**Raffles Institution**
**Year 5-6 Physics Department**

**2025 Year 6 H2 Physics Remedial**
**Chapter 12: Superposition**

**Suggested Solutions**

**1** Rayleigh criterion for 2 images to be just resolved:

limiting angle of resolution $\theta_{\text{min}} \approx \frac{\lambda}{b}$

Approximate minimum separation, $s \approx r\theta_{\text{min}} \approx r\frac{\lambda}{b}$

Wavelength of visible light region is in the range 400 nm to 700 nm.

Subst. $\lambda = 500$ nm, $s \approx r\frac{\lambda}{b} = \left(20 \times 9.5 \times 10^{15}\right)\frac{500 \times 10^{-9}}{3.0} = 3.2 \times 10^{10}$ m

Option C gives the correct order of magnitude.

*NOTE: The exact wavelength of the visible light used is not crucial as the options given are all in different orders of magnitude.*

**2** Single slit first order minima:
$b\sin\theta = \lambda$ ----- (1)
Double slit maxima
$a\sin\theta = n\lambda$ ----- (2)

Where the first minima of the single slit diffraction pattern coincide with the maxima of the double-slit pattern, $\theta$ is the same.

$\frac{(2)}{(1)} \quad \Rightarrow \quad \frac{a}{b} = n \quad \Rightarrow \quad n = \frac{0.18}{0.030} = 6$

The 6th order bright fringe will coincide with the first minima of the single slit diffraction pattern.

So there will be 5 bright fringes on either side of the central axis and a bright fringe at the centre. Number of bright fringes between the two first order minima of the single slit diffraction pattern is 5 + 5 + 1 = 11.

**3** **(a)** A stationary wave is formed when 2 identical waves with same amplitude, frequency and wavelength (or speed) travelling in opposite directions towards each other superpose.
**(i)** 0
**(ii)** 3
**(iii)** A solid straight line across the centre of the wave (ie at the dotted line)

**4** **(a)** **(i)** Microwaves.
The degree of diffraction of a wave depends on its wavelength relative to the opening/obstacle size.

**(ii)** $\lambda = \frac{c}{f} = \frac{3.00 \times 10^8}{90.5 \times 10^6} = 3.315$ m
400 nodes correspond to 399 $\lambda/2$ segments.
Hence, distance is $399 \times \frac{3.315}{2} = 661$ m.

**(b)** **(i)** $x = \frac{\lambda D}{a} = \frac{\left(690 \times 10^{-9}\right)(1.20)}{\left(0.333 \times 10^{-3}\right)} = 0.002486 = 2.49$ mm

**(ii)** Since the screen is 2.40 m wide and a distance 1.20 m away, the maximum diffraction angle is $\theta = \tan^{-1}\dfrac{2.40/2}{1.20} = \tan^{-1}1 = 45°$.

$d\sin\theta = n\lambda$

$n = \dfrac{d\sin\theta}{\lambda} = \left(\dfrac{1}{300000}\sin 45°\right)\Big/\left(690\times10^{-9}\right) = 3.4$

The highest visible order is 3.

**5 (a)** Waves must be of the same (transverse/longitudinal) type.
Transverse waves must be unpolarised or polarised in the same plane.

**(b) (i)** To produce coherent sources at the two slits ($s_1$ and $s_2$).

**(ii)** intensity = $k$(amplitude)$^2$ → amplitude of each wave = $\sqrt{\dfrac{I}{k}}$

resultant intensity = $k$(resultant amplitude)$^2$ = $k\left(\sqrt{\dfrac{I}{k}}+\sqrt{\dfrac{I}{k}}\right)^2 = 4I$

**(iii)** $\pi$ rad OR 180°

**(iv)** Light from $S_1$ and $S_2$ interferes destructively. This leaves light from $S_3$ at point P. Point P will not be dark.

**6 (a)** Interference is the superposition of two or more coherent waves to give a resultant wave whose resultant amplitude is given by the principle of superposition.

**(b)** To produce 2 water waves with circular wavefronts, 2 (ball-typed) dippers are used.

To ensure that they are coherent, the dippers are connected to the same vibrator source / motor. [Note: Also accept 1 dipper as source and 2 slits]

For observations of interference patterns, a lamp is set-up above the tank and a screen below the tank.

**(c) (i)** $v = f\lambda$

$320 = 400\times\lambda$

$\lambda = 0.80$ m

**(ii)** It is a maximum.

Distance SPX is 7.0 m and distance SX is 5.0 m, hence the path difference is 2.0 m which is equivalent to 2.5 $\lambda$.

After considering the $\pi$ radians phase change upon reflection, the 2 waves meet in phase.