Exercise Sheet 11

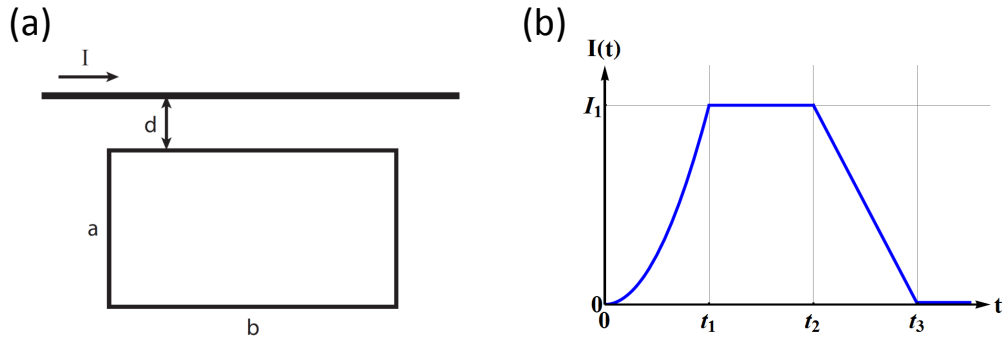
Discussion 26.11.2025

Exercise 1 - Induction in a loop

A rectangle loop wire of resistance R and sides a and b is placed at distance d from an infinitely long straight wire which carries a current I as shown in the figure below. Up to t_1 a parabolic increase, then constant, and after t_2 a linear decrease.

a) Evaluate the flux of the magnetic field through the loop.

b) In part (b) a plot of $I(t)$ is shown. Make a plot of the current induced $I_{ind}(t)$ in the loop as a function of time, and make sure to specify the values on the coordinates axes.



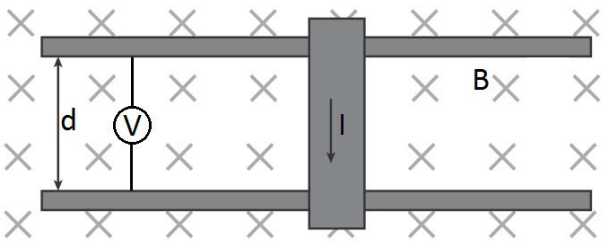
Exercise 2 - Rail gun

A metal bar of resistance R and mass m is placed and can slide over two conducting rails separated by a distance d, and they are immersed in a homogeneous magnetic field B, as shown in the figure below. We apply a voltage Φ between the two rails, so that a current I flows in the bar in the direction as shown in the figure.

a) Evaluate the current I as a function of the speed of the bar.

b) Determine the acceleration $\vec{a}$ of the bar.

c) Evaluate the maximum speed v_{max} attained by the bar. What is the current I when the bar reaches v_{max}?



Exercise 3 - Current loops

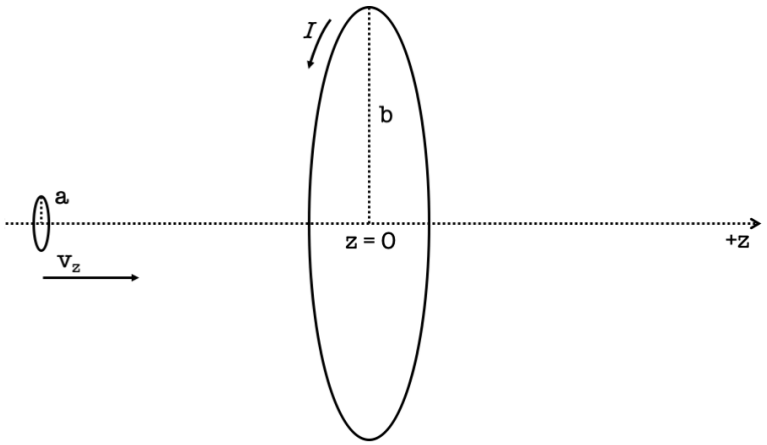
Consider a round wire loop (or coil) 1 of radius b and a round wire loop 2 of radius a, with $b >> a$, separated by a distance d and with their axis aligned with each other. A current I_1 flows in coil 1.

a) Evaluate the (mutual) inductance of loop 2 with respect to loop 1.

b) The dependence of the current I_1 on time is $I_1(t) = 0.5 \cos(2\pi 50\ Hz \cdot t)\ A$. Evaluate the peak of the induced voltage in the small loop ($d = 30\ cm$, $b = 10\ cm$, $a = 1\ cm$).

c) The current is set to be constant again at I_1 and the small coil is made to move towards and through the big one with a constant velocity v_z as illustrated in the figure. Determine the voltage induced in the small loop and indicate the direction of the induced dipole moment $\vec{m}$.

d) (discussion) Now consider that the small current loop in is inclined by 30° away from the plane of the big coil, but still moving along the axis of the latter. What is the frequency with which the small loop will precess. What will happen if the angle is 90°?



Exercise 4 - LR circuit

Consider a simple network made of a source (Φ_0), an inductance (L), and a resistance (R) in series.

a) At time $t = 0$ a switch is closed to connect the inductance and resistance to the source so that a current starts flowing. Determine the current flowing in the circuit as a function of time.

b) Consider a current I_0 flowing through the circuit when at time $t = 0$ a switch is switched that decouples the L and R from the source. Again determine the current flowing as a function of time.