AQA AS Stationary Waves and Harmonics worksheet

35–40 minutes independent practice + 15–20 minutes review | 41 marks

Specification points covered

• 3.3.1.3(a) Nodes and antinodes on a string. • 3.3.1.3(b) Use $f = (1/2\ell)\sqrt{(T/\mu)}$. • 3.3.1.3(c) Formation from equal-frequency opposite waves. • 3.3.1.3(d) Graphical explanation of stationary waves.	• 3.3.1.3(e) Stationary waves in strings, microwaves and sound. • 3.3.1.3(f) Harmonics on strings. • 3.3.1.3(g) AQA harmonic terminology.

Wind-turbine support-cable monitor

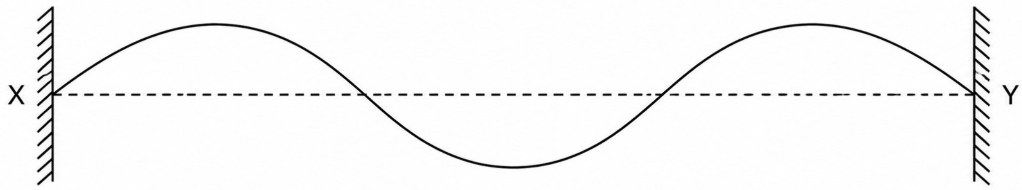
Engineers use vibration patterns in a six-metre support cable to detect icing and choose safe damper positions.
Interpret the whole spatial pattern before applying string, microwave or sound-wave equations.

1. How the pattern forms

1. Two waves travel along a wind-turbine support cable in opposite directions. State the conditions required for them to form a stationary wave and explain the origin of nodes and antinodes. [3 marks]

2. Reading the cable pattern

2. The diagram shows the vibration pattern on a 6.00 m cable fixed at X and Y. State (a) the number of nodes, (b) the number of antinodes, (c) the harmonic shown and (d) the wavelength. [4 marks]



3. Compare the phase and amplitude of (a) two points within the same loop and (b) points in adjacent loops. State the amplitude at a node. [3 marks]

3. Cable calculations

4. The pattern in the diagram has frequency 12.0 Hz. Calculate the wave speed along the cable. [2 marks]

5. The cable has mass per unit length 3.20 kg m^{-1}. Calculate the tension in the cable when the wave speed has the value found in Question 4. [3 marks]

6. Ice increases the cable's mass per unit length by a factor of 1.44 while length and tension stay constant. Calculate the new frequency of the same harmonic. [3 marks]

7. The first harmonic of the unloaded cable is 6.0 Hz. The monitoring system detects a strong response at 18.0 Hz. Identify the harmonic and describe its loop pattern. [2 marks]

4. Applying nodes and antinodes

8. An engineer proposes fitting a damper at the cable midpoint. Explain why this strongly suppresses the first harmonic but can leave the second harmonic much less affected. [3 marks]

9. A microwave inspection chamber has adjacent detector minima separated by 6.10 cm. Calculate the microwave wavelength and frequency. [3 marks]

10. In a sound-tube demonstration, adjacent powder heaps occur at displacement nodes 3.40 cm apart. The sound speed is 340 m s^{-1}. Calculate the wavelength and frequency. [3 marks]

11. Compare a stationary wave with either travelling wave that forms it. Include amplitude, phase and net energy transfer. [3 marks]

5. Testing the model

12. Design a method to test $f = (1/2\ell)\sqrt{(T/\mu)}$ for the cable material using a vibration generator, pulley and hanging masses. Include measurements, control variables, a graph and safety. **[6 marks]**

13. For a fixed length and cable, explain why a graph of f^2 against T should be a straight line through the origin and state what its gradient equals. **[3 marks]**

Review and improve

□ I infer wavelength from the number of half-wavelengths in the pattern.
□ I use phase and amplitude correctly at nodes, antinodes and adjacent loops.
□ I linearise the string equation to test it experimentally.