

Solutions

These allocations are for the original questions on this sheet. B1 = one standalone point, M1 = one method point, A1 = one accuracy point.

2.1 Points within the gap supply secondary wavelets. Their forward envelope forms curved spreading wavefronts beyond the restricted opening.

2.2 Convert density: $N = 500 \times 10^3 \text{ m}^{-1}$ and $d = 1/N = 2.0 \times 10^{-6} \text{ m}$. $k\lambda = d \sin \theta$, so $\theta = \sin^{-1}(600 \times 10^{-9}/2.0 \times 10^{-6}) = 17.5^\circ$.

2.3 The time covers travel to the boundary and back. $s = vt/2$. $s = 5000 \times 20 \times 10^{-6}/2 = 0.050 \text{ m}$.

3.1 $\lambda = h/p$. Initially $\lambda = 3.32 \times 10^{-10} \text{ m}$; finally $\lambda = 1.66 \times 10^{-10} \text{ m}$. A regular diffraction pattern involves reinforcement/cancellation characteristic of waves, which simple straight-path particles alone do not explain.

3.2 Mean $x = (0.48 + 0.50)/2 = 0.49 \text{ m}$. $\theta = \tan^{-1}(x/D) = 18.1^\circ$. $d = 1/(600 \times 10^3) = 1.67 \times 10^{-6} \text{ m}$, so $\lambda = d \sin \theta = 5.17 \times 10^{-7} \text{ m}$. Repeat distances or use clearly visible higher orders; keep beam below eye level and never look into it. D is the adjacent side, not the hypotenuse: the exact ratio is $\tan \theta = x/D$.

3.3 The extra round-trip path is $2\Delta s$. $\Delta t = 2\Delta s/v = 2 \times 0.0040/5000 = 1.6 \mu\text{s}$. This is shorter than the pulse duration, so the echoes overlap. Use a shorter pulse, less than their time separation, to improve echo separation.