

Mark Scheme

Q1.

Question Number	Answer	Mark
	A is the correct answer as a large change in density causes most of the ultrasound to reflect, so the ultrasound does not penetrate deeper into the body. B is not the correct answer as this does not affect whether ultrasound can enter the lungs C is not the correct answer as this does not affect whether ultrasound can enter the lungs D is not the correct answer as ultrasound is not considered to cause damage to the body.	(1)

Q2.

Question Number	Answer	Mark
	B is the correct answer A is not the correct answer as the number of pulses detected is not related to the amount of interference that takes place. C is not the correct answer as the number of pulses detected is not related to the frequency of the waves. D is not the correct answer as the number of pulses detected is not related to the wavelength of the waves.	(1)

Q3.

Question Number	Answer	Mark
	C is the correct answer as speed = distance/time and t is the time taken for the ultrasound to travel a distance of $2d$ A is not the correct answer as this does not take into account the fact that the time t for the ultrasound travel a distance of $2d$. B is not the correct answer as the time taken for the ultrasound to return to the boat is unrelated to the frequency of the ultrasound used. D is not the correct answer as the time taken for the ultrasound to return to the boat is unrelated to the frequency of the ultrasound used.	(1)

Q4.

Question Number	Answer	Mark
	B is the correct answer A is not the correct answer as this would reduce the detail C is not the correct answer as this would have no effect on detail D is not the correct answer as this would reduce the detail	1

Q5.

Question Number	Answer	Mark
	A is the correct answer B is not correct because the distance should be doubled. C is not correct because the time should be halved. D is not correct because the time should be halved and the expression is inverted.	1

Q6.

Question Number	Answer	Mark
	The only correct answer is C - $0.5vt$ A is not correct because the pulse has to travel to the object and back, so the distance should be halved. B is not correct because distance should be velocity $\times$ time and the pulse has to travel to the object and back, so the distance should be halved. D is not correct because distance should be velocity $\times$ time.	1

Q7.

Question Number	Answer	Mark
	The only correct answer is D $\left(\frac{340 \times 4 \times 10^{-3}}{2}\right)$ A is not correct because this doubles time or doubles distance B is not correct because this is an incorrect rearrangement C is not correct because this does not halve distance or time	1

Q8.

Question Number	Answer	Mark
	D is the correct answer as the shorter the pulse, the shorter the time over which reflections are received. A is not the correct answer as only some of the ultrasound is reflected B is not the correct answer as the air is less dense than body tissues C is not the correct answer as higher resolution is gained with smaller λ.	(1)

Q9.

Question Number	Answer	Mark
	C is the correct answer A is not the correct answer as the time has not been converted from ms to s. B is not the correct answer as the time has not been converted from ms to s, and the given time has not been halved. D is not the correct answer as the given time has not been halved.	(1)

Q10.

Question Number	Answer	Mark
	B is the correct answer A is not the correct answer as distance has not been doubled C is not the correct answer as time has been doubled, instead of halved D is not the correct answer as distance has been doubled and time halved	(1)

Q11.

Question Number	Answer	Mark
	Waves <u>reflect</u> off surrounding objects / surfaces	(1)
	Time to return is detected	(1)
	This time can be used to determine the distance/position of an object	(1)
	Total for question	3

Q12.

Question Number	Answer	Additional Guidance	Mark																																								
*	This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning. Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning. The following table shows how the marks should be awarded for indicative content. <table><tr><th>IC points</th><th>IC mark</th><th>Max linkage mark</th><th>Max final mark</th></tr><tr><td>6</td><td>4</td><td>2</td><td>6</td></tr><tr><td>5</td><td>3</td><td>2</td><td>5</td></tr><tr><td>4</td><td>3</td><td>1</td><td>4</td></tr><tr><td>3</td><td>2</td><td>1</td><td>3</td></tr><tr><td>2</td><td>2</td><td>0</td><td>2</td></tr><tr><td>1</td><td>1</td><td>0</td><td>1</td></tr><tr><td>0</td><td>0</td><td>0</td><td>0</td></tr></table> The following table shows how the marks should be awarded for structure and lines of reasoning. <table><tr><th></th><th>Number of marks awarded for structure of answer and sustained line of reasoning</th></tr><tr><td>Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout</td><td>2</td></tr><tr><td>Answer is partially structured with some linkages and lines of reasoning</td><td>1</td></tr><tr><td>Answer has no linkages between points and is unstructured</td><td>0</td></tr></table> Indicative content IC1 <u>Pulses</u> of ultrasound are used IC2 Ultrasound is <u>reflected</u> from the crack IC3 Time taken between pulse being sent and received is measured IC4 Speed of ultrasound is known IC5 Speed = distance / time is used to calculate distance to the crack IC6 Using half time or half distance	IC points	IC mark	Max linkage mark	Max final mark	6	4	2	6	5	3	2	5	4	3	1	4	3	2	1	3	2	2	0	2	1	1	0	1	0	0	0	0		Number of marks awarded for structure of answer and sustained line of reasoning	Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2	Answer is partially structured with some linkages and lines of reasoning	1	Answer has no linkages between points and is unstructured	0	For IC3 accept the time taken for the ultrasound to return is measured	6
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(6)

Question Number	Answer	Mark
a	Either Ultrasound is (partially) <u>reflected</u> (from boundaries) (1) (Measure) the <u>time</u> taken or <u>time</u> delay (for signal to return) (1) Calculate expected time for pulse to return (if no air gap) (1) Or Compare to known time for pulse to return If time for pulse to return < time calculated, air gap is present (1) Or Ultrasound is (partially) <u>reflected</u> (from boundaries) (1) (Measure) the <u>time</u> taken or <u>time</u> delay (for signal to return) (1) Calculate distance for pulse to travel (1) If distance pulse returns from < thickness of RSJ, air gap is present Or If distance pulse returns from = thickness of RSJ, no air gap (1)	4
b	(Higher frequency) gives smaller wavelength (1) (Smaller wavelength leads to) high level of detail/resolution (1) (Smaller wavelength) can detect small(er) objects/gaps Or (With 20kHz) the detail would not be sufficient to identify air gaps Or (With 20kHz,) air gaps might be smaller than the wavelength (1)	3
	Total for question	7

Q15.

Question Number	Acceptable Answer	Additional Guidance	Mark
(a)	Ultrasound speed read from graph at 23°C (1) = 4115 (m s⁻¹) Use of $v = \frac{s}{t}$ (1) Correctly use a factor of 2 for distance or time (1) $t = 1.94 \times 10^{-5}$ s which is less than 200 μs so crack will not be detected Or $s = 0.41$ m which is more than 0.04m so crack will not be detected Or $v = 400$ ms⁻¹ which is less than 4115 ms⁻¹ so crack will not be detected (1)	allow range 4110 to 4120 (m s⁻¹) allow t in range 1.94×10^{-5} s to 1.95×10^{-5} s <u>example of calculation</u> $t = \frac{s}{v} = \frac{0.08 \text{ m}}{4115 \text{ m s}^{-1}}$ $t = 1.94 \times 10^{-5} \text{ s}$ Or $s = \frac{4115 \text{ m s}^{-1} \times 200 \times 10^{-6} \text{ s}}{2} = 0.41 \text{ m}$	4
(b)	(Ultrasound with a higher frequency) will have a shorter wavelength (1) (Shorter wavelengths) will <u>diffract</u> less (1) Or (Shorter wavelengths) give better <u>resolution</u>		2

Question Number	Answer	Mark
(a)	Use of $v = \frac{s}{t}$ (1) Halves distance or doubles time (1) Distance = 28 m (1) <u>Example of calculation</u> $s = 1500 \text{ m s}^{-1} \times 37 \times 10^{-3} \text{ s} = 55.5 \text{ m}$ $\frac{55.5 \text{ m}}{2} = 27.8 \text{ m}$	3
(b)	An echo must return to the transducer before the next pulse is transmitted (1) Or T (should be) $>$ time for the echo to return (1) So if T increases, the maximum distance increases (1)	2
(c)	Higher frequency sound waves lead to smaller wavelength (1) This gives better resolution (dependent on MP1) (1) Or Higher frequency sound waves will diffract less	2
Total for question		7

Q17.

Question Number	Answer	Mark
a	(Pulse reflects at) a boundary between different materials/media/densities (1) (allow “between steel and air” for “between different materials”) (allow “speed of ultrasound in air is different to that of steel”)	(1)
b	Method 1 (Calculating distance to crack) Reads time difference of 24.5 - 25 μs from graph (1) Use of speed = distance/time to calculate distance (1) Uses half time or half distance in calculation (1) Depth = 7.1 - 7.3 cm < 15cm, so reflection is from a crack Or Depth = 7.1 - 7.3 cm < 15cm, so cannot be from bottom of rail (1) OR Method 2 (Calculating time to bottom of rail and back) Use of speed = distance/time to calculate time (1) Uses 30cm in calculation (1) Reads time difference of 24.5 - 25 μs from graph (1) Time = 52 μs > 24.5 - 25 μs , so reflection is from a crack Or Time = 52 μs > 24.5 - 25 μs , so cannot be from the bottom of rail (1) <u>Example of calculation</u> Time between transmitting and receiving = 24.75 μs So time taken to get to point of reflection = 12.375 μs Distance = speed $\times$ time = 5800 m s ⁻¹ $\times$ (12.375 $\times$ 10 ⁻⁶) = 0.072 m	(4)
c	Most/all of the ultrasound is reflected by the first crack Or Pulse does not reach second crack Or None of the pulse is transmitted after the crack Or Ultrasound signal from deeper cracks is too weak to be detected (1)	(1)
d	The idea that there is a time delay before reflected/received signals return (1) The idea that the train will no longer be in the same position if it is moving too fast. Or the idea that the train will be in the same/similar position if it is moving slowly (1)	(2)
Total for question		8

Q18.

Question Number	Answer	Mark
(a)	Some of the pulse passes/refracts through crack A (1) (Some of the pulse) <u>reflects</u> from crack (B) (1) Because the density/material/medium of the crack will be different (to the metal) (1)	3
(b)	Use of speed = distance / time (1) Correct factor of 2 in converting time or distance (1) Depth = 4.1 cm / 0.041 m, hence crack A (1) <u>Example of calculation</u> Distance = speed $\times$ time = $5900 \text{ m s}^{-1} \times \frac{1.4 \times 10^{-5} \text{ s}}{2} = 0.041 \text{ m}$	3
(c)	Higher frequency means lower wavelength (1) Therefore greater level of detail possible (1) (MP1 – allow converse statement i.e. “lower frequency means greater wavelength”) (MP2 - allow reference to greater resolution or that smaller objects can be seen)	2
Total for question		8

Q19.

Question Number	Answer	Mark
(a)	Use of $I = P / A$ (1) $A = 4\pi r^2$ with $r = 1.50 \times 10^{11}$ (m) (1) Solar intensity at the solar panel = 1350 W m^{-2} (1) <u>Example of calculation</u> For intensity of sunlight at the panel: $I = P / A = (3.83 \times 10^{26} \text{ W}) / 4\pi (1.50 \times 10^{11} \text{ m})^2 = 1355 \text{ W m}^{-2}$	3
(b)	Use of $v = f\lambda$ with $v = 3.00 \times 10^8 \text{ m s}^{-1}$ (1) Use of $E = hf$ (1) Energy of photon = $3.7 \times 10^{-19} \text{ J}$ (1) (Correct substitution into $E = hc/\lambda$ can score both MP1 & MP2) <u>Example of calculation</u> $v = f\lambda$, $(3.00 \times 10^8 \text{ m s}^{-1}) = f \times (532 \times 10^{-9} \text{ m})$, $f = 5.64 \times 10^{14} \text{ Hz}$ $E = hf = (6.63 \times 10^{-34} \text{ J s}) \times (5.64 \times 10^{14} \text{ Hz}) = 3.74 \times 10^{-19} \text{ J}$	3
(c)(i)	Use of speed = distance / time with $v = 3.00 \times 10^8 \text{ m s}^{-1}$ (1) Height of orbit = $4.8 \times 10^5 \text{ m}$ (1) (Allow MP1 for candidates who fail to halve the time) <u>Example of calculation</u> Distance = speed $\times$ time = $(3.00 \times 10^8 \text{ m s}^{-1}) \times (3.20 \times 10^{-3} \text{ s} / 2)$ Height of orbit = 480 km	2
(c)(ii)	Photons from other/unknown sources also arrive at the satellite Or only photons emitted (by the laser) should be recorded Or other (wavelengths of) photons are not emitted (by the laser) (1) (Allow 'light' or 'waves' for 'photons')	1
(d)	(For a flat surface) measurements give the same time/distance (1) (Higher elevation means that) photons/light will return in less time Or $s = vt/2$ gives smaller distance to the ice (1)	2
Total for question		11