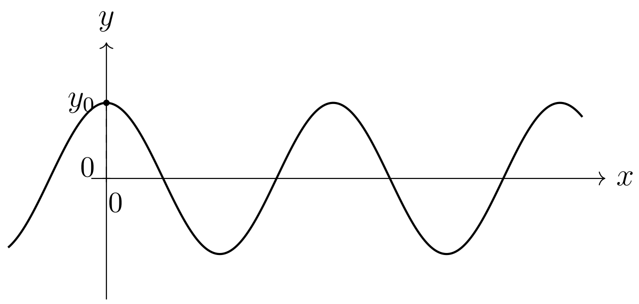
2nd Midterm Exam – Physics at FRI
14th January 2026, 19:00 – 20:30

1. Waves with an amplitude of $y_0 = 2\,\mathrm{cm}$ travel along a string at a speed of $c = 15\,\mathrm{m/s}$ and a wavelength of $\lambda = 0.3$ m. They travel in the positive x-direction, such that at $t = 0$ they have a maximum upward displacement at the point $x = 0$ (see sketch). What is the frequency ν of the wave? What is the wave vector? What is the displacement at the point $x_1 = 0.14\,\mathrm{m}$ at $t_1 = 0.2\,\mathrm{s}$?



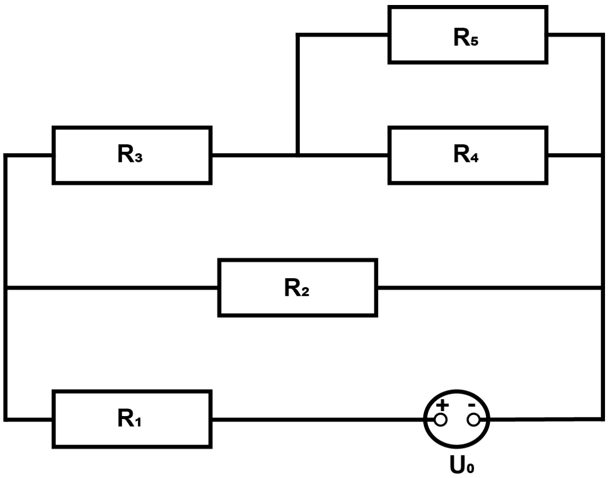
2. We have a circuit as shown in the sketch, where the resistors are $R_1 = 1\,\Omega$, $R_2 = 5\,\Omega$, $R_3 = 2\,\Omega$, $R_4 = 3\,\Omega$ and $R_5 = 7\,\Omega$. The battery's voltage is $U_0 = 5\,\mathrm{V}$.

   a) What is the equivalent resistance of the resistors in the circuit?

   b) What is the current flowing through the battery?

   c) What is the power dissipated by resistor R_2?

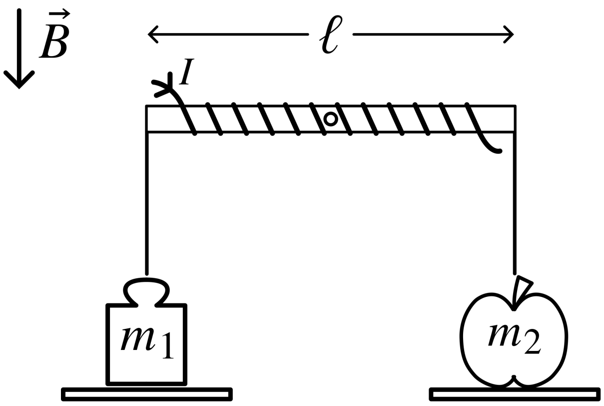
   d) What is the power dissipated by resistor R_4?



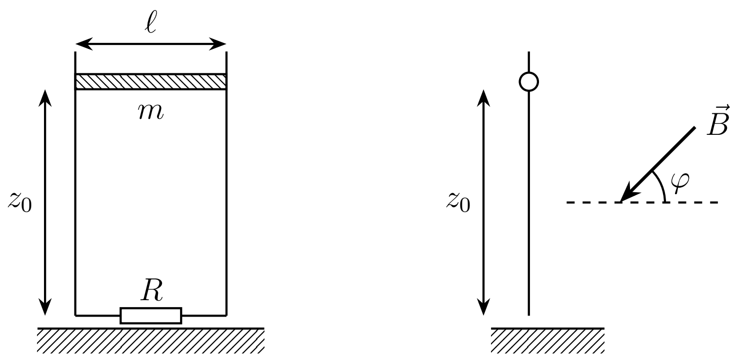
3. A fruit seller at the market comes up with an unusual idea for increasing his profits through fraud. He imagines a modified balance scale on which he would secretly wind a conductive wire in the form of a coil with $N = 1000$ turns around the horizontal bar of length $\ell = 30\,\mathrm{cm}$ (see sketch) and connect it to a voltage source hidden under the sales counter. While weighing the fruit, he would simultaneously send a current through the coil. Due to the presence of the Earth's magnetic field, the coil would change the horizontal equilibrium position of the scale such that the masses on each side of the scale could be different. The scale can rotate freely around the center of the horizontal bar. The Earth's magnetic field with a magnitude of $B = 60\,\mu\mathrm{T}$ points vertically downward (see sketch).

   a) Calculate the difference in masses m_1 and m_2 when the scale is at rest in the horizontal equilibrium position if a maximum current of $I = 10\,\mathrm{A}$ can be run through the coil in the direction shown in the sketch. The coil's radius is $r = 1.25\,\mathrm{cm}$.

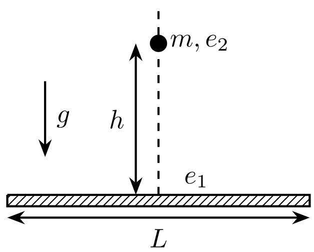
   b) Which of the masses m_1 and m_2 is larger in the equilibrium position? Justify your answer.



4. A conductive bar with mass $m = 0.2\,\mathrm{kg}$ and length $\ell = 3\,\mathrm{m}$ slides along two vertical conductive guides, which are connected at the bottom through a resistor with resistance $R = 1.5\,\Omega$. A homogeneous magnetic field with a density of $B = 0.5\,\mathrm{T}$ surrounds the system, and is angled at $\varphi = 45°$ relative to the horizontal plane (see the sketch of the side profile of the loop). A frictional force with a coefficient of friction $k_{\mathrm{tr}} = 0.2$ acts between the bar and the guides. At time $t = 0$, the crossbar is at a height of $z_0 = 3\,\mathrm{m}$. Calculate the time it takes for the crossbar to reach the bottom of the loop. You can assume constant velocity of the bar.



5. A charge $e_1 = 5 \cdot 10^{-6}\,\mathrm{A\,s}$ is evenly distributed on a light thin rod of length $L = 25\,\mathrm{cm}$. Find the height h above the rod at which a small ball with a charge $e_2 = 2 \cdot 10^{-7}\,\mathrm{A\,s}$ and mass $m = 10\,\mathrm{g}$ will be at rest if the ball is placed exactly above the center of the rod (see sketch)!



The following indefinite integrals may be helpful ($X = x^2 + a^2$, $+c$ is omitted):

$$\int \frac{dx}{X} = \frac{1}{a}\arctan\frac{x}{a}, \quad \int \frac{dx}{\sqrt{X}} = \ln\left(x + \sqrt{X}\right), \quad \int \frac{dx}{\sqrt{X^3}} = \frac{x}{a^2\sqrt{X}}, \quad \int \frac{x\,dx}{\sqrt{X^3}} = -\frac{1}{\sqrt{X}}.$$