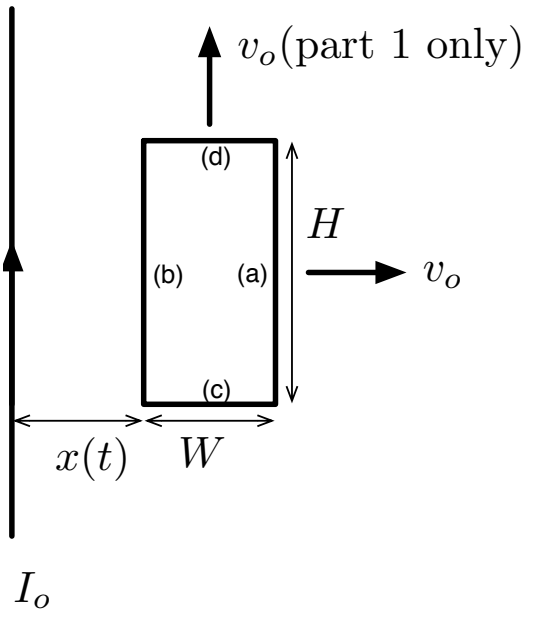
1 A loop in a magnetic field

A wire carries current I_o. A rectangular loop of wire of width W and height H, and total resistance $\mathcal{R}$ is pulled away from the wire with velocity v_o. The position of the lower left corner of wire is $x(t) = x_o + v_o t$.



Answer the following questions as a short report. Use neat hand drawn figures as necessary. Correct, clear, concise reports will receive top marks. The report should be neat enough that it can effectively convey the information. Working together is strongly encouraged. **Do NOT type your report**.

As with the previous report, your report will be graded on correctness (60%) and clarity and concision (40%) with clarity more important than concision.

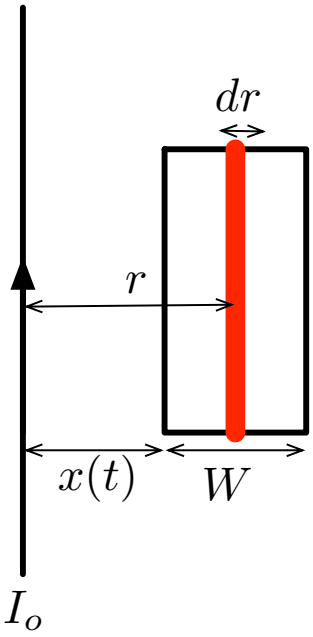
1. If the loop is pulled straight up at speed v_o, what is the direction of current flow? Explain.

2. Now if the loop is pulled to the right, what is the direction of current flow? Explain.

3. At a particular time moment when the separation between the wire and the loop is $x(t)$, show that the total flux through the loop is

$$\Phi_B(t) = \frac{\mu_o I_o H}{2\pi} \left[\ln(W + x(t)) - \ln(x(t))\right]$$

(Hint – you will need to integrate. First determine the flux, $d\Phi_B$, through a tiny rectangle of width dr displaced from the wire by a distance r – see below. Then sum up, i.e. integrate, the contributions from these rectangles.)



4. Show that the magnitude of the current in the loop is

$$I(t) = \frac{\mu_o I_o H v_o}{2\pi \mathcal{R}} \frac{W}{x(t)(W + x(t))}$$

5. Answer the following questions about the forces in the loop

   (a) For the two legs running vertically ((a) and (b)), determine the magnitude and direction of the force.

(b) For the horizontal legs ((c) and (d)), determine the direction of the force on the legs.

(c) Explain qualitatively what will the forces try to do and why?

(d) Combining the previous parts determine the net force on the rectangular loop, and the external force that must be provided to maintain a constant velocity. You should find

$$F_{\text{net}} = \left(\frac{\mu_o I_o H}{2\pi}\,\frac{W}{x(x+W)}\right)^2 \frac{v_o}{\mathcal{R}}$$

6. Using the net force found in part (5), determine the power delivered by the external force.

7. Using the current found in part(4), determine the power dissipated in the resistor. Explain why this result for the power dissipated in the resistor should agree with power delivered by the external force.