SFU Department of Physics

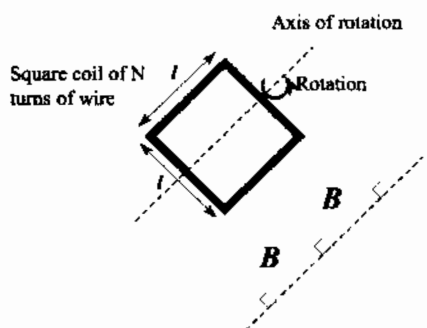
phys102q – Fall 2004 – Assignment 6.
Due Thr, Nov 4, 2004 at 23:59hrs. CAPA ID is **2527**

A piece of wire is formed into a circular loop of radius 25cm. The loop has a resistance of 165Ω. A magnetic field of 0.5T is applied perpendicular to the plane of the loop and then increased at a constant rate by a factor of 2.8 in 15s.

1. [1 pt.] Calculate the magnitude of the induced emf in the loop during that time.

2. [1 pt.] Calculate the current induced in the loop during that time.

3. [1 pt.] Calculate the average induced emf when the magnetic field is constant at 1.40T while the loop is pulled horizontally out of the magnetic field region in 7.7s.



4. [1 pt.] What is the peak $e.m.f$ produced by a 52-turn square coil (of side l=17.0cm, as shown in the diagram above,) rotating on an axis with a frequency of 36.0Hz in a uniform magnetic field of 0.750T perpendicular to the coil's axis of rotation?

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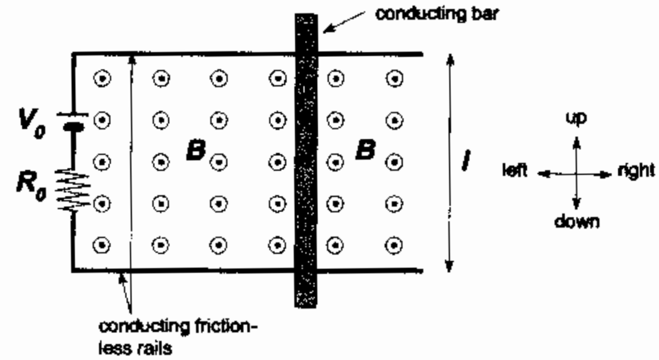
5. [1 pt.] You have a piece of thin wire that is 25.5m long, a constant uniform magnetic field of 0.130T, and a device that can rotate a coil at a fixed frequency of 71.5Hz. What is the radius of a circular coil made from this length of wire that will produce an $ACe.m.f$ of maximum voltage 118V? (Neglect the amount of wire used in the connections.)

Consider a battery $e.m.f = V_0$ attached to two conducting frictionless rails that are a distance l apart. There is a magnetic field **B** perpendicular to the rails (out of the page), and a conducting bar can slide over the rails perpendicular to them as well as the field, as shown in the diagram below (Note, assume that any field effects from the battery are negligible.) The bar is placed on the rails, starts from rest, and accelerates.

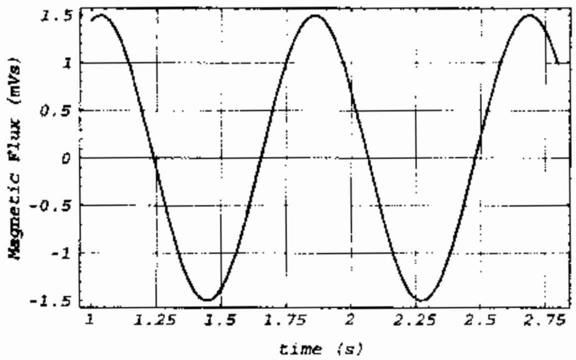


6. [1 pt.] Consider the situation as described and the following statements. If the statement is true, answer 'T', if it is false, answer 'F', and if the answer cannot be determined from the information provided, answer 'C'. Answer the questions in the order that they are posed - no spaces, no commas. For example if 'B' and 'C' are true and there is not enough information to answer 'D' and the rest are false, then answer 'FTTCF'.

A)The bar will accelerate towards the battery.
B)If the magnetic field were reversed, the bar would accelerate away from the battery.
C)The direction of the induced e.m.f in the bar will be ↑
D)Faraday's Law is such that changing magnetic fields generate electric fields.
E)Lenz's Law is such that induced currents produce magnetic fields that tend to magnify the flux changes that induce those currents.

7. [1 pt.] Given that the total resistance of the circuit is R_0=0.245Ω, V_0=3.0V, l=0.145m, and **B**=0.280T, calculate the current in the bar when its speed is 1.25m/s.

A thin square coil has 79 turns of conducting wire. It is rotating with constant angular velocity in a uniform magnetic field of 0.309T. The axis of rotation lies in the plane of the coil, and is perpendicular to the magnetic field. The graph below shows the magnetic flux through the coil as a function of time.



8. [1 pt.] What is the length of a side of the coil?

9. [1 pt.] Calculate the angular velocity of the coil.

10. [1 pt.] Evaluate the magnitude of the induced voltage in the coil, V_{emf}, at time $t = 2.50$s.

11. [1 pt.] The total electrical resistance of the coil of wire is 3.14Ω. Calculate the power dissipated at time $t =$ 2.50s.

12. [1 pt.] Select all correct answers for the current in the loop. B field shown by x's in fig2. North is up on both figures.

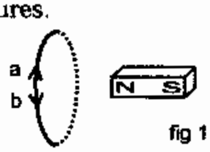


fig 1.

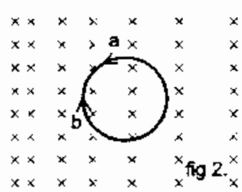


fig 2.

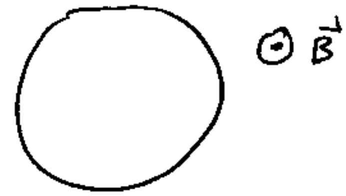
A) fig2:Loop moving south, no induced current.
B) fig1:Magnet moving east, induced current 'a'.
C) fig1:Loop moving west, induced current 'a'.
D) fig2:Loop moving north, induced current 'b'.
E) fig1:Magnet moving west, induced current 'a'.
F) fig2:Loop moving east, induced current 'b'.

Baking Tip: 1/4 teaspoon ground thyme plus 3/4 teaspoon ground sage can be substituted for 1 teaspoon poultry seasoning.

Physics 102

CAPA set #6 solutions.

1. $r = 25\ cm = 0.25\ m$, $N = 1$



$R = 165\ \Omega$.

$B_0 = 0.5\ T$

$$\frac{dB}{dt} = \frac{\Delta B}{\Delta t} = \frac{2.8 B_0 - B_0}{15\ sec} = \frac{1.8 B_0}{15 sec.} = \frac{(1.8)(0.5)}{15} = 0.06\ T/s$$

$$|\mathcal{E}_{emf}| = \frac{d\Phi}{dt} = A \cdot \frac{dB}{dt} = \pi r^2 \cdot \frac{\Delta B}{\Delta t}.$$

$$= \pi (0.25)^2 \cdot 0.06$$

$$= 0.0118\ V.$$

2. $$I = \frac{\mathcal{E}}{R} = \frac{0.0118\ V}{165\ \Omega} = 7.14 \times 10^{-5}\ A.$$

3. $$\left|\frac{\Delta B}{\Delta t}\right| = \left|\frac{0 - 1.4\ T}{7.7\ s}\right| = 0.18182\ T/s.$$

$$|\mathcal{E}_{emf}| = \pi r^2 \left|\frac{\Delta B}{\Delta t}\right| = \pi (0.25)^2 (0.18182) = 0.0357\ V$$

4. $$\mathcal{E} = -N \frac{d\Phi}{dt}, \quad \left[\Phi = BA \cdot \cos\theta = BL^2 \cos(2\pi f t)\right]$$

$$= N \cdot 2\pi f BL^2 \cdot \sin(2\pi f t)$$

$$\mathcal{E}_{peak} = N \cdot 2\pi f \cdot BL^2 = (52)(2\pi)(36)(0.75)(0.17)^2 = 255\ V$$

5. length of wire : $L = 25.5\ m$.

N turns of loop with radius r : $2\pi r \cdot N = L$, $A = \pi r^2$

$$\mathcal{E}_{emf} = -N \cdot \frac{d\Phi}{dt} = -N \cdot \pi r^2 \cdot B \cdot \frac{d}{dt}[\cos(2\pi f t)]$$

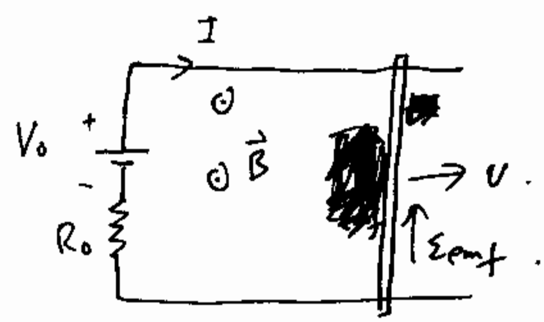
$$= N \pi r^2 \cdot B \cdot (2\pi f) \sin(2\pi f t)$$

$$\mathcal{E}_{emf\,max} = 2N \cdot \pi^2 f r^2 B = \pi L r f B \quad (\because 2\pi r N = L)$$

$$r = \frac{\mathcal{E}_{max}}{\pi L f B} = \frac{118}{\pi (25.5)(71.5)(0.13)} = 0.158\ m.$$

6. T T T T F

7.



$$I = \frac{V_0 - |\mathcal{E}_{emf}|}{R_0}$$

$$= \frac{V_0 - B\ell v}{R_0}$$

$$= \frac{3.0 - (0.28)(0.145)(1.25)}{0.245\,\Omega}$$

$$= 12.0\ A.$$

$$|\mathcal{E}_{emf}| = B\ell v = (0.28)(0.145)(1.25)$$

8. $\Phi = BA\cos\theta = Bl^2\cos(\omega t + \varphi)$

$\Phi_{max} = Bl^2 = 1.5\times10^{-3}$ web

$l = \sqrt{\frac{\Phi_{max}}{B}} = \sqrt{\frac{1.5\times10^{-3}}{0.309}} = 0.0697$ m.

9. $T = 0.90$ sec (from the graph)

$\omega = \frac{2\pi}{T} = 6.98$ rad/s.

10. $\varepsilon = -N\frac{d\Phi}{dt} = BNl^2\cdot\omega\cdot\sin(\omega t+\varphi)$

from the diagram, when $t=1.82$, $\omega t + \varphi = 0$

$\varphi = -\omega\cdot t = -(6.98)(1.82) = -12.7$ rad.

$\therefore\ \varepsilon = NBl^2\omega\sin(\omega t - 12.7)$

(a) $t = 2.50s$, $\varepsilon = (79)(0.309)(0.0697)^2(6.98)\sin(6.98t - 12.7)$

$= 0.827$ V

11. $P = \frac{\varepsilon^2}{R} = (\varepsilon I) = \frac{(0.827V)^2}{3.14\,\Omega} = 0.219$ W.

12. ABCF.