

# Melde's Experiment

## 1 Objective

- Generating standing, circularly polarised thread waves for various tension forces  $F$ , thread lengths  $s$  and thread densities  $m^*$ .
- Determining the phase velocity  $c$  of thread waves as a function of the tension force  $F$ , the thread length  $s$  and thread density  $m^*$ .

## 2 Prelab Questions

1. What are standing waves?
2. How do standing waves form and what are the conditions for their formation?

## 3 Principles

An elastically tensioned thread is attached to a mechanical vibrator and weighted from the other end is allowed to vibrate. Standing waves form and are analysed.

## 4 Apparatus

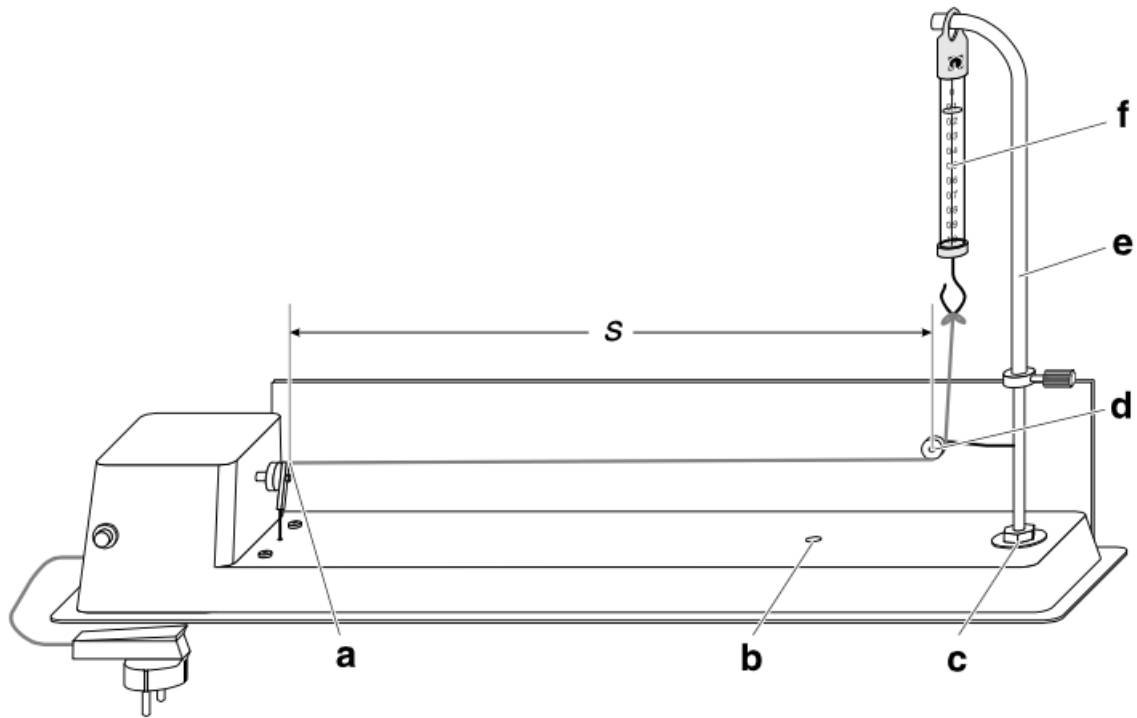


Fig. 1: Schematic representation of Melde's setup:

- a: Cam.
- b: Mounting point for thread length  $s = 0.35$  m.
- c: Mounting point for thread length  $s = 0.48$  m.
- d: Deflection pulley.
- e: Holding arm.
- f: Dynamometer.

## 5 Precautions

1. When measuring the length of the thread  $s$ , note that the actual length (effective) of the string is measured between cam **a** and the centre of the deflection pulley **d**.
2. Be careful not to overload the string and cause it to snap violently.

## 6 Experimental Steps

1. Measure the distance  $s$  between cam **a** and the centre of the deflection pulley **d**. **This is your effective thread length.**
2. Switch on the motor of the apparatus.
3. On the holding arm **e**, loosen the adjusting screw and vary the force  $F$  by changing the height of the holding arm until a standing wave of maximum amplitude with the wavelength  $\lambda = 2s$  is formed. **You should be able to see one oscillation antinode, in this case  $n = 1$ .**
4. Read off the corresponding force  $F_1$  and write this value in the experiment log.
5. Use the stroboscope to determine the excitation frequency  $f$ . Set the dial to the maximum frequency and slowly reduce the frequency until a simple standing sinusoidal wave becomes visible. **You should be able to see a perfect sine wave, standing still clearly.**
6. Repeat Steps [3-5] for different values of  $F_n$ ,  $f$  and  $n$ , until  $n = 6$ .
7. Switch off the motor.
8. Measure the mass  $m_0$  of the thread.
9. Measure the entire length of the thread  $s_0$ .

## 7 Evaluation

1. Calculate the linear mass density  $m^*$  of the thread.

$$m^* = \frac{m}{s} \quad (1)$$

2. Calculate the phase velocity (propagation speed)  $c_F$  of the thread for each  $F$ .

$$c_F = \sqrt{\frac{F}{m^*}} \quad (2)$$

3. Calculate the wavelength  $\lambda$  for each mode.

$$\lambda_n = \frac{2s}{n} \quad (3)$$

4. Using the results from Eq (3), calculate the phase velocity (propagation speed)  $c$ .

$$c = \lambda f \quad (4)$$

5. Plot  $c$  vs.  $c_F$  and calculate the slope. It should be  $\approx 1$ .
6. Explain why the slope should be  $\approx 1$ , and calculate the error percentage in your experiment.

## 8 Postlab Questions

1. What is the difference between standing waves on a string and standing waves in air columns?
2. What are the natural frequencies for a one dimensional string, with one free end and one fixed end, of length  $s$  and linear mass density  $m^*$  under tension  $F$ ?