Assessment Schedule – 2011

Physics: Demonstrate understanding of wave systems (90520)

Evidence Statement

Q	Evidence	Achievement	Merit	Excellence
ONE (a)(i)	The incident wave is reflected at the bottom, and so the reflected wave travels up through the incident wave.	[1] Correct answer. Must give the idea of reflected wave **travelling up** and interfering or **combining** with the incident wave		
(ii)	At a node the medium is fixed. The top of the string is fixed. The bottom of the string is free to move, and so will not be a node, The top end is a node because the two waves combine destructively and the bottom end is an antinode because the two waves combine constructively.	[1] Answer describes how the **restriction** on the movement of the string at the top causes a node. AND the bottom end is **free** to move/ not fixed, so will not be a node / be an antinode	[1] Achievement + since the top end is fixed so **destructive interference** (or crest on a trough) happens making it a node. OR Achievement + since the **bottom** end is free so **constructive interference** (or crest on a crest) happens making it an antinode.	
(b)	$\frac{3\lambda}{4} = 12 \quad \Rightarrow \lambda = 16$ cm $v = f\lambda \quad \Rightarrow f = \frac{2.5}{0.16} =$ **15.625 = 16 Hz**	[2] Correct wavelength. 16 cm. OR Incorrect wavelength is used to calculate the frequency but λ must be in metres.	[2] Correct answer. **16 Hz.**	

(c)	$f(\text{2nd}) = 2 \times f(\text{1st})$ $= 2 \times (15.625 \div 3)$ **10.526 Hz** $\Rightarrow \lambda(\text{2nd}) = \frac{v}{f} = \frac{2.5}{10.526} = 0.2375 = 24$ cm The string is **12 cm** long, which is **half** of the wavelength of the second harmonic ($\lambda_2 = 24$cm). The top end of the string has to be a node and **12 cm from the top will be another node** and as the **bottom** of the string has to be an **antinode**, it is not possible to **fit a wave of this length into the string.**	[2] Correct fundamental = 5.2Hz OR Correct answer for the wavelength of the second harmonic wave can supply replacement evidence. [1] ONE idea is described correctly.	[2] Correct answer,10 Hz or consequential to 1(b). [1] BOTH ideas are linked correctly. OR Some other correct and valid explanation Do not accept closed pipe has only odd harmonics.	[½] Correct frequency and correct explanation.
TWO (a)(i)	A spectrum is produced because the amount of bending as the light goes through the grating depends on the wavelength of the light ($n\lambda = d\sin\theta$).	[1] Correct statement of why a spectrum is produced. **Differentwavelengths**/frequencies /colour bend/**diffract** at **different angles**		
(ii)	Because red light has the longest wavelength, it is bent away from the straight-through direction the most, so each spectrum will have its red side furthest from the centre.	[1] Correct idea that **red end** of the spectrum is **furthest out** from the central position. or The **longest wavelength is** furthest out.	[1] Correct explanation that **red has longest wavelength**. AND **Longer (not long) wavelength diffracts more.**	
(b)	$n\lambda = d\sin\theta$ and so, for a particular wavelength, d is directly related to θ. This means that, as d gets smaller, each order spectrum is bent more and so there will be fewer spectra produced.	[1] Smaller d linked to spectra being more **spread out.** OR Smaller d is linked to **fewer n** without the evidence of the equation.	[1] Achievement, plus **fewer spectra** produced. OR Relates that **n is directly proportional** to d because $n\lambda = d\sin\theta$ / λ is constant.	

(c)	$n\lambda = d\sin\theta$, $n = 1$, $\lambda = \frac{c}{f} = 7.05 \times 10^{-7}$ m $\Rightarrow \sin\theta = 1 \times \frac{3.00\times10^{8}}{4.25\times10^{14}} \times \frac{1}{6.6\times10^{-7}}$ $\Rightarrow \sin\theta = 1.070$ This angle does not exist (so light of this frequency does not form a spectrum). OR $\sin\theta$ is substituted as 1 and then n is calculated to have a value of 0.935, and since this is not a whole number so no spectra will be seen.	[2] Correct λ **7.05×10^{-7} m** [1] Correct answer. Do not accept mathematical error.	[2] Correct **$\sin\theta = 1.070$**	
(d)(i)	The waves having wavelengths **greater** than 5.2×10^{-7} **cannot be diffracted** through an angle **less than 90°,** so these wavelengths cannot contribute to the flash / spectrum.	[1] **Some idea** of why only part of a full spectrum is produced.	[1] **Clear idea** of why only part of a full spectrum is produced. Do not accept ,light is reflected back.	[½] Correct explanation and correct answer.
(ii)	$n\lambda = d\sin\theta$, $n = 1$, $\sin 90 = 1$ $\Rightarrow d = \lambda = 5.2 \times 10^{-7}$ m $= 5.2 \times 10^{-4}$ mm $N = \frac{1}{5.2\times10^{-4}} = 1923$ = **1 900 lines mm^{-1}**	[2] **Correct answer** without the evidence. OR Value of **N is given in metres.**	[2] Correct answer **1 900 lines per mm** with the **evidence**, evidence that : $d = \lambda = 5.2 \times 10^{-7}$ m, because $\sin 90 = 1$ evidence can come from any part of the question.	

THREE (a)	When a source of waves is moving towards a detector, each time the source produces a wave **crest,** it is slightly **nearer to the detector** than it was when it produced the **previous crest.** This means the effective wavelength of the waves reaching the detector is less than the wavelength of the waves produced by the source.	[1] Some idea of why the wavelength is shorter, eg: Because waves **bunch up**. OR Waves get **compressed**. OR Source is **catching up** on the waves. OR **Correct diagram.** **Do not accept,** since **frequency is higher so λ is shorter.**	[1] Clear idea of why the wavelength is shorter. As given in the evidence. The decreasing distance between the source and detector is linked to **successive wave is emitted closer to the detector** so apparent λ is shorter. OR Catching up of the source is linked to, each successive wave is emitted closer to the detector so apparent λ is shorter. Waves bunch up because **velocity of the waves relative to the source has decreased,** so waves have **less space to occupy.**	

(b)	$f' = \frac{v}{\lambda} = \frac{1545}{1.467\times10^{-3}} = 1.05317\times10^{6}$ $f' = f\frac{v_W}{v_W - v_S}$ $v_S = v_W\frac{f'-f}{f'} = 1545\frac{(1.0532-1.0522)\times10^{6}}{1.0522\times10^{6}} = 1.47 \text{ m s}^{-1}$ OR $\lambda = \frac{v}{f} = \frac{1545}{1.0522\times10^{6}} = 1.4684\times10^{-3}$ $\Delta\lambda = (1.4684-1.4670)\times10^{-3} = 1.4\times10^{-6} \text{ m}$ $T = \frac{1}{f} = \frac{1}{1.0522\times10^{6}}$ $v = \frac{\Delta\lambda}{T} = 1.4\times10^{-6}\times1.0522\times10^{6} = 1.47 \text{ m s}^{-1}$ OR Relative $v = f'\lambda'$ $= 1.0522\times10^{6}\times1.4670\times10^{-3}$ $= 1543.5774 \text{ m s}^{-1}$ Speed of sound in blood $= 1545 \text{ m s}^{-1}$ Difference between relative v and v $= 1545 - 1543.577 = 1.4226 \text{ m s}^{-1}$	2 Correct f' 1.05317×10^{6} Hz. OR Wrong f', but rest of the substitution is correct. OR λ is calculated $= 1.4684\times10^{-3}$ m OR velocity is calculated as $v = 1543.5774 \text{ m s}^{-1}$ but does not mention that it is the relative velocity.	2 Correct f'. + Correct substitution into formula. OR λ is calculated $= 1.4684\times10^{-3}$ m AND $T = 1/f = 1/ 1.0522\times10^{6}$ But does not calculate. v = change in λ / T = 1,423) OR Relative velocity is calculated as $v = 1543.5774 \text{ m s}^{-1}$ mentions that it is the relative velocity.	2 Correct answer. 1.423 m s^{-1} Allow answers that have correctly used the double Doppler equation, typically used by radiologists, or from first principles.

Judgement Statement

Achievement	Achievement with Merit	Achievement with Excellence
2 **A1** + 2 **A2**	2 **M1** + 2 **M2** + 1 **A**	2 **E** + 2 **M1** + 1 **M2** + 1 **A**

Note: where the criterion is not specified, the required grade(s) can be from either.