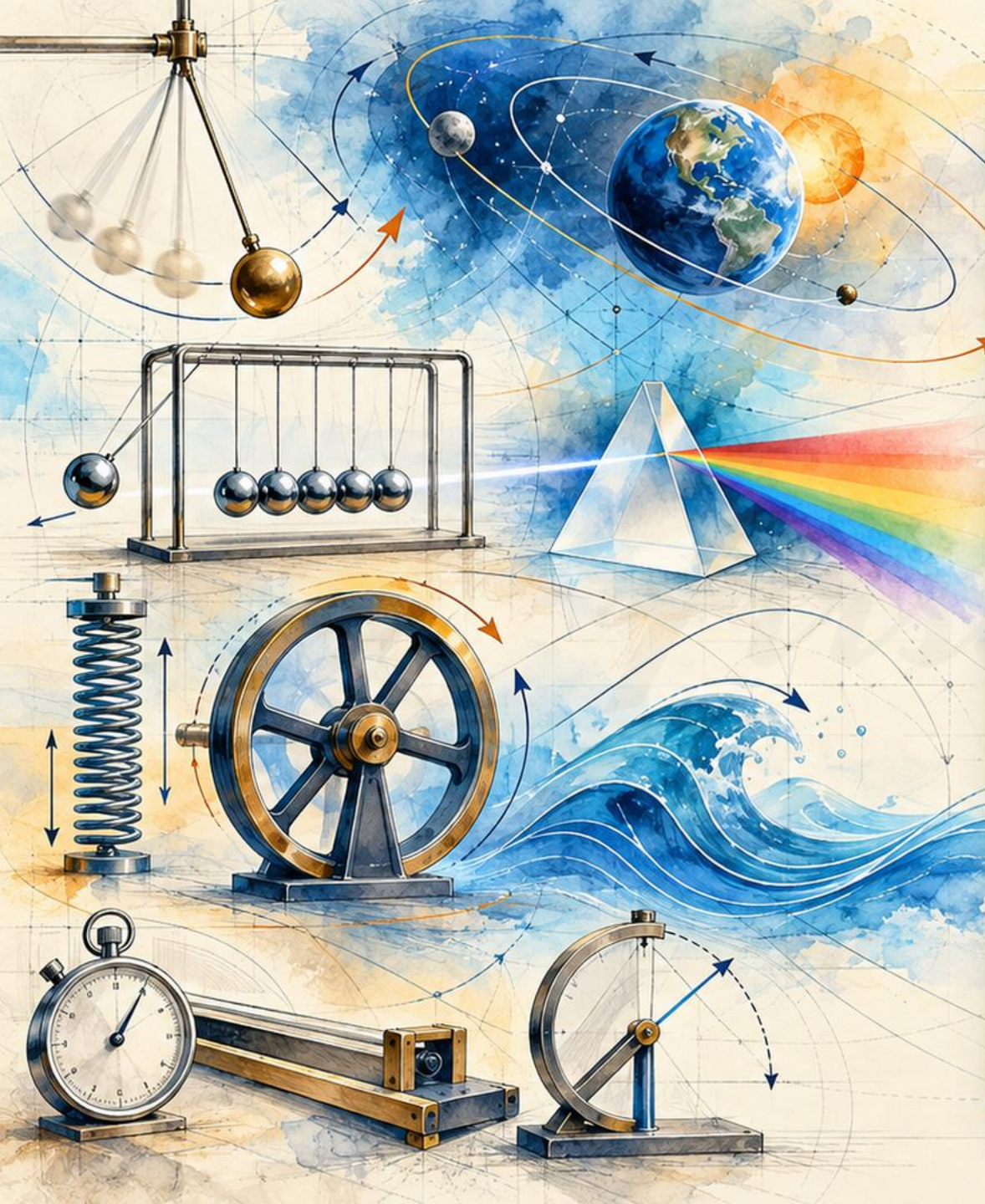




PHYSICS • CLASS 11

14

CHAPTER

Waves

NCERT SOLUTIONS

EXERCISE SOLUTION: QUESTION 14.1

A stretched string has mass 2.50 kg, length 20.0 m and tension 200 N. A transverse jerk is given at one end. How long does the disturbance take to reach the other end?

Answer:

First find the mass per unit length of the stretched string.

$$\mu = \frac{m}{L} = \frac{2.50}{20.0} = 0.125 \text{ kg m}^{-1}$$

The transverse wave speed depends on tension and linear mass density.

$$v = \sqrt{\frac{F}{\mu}} = \sqrt{\frac{200}{0.125}} = 40.0 \text{ m s}^{-1}$$

The disturbance travels the full string length at this speed.

$$t = \frac{L}{v} = \frac{20.0}{40.0} = 0.500 \text{ s}$$

Travel time = 0.50 s

This is the travel time of the disturbance, not the time for a piece of string to move from one end to the other.

EXERCISE SOLUTION: QUESTION 14.2

A stone is dropped from a tower 300 m high into a pond near its base. When is the splash heard at the top? Use sound speed 340 m s^{-1} and $g = 9.8 \text{ m s}^{-2}$.

Stone falling.

The stone starts from rest.
Neglect air resistance.

$$h = \frac{1}{2}gt_1^2$$

$$t_1 = \sqrt{\frac{2h}{g}} = \sqrt{\frac{(2 \times 300)}{9.8}} \\ \approx 7.825 \text{ s.}$$

Sound returning.

After the stone hits the water, sound travels back up to the observer.

$$t_2 = \frac{h}{v_{\text{sound}}} = \frac{300}{340} \\ \approx 0.882 \text{ s.}$$

$$t_{\text{total}} = t_1 + t_2 = 7.825 + 0.882 \\ \approx 8.707 \text{ s.}$$

Add the two times because the fall and the sound's return happen one after the other.

Splash heard after about 8.7 s.

EXERCISE SOLUTION: QUESTION 14.3

A steel wire is 12.0 m long and has mass 2.10 kg. What tension makes its transverse-wave speed equal to the speed of sound in dry air at 20 °C, namely 343 m s⁻¹?

Answer:

Find the wire's linear mass density.

$$\mu = \frac{m}{L} = \frac{2.10}{12.0} = 0.175 \text{ kg m}^{-1}$$

$$v = \sqrt{\frac{F}{\mu}}$$

Rearrange the wave-speed equation to find the required tension.

$$F = \mu v^2$$

Use the supplied air sound speed as the target transverse-wave speed of the stretched wire.

$$\begin{aligned} F &= (0.175)(343)^2 \text{ N} \\ &= 20588.575 \text{ N} \end{aligned}$$

$$F \approx 2.06 \times 10^4 \text{ N}$$

Required tension $\approx 20.6 \text{ kN}$.

EXERCISE SOLUTION: QUESTION 14.4

Use $v = \sqrt{\gamma P / \rho}$ to explain why sound speed in air is (a) independent of pressure, (b) greater at higher temperature and (c) greater with humidity.

For an ideal gas, relate density to pressure and absolute temperature.

$$\rho = PM/(RT), \text{ so } v = \sqrt{\gamma RT/M}.$$

(a) Pressure

At fixed temperature and composition, pressure and density change in the same proportion. Their ratio stays constant, so pressure cancels from the sound-speed formula.

(b) Temperature

With composition fixed and the heat-capacity ratio treated as constant, warmer air carries sound faster. Use temperature in kelvin.

$$v \propto \sqrt{T}.$$

(c) Humidity

At the same pressure and temperature, water vapour replaces some heavier dry-air molecules. Humid air has a smaller mean molar mass and lower density, so sound speed increases.

$$M_{\text{water}} = 18 \text{ g mol}^{-1} < M_{\text{dry air}} \approx 29 \text{ g mol}^{-1}.$$

The simple explanation treats the small change in the heat-capacity ratio as negligible.



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