8	A - wavelength is unchanged B - speed is unchanged C - both wavelength and speed are unchanged **D - correct answer**	**1**

10	**B is the correct answer** A is not the correct answer as X and Z are in antiphase C is not the correct answer as Y and Z have the same frequency D is not the correct answer as point Z is an antinode	**(1)**

6	**A is the correct answer as $v = \sqrt{(T/\mu)}$, where $T = Mg$ and μ = mass m per unit length, where length = $4L/3$** B is not the correct answer as this suggests the overall length of the string is $2L/3$ C is not the correct answer as this suggests the overall length of the string is L D is not the correct answer as this suggests the overall length of the string is $L/3$	**(1)**

8	**C is the correct answer** A is not the correct answer as $T = \mu v^2$ or $T \propto {}^{m}/_{l}$ so $2l$ is $T/2$ B is not the correct answer as $T = \mu v^2$ or $T \propto {}^{m}/_{l}$ so $2l$ is $T/2$ D is not the correct answer as $T = \mu v^2$ or $T \propto {}^{m}/_{l}$ so $2l$ is $T/2$	**(1)**

3	**D is the correct answer** as $n\lambda = d\sin\theta$ where $n = 1$ and $d = 1/300$. $\tan\theta =$ 0.40m / 2.00m. A is not the correct answer as the wavelength is not $300\sin\theta$ B is not the correct answer as the wavelength is not $300\sin\theta$ C is not the correct answer as θ is not $\sin^{-1}(0.40/2.00)$	**(1)**

2	**C is the correct answer as the distance between the laser and diffraction grating is not required in the equation $n\lambda = d\sin\theta$** A is not the correct answer as the distance from the diffraction grating to the screen is used to calculate θ in the equation $n\lambda = d\sin\theta$ B is not the correct answer as the distance from the central maximum to the first order maximum is used to calculate θ in the equation $n\lambda = d\sin\theta$ D is not the correct answer as the distance between the slits in the diffraction grating is used to calculate d in the equation $n\lambda = d\sin\theta$	**(1)**

Question Number	Answer	Mark
1	**The only correct answer is A diffraction**	**1**
	***B** is not correct because polarisation is not the spreading of a wave* ***C** is not correct because reflection occurs at an interface between two media* ***D** is not correct because refraction is the change in direction of a wave when incident at an interface between two media*	

9	**B is the correct answer as λ is much smaller than the gap size** A is not the correct answer as λ matches the gap size C is not the correct answer as λ is larger than the gap size D is not the correct answer as λ matches the gap size	**(1)**

4	**The only correct answer is C size of gap = wavelength of wave** ***A*** *is not correct because size of gap is greater than the wavelength* ***B*** *is not correct because size of gap is greater than the wavelength* ***D*** *is not correct because size of gap is greater than the wavelength*	**1**

8	**The only correct answer is A** B is not correct because this does not show reflection C is not correct because this does not show refraction D is not correct because this does not show superposition	**1**

Question Number	Answer		Mark
*16(a)(i)	**(QWC – work must be clear and organised in a logical manner using technical terminology where appropriate)** Cold spots formed at nodes **and** hot spots formed at antinodes **Either** Nodes formed where waves meet in antiphase resulting in zero/minimum <u>amplitude</u> **Or** Antinode formed where waves meet in phase resulting in maximum <u>amplitude</u> (For MP2 and MP3 allow cold spot for nodes and hot spot for antinodes)	(1) (1) (1) (1) (1)	**3**
16(a)(ii)	Use of $v=f\lambda$ with $v = 3.0 \times 10^8$ Using $\lambda = 2.8$ cm $f = 1.1 \times 10^{10}$ Hz <u>Example of Calculation:</u> $f = \frac{3\times10^8 \text{ ms}^{-1}}{0.028 \text{ m}} = 1.07 \times 10^{10}$ Hz	(1) (1) (1)	**3**
16(a)(iii)	The positions of nodes and antinodes within the food are constantly changing **Or** The standing wave is constantly changing position **Or** Points of max **or** min amplitude are constantly changing position **Or** The amplitude of the standing wave at one point in the food is constantly changing	(1) (1) (1) (1)	**1**

*16(b)(i)	**(QWC – work must be clear and organised in a logical manner using technical terminology where appropriate)** Constructive interference (1) Waves arrive in phase (1) As they have zero path difference **Or** point O is equidistant from both slits (1)	**3**
16(b)(ii)	Maxima where path difference is nλ. (1) Minima where path difference is (n + ½) λ. (1)	**2**
	Total for question 16	**12**

Question Number	Answer	Mark
18(a)	Wave (on string) is reflected (1) At the end/peg/bridge (1) Superposition/interference takes place (1)	**3**
18(b)	Use of $v = \sqrt{\frac{T}{\mu}}$ (1) Use of $v = f\lambda$ (1) And $\lambda = 2L$ (1) f = 293 (Hz, which is closest to) String 2 (1) Example of calculation $v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{71.5\ \text{N}}{2.03 \times 10^{-3}\ \text{kg m}^{-1}}} = 187.7\ \text{m s}^{-1}$ $v = f\lambda$, so f = 187.7 m s^{-1} / (2 × 0.32 m) = 293 Hz	**4**
18(c)	Waves have the same frequency/period (1) Waves have different speeds/wavelengths (1) Sound wave has same amplitude for all points **and** stationary wave does not (1) Sound waves transfer energy **and** stationary waves do not (1) Waves on string are transverse **and** sound waves are longitudinal (1) (MP2 – do not allow contradictions e.g. "they have different speeds but the same wavelength")	**5**
	Total for question 18	**12**

14(a)	Oscillations / vibrations are perpendicular to the direction of energy transfer **Or** Oscillations / vibrations are perpendicular to the direction of wave travel (allow propagation for wave travel) (1)	**1**

14(b)(i)	Uses appropriate trigonometry to determine θ	**(1)**	
	Use of $n\lambda = d\sin\theta$ to calculate d	**(1)**	
	Calculate $\frac{1}{d}$	**(1)**	
	Number of lines per mm = 260	**(1)**	**4**
	Example calculation $\theta = \tan^{-1}\left(\frac{0.22\text{ m}}{1.30\text{ m}}\right) = 9.61°$ $1 \times 650 \times 10^{-9}\text{ m} = d\sin(9.61°)$ $d = \frac{650 \times 10^{-9}\text{ m}}{\sin(9.61)} = 3.89 \times 10^{-6}\text{ m}$ No. of lines per mm = $\frac{10^{-3}}{3.89 \times 10^{-6}\text{ m}} = 257$		

14(b)(ii)	The path difference (for light from different slits travelling to the screen) is one wavelength	**(1)**	
	(So) the waves are in phase at the screen	**(1)**	
	(So) constructive interference occurs (causing a maximum)	**(1)**	**3**
	Total for question 14		**8**

15(a)	Oscillations / vibrations are perpendicular to the direction of energy transfer **Or** Oscillations / vibrations are perpendicular to the direction of wave travel (allow propagation for wave travel)	**(1)**	**1**

15(b)	Shape of wave correct	**(1)**	
	Node labelled at each end and antinode labelled in the middle (MP2 dependent on MP1)	**(1)**	**2**
	Example of diagram  		

15(c)	Use of $v = f\lambda$	**(1)**	
	Use of $v = \sqrt{\frac{T}{\mu}}$	**(1)**	
	Use of $\mu = \frac{m}{l}$ [with l = 1.5 m]	**(1)**	
	Mass of string = 3.1 (g), so string B	**(1)**	**4**
	[Allow reverse working for full marks]		
	Example of calculation $v = 196\ \text{Hz} \times 0.72\ \text{m} = 141\ \text{m s}^{-1}$		
	$\mu = \frac{41\ \text{N}}{(141\ \text{m s}^{-1})^2} = 2.06 \times 10^{-3}\ \text{kg m}^{-1}$		
	$\text{m} = 1.5\ \text{m} \times 2.06 \times 10^{-3}\ \text{kg m}^{-1} = 3.09 \times 10^{-3}\ \text{kg}$		
	Total for question 15		**7**

17(a)	Each point on a wavefront is (treated as) a source of (secondary) wavelets	**(1)**	
	these further wave (let)s interfere / superpose (and the resulting waves predict the shape)	**(1)**	**2**

***17(b)**	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. 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 The following table shows how the marks should be awarded for structure and lines of reasoning. Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout — Number of marks awarded for structure of answer and sustained line of reasoning: 2 Answer is partially structured with some linkages and lines of reasoning — 1 Answer has no linkages between points and is unstructured — 0 **Indicative content** IC1 Waves (from each gap) interfere / superpose IC2 At position A there is no path / phase difference IC3 So, there is constructive interference (leading to large amplitude oscillations) IC4 At position B, the phase difference varies with wavelength IC5 If there is an odd number of half wavelengths path difference, there is destructive interference leading to small oscillations **Or** If the waves are in antiphase there is destructive interference leading to small oscillations IC6 And if there is a whole number of wavelengths path difference there is constructive interference leading to large oscillations **Or** If the waves are in phase there is constructive interference leading to large oscillations	**6**
	Total for question 17	**8**