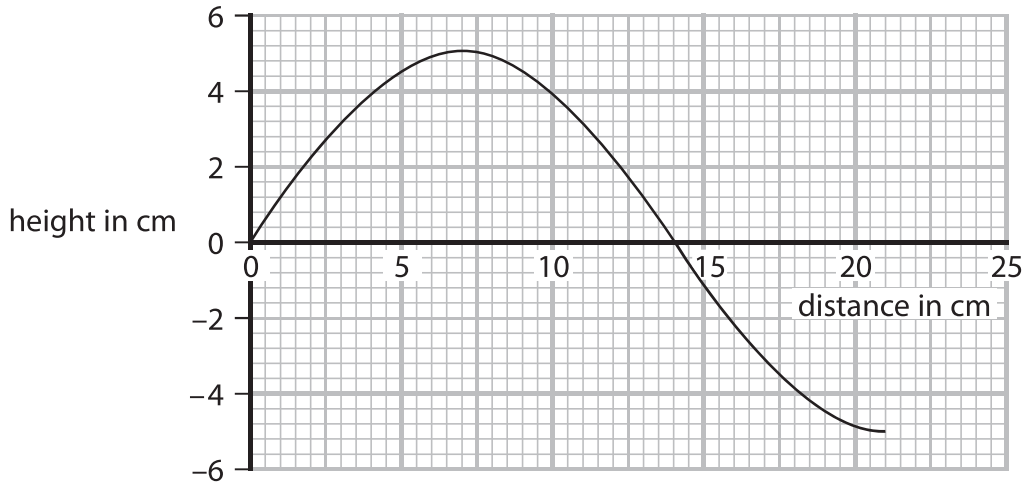


Figure 1

Use data from Figure 1 to calculate the wavelength of the wave.

(2)

wavelength = ... cm

(b) (i) Figure 2 shows a student sitting on the shore of a lake watching ripples on the surface of the water moving past a toy boat.

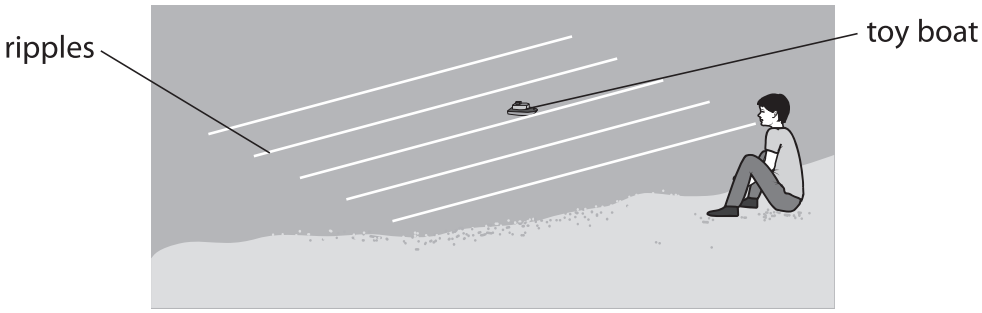


Figure 2

The student has a stopwatch.

Describe how the student could determine the frequency of the ripples on the lake.

(3)

.....

.....

.....

.....

.....

.....

(ii) The speed of a water wave is 1.5 m/s.

The frequency of the wave is 0.70 Hz.

Calculate the wavelength of this wave.

Use the equation

$$v = f \times \lambda$$

(2)

wavelength = ... m

(iii) Water waves are transverse waves.

Describe the difference between transverse waves and longitudinal waves.

(2)

.....

.....

.....

.....

(Total for Question 1 = 9 marks)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

3 A student is investigating the refraction of light.

Figure 4 shows part of the apparatus and the angles to be measured.

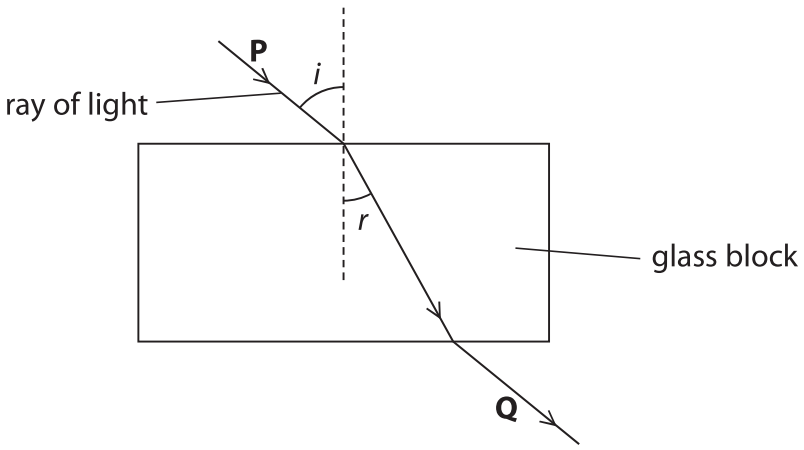


Figure 4

The student measures angle *r* for several different values of angle *i*.

Figure 5 shows the student's results.

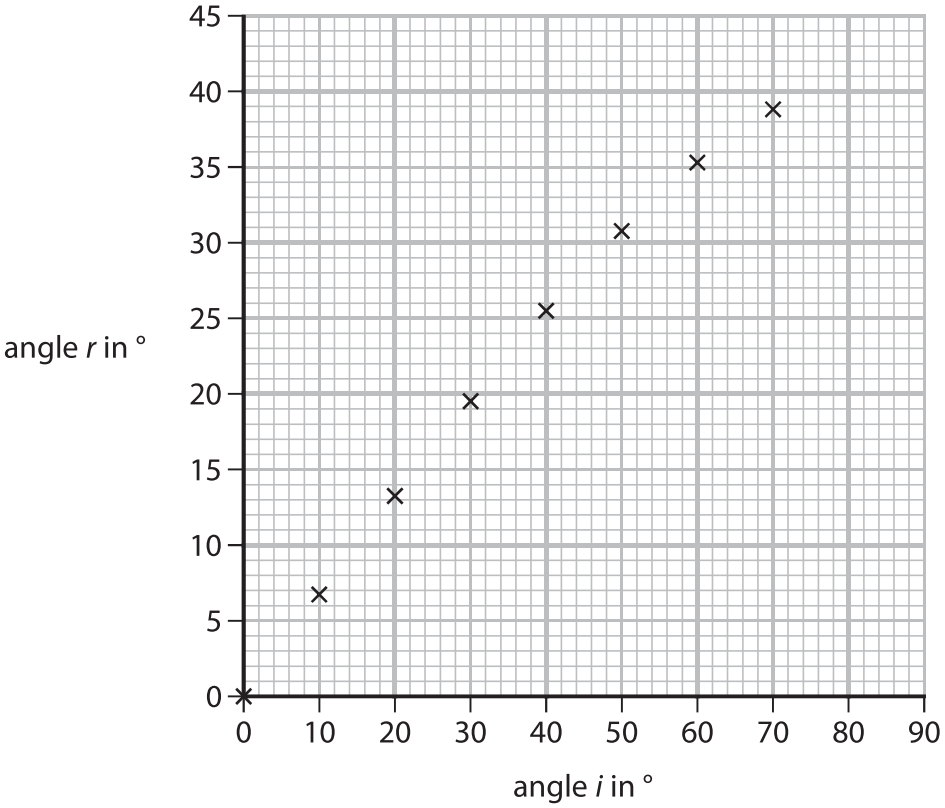


Figure 5

(a) (i) On the graph in Figure 5, draw the best fit curve.

(1)

(ii) Use the graph in Figure 5 to estimate the value of angle *r* when angle *i* is 80°.

(1)

angle *r* = ... °

(iii) Describe how angle *r* changes with angle *i* for the results shown on the graph in Figure 5.

(2)

.....

.....

.....

.....

(b) In Figure 4, the frequency of the light remains the same in glass as in air.

Which row of the table describes what happens to the wave velocity and to the wavelength of the light when the light travels from air to glass?

(1)

	wave velocity	wavelength
☒ **A**	decreases	decreases
☒ **B**	decreases	increases
☒ **C**	increases	decreases
☒ **D**	increases	increases

(c) In Figure 6, only refraction of light is shown.

Other things happen to the light as it travels from **P** to **Q**.

The intensity (brightness) of the light at **Q** is less than the intensity of the light at **P**.

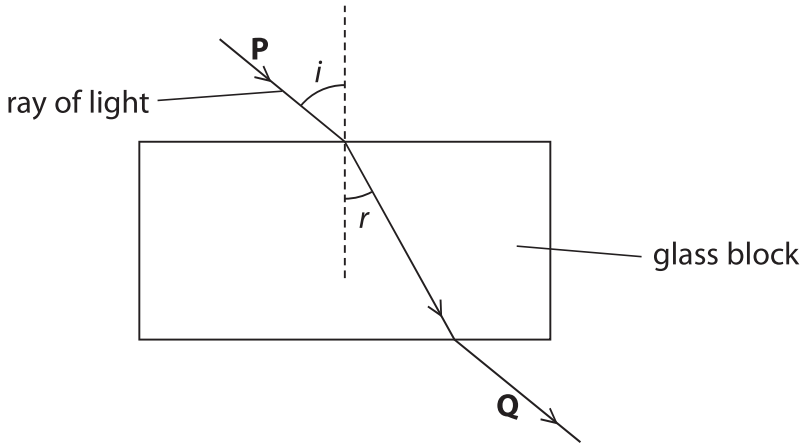


Figure 6

Explain the decrease in intensity as the light travels from **P** to **Q**.

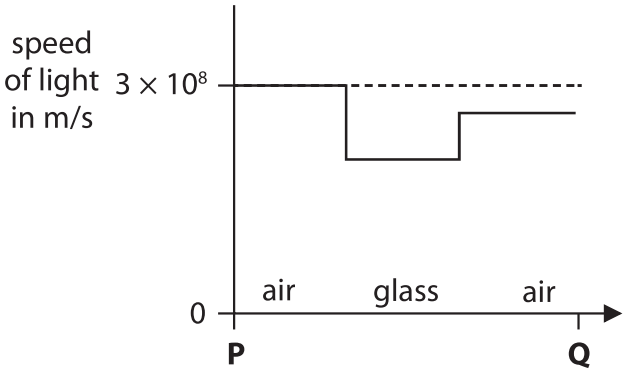
You may add to Figure 6 to help your answer.

(3)

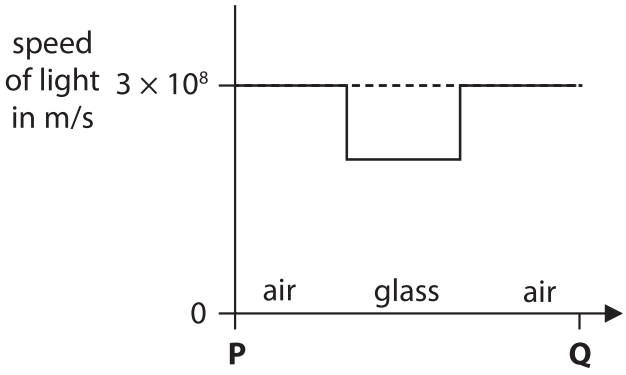
(d) Which of these sketch graphs represents the speed of light as it travels from **P** to **Q**?

(1)

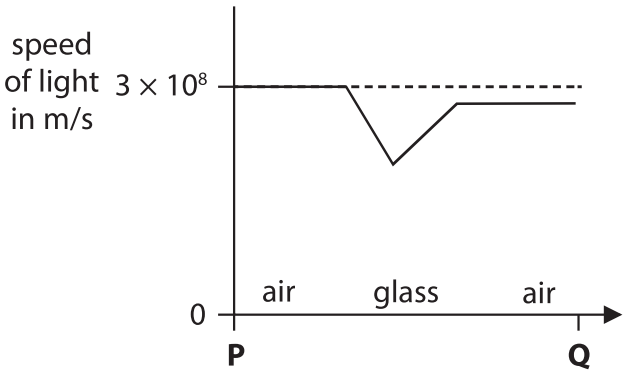
☒ **A**



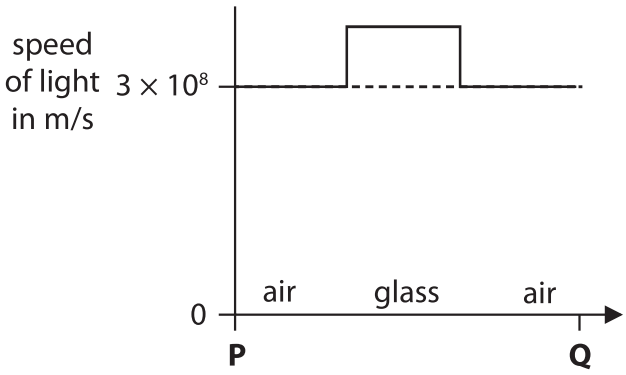
☒ **B**



☒ **C**



☒ **D**



(Total for Question 3 = 9 marks)

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DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

Question Number	Answer	Mark
6a	**B** frequency increases ***A*** *is not correct because the danger does not increase with decreasing frequency* ***C*** *is not correct because all waves in the e-m spectrum have the same velocity* ***D*** *is not correct because all waves in the e-m spectrum have the same velocity*	**(1)** **AO1**

Question Number	Answer	Additional guidance	Mark
6b(i)	selection and substitution (1) $3(.00) \times 10^8 = 2.45 (\times 10^9) \times \lambda$ rearrangement (1) $(\lambda =) \frac{3(.00)\times 10^8}{2.45 (\times 10^9)}$ evaluation (1) 0.12 (m)	allow substitution and rearrangement in either order $2.45 \left(\times 10^9\right) = \frac{3(.00) \times 10^8}{\lambda}$ $\lambda = \frac{v}{f}$ accept 0.122(m) power of ten error gains 2 marks award full marks for the correct answer without working	**(3)** **AO2**

Question Number	Answer	Additional guidance	Mark
6b(ii)	selection and substitution (1) $(0.)55=\frac{42\ 000}{\text{total energy supplied (to device)}}$ rearrangement (1) $(\text{total energy supplied to device}=)\frac{42\ 000}{(0.)55}$ evaluation (1) 76 000(J)	allow substitution and rearrangement in either order $(0.)55=\frac{42\ 000}{x}$ accept any value that rounds to 76 000(J) 760/764/763(J) gains 2 marks any other power of ten error gains 1 mark award full marks for the correct answer without working	**(3)** **AO2**

Question number	Indicative content	Mark
6c	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive, and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. AO1 **Comparison** X–rays: high frequency / short wavelength / ionising / high energy Radio waves: low frequency / long wavelength / not ionising / low energy **X ray are used** • in medical diagnosis, to find broken bones, damage to lungs • radiotherapy • treatment of cancer • airport security • revealing counterfeit art **X-rays are emitted when electrons change energy levels because** • electrons in lower energy levels can absorb energy • the electrons move to higher energy levels • when the electrons return to a lower energy level • the electrons lose energy as radiation. • the electrons need to lose a large amount of energy • (so that) they emit x-ray radiation of high energy/frequency • **Radio waves are used** • broadcasting television • broadcasting radio • communications • satellite transmissions • mobile phones • radar	**(6)** **AO1**

	Radio-waves are emitted when • electrons oscillate in electrical circuits **oscillations are** • current (flow of electrons) that continually change direction • current flows up and down in a (transmitting) aerial • alternating current (AC) • this generates radio waves in the air around the aerial • the frequency of the radio waves corresponds to the oscillation frequency **N.B. No credit is given for:** **Electrons within an atom go through energy changes** **OR** **Radio waves are produced in electrons in circuits** **These phrases are in the stem of the question**	

Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1–2	Demonstrates elements of physics understanding, some of which is inaccurate. Understanding of scientific, enquiry, techniques and procedures lacks detail. (AO1) Presents a description which is not logically ordered and with significant gaps. (AO1)
Level 2	3–4	Demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas, enquiry, techniques and procedures is not fully detailed and/or developed. (AO1) Presents a description of the procedure that has a structure which is mostly clear, coherent and logical with minor steps missing. (AO1)
Level 3	5–6	Demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas, enquiry, techniques and procedures is detailed and fully developed. (AO1) Presents a description that has a well-developed structure which is clear, coherent and logical. (AO1)

Level	Mark	Additional Guidance	General additional guidance – the decisions within levels e.g. – At each level as well as content, the scientific coherency of what is stated will help place the answer at the top or bottom of that level
	0	No rewardable material	
Level 1	1-2	Additional guidance Elements of physics present i.e. isolated knowledge of principles, **two** unconnected statements	Possible candidate response any use of X rays any use of radio waves any comparison electrons are around the nucleus a current is electrons (moving) electrons oscillate
Level 2	3-4	Additional guidance Some knowledge of principles with limited detail on use and a comparison or process	Possible candidate response any use of x-rays and of radio waves with limited detail and one of: a comparison or electrons lose energy to emit X-rays or electrons oscillate in circuits
Level 3	5-6	Additional guidance Detailed knowledge of principles on use with logical connections made about one process	Possible candidate response Use of X-rays and of radio waves with detail and one of: electrons lose energy to change to lower energy level and emit energy as X–rays or electrons oscillate in circuit and currents move up and down in aerials to generate radio waves

Total for Question 6 = 13

*there will be situations where an AO1 question will include elements of recall of knowledge directly from the specification (up to a maximum of 15%). These will be identified by an asterisk in the mark scheme.

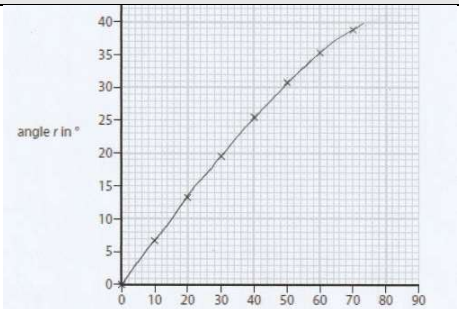
Question number	Answer	Additional guidance	Mark
1(a)	uses data taken from x axis (1) 28(cm) (1)	award full marks for correct answer without working	**(2)** **AO3**

Question number	Answer	Additional guidance	Mark
1 b(i)	a description to include count the number of waves(1) (arriving/passing a point) in a specific time(1) use frequency = number of waves / time (1)	ignore in one second count the number of waves in one second scores 2 marks (MP1 and MP3) find the time between one wave and the next scores 2 marks (MP1 and MP2)	**(3)** **AO1**

Question number	Answer	Additional guidance	Mark
1 b(ii)	substitution (1) $1.5 = 0.7 \times \lambda$ rearrangement and evaluation 2.1(4) m	 $\frac{1.5}{0.7}$ allow $\frac{0.7}{1.5}$ for 1 mark award full marks for correct answer without working. $\lambda = v/f$ scores 1 mark	**(2)** **AO2**

Question number	Answer	Additional guidance	Mark
1 b(iii)	A description to include: mention of oscillations/vibrations (1) EITHER transverse – (oscillations) perpendicular to direction of wave (travel) (1) OR longitudinal - (oscillations) in same direction as wave (travel) (1)	 up and down OR side to side (movements) OR back and forth transverse movement up and down but longitudinal is side to side (1 mark only)	**(2)** **AO1**

Total marks for Question 1H =9

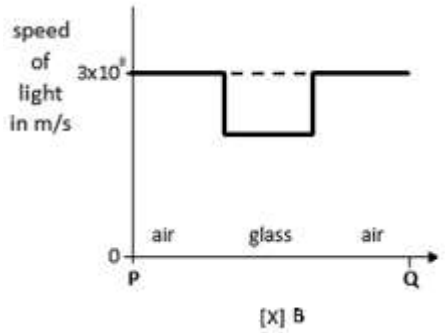
Question number	Answer	Additional guidance	Mark
3 (a)(i)	curve through origin, through all points – by eye (1)	 Figure 6	**(1)** **AO1**

Question number	Answer	Additional guidance	Mark
3 (a)(ii)	(***r*** =) 42(°) ± 2(°) (1)	ECF their graph	**(1)** **AO3**

Question number	Answer	Additional guidance	Mark
3 (a)(iii)	Description to include two from: ***r*** increases as ***i*** increases (1) (but) not in proportion (1) increase in ***r*** becomes less (for same increase in ***i***) (1)	 ***r*** increases as ***i*** increases (but) not in even steps/not straight line/non-linear/gradient changes ***r*** always less than ***i***	**(2)** **AO3**

Question number	Answer	Mark
3 (b)	<table><tr><th></th><th>wave velocity</th><th>wavelength</th></tr><tr><td>[x] **A**</td><td>decreases</td><td>decreases</td></tr></table> B is not correct because the wavelength does not increase C and are not correct because the wave velocity does not increase	**(1)** **AO1**

Question number	Answer	Additional guidance	Mark
3 (c)	Explanation linking **three** from: (some) light is <u>reflected</u> (1) (at) the top edge (1) (some) light is <u>absorbed</u> (1) by the glass (1)	 in the air in the (glass) block credit responses in terms of attenuation/ dispersion/reflection at the second face/spreading out	**(3)** **AO2**

Question number	Answer	Mark
3 (d)	 [X] B **B** is the correct answer A is not correct because the velocity in air is the same before and after the glass C is not correct because the velocity is constant inside the glass D is no correct because the velocity in glass is not greater than the velocity in air	**(1)** **AO3**

Total for Question 3H = 9 marks)

If you're taking **GCSE (9–1) Combined Science** or **GCSE (9–1) Physics**, you will need these equations:

HT = higher tier

	distance travelled = average speed × time	
	acceleration = change in velocity ÷ time taken	$a = \frac{(v-u)}{t}$
	force = mass × acceleration	$F = m \times a$
	weight = mass × gravitational field strength	$W = m \times g$
HT	**momentum = mass × velocity**	$\boldsymbol{p = m \times v}$
	change in gravitational potential energy = mass × gravitational field strength × change in vertical height	$\Delta GPE = m \times g \times \Delta h$
	kinetic energy = 1/2 × mass × (speed)^2	$KE = \frac{1}{2} \times m \times v^2$
	efficiency = $\frac{(\text{useful energy transferred by the device})}{(\text{total energy supplied to the device})}$	
	wave speed = frequency × wavelength	$v = f \times \lambda$
	wave speed = distance ÷ time	$v = \frac{x}{t}$
	work done = force × distance moved in the direction of the force	$E = F \times d$
	power = work done ÷ time taken	$P = \frac{E}{t}$
	energy transferred = charge moved × potential difference	$E = Q \times V$
	charge = current × time	$Q = I \times t$
	potential difference = current × resistance	$V = I \times R$
	power = energy transferred ÷ time taken	$P = \frac{E}{t}$
	electrical power = current × potential difference	$P = I \times V$
	electrical power = (current)^2 × resistance	$P = I^2 \times R$
	density = mass ÷ volume	$\rho = \frac{m}{V}$

	force exerted on a spring = spring constant × extension	$F = k \times x$
	(final velocity)^2 – (initial velocity)^2 = 2 × acceleration × distance	$v^2 - u^2 = 2 \times a \times x$
HT	**force = change in momentum ÷ time**	$\boldsymbol{F = \frac{(mv - mu)}{t}}$
	energy transferred = current × potential difference × time	$E = I \times V \times t$
HT	**force on a conductor at right angles to a magnetic field carrying a current = magnetic flux density × current × length**	$\boldsymbol{F = B \times I \times l}$
	For transformers with 100% efficiency, potential difference across primary coil × current in primary coil = potential difference across secondary coil × current in secondary coil	$V_P \times I_P = V_S \times I_S$
	change in thermal energy = mass × specific heat capacity × change in temperature	$\Delta Q = m \times c \times \Delta\theta$
	thermal energy for a change of state = mass × specific latent heat	$Q = m \times L$
	energy transferred in stretching = 0.5 × spring constant × (extension)^2	$E = \frac{1}{2} \times k \times x^2$

If you're taking **GCSE (9–1) Physics**, you also need these extra equations:

	moment of a force = force × distance normal to the direction of the force	
	pressure = force normal to surface ÷ area of surface	$P = \frac{F}{A}$
HT	$\frac{\textbf{potential difference across primary coil}}{\textbf{potential difference across secondary coil}} = \frac{\textbf{number of turns in primary coil}}{\textbf{number of turns in secondary coil}}$	$\frac{V_p}{V_S} = \frac{N_p}{N_S}$
	to calculate pressure or volume for gases of fixed mass at constant temperature	$P_1 \times V_1 = P_2 \times V_2$
HT	**pressure due to a column of liquid = height of column × density of liquid × gravitational field strength**	$\boldsymbol{P = h \times \rho \times g}$

END OF EQUATION LIST