Unit 7 · Mechanical Waves

WORKSHEET

Full marks 33

Name _____ Class _____ Roll no. _____ Date _____ Marks _____ / 33

1 Key words [4]

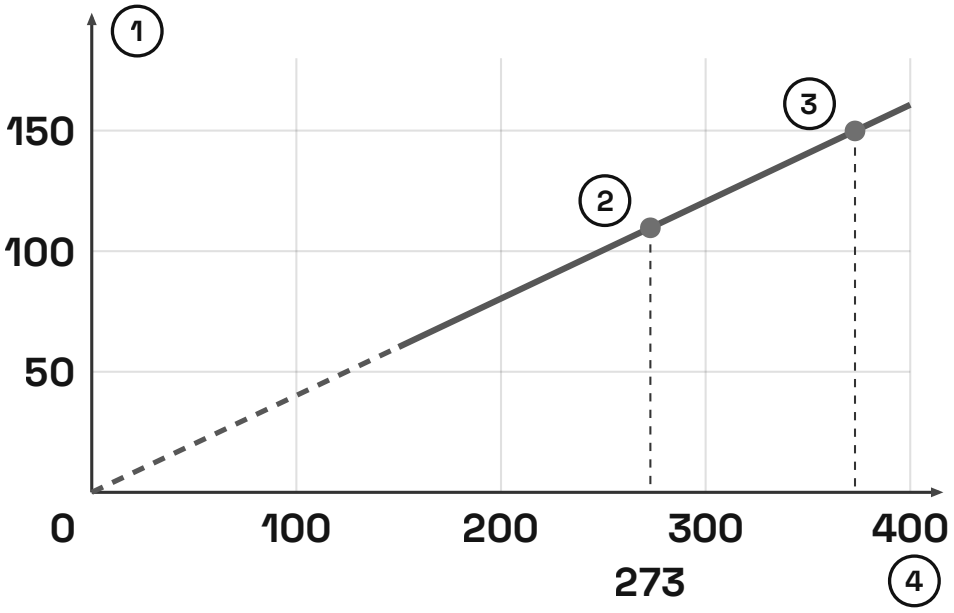
Fill in the blanks with words from the box. Two words in the box are not needed. Each blank carries 0.5 mark.

adiabatic	**amplitude**	**bulk modulus**	**elastic property**	**humidity**	**inertial property**
isothermal	**mechanical wave**	**tension**	**Young's modulus**		

A disturbance that needs a material medium to travel through is a _____. The speed of such a wave depends on two properties of the medium: its _____, which pulls a displaced particle back, and its _____, measured by its density. For sound in a solid rod, the modulus that matters is _____; for sound in a liquid or a gas, it is the _____. Newton assumed that the changes in a sound wave are _____; Laplace showed that they are _____. Water vapor in the air, or _____, makes sound travel a little faster.

2 Label the diagram [2]

The graph shows the square of the speed of sound in air against its absolute temperature, with the speeds at 0 °C and 100 °C marked. Write the label that belongs in place of 1 to 4. Each carries 0.5 mark.



1. _____ 2. _____

3. _____ 4. _____

3 Multiple choice [5]

Choose the correct option for each of the following questions.

i. A string of mass per unit length 0.025 kg/m is stretched with a tension of 90 N. Waves travel along it at: [1]

a. 3600 m/s **b.** 60 m/s
c. 2.25 m/s **d.** 1.7 m/s

ii. The absolute temperature of a gas rises from 300 K to 363 K. The speed of sound in it: [1]

a. rises 1.21 times **b.** rises 1.1 times
c. rises by 63 m/s **d.** stays the same

iii. By Laplace's correction, the bulk modulus of a gas for a sound wave is: [1]

a. P **b.** γP
c. P/γ **d.** ρP

iv. At the same temperature, sound travels faster in hydrogen than in oxygen because hydrogen: [1]

a. is more elastic
b. has a much smaller molar mass, so is less dense
c. is at a higher pressure
d. has a larger γ

v. A sound passes from air into water. Its frequency and wavelength: [1]

a. the frequency stays the same, the wavelength increases
b. the frequency increases, the wavelength stays the same
c. both increase
d. the frequency stays the same, the wavelength decreases

4 Short answers [7]

Write short answers to the following questions.

a. Steel is about 6000 times as dense as air, yet sound travels about 15 times faster in steel. Why? [2]

b. State the assumption Newton made about sound in a gas, and why it was wrong. [2]

c. Ethanol has a bulk modulus of 9.0×10^8 N/m^2 and a density of 790 kg/m^3. Find the speed of sound in it, and the wavelength of a 2000 Hz sound in it. **[3]**

5 Long answer **[4]**

Write a long answer to the following question.

Starting from Laplace's formula $v = \sqrt{\gamma P/\rho}$, show that the speed of sound in a gas is proportional to the square root of its absolute temperature. Use it to show that near 0 °C the speed of sound in air rises by about 0.6 m/s for each degree.

6 Numerical problems **[8]**

Solve the following problems. Show your working.

a. Hydrogen at 0 °C and a pressure of 1.013×10^5 Pa has a density of 0.090 kg/m^3, and $\gamma = 1.41$. Find i. the speed of sound in it by Newton's formula, ii. the speed by Laplace's formula, and iii. the wavelength of a 500 Hz sound in it. **[4]**

Answer:

b. A copper wire of radius 0.50 mm is stretched with a tension of 60 N. Copper has a density of 8900 kg/m^3 and a Young's modulus of 1.2×10^{11} N/m^2. Find i. its mass per unit length, ii. the speed of transverse waves along it, and iii. the speed of sound (longitudinal waves) along it. How many times faster is the sound? **[4]**

Answer: _____

7 Think **[3]**

Inside a pressure cooker the air is at twice the pressure of the room and at 120 °C. Prakash says sound travels faster inside because the pressure is higher. Is he right? By how many times does the speed really change from the room at 27 °C?

8 Activity: Clap for an echo (not marked)

Stand about 50 m in front of a large wall. Clap, and keep clapping so that each clap falls exactly on the echo of the one before. Time 20 claps, then step back and do it again.

Distance to the wall (m)	Time for 20 claps (s)	Speed of sound (m/s)

How does your speed compare with 331 + 0.6t m/s at today's temperature t?