Year 12 Science: Wave behaviour: reflection, refraction, diffraction and interference

Name: _____ Date: _____

Try these without your notes first, then check the answer key.

Practice

1. A wave has a frequency of 4.0 Hz and a wavelength of 0.60 m. Find its speed.

2. Find the period of that wave.

3. Find the wavelength of a 2.4 GHz Wi-Fi signal.

4. Water waves travel at 0.30 m s^{-1} in deep water and 0.20 m s^{-1} in shallow water. They meet the boundary at 30° to the normal. Find the angle in the shallow water.

5. Two dippers in phase make waves with λ = 2.0 cm. A point is 9.0 cm from one dipper and 12.0 cm from the other. Is it on a nodal or an antinodal line?

Exam-style question: swell at a marina

Ocean swell with a period of 8.0 s and a wavelength of 100 m rolls towards a marina. The breakwater has a 12 m wide entrance, and the water inside gets shallower towards the boat ramp.

6. Calculate the speed of the swell.

7. Describe what happens to the waves as they pass through the entrance, and why.

8. Inside, the water gets shallower. Explain what happens to the speed, frequency, wavelength and amplitude of the waves.

9. A second entrance is opened further along the breakwater. Explain why boats at some moorings now rock a lot while boats at others hardly move.

Fix the mistake

10. Correct this statement: "The waves slow down in shallow water, so their frequency goes down."

11. Correct this statement: "Diffraction through the gap makes the wavelength longer."

12. Correct this statement: "A nodal line is where the crests from both sources meet."

13. Correct this statement: "12 waves in 4.0 s, 2.5 cm apart: $v = 3.0 \times 2.5 = 7.5\ m\ s^{-1}$."

Answer key (for parents and tutors)

1. A wave has a frequency of 4.0 Hz and a wavelength of 0.60 m. Find its speed.
   $v = f\lambda = 4.0 \times 0.60 = 2.4\ m\ s^{-1}$.

2. Find the period of that wave.
   $T = 1/f = 1 \div 4.0 = 0.25\ s$.

3. Find the wavelength of a 2.4 GHz Wi-Fi signal.
   $\lambda = c \div f = 3.00 \times 10^8 \div 2.4 \times 10^9 = 0.125\ m$ (12.5 cm).

4. Water waves travel at 0.30 m s^{-1} in deep water and 0.20 m s^{-1} in shallow water. They meet the boundary at 30° to the normal. Find the angle in the shallow water.
   $\sin\theta_2 = \sin 30° \times 0.20 \div 0.30 = 0.5 \times 0.667 = 0.333$, so $\theta_2 = 19.5°$.

5. Two dippers in phase make waves with $\lambda = 2.0$ cm. A point is 9.0 cm from one dipper and 12.0 cm from the other. Is it on a nodal or an antinodal line?
   Path difference = 12.0 − 9.0 = 3.0 cm = 1.5λ, an odd number of half wavelengths, so it is on a nodal line.

6. Calculate the speed of the swell.
   $v = \lambda \div T = 100 \div 8.0 = 12.5\ m\ s^{-1}$ (Achieved).

7. Describe what happens to the waves as they pass through the entrance, and why.
   They diffract: the wavelength (100 m) is much bigger than the 12 m gap, so the waves spread out into the marina as curved wavefronts, reaching boats that are not in line with the entrance; the wavelength, frequency and speed do not change (Merit with the reason).

8. Inside, the water gets shallower. Explain what happens to the speed, frequency, wavelength and amplitude of the waves.
   In shallower water the waves slow down; the frequency stays the same because it is set by the source (each wave arriving must pass on), so by $v = f\lambda$ the wavelength gets shorter, and the amplitude grows as the energy is squeezed into slower, shorter waves (Excellence for all four, each with a reason).

9. A second entrance is opened further along the breakwater. Explain why boats at some moorings now rock a lot while boats at others hardly move.
   The two entrances act as two sources with the same frequency, in phase, so the waves interfere. At moorings where the distances to the two entrances differ by a whole number of wavelengths, crest meets crest (constructive, antinodal), so boats rock a lot; where they differ by an odd number of half wavelengths, crest meets trough (destructive, nodal), so boats hardly move (Excellence needs path difference).

10. Correct this statement: "The waves slow down in shallow water, so their frequency goes down."
    The source sets the frequency, so it stays the same; the speed falls, so by $v = f\lambda$ the wavelength gets shorter.

11. Correct this statement: "Diffraction through the gap makes the wavelength longer."
    Diffraction only spreads the wave; its speed, frequency and wavelength are unchanged because it stays in the same material.

12. Correct this statement: "A nodal line is where the crests from both sources meet."
    Crest meets crest on antinodal lines; nodal lines are where crest meets trough, a path difference of an odd number of half wavelengths.

13. Correct this statement: "12 waves in 4.0 s, 2.5 cm apart: $v = 3.0 \times 2.5 = 7.5\ m\ s^{-1}$."
    Change cm to m first: $v = 3.0 \times 0.025 = 0.075\ m\ s^{-1}$.