

# Workbook



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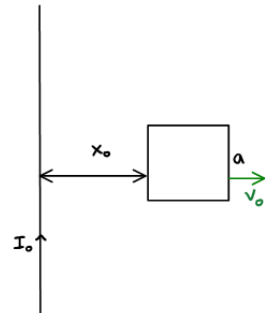
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# Faraday's Law of Induction

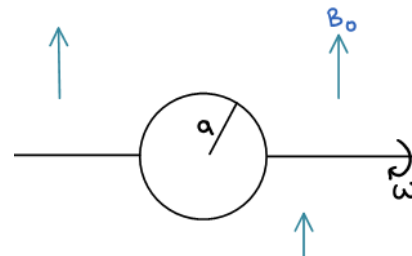
## Faraday's Law of Induction

### Questions

- 1) An infinite wire has current  $I_0$  flowing through it. A square frame of side length  $a$  and resistance  $R$  is located at  $x_0$ . At  $t = 0$  the frame begins to move with a velocity  $v_0 \hat{x}$ . There is a magnetic field  $\vec{B}$ .
- Calculate the emf.
  - Calculate the current.
  - What external force is required in order for the frame to move at a constant velocity?

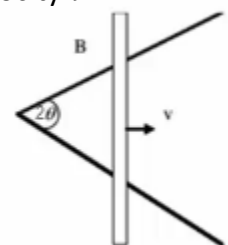


- 2) A conducting ring, of radius  $a$  and resistance  $R$ , is attached to two non conducting rods. These rods rotate the ring with an angular velocity  $\omega$ . There is a magnetic field  $B_0$  throughout.
- Calculate the emf.
  - Calculate the current in the ring
  - Now the magnetic field is  $B = B_0 \cos(\omega t)$ . Calculate the emf.

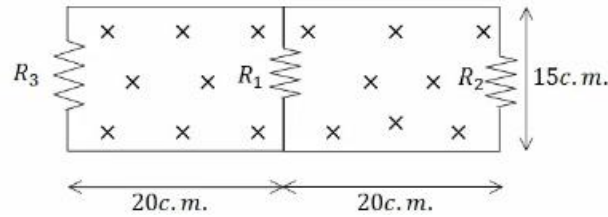


- 3) Two conducting tracks are placed at an angle of  $2\theta$  to one another. A conducting rod is placed on top of them, creating an equilateral triangle. At  $t = 0$  the rod is at the vertex. The rod moves across the tracks at a velocity  $v$ . There is a constant magnetic field  $B$  out of the page.

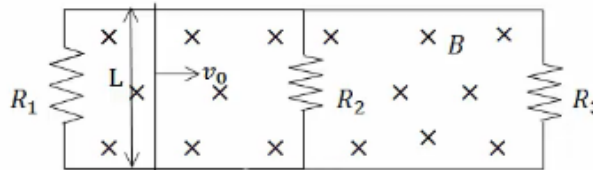
- Calculate the emf.
- The resistance of the rod, per unit length, is  $R_1$  and the tracks have no resistance. Calculate the current.
- Calculate the power transferred to the system to produce the current.



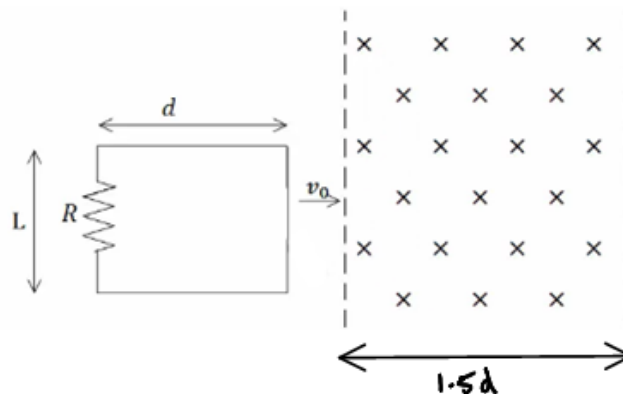
- 4) The resistors have the following resistances:  $R_1 = 1\Omega$ ,  $R_2 = 2\Omega$  and  $R_3 = 3\Omega$ . There is a magnetic field  $B = 2 \frac{T}{sec} \cdot t$  into the page. The height of the circuit is  $15cm$ , and the width of each sub-circuit is  $20cm$ . Calculate the current through each resistor.



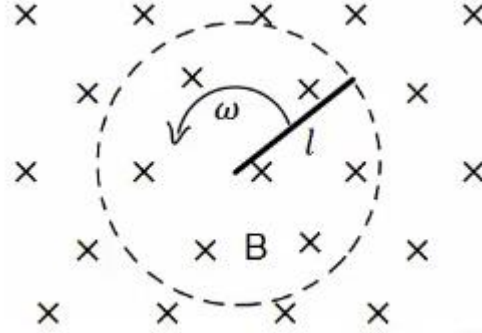
- 5) A conducting rod of length  $L$  moves along the sides of a circuit (see diagram). Inside the circuit is a uniform magnetic field  $B$  into the page. We are given  $B$ ,  $R_1$ ,  $R_2$ ,  $R_3$ ,  $v_0$ ,  $L$ . Calculate the current when:
- The rod is located between resistors  $R_1$  and  $R_2$ .
  - The rod is located between resistors  $R_2$  and  $R_3$ .



- 6) Given is a rectangular frame of length  $d$  and width  $L$ . It moves with a constant velocity  $v_0$  in the direction of a constant magnetic field  $B$ . The length of the region is  $1.5d$  and its width is infinite. The frame has a total resistance  $R$ . At  $t = 0$  the right side of the frame enters the region of the magnetic field.
- Calculate the emf of the frame.
  - Calculate the current in the frame.
  - Calculate the force required in order for the frame to move at a constant velocity.
  - What is the power of the force and the power turned to heat in the resistor?



- 7) A rod of length  $L$  rotates about one of its edges at a constant angular velocity  $\omega$ .  
The rod is in a uniform magnetic field  $B$ , which is perpendicular to the plane of rotation.
- Calculate the voltage between the two edges of the rod by integration using Lorentz's law.
  - Calculate the voltage in the rod using Faraday's law.



\*For the solutions go see the videos