

PHYSICS



EXAM QUESTION PACK

TOPIC 4: WAVES (PACK 2)

SCORE

/68

PERCENTAGE

%

STEMUP

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Q1.

Figure 4 is a simplified diagram to show radio waves from a transmitter moving upwards, then meeting a boundary between lower and upper layers of the atmosphere.

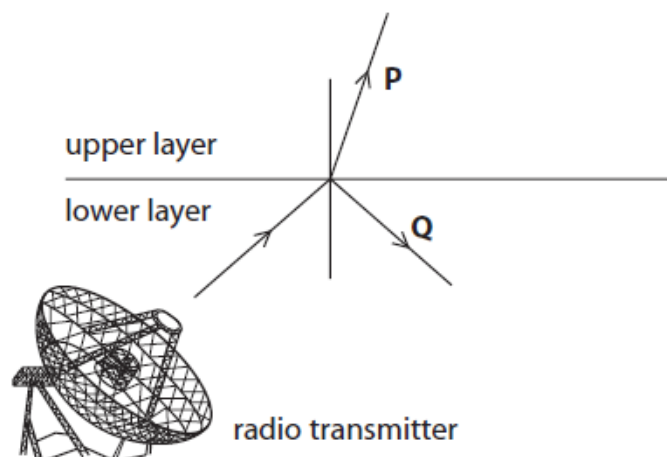


Figure 4

Explain what happens to the radio waves after they meet the boundary between the lower and upper layers as shown in Figure 4.

Your explanation should refer to changes in direction and speed of the waves.

(4)

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(Total for question = 4 marks)

Q2.

The speed of light is 3.0×10^8 m/s.

The wavelength of yellow light is 5.8×10^{-7} m.

Calculate the frequency of yellow light.

State the unit.

Use the equation

$$\text{frequency} = \frac{\text{speed}}{\text{wavelength}}$$

(3)

frequency = ... unit

(Total for question = 3 marks)

Q3.

Answer the question with a cross in the box you think is correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

(i) In a controlled chain reaction of uranium-235, which of these could cause a uranium-235 nucleus to undergo fission?

(1)

☐ **A** an alpha particle

☐ **B** a beta particle

☐ **C** a neutron

☐ **D** a proton

(ii) The kinetic energy of one of the particles released in a fission reaction is 1.2×10^{-11} J.

The mass of the particle is 1.4×10^{-25} kg.

Calculate the velocity of the particle.

(3)

velocity of the particle = ... m/s

(Total for question = 4 marks)

Q4.

Electricity can be generated using a water turbine.

(i) Water gains kinetic energy by falling from the top of a dam.

Calculate the minimum height that 7.0 kg of water must fall to gain 1300 J of kinetic energy.

(3)

minimum height = ... m

(ii) As water enters the turbine at the bottom of the dam, the kinetic energy of 8.0 kg of moving water is 1100 J.

Calculate the speed of the moving water as it enters the turbine.

(3)

speed = ... m/s

(Total for question = 6 marks)

Q5.

Moving air can be used to generate electricity using a wind turbine.

Figure 8 is a graph of kinetic energy against wind speed for a mass of moving air.

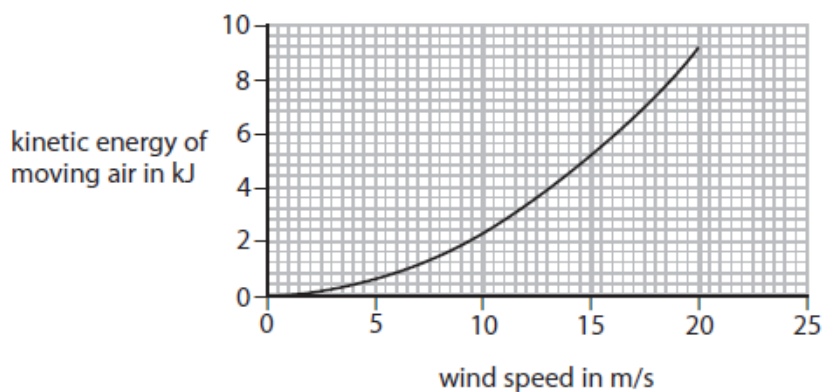


Figure 8

Just before the air reaches a wind turbine it has a wind speed of 15 m/s.

When the air has gone through the turbine it has a wind speed of 13 m/s.

As the air moves through the turbine some of its kinetic energy is transferred to the turbine.

Use the graph to determine the percentage of the kinetic energy transferred to the turbine from the air.

(3)

percentage of kinetic energy transferred from the air = ... %

(Total for question = 3 marks)

Q6.

Figure 13 shows wind turbines, used to generate electricity for the National Grid.



(Source: © MarcelClemens/Shutterstock)

Figure 13

The wind turns the turbine blades.

The wind is a renewable source of energy.

(i) State **two** other renewable sources of energy.

(2)

1

2

(ii) For one turbine

- the energy input per second from the wind is 6.2 kJ
- the energy output per second to the National Grid is 2.2 kJ.

Calculate the efficiency of this turbine.

(2)

efficiency = ...

(iii) Suggest a reason why it is impossible for the turbine to use all the kinetic energy of the wind.

(1)

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.....
.....

(Total for question = 5 marks)

Q7.

Which of these is a non-renewable source of energy?

(1)

- ☐ **A** geothermal
- ☐ **B** natural gas
- ☐ **C** tidal
- ☐ **D** solar

(Total for question = 1 mark)

Q8.

Explain why renewable sources provide an increasing fraction of the electricity supply for many countries.

(2)

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.....

(Total for question = 2 marks)

Q9.

When white light crosses the boundary between air and glass, it can split up into the colours of the spectrum.

Explain, in terms of speed, why the light behaves like this.

(3)

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(Total for question = 3 marks)

Q10.

A student lifts a toy car from a bench and places the toy car at the top of a slope as shown in Figure 2.

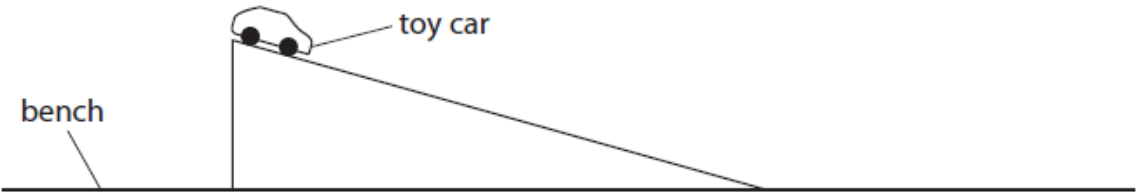


Figure 2

When the toy car rolls down the slope, some energy is transferred to the surroundings as thermal energy.

State how the student could calculate the amount of energy transferred to the surroundings.

(1)

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.....

Q11.

Figure 5 shows a way of projecting a small trolley up a sloping track.

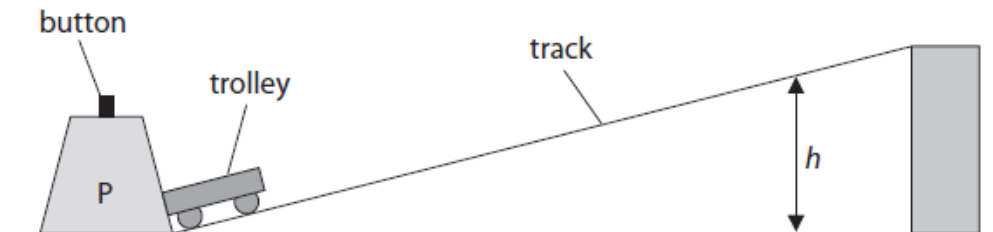


Figure 5

When the button is pressed, a spring is released in P that projects the trolley up the track.

The trolley travels up the track, stops and then rolls back down.

The spring in P always exerts the same force when projecting the trolley.

A student investigates how the mass of the trolley affects the maximum vertical height, h , reached by the trolley.

State the measurements the student should make to complete the investigation.

You should make use of the equipment shown in Figure 5 and any other equipment that is needed.

(4)

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Q12.

A student lifts a toy car from a bench and places the toy car at the top of a slope as shown in Figure 2.

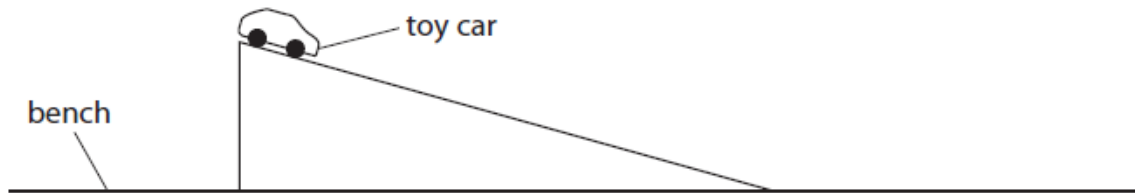


Figure 2

The student needs to develop the experiment to determine the loss in potential energy and the gain in kinetic energy as the toy car is rolling down the slope.

State the other measurements the student must make.

(2)

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.....

.....

(Total for question = 2 marks)

Q13.

State **three** differences between radio waves and sound waves.

(3)

1

.....

- 2
- 3

(Total for question = 3 marks)

Q14.

Before a car brakes it has kinetic energy.
The kinetic energy decreases as it brakes.

State what happens to the kinetic energy during braking.

(1)

(Total for question = 1 mark)

Q15.

Figure 7 shows a submarine being propelled forward underwater.

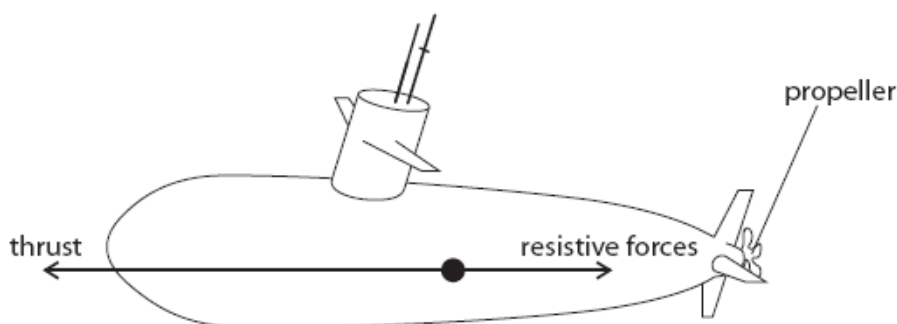


Figure 7

The thrust and the resistive forces are represented in magnitude and direction by the arrows in Figure 7.

Suggest **two** advantages of using nuclear-powered submarines compared to diesel-powered submarines.

(2)

1

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2

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(Total for question = 2 marks)

Q16.

Figure 5 shows how a glass prism is used to produce a spectrum from a beam of sunlight.

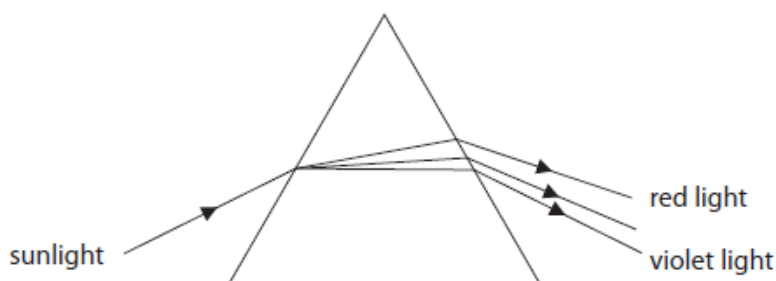


Figure 5

(i) Explain, in terms of refraction and wavelength, the paths taken by the light through the prism.

(3)

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(ii) Describe how a student could develop the procedure shown in Figure 5 to search for

evidence that sunlight consists of additional electromagnetic waves with frequencies lower than visible light.

(2)

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(Total for question = 5 marks)

Q17.

Figure 6 is a graph of the student's results.

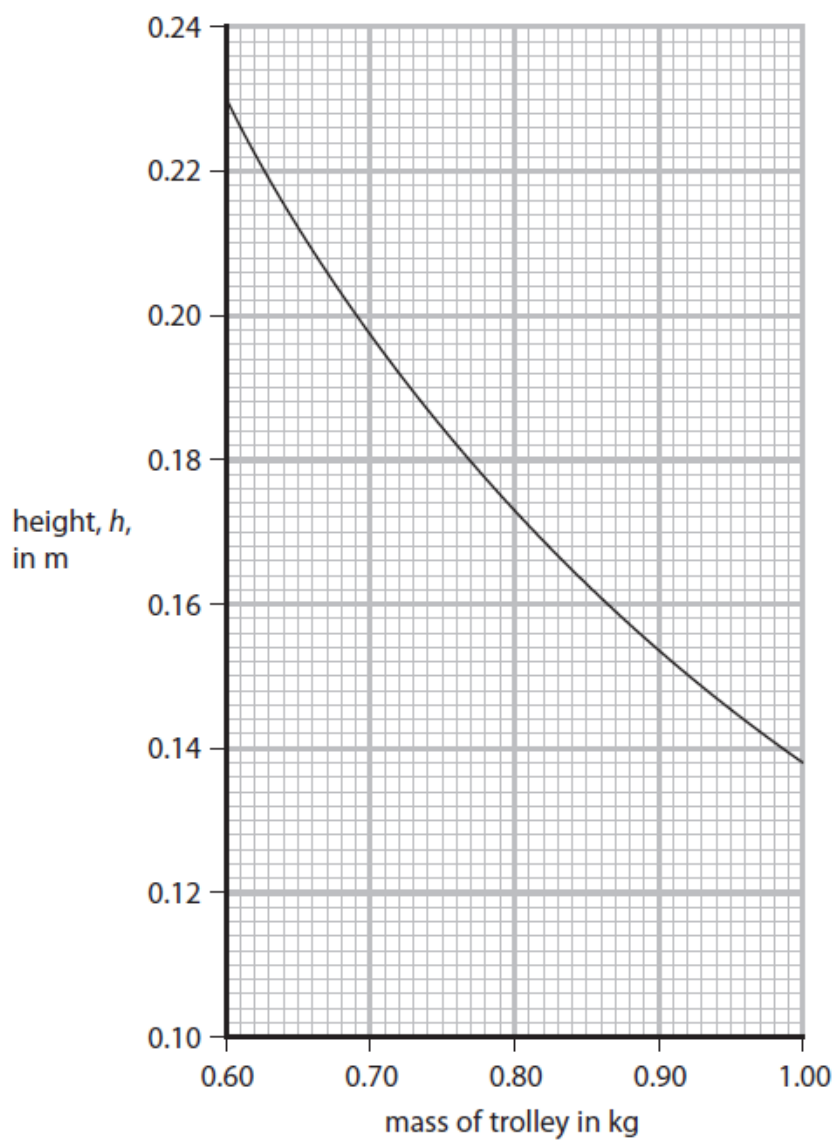


Figure 6

The student states that the energy transferred by the spring is the same each time it is used.

Use data from any two points on the graph in Figure 6 to support this statement.

(3)

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(Total for question = 3 marks)

Q18.

Sound travels slower in cold air than it does in warm air.

The equation relating the speed of sound in air to the density of the air is

$$\text{speed of sound} = \frac{K}{\sqrt{(\text{density})}} \quad \text{where K is a constant.}$$

The table in Figure 7 gives some data about the speed of sound in air and the density of air.

	speed of sound in m/s	density of air in kg / m ³
in cold air	331	1.29
in warm air		1.16

Figure 7

Use the equation and the data in the table in Figure 7 to calculate the speed of sound in warm air.

Give your answer to an appropriate number of significant figures.

(3)

speed of sound in warm air = ... m/s

(Total for question = 3 marks)

Q19.

Figure 1 is a diagram of a water wave.

A cork is floating on the water.

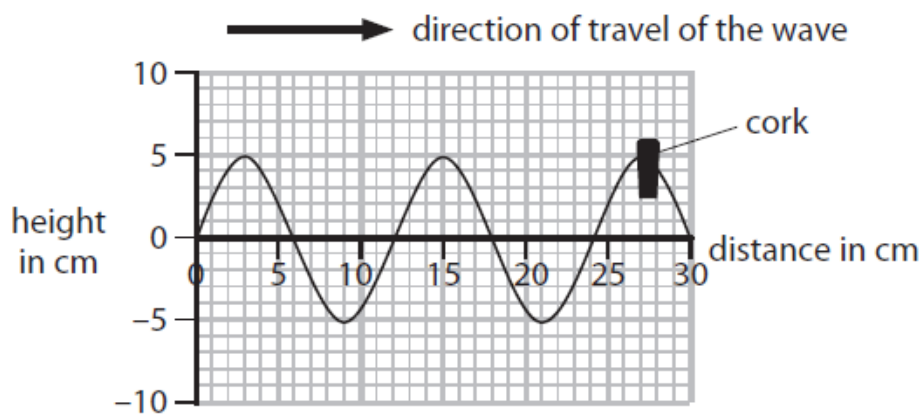


Figure 1

(i) Use the scale on the diagram to measure the wavelength of the wave.

(2)

wavelength = ... cm

(ii) Describe the motion of the cork.

You should include how the cork moves relative to the direction of travel of the wave.

(2)

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(Total for question = 4 marks)

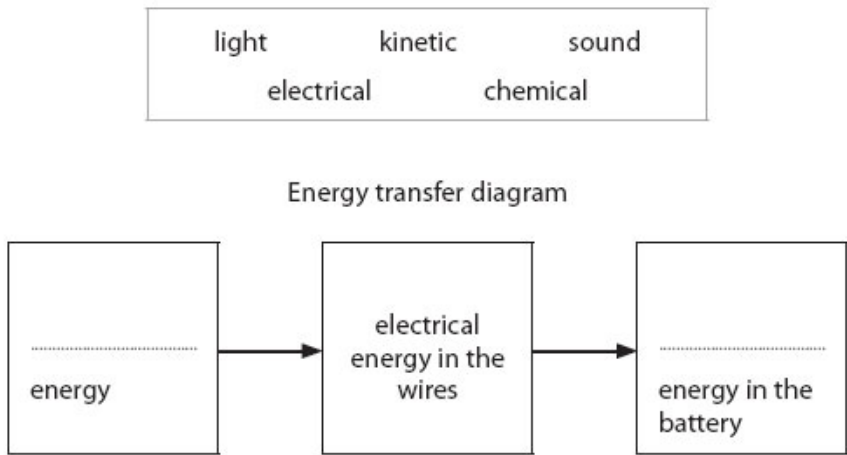
Q20.

A student uses a solar powered battery charger to charge some batteries.

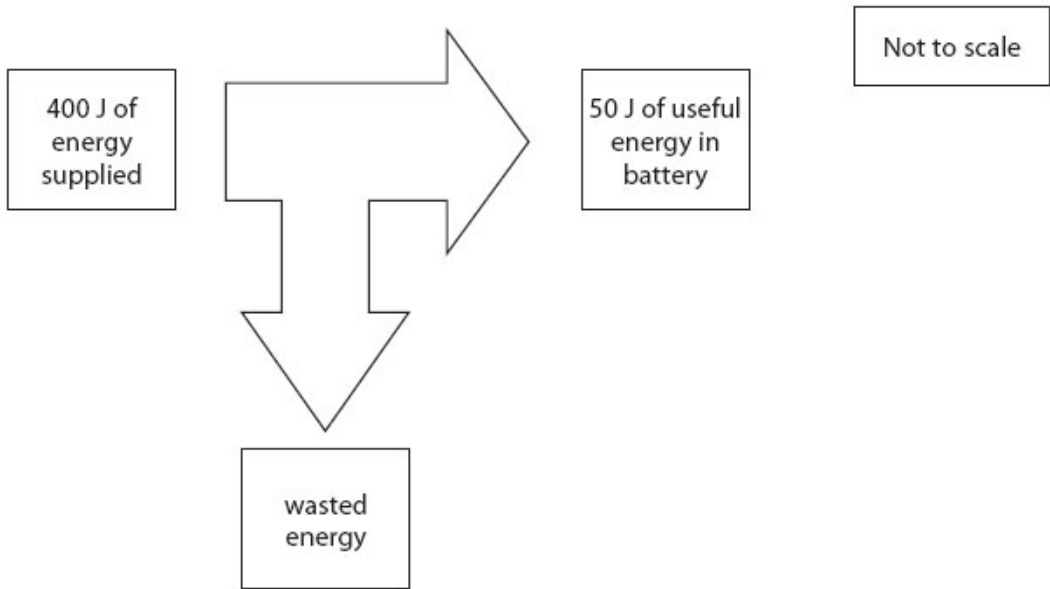


(a) The diagram is an energy transfer diagram for a battery being charged.

Use words from the box to complete the energy transfer diagram.



(b) The diagram shows how much energy is usefully transferred by the battery charger.



(i) Calculate the amount of wasted energy.

(1)

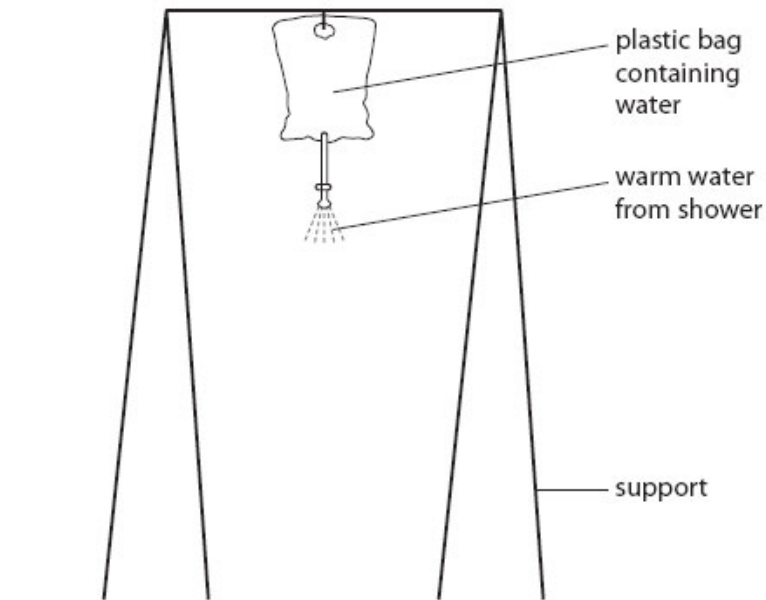
wasted energy = ...J

(ii) Calculate the efficiency of the battery charger.

(2)

efficiency of the battery charger = ...%

(c) The following arrangement is used as a solar powered shower.



The bag is left out in the sunlight during the day.

(i) Explain what colour the bag should be to heat the water to the highest temperature.

(2)

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(ii) On a sunny day the bag is filled with cold water.

Explain why the temperature of the water increases and then stays constant.

(3)

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(Total for Question = 10 marks)

Q21.

Figure 7 shows a tuning fork.

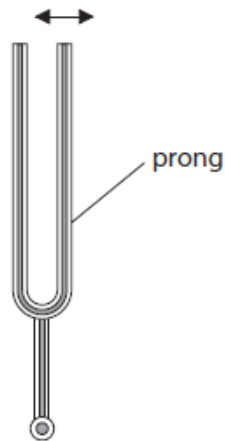


Figure 7

When the prongs of the tuning fork are struck, the prongs vibrate in the directions shown by the arrows on Figure 7.

Describe how the vibrating tuning fork causes a sound wave to travel through the air.

You may add to the diagram if it helps your answer.

(2)

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(Total for question = 2 marks)

Q22.

(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.

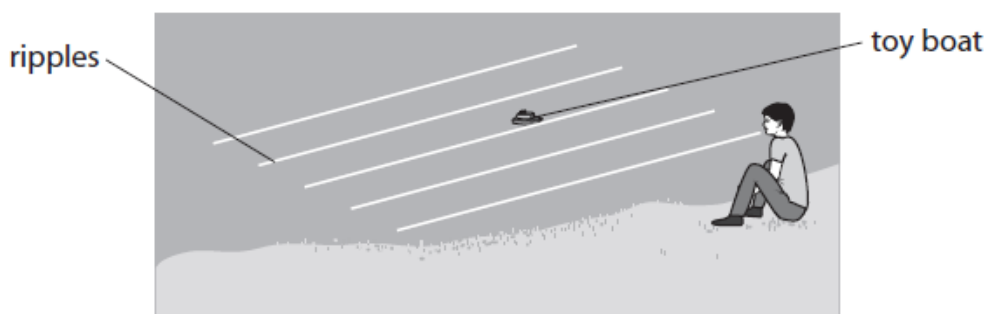


Figure 2

The student has a stopwatch.

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

(3)

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(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)

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(Total for question = 7 marks)

Q23.

* Explain the differences between longitudinal and transverse waves.
Your explanation should refer to ultraviolet, ultrasound and seismic waves.

(6)

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Q24.

A light wave from a star has a frequency of 6.67×10^{14} Hz and a wavelength of 4.50×10^{-7} m.

The star is 4.00×10^{16} m away from Earth.

Calculate the time it takes light from the star to reach the Earth.

(3)

time to reach Earth = ... s

Mark Scheme

Q1.

Question number	Answer	Additional guidance	Mark
	explanation linking: wave P refracts (towards the normal) (1) because P slows down (1) AND wave Q is reflected (at an equal angle from the boundary) (1) without change of speed of Q (1)	accept 'upper layer' for 'P' accept 'wavelength decreases' accept 'bends' for 'refracts' in this instance accept 'lower layer' for 'Q' accept 'wavelength unchanged' accept 'wave Q bounces off' (at an equal angle) allow one mark for refraction and reflection if no other mark awarded	(4)

Q2.

Question Number	Answer	Additional guidance	Mark
	substitution (1) $\frac{3.0 (\times 10^8)}{5.8 (\times 10^{-7})}$ evaluation (1) 5.2×10^{14} unit (1) Hz	 answers that round to 5.2×10^{14} award 2 marks for a correct answer without working allow 1 mark for answers that round to 5.2 to any power of ten independent mark accept hz or s^{-1} or per sec(ond) or hertz accept kHz, MHz etc with correct power (10^{11} kHz, 10^8 MHz)	(3) AO 2 1

Q3.

Question Number:	Answer	Mark
(i)	☐ C a neutron The only correct answer is C (neutron causes U-235 fission) A is not correct – incorrect particle B is not correct – incorrect particle D is not correct – incorrect particle	(1)

Question Number	Answer	Additional guidance	Mark
(ii)	recall and substitution (1) $1.2 \times 10^{-11} = \frac{1}{2} \times 1.4 \times 10^{-25} \times v^2$ rearrangement (1) $v^2 = \frac{2 \times 1.2 \times 10^{-11}}{1.4 \times 10^{-25}}$ evaluation (1) (v=) 1.3×10^7 (m/s)	accept rearrangement and substitution in either order ignore POT until evaluation $v^2 = 1.71 \times 10^{14}$ allow numbers that round to 1.3×10^7 (m/s) 1.3 to any other power of ten scores 2 marks award full marks for the correct answer without working	(3)

Q4.

Question Number	Answer	Additional Guidance	Mark
(i)	recall (1) $(\Delta PE) = mgh$ substitution and rearrangement (1) $h = \frac{1300}{7 \times 10}$ evaluation (1) 19 (m)	$1300 = 7 \times 10 \times h$ work done = force x distance accept answers that round up to 19 (m) (e.g. 18.57 (m)) award full marks for the correct answer with no working	(3) AO 1 1 AO 2 1

Question Number	Answer	Additional guidance	Mark
(ii)	recall (1) $KE = \frac{1}{2} m v^2$ substitution and rearrangement (1) $v = \sqrt{2 \times 1100 \div 8}$ evaluation (1) 17 (m/s)	$v^2 = \frac{2 \times 1100}{8}$ accept answers that round up to 17 (m/s) (e.g. 16.58 (m/s)) award full marks for the correct answer with no working	(3) AO 1 1 AO 2 1

Q5.

Question Number	Answer	Additional guidance	Mark
	reading energies from graph (1) 5.2 and 3.9 (kJ) substitution (1) e.g. $\frac{1.3 \times (100)}{5.2}$ evaluation (1) 25(%)	accept 5.0 to 5.4 and 3.7 to 4.1 0.18 to 0.32 18 to 32 (%) award full marks for the correct answer with no working	(3) AO 2 1

Q6.

	Answer	Additional guidance	Mark
i	Two from: falling water/hydro (1) tides (1) sun/solar (1) geothermal (1) biomass (1)		(2) AO1

	Answer	Additional guidance	Mark
(ii)	recall and substitution (1) (%) efficiency = $\frac{2.2 \times 100}{6.2}$ evaluation (1) 0.35 (1)	allow numbers that round to 0.35 e.g. 0.3548 accept 35(%) for full marks award full marks for correct answer without working.	(2) AO2

	Answer	Additional guidance	Mark
(iii)	One from: air (has to be) moving on the other side of the blades (1) not all of the air hits the blade (1) friction within the turbine/generator (1) some energy (always) transferred to thermal (1) it is fitted with a speed limiter (1)		(1) AO3

Q7.

Question Number	Answer	Mark
	B natural gas is the only correct answer <i>A geothermal is not a non-renewable source of energy</i> <i>C tidal is not a non-renewable source of energy</i> <i>D solar is not a non-renewable source of energy</i>	(1) AO 1 1

Q8.

Question Number	Answer	Additional guidance	Mark
	an explanation linking: increased use of renewables/decrease use of nonrenewables (1) reason (1)	accept "them" as renewable accept reason why renewables are beneficial accept reason why non-renewable(s) are not beneficial	(2) AO 1 1

Q9.

Question Number	Answer	Additional guidance	Mark
	an explanation linking: (the colours have) different wavelengths (1) different wavelengths / colours travel at different speeds (1) so refract by different amounts (1)	allow the word frequencies for wavelengths for refract allow bend/change direction/follow different path	(3) AO 2 1

Q10.

Question number	Answer	Additional guidance	Mark
	(original) GPE – KE (at bottom) (1)	allow (idea of) input – output allow wrong way round (eg output-input)	(1)

Q11.

Question Number	Answer	Additional guidance	Mark
	An answer that includes: (measure) mass of the trolley (1) (measure) (vertical) height / h (1) repeat for a range of masses (1) plus any one from: method of identifying / measuring h (1) OR repeat firing with same mass (1)	weigh the trolley NOT measure height of ramp e.g. use of reference mark accept "use ruler to measure height/h" for 2 marks NOT "use ruler to measure height of ramp"	(4)

Q12.

Question number	Answer	Additional guidance	Mark
	(vertical) height of slope (1) mass (of the toy car) (1)	allow (in this context) weight if no other mark scored allow 1 mark for quoting either equation $(\Delta)GPE = mgh$ OR $KE = \frac{1}{2} mv^2$	(2)

Q13.

Question number	Answer	Mark
(i)	Any three of • sound waves are longitudinal but radio waves are transverse. • sound waves need a medium but radio waves travel through a vacuum. • sound waves have (much) lower velocity than radio waves. • sound waves have lower frequency / greater wavelength than radio waves • sound waves are vibrations but radio waves are electromagnetic waves.	(3)

Q14.

Question Number	Answer	Additional Guidance	Mark
	one from causes heating of the surroundings (1) transferred to thermal energy of surroundings (1) increases the kinetic energy of molecules in the brake pads (1)	must include destination of final energy increases thermal energy of brake pads / wheels	(1)

Q15.

Question Number	Answer	Additional guidance	Mark
	Any two advantages such as: nuclear fuel • does not contribute to global warming • does not use up fossil fuels • occupies less space • does not involve a supply of air • gives less reason to surface/refuel • lasts longer	accept reverse arguments does not produce carbon dioxide / greenhouse gases ignore cheaper, cleaner, greener, pollutes the sea, more efficient, unqualified safety, renewable	(2)

Q16.

Question number	Answer	Acceptable	Mark
(i)	An explanation that combines identification - understanding (1 mark) and reasoning/justification - understanding (2 marks): • white light is a mixture of different wavelengths (1) • each wavelength / colour is refracted by a different amount (1) • short <u>wavelengths</u> are refracted more / ORA (1)	ignore colours	(3)

Question number	Answer	Acceptable	Mark
(ii)	An answer that combines the following points to provide a logical description of the method: • Place a thermometer (with blackened bulb) beyond position of red light (1) • Look for rise in temperature (measured by thermometer) (1)		(2)

Q17.

Question Number	Answer	Additional guidance	Mark
	reference to $\Delta PE = mg(\Delta)h$ (1) relevant values from graph and one calculation to find energy (1) repeated with 2nd set of values (1)	can be seen in calculations e.g. $0.6 \times 10 \times 0.230 \approx 1.4$ (J) e.g. $1.0 \times (10) \times 0.138 \approx 1.4$ (J) must see calculations for mp2 and 3 1 mark for 2 calculations of mh with 'g' omitted (MP3)	(3)

Q18.

Question Number	Answer	Additional guidance	Mark
	using cold row: evaluate (K=)376 (1) using warm row: substitute K and ρ $\frac{376}{\sqrt{1.16}}$ OR 349.10.... (1) 349 (m/s) to 3 sig figs (1)	other K from earlier calculation $\sqrt{1.16}$ any answer to 3 sig figs 349.10... scores MP1 and MP2 award full marks for the correct answer without working	(3)

Q19.

Question Number	Answer	Additional guidance	Mark
(i)	evidence of use of scale on horizontal distance axis only (1) 12 (cm) (1)	may be seen on the diagram range 11.5 to 12.5 (cm) award full marks for the correct answer without working 6 (cm) or 30(cm) scores 1 mark (evidence of use)	(2)

Question Number	Answer	Additional guidance	Mark
(ii)	a description to include: moves up and down (1) at right angles / normal / perpendicular to (direction of) wave / travel (1)	independent marking points vertical (oscillations) not in the (direction of) wave / travel accept 'transverse wave' for 2nd MP	(2)

Q20.

	Answer	Acceptable answers	Mark
(a)	light → electrical → chemical energy energy energy	These answers must be in the correct order	(2)

	(1)	(1)		
(b)(i)	350 (J)		400 - 50 (J)	(1)
(b)(ii)	Substitution $50 \div 400$ (1) or $50 \times 100 / 400$ (%) Evaluation 13(%) (1)		12.5(%), 0.125, 0.13 or 1/8 Give full marks for correct answer, no working	(2)
(c)(i)	An explanation linking the following points: black (1) (because) (good) absorber (of thermal radiation) (1)		{absorbs / takes in} heat radiation ignore references to: attract good emitter light dark / darker	(2)
(c)(ii)	an explanation linking any three of the following points: • (bag / water) absorbs {thermal energy / heat / radiation} (1) • (bag / water) {radiates / emits} {thermal energy / heat / radiation} (1) • more heat radiated at higher temperature (1) • input and output are balanced (at steady temperature) (1)		idea of energy input e.g. "sun heats the bag up" idea of energy output idea of more heat lost (to surroundings) at higher temperature "absorbing heat at same rate as radiating heat" (3) ignore (sun) light / rays	(3)

Question Number	Answer	Additional guidance	Mark
	a description to include: (the prong makes the) air vibrate/oscillate (1) in the same direction as /parallel to the wave travels (1)	causes compressions and rarefactions in air transfers ke to air longitudinal credit can be given for a labelled diagram	(2) AO 1 1

Q22.

Question number	Answer	Additional guidance	Mark
(i)	a description to include count the number of waves(1) (arriving/passing a point) in a specific time(1) use frequency = $\frac{\text{number of waves}}{\text{time}}$ (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
(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
(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

Q23.

Question Number	Indicative Content	Mark
QWC *	An explanation including some of the following points - Longitudinal {vibrations/oscillations} are {along/parallel to/in the same direction as} the direction of {travel/energy transfer} - Transverse {vibrations/oscillations} are {across/perpendicular to/90° to/right angles to} the direction of {travel/energy transfer} - Ultraviolet waves are transverse - Ultrasound waves are longitudinal (ignore sound – not on list) - Some seismic waves are longitudinal and some are transverse - P waves are longitudinal - S waves are transverse - Longitudinal waves need a material for the vibrations whereas electromagnetic waves can pass through a vacuum IGNORE irrelevant material	(6)

Level	0	No rewardable content
1	1 - 2	- a limited explanation of: EITHER the {vibration/movement} direction and direction of {travel/movement} for transverse or longitudinal wave OR correctly identifying the wave type for at least one example from the list, e.g. - Longitudinal waves move in the same direction as the wave moves - Ultraviolet waves are transverse - the answer communicates ideas using simple language and uses limited scientific terminology
2	3 - 4	- a simple explanation linking: EITHER directions of {<u>vibration/oscillation</u>} and wave travel for both types of wave OR direction of {<u>vibration/oscillation</u>} and wave travel of one type of wave with at least one example of a wave from the list OR the direction of 'movement' and direction of {travel/movement} for transverse AND longitudinal waves AND correctly identifying the wave type for at least one example from the list e.g. - In longitudinal waves the vibrations are in the same direction as the wave travels. In transverse waves the vibrations are at right angles to the direction the wave travels. - In longitudinal waves the vibrations are in the same direction as the wave travels. Ultraviolet waves are transverse. - Longitudinal waves move in the same direction as the wave moves. Transverse waves move at right angles to the direction the wave moves. Ultrasound waves are longitudinal. - 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 explanation clearly differentiating between the directions of {vibration/oscillation} for longitudinal AND transverse waves AND at least one example of <u>each type of wave</u> from the list, e.g. - In longitudinal waves the vibrations are in the same direction as the wave travels. In transverse waves the vibrations are at right angles to the direction the wave travels. Ultrasound waves are longitudinal and ultraviolet waves are transverse. - the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately - spelling, punctuation and grammar are used with few errors
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Q24.

Question Number	Answer	Acceptable answers	Mark
	Substitution (1) (Speed =) $6.67 \times 10^{14} \times 4.5 \times 10^{-7}$ Transposition AND substitution (1) (time =) $\frac{4 \times 10^{16}}{(6.67 \times 10^{14} \times 4.5 \times 10^{-7})}$ Evaluation (1) 1.33×10^8 (s)	Award full marks for correct answer with no working 3×10^8 (m/s) seen anywhere $\frac{4 \times 10^{16}}{3 \times 10^8}$ ECF candidate's speed maximum 2 marks Allow answers which round to 130 000 000 IGNORE Power of Ten error until evaluation	(3)