Question number	Answer	Mark
1(a)	D	(1)

Question number	Answer	Mark
1(b)	C	(1)

Question number	Answer	Additional guidance	Mark
1(c)(i)	An explanation that combines identification – application of knowledge (1 mark) and reasoning/justification – application of understanding (1 mark): • frictional forces increase as more trucks are added (1) Plus **one** from: • hence, in order to keep constant speed, the student must increase the force she applies to **Z** (1) • when **Y** and **Z** separate, the frictional forces (to the left) are more than magnetic attraction between **Y** and **Z** (1)		**(2)**

Question number	Answer	Mark
1(c)(ii)	An answer that combines the following points to provide a plan: • use of a Newton meter used horizontally (1) • record largest force observed (1) • repeat readings several times under same conditions (1)	(3)

Question number	Answer	Mark
1(c)(iii)	An explanation that combines identification – understanding (1 mark) and reasoning/justification – understanding (1 mark): • the applied force must be resolved horizontally to determine the force that separates the engine from the trucks • and since the (size of) the resolved force is always less than the (size of) the actual force then a larger force (applied at an angle) is needed to separate the trucks from the engine	(2)

Question number	An		Mark
2(a)	substitution into correctly rearranged equation (1) $I = \frac{F}{B} \times l$ $= \frac{0.089}{0.47} \times 0.713$ evaluation to 2 s.f. (1) current = 0.27 (A)	give full marks for correct numerical answer without working	**(2)**

Question number	Answer	Additional guidance	Mark
2(b)	Any three from: • use a higher current as the force depends on the current (1) • use more/stronger/larger range of magnets (1) • use a force meter with smaller range, e.g. 0.00 to 0.01 (1) • use a longer distance from pivot to increase the moment of the force on the wire (1)	accept voltage for current add variable resistor (in series) with power supply accept use more sensitive force meter	**(3)**

Question number	Answer	Mark
2(c)	An explanation that combines identification – understanding (1 mark) and reasoning/justification – understanding (1 mark): • if the voltage changes sign, then the current is changing direction • so in Figure 21 the current is a.c. as the voltage is changing sign and in Figure 22 the current is d.c. as the voltage is always positive	**(2)**

Question number	Answer	Additional guidance	Mark
2(d)	An explanation that combines identification – understanding (1 mark) and reasoning/justification – understanding (3 marks): • the transmission wire carries an alternating current (1) • the force is caused by this current which varies in size and direction (1) • the direction of this force depends on the direction of the current so the direction of the force also changes (1) • the magnitude of this force depends on the magnitude of the current so the magnitude of the force also changes (1)	allow responses that link the changes in the force to the interaction of the changing field around the wire with the constant field of the Earth	**(4)**

Question Number	Answer	Acceptable answers	Mark
3(a)(i)	Substitution (1) 2900 = 230 × current Transposition (1) $\frac{2900}{230}$ Evaluation (1) 13 (A)	Award full marks for correct answer with no working Allow substitution and transposition in either order Ignore powers of ten errors until evaluation Allow numbers which round up to 13	**(3)**

Question Number	Answer	Acceptable answers	Mark
3(a)(ii)	Substitution (1) 97 = 2.9 × time × 17 Transposition (1) $\frac{97}{2.9 \times 17}$ OR $\frac{97}{49.3}$ Evaluation (1) 2.0 (h)	Award full marks for correct answer with no working Allow substitution and transposition in either order Ignore powers of ten errors until evaluation Allow $\frac{97}{17}$ = 5.7 for 1 mark Allow numbers which round up to 2.0	**(3)**

Question Number		Indicative Content	Mark
QWC	***3(b)**	An explanation including some of the following points • a current/voltage/emf is induced when there is relative movement between a magnet and a coil of wire • the current is bigger when the movement is faster • the current is alternating/regularly changing direction • the current is zero when the magnet is not moving • points P and R on the graph correspond to the fastest movement of the magnet • the magnet is changing direction at points O, Q, S on the graph (quoting positive and negative current values from graph is sufficient to indicate a change in direction of current on graph) • the magnet is at the top/bottom of its movement at points O, Q, S on the graph • the magnet is not moving at points O, Q, S on the graph IGNORE references to number of turns or stronger magnet	**(6)**

Level	0	No rewardable content
1	1 - 2	• a limited explanation linking induced current to idea of movement of magnet OR limited reference linking graph to type of current with no link to model e.g. magnet moving in coil (induces a current) / (magnetic) field lines cut coil OR (the graph shows) an alternating current • spelling, punctuation and grammar are used with limited accuracy • the answer communicates ideas using simple language and uses limited scientific terminology
2	3 - 4	• a simple explanation linking the motion of the magnet to the size/direction of the induced current OR {a limited explanation linking induced current to idea of movement of magnet AND limited reference linking graph to type of current with no link to model} e.g. Magnet moving in the coil induces a current. The faster it moves the bigger the induced current. OR Magnet moving in the coil induces a current. When the magnet changes direction, the current changes direction. OR Magnet moving in the coil induces a current. The graphs shows an alternating current. OR Magnet moving in the coil induces a current. The current is positive at P and negative at R. • the answer communicates ideas showing some evidence of clarity and organisation and uses scientific terminology appropriately
3	5 - 6	• a detailed explanation linking the motion of the magnet to the size/direction of the induced current AND reference to graph for one factor e.g. Magnet moving in the coil induces a current. The faster it moves the bigger the induced current. The magnet is moving fastest at point P on the graph. OR Magnet moving in the coil induces a current. When the magnet changes direction the current changes direction. At P and R the magnet is moving in opposite directions. OR Magnet moving in the coil induces a current. The current is positive at P and negative at R. The magnet is moving up at P and down at R. • the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately • spelling, punctuation and grammar are used with few errors

Total for Question 6 = 12 marks

Question Number	Answer	Acceptable answers	Mark
4(a)(i)	D		**(1)**

Question Number	Answer	Acceptable answers	Mark
4(a)(ii)	ampere(s), amp(s), A		**(1)**

Question Number	Answer	Acceptable answers	Mark
4(b)(i)	A description linking magnet (1) (in/near) coil (1) (magnet/coil) spins/moves/turns (1)	 IGNORE handle turns	 **(3)**

Question Number	Answer	Acceptable answers	Mark
4(b)(ii)	Any one from the following: Increase strength of magnet (1) Increase number of coils/turns of wire (1) Increase speed of rotation (1)	 add another magnet / move magnets closer turn handle/magnet/coil faster IGNORE bigger magnet/coil/ generator / longer wire	**(1)**

Question Number		Indicative Content	Mark
QWC	*)	A comparison including some of the following points Non- renewable sources • coal, oil, gas and nuclear • coal, oil, gas are fossil fuels • fossil fuels will run out • fossil fuels burn and produce CO_2 • fossil fuels burn to produce atmospheric pollution • CO_2 contributes to global warming • are a more expensive source • Nuclear power stations do not produce CO_2 • Nuclear power produces radioactive waste • Radioactive waste is dangerous and difficult to store safely Renewable resources • Wind, waves, solar, biofuels, geothermal and hydroelectric • are a free/cheaper source • The energy source is unreliable • No (net) CO_2 produced • No atmospheric pollution (except biofuels) • Waves and hydroelectric cause environmental changes • Wind farms and solar panels give visual pollution • Wind farms can be built off shore Comparison • Fossil fuel power stations are cheaper to build than wind farms for the same power output • Coal, oil, gas and nuclear fuel will run out, wind, waves and sun will always be available • Fossil fuel power stations produce CO_2 which may increase global warming, renewable energy generators (wind farms) do not • Renewable energy generators have a free/cheaper source of fuel • fossil fuels have to be taken out of the ground • Nuclear power stations produce radioactive waste, which is dangerous, none of the other energy generators do this. • Wind, waves and sun are unreliable sources of energy but fossil and nuclear fuels are always available	**(6)**

Level	0	No rewardable content
1	1 - 2	• a limited statement about either renewable or non-renewable e.g. Coal is non-renewable **OR** renewable energy will not run out **OR** oil will run out • the answer communicates ideas using simple language and uses limited scientific terminology. • spelling, punctuation and grammar are used with limited accuracy.
2	3 - 4	• a simple comparison including 2 statements covering renewable and non-renewable e.g. Coal is non-renewable and solar power is renewable **OR** renewable energy sources will not run out and non-renewable sources do not pollute the atmosphere **OR** oil will run out, solar will not • the answer communicates ideas showing some evidence of clarity and organisation and uses scientific terminology appropriately. • spelling, punctuation and grammar are used with some accuracy.
3	5 -6	• a detailed comparison including at least 3 statements with a direct comparison between a renewable and a non-renewable source, at least one named e.g. Renewables will not run out but non-renewables like coal will. **OR** Coal is non-renewable. When it is burnt carbon dioxide is produced. Wind farms do not produce any carbon dioxide. **OR** Carbon dioxide is produced when coal is used. Wind farms do not produce any carbon dioxide. Wind farms are noisy. **OR** Oil will run out, solar will not. Oil causes air pollution • the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately. • spelling, punctuation and grammar are used with few errors.