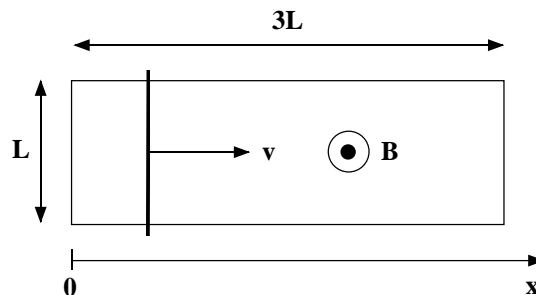


## Electrodynamics, spring 2008

### Exercise 6 (28.2., 29.2.; Friday group in English)

1. Consider a simple model of an electromagnet. A toroid (radius  $R$ ) is filled with a strongly magnetizing but linear material ( $\mu_r \gg 1$ ), and there is with a thin air gap (width  $L$ ,  $\mu_r L \ll 2\pi R$ ).
  - a) Determine the magnetic flux density  $\mathbf{B}$  and the magnetic field strength  $\mathbf{H}$  in the gap. Compare to a toroid filled by air only.
  - b) If the material were ferromagnetic then in the toroid  $B = B(H)$ . How could you then solve  $\mathbf{B}$ ?
2. Plane  $z = 0$  divides the space into two uniform regions:  $z > 0$  (permeability  $\mu_0$ ) and  $z < 0$  (permeability  $\mu$ ). There is an infinitely long line current (amplitude  $I$ ) above the plane at height  $h$ . Calculate the magnetic flux density everywhere. Tip: method of images.
3. Faraday's homopolar generator is a metal disc (radius  $a$ ), which is rotating at a constant angular velocity  $\omega$  around the axis across the centre of the disc. There is a uniform magnetic field  $\mathbf{B}_0$  parallel to the rotation axis. One end of a conducting wire is connected to the axis and another end touches the edge of the disc (the circuit also contains some useful device). The total resistance of the circuit is  $R$ . Calculate the current in the circuit.
4. A conducting rod moves at a constant velocity  $\mathbf{v}$  above a circuit as shown in the figure. There is uniform magnetic field  $\mathbf{B}$  perpendicular to the plane of the circuit.
  - a) Determine currents in the system when the rod is at  $x = L$ . The resistance per unit length is  $r$  for all conductors.
  - b) Calculate the power needed to move the rod, and compare it to the losses in the conductors.Inductance is neglected.



5. Calculate the inductance per unit length for a coaxial cable whose inner and outer radii are  $R_1$  and  $R_2$ , respectively. The relative permeability of the insulator between the inner and outer cores is 1.

Return the answers until Tuesday 26.2. 12 o'clock. On Thursday lecture on 28.2. we will revise the topics of the first exam (in Finnish).

The first exam will be on Friday 7.3. at 9-13 in D101.

Area of the exam: chapters 1-7 of the lecture notes and exercises 1-6.

During the week 3.-7.3. there are neither lectures nor exercises. Exercise 7 will be only on the last week of March.