Unit C – Practical 6

Measuring the vibrations of a tuning fork using a sonometer

Safety

Wear protective glasses/goggles.

Apparatus and materials

- sonometer (box, fixed peg F, two fixed bridges A and B, movable bridge C, pulley P, mass hanger and slot masses W)
- steel wire (diameter 0.5 mm)
- micrometer
- set of tuning forks and rubber bung

Introduction

In this practical, you will use a sonometer to determine the frequency of vibrations of a tuning fork.

The wave equation links the speed of a wave c with its frequency f and wavelength λ and is $c = \lambda f$. In the case of a stretched wire this speed is also given by:

$$c = \sqrt{\frac{T}{\mu}}$$

where T is the tension in the wire and μ the mass per unit length of the wire. Combining these equations we get:

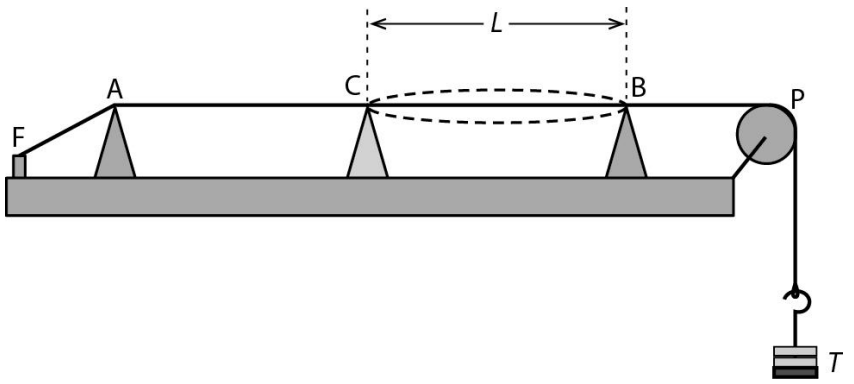
$$f = \frac{1}{\lambda}\sqrt{\frac{T}{\mu}}$$

When stationary waves form in the wire, in the case of the fundamental mode the length of the wire between the nodes, L, is equal to half a wavelength. Furthermore, for a wire of radius r and density ρ the mass per unit length is $\mu = \pi r^2 \rho$. Therefore, the frequency of the vibrations is given by:

$$f = \frac{1}{2L}\sqrt{\frac{T}{\pi r^2 \rho}} = \frac{1}{2Lr}\sqrt{\frac{T}{\pi \rho}}$$

Procedure

1 Use the micrometer to measure the diameter of the wire at five points and calculate its average value.



2 Position initially the movable bridge C midpoint between bridges A and B.

3 Strike the lowest frequency fork with the bung and place above bridge C.

4 Add slot masses to the mass hanger and pluck the wire between B and C until the wire emits the same note with as the tuning fork.

5 Move the position of C so that the frequency of vibrations on the wire is exactly the same as the tuning forks. (When the frequencies are close, beats will be heard from both the wire and the fork. These beats get slower and they can no longer be heard when the frequencies match.)

6 Record your measurements of L, f and T. (The tension T in the wire is equal to the load added at its end.)

7 Keeping the length between B and C the same, for forks of increasing frequency increase the tension so that the frequency of vibrations of the wire matches the ones of the fork. Record your measurements.

8 Process your data and plot a graph of suitable axes to have a linear (theoretical) relationship.

9 Calculate the gradient of the line and its uncertainty.

10 Use the value of the gradient to calculate the density of the material of the wire (steel) and compare it with the accepted value.

Questions

1 What is the relationship between the length of a stretched string and the frequencies at which resonance occurs?

2 What is the relationship between the number of antinode segments and the number of the resonant mode?

3 A wire is stretched by a 5 kg mass, the vibrating length is 1 m and the first harmonic has a frequency of 200 Hz. What is the mass per unit length μ of the wire?

