3	**A is the correct answer as frequency is unchanged when travelling into a different medium** B is not the correct answer as some of the light intensity becomes the reflected light. C is not the correct answer as the speed decreases when travelling into a more optically-dense substance D is not the correct answer as the wavelength decreases when travelling into a more optically-dense substance	**(1)**

9	**A is the correct answer. The power of the Sun is constant, so IA is constant for all the planets. $I_E \times 4\pi (1.49 \times 10^{11}\ m)^2 = I_J \times 4\pi (7.78 \times 10^{11} m)^2$** B is not the correct answer as 4π cancels in the equation C is not the correct answer as the radius of orbit has not been squared D is not the correct answer as 4π cancels in the equation and the radius of the orbit has not been squared	**(1)**

1	**B is the correct answer as the base units for power are kgm^2s^{-3}** A is not the correct answer as the newton is not a base unit C is not the correct answer as the joule is not a base unit D is not the correct answer as the ampere does not appear in kgm^2s^{-3}	**(1)**

6	**C is the correct answer as the path difference of 1.5λ is equivalent to a phase difference of π radians** A is not the correct answer as 0 radians would mean that the path difference was 0, λ, 2λ etc. B is not the correct answer as $\pi/2$ radians would mean that the path difference was 0.25λ, 1.25λ etc. D is not the correct answer as $3\pi/2$ radians would mean that the path difference was 0.75λ, 1.75λ etc.	**(1)**

10	**The only correct answer is C** A is not correct because reflection is the correct answer B is not correct because diffraction is not relevant in this context D is not correct because reflection is the correct answer	**1**

Question Number	Answer	Mark
7	**C is the correct answer as the path difference of 12cm is half the wavelength, causing destructive interference (no heating).** A is not the correct answer as the path difference of 12cm would only cause maximum heating if it was a multiple of the wavelength B is not the correct answer as the path difference of 12cm would only cause maximum heating if it was a multiple of the wavelength. D is not the correct answer as the path difference of 12cm would only cause no heating if it was an odd half multiple of the wavelength.	**(1)**

8	**C is the correct answer** (Both transverse and longitudinal waves can be refracted) A is not the correct answer as it is only electromagnetic waves that travel at the same speed in a vacuum – there are other transverse waves which travel at different speeds B is not the correct answer as transverse waves have vibrations that are perpendicular to the direction of wave travel D is not the correct answer as light is a transverse wave that can travel through liquids	**(1)**

9	**The only correct answer is D** A is not correct because this does not show an increasing I with θ B is not correct because this does not show an increasing I with θ C is not correct because this shows zero current at θ=0°C	**1**

2	**A is the correct answer as this represents the current in the internal resistance multiplied by the p.d. across the internal resistance.** B is not the correct answer as this is the power dissipated by the external resistance C is not the correct answer as this is the power dissipated by the whole circuit. D is not the correct answer as this equation combines the p.d. across the external resistance with the value for the internal resistance – as a result, it does not represent the power of any of the components in the circuit	**(1)**

5	**The only correct answer is A - the number of conduction electrons decreases so the ammeter reading decreases.** **B** is not correct because the current would decrease. **C** is not correct because the number of conduction electrons would decrease. **D** is not correct because the number of conduction electrons would decrease, and the current would decrease.	**1**

7	**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)**

5	The only correct answer is **C** A is not correct because attraction would not produce an interference pattern B is not correct because scattering would not produce an interference pattern D is not correct because refraction would not produce an interference pattern	**1**

7	**D is the correct answer** A is not correct because this gives the time period of the wave. B is not correct because this gives half the time period of the wave. C is not correct because the denominator is half the time period.

7	**The only correct answer is B** $(\sqrt{2} \times f)$ A is not correct because this would be the value of tension was halved C is not correct because this would be the value if the tension were reduced by a factor 4 D is not correct because this would be the value if the tension were increased by a factor 4	1

3	**A Diode has the shape of IV graph shown**	1
	Incorrect answers: B incorrect graph for a filament lamp C incorrect graph for a light dependent resistor D incorrect graph for a thermistor	

Question Number	Answer	Mark
*17(a)	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 structure and lines of reasoning.	

	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 throughc	2
Answer is partially structured with some linkages and lines c reasoning	1
Answer has no linkages between points and is unstructured	0

Total marks awarded is the sum of marks for indicative content and the marks for structure and lines of reasoning

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

Indicative content

IC1 Photons (of ultraviolet light)

IC2 cause (photo)electrons to be emitted

IC3 from (the surface of) the magnesium / ribbon

IC4 as the (photon) energy is greater than the work function of magnesium
Or as the frequency of the ultraviolet light is greater than the threshold frequency of magnesium

IC5 The electrons are attracted to the positively charged gauze (and create the current).

IC6 When the polarity is reversed the current is zero because the electrons no longer have enough kinetic energy to move across the gap
Or When the polarity is reversed the current is zero because the work function of copper is larger than the photon energy
Or When the polarity is reversed the current is zero because the threshold frequency of copper is larger than the frequency of ultraviolet light

6

Question Number	Answer	Mark
*17(a)	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 structure and lines of reasoning.	

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Indicative content

IC1 Photons (of ultraviolet light)

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Or as the frequency of the ultraviolet light is greater than the threshold frequency of magnesium

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Or When the polarity is reversed the current is zero because the work function of copper is larger than the photon energy
Or When the polarity is reversed the current is zero because the threshold frequency of copper is larger than the frequency of ultraviolet light

6

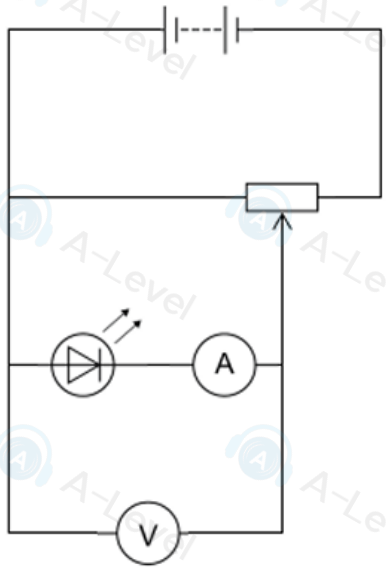
Question Number	Acceptable Answer		Additional Guidance	Mark
17(a)	Oscillations / waves reflect from (each) end of the cable The (reflected) waves interfere / superpose A node forms where there is destructive interference **Or** An antinode forms where there is constructive interference	**(1)** **(1)** **(1)**	For "end" allow "road" or "main cable"	**3**
17(b)	Point X has a large / maximum amplitude At point X the displacement varies (between maximum and zero) At point Y the cable always has zero displacement **Or** At point Y the cable is stationary	**(1)** **(1)** **(1)**		**3**
17(c)(i)	Calculates mass per unit length μ = 24.1 (kg m^{-1})	**(1)** **(1)**	Example calculation $\mu = \frac{2.10 \times 10^3 \text{ kg}}{87.0 \text{ m}}$ μ = 24.14 kg m^{-1}	**2**
17(c)(ii)	Use of factor of 500 Use of $W = mg$ Use of $v = \sqrt{\frac{T}{\mu}}$ Use of $v = f\lambda$ with λ = 320 m **or** λ = 7 m **Or** Use of $v = f\lambda$ with f = 280 Hz Lowest frequency produced by standing wave on longest cable = 1.1 Hz **Or** Lowest frequency produced by standing wave on shortest cable = 48 Hz	**(1)** **(1)** **(1)** **(1)** **(1)**	Example calculation $W = 140 \times 10^6 \text{ kg} \times 9.81 \text{ N kg}^{-1} = 1.37 \times 10^9 \text{ N}$ $T = \frac{1.37 \times 10^9 \text{N}}{500} = 2.74 \times 10^6 \text{ N}$ $v = \sqrt{\frac{2.74 \times 10^6 \text{ N}}{24 \text{ kg m}^{-1}}} = 338 \text{ m s}^{-1}$ $f = \frac{338 \text{ m s}^{-1}}{320} = 1.06 \text{ Hz}$ **or** $f = \frac{338 \text{ m s}^{-1}}{7} = 48.3 \text{ Hz}$ Lowest frequency waves produced < 280 Hz so humming is not produced by standing waves on the suspending cables	**6**
	Or Length of cable needed to give lowest frequency of 280 Hz = 0.60 m Calculated frequency compared to 280Hz with consistent conclusion **Or** Calculated length of cable compared to 3.5m or 160m with consistent conclusion	**(1)**		
	Total for question 17			**14**

Question Number	Answer	Mark
11a	Recognises that node to node distance = $\lambda/2$ **Or** $\lambda = L/2$ stated (1) Wavelength = 0.85m (1) Example of calculation Node to node distance = $\lambda/2$. String has 4 loops so total length of string is 2λ $\lambda = 1.70$ m / 2 = 0.85 m.	**(2)**
11b	Use of $v = \sqrt{(T/\mu)}$ (1) Use of $T = mg$ (1) $v = 21$ m s^{-1} (1) Example of calculation $T = mg = 0.20$ kg × 9.81 Nkg^{-1} = 1.96 N $v = \sqrt{(T/\mu)} = \sqrt{(1.96 \text{ N} / 4.5 \times 10^{-3} \text{ kgm}^{-1})} = 20.9$ ms^{-1}	**(3)**
11c	T and μ are the same **Or** (As f decreases,) λ *in*creases (1) Speed would be the same **Or** There is no effect (on the speed) (1)	**(2)**
	Total for question 11	**7**

Question Number	Answer		Mark
15a	There is a decrease in speed/velocity	(1)	
	Part of the wavefront meets the boundary before the rest	(1)	
	(Ignore references to density and refractive index) (Allow MP2 for correct addition to the diagram by eye for wavefronts both before and after the boundary)		**(2)**
15bi	Use of $v = \sqrt{\frac{g\lambda}{2\pi}}$ to find speed in deep water	(1)	
	Use of $v = \sqrt{(gd)}$ to find speed in shallow water	(1)	
	Calculates ratio of speeds	(1)	
	Correctly equates ratio of speeds to ratio of sine of each angle	(1)	
	$r = 17°$	(1)	
	Example of calculation $v = \sqrt{\frac{g\lambda}{2\pi}} = \sqrt{\frac{(9.81 \text{ ms}^{-2} \times 15 \text{ m})}{2\pi}} = 4.8 \text{ ms}^{-1}$ (deep water) $v = \sqrt{(gd)} = \sqrt{(9.81 \text{ ms}^{-2} \times 0.50 \text{ m})} = 2.2 \text{ ms}^{-1}$ (shallow water) ratio of speeds = $(4.8 \text{ ms}^{-1}) / (2.2 \text{ ms}^{-1}) = 2.2$ $\sin r = \sin(40) / 2.2 = 0.29$ $r = 17°$		**(5)**
15bii	Use of $f = 1/T$ and $v = f\lambda$ to find speed of wave	(1)	
	Use of $v = \sqrt{\frac{g\lambda}{2\pi}}$ to find same speed in deep water, confirming that deep water equation is the correct equation for this wave	(1)	
	Deep water equation only works if $d > 342 / 2$ so d must be > 171m	(1)	
	Example of calculation $f = 1 / 14.8 \text{ s} = 0.0676 \text{ Hz}$ $v = 0.0676 \text{ Hz} \times 342 \text{ m} = 23.1 \text{ ms}^{-1}$ $v = \sqrt{\frac{g\lambda}{2\pi}} = \sqrt{\frac{(9.81 \text{ ms}^{-2} \times 342 \text{ m})}{2\pi}} = 23.1 \text{ ms}^{-1}$ (deep water)		**(3)**
	Total for question 15		**10**

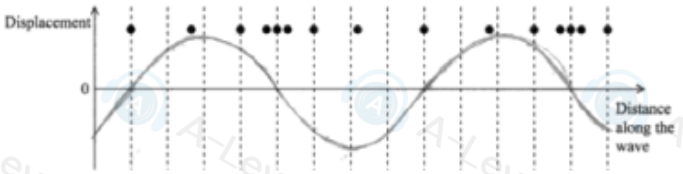
18(a)	Use of $V=IR$	(1)	
	Use of $R=\frac{\rho l}{A}$	(1)	
	$\rho = 440\ \Omega\ \text{m}$	(1)	**3**
	Example of calculation $R=\frac{12\ \text{V}}{8.5\times10^{-3}\ \text{A}}=1412\ \Omega$ $\rho=\frac{1412\ \Omega\times0.25\ \text{m}^2}{0.80\ \text{m}}=441\ \Omega\ \text{m}$		
18(b)	States a value for the resistivity of a layer	(1)	
	Makes a comparison between the resistivity of layers	(1)	
	(Between topsoil and subsoil) the resistivity decreases slowly indicating the varying depth **or** incline of the subsoil **Or** (At 5 m) resistivity increases suddenly indicating the constant depth of bedrock	(1)	**3**
18(c)(i)	Potential divider **Or** resistance is proportional to length	(1)	
	so V is proportional to l	(1)	
	$V = 3$ V	(1)	**3**
18c(ii)	**Max 1** Cross sectional area will be more constant (over a small length) Less variation in resistance/resistivity/material (over a shorter length) Eliminates contact resistance of electrodes with the ground (Second arrangement) combines both methods so two values of resistivity can be calculated and compared	(1)	**1**
	Total for question 18		**10**

Question Number	Answer	Mark

14(a)	LED, power supply and ammeter, in series (allow diode for LED)	**(1)**	
	Method to vary the potential difference across the LED	**(1)**	
	LED connected in forward bias **and** voltmeter connected in parallel with LED	**(1)**	**3**
	Example circuit  		

14(b)	Current = 37 (mA) read from graph (allow range 36 to 38 mA)	**(1)**	
	Use of $P = VI$	**(1)**	
	Power of LED = 0.0814 W (allow range 0.079 to 0.084 W)	**(1)**	**3**
	Example calculation $P = 2.2\ \text{V} \times 37 \times 10^{-3}\ \text{A} = 0.0814\ \text{W}$		

14(c)	Between 0 V and 1.6 V the resistance of the LED was (almost) infinite	**(1)**	
	(As p.d. increased) above 1.6 V, the resistance of the LED decreased	**(1)**	**2**
	Max 1 mark for statement that resistance is initially (almost) infinite and then decreases		
	Total for question 14		**8**

Question Number	Answer	Mark
14(a)(i)	One correct position for compression labelled (1 	**1**
14(a)(ii)	Correct wavelength 54 mm / 5.4 cm / 0.054 m (1	**1**
14(b)	Sine wave drawn with one wavelength between compressions (1) Zero displacement at both compressions **and** the rarefaction inbetween (1) 	**2**
	Total for question 14	**4**