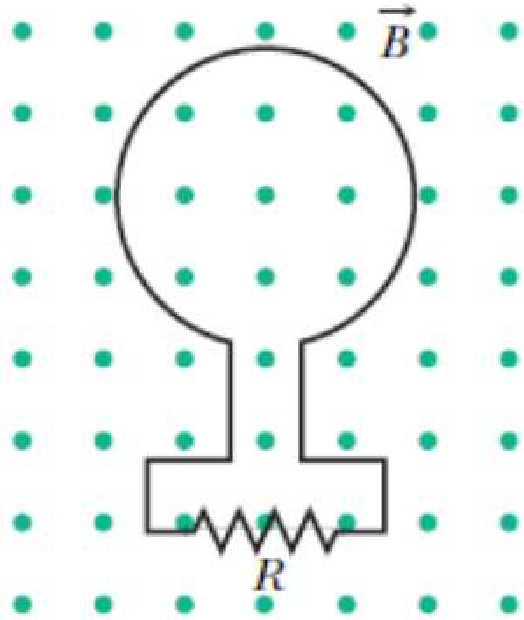
Problem 1

In the figure, the magnetic flux through the loop increases according to the relation $\Phi_B = 6t^2 + 7t$, where Φ_B is in milliwebers and t is in seconds. (a) What is the magnitude of the emf induced in the loop when $t = 2$ s? (b) Is the direction of the current through R to the right or left? (02小題)



(a) the emf=_________mV

01: **ANS:=31**

(b) the direction=_________;to right=1,to left=2

02: **ANS:=2**

Solution:

$$(a)|\epsilon| = |\frac{d\Phi_B}{dt}| = \frac{d}{dt}(6t^2 + 7t)$$

$$= 12t + 7$$

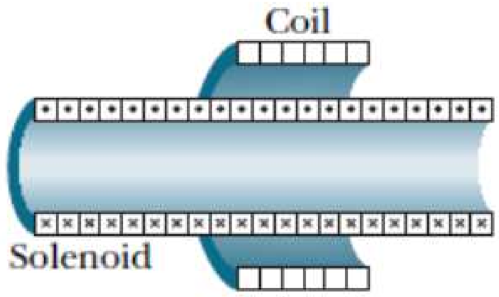
$$= 12(2) + 7$$

$$= 31mV$$

(b) Appealing to Lenz's law we see that the current flow in the loop is clockwise. Thus, the current is to left through R.

Problem 2

In the figure, a 120-turn coil of radius 1.8 cm and resistance 5.3 Ω is coaxial with a solenoid of 220 turns/cm and diameter 3.2 cm. The solenoid current drops from $1.5A$ to zero in time interval $\Delta t = 25$ ms. What current is induced in the coil during Δt? (01小題)



the current $I =$ ________ A

03: **ANS:=0.03**

$$\epsilon = -N\frac{d\Phi_B}{dt}$$

$$= -NA\frac{dB}{dt}$$

$$= -NA\frac{d}{dt}(\mu_0 ni)$$

$$= -N\mu_0 nA\frac{di}{dt}$$

$$= -N\mu_0 n(\pi r^2)\frac{di}{dt}$$

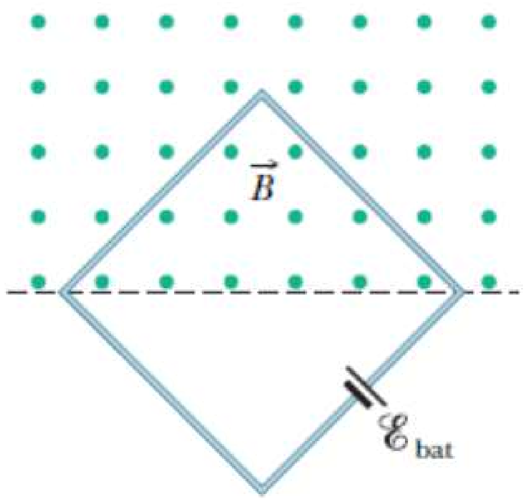
$$= -(120)(4\pi * 10^{-7}T\cdot m/A)(22000/m)\pi(0.016m)^2(\frac{1.5A}{0.025s})^2$$

$$= 0.16V$$

$$i = \frac{|\epsilon|}{R} = \frac{0.016V}{5.3\Omega} = 0.03A$$

Problem 3

A square wire loop with 2.00 m sides is perpendicular to a uniform magnetic field, with half the area of the loop in the field as shown in the figure. The loop contains an ideal battery with emf $\epsilon = 20$ V . If the magnitude of the field varies with time according to $B = 0.042 - 0.87t$, with B in teslas and t in seconds, what are (a) the net emf in the circuit and (b) the direction of the (net) current around the loop? (02小題)



(a) the net emf=________V

04: **ANS:=21.74**

(b) the direction=____

05: **ANS:=2**

(a) Let L be the length of a side of the square circuit. Then the magnetic flux through the circuit is $\Phi_B = L^2 B/2$, and the induced emf is

$$\varepsilon_i = -\frac{d\Phi_B}{dt} = -\frac{L^2}{2}\frac{dB}{dt}.$$

Now $B = 0.042 - 0.870t$ and $dB/dt = -0.870$ T/s. Thus,

$$\varepsilon_i = \frac{(2.00\text{ m})^2}{2}(0.870\text{ T/s}) = 1.74\text{ V}.$$

The magnetic field is out of the page and decreasing so the induced emf is counterclockwise around the circuit, in the same direction as the emf of the battery. The total emf is

$$\varepsilon + \varepsilon_i = 20.0\text{ V} + 1.74\text{ V} = 21.7\text{ V}.$$

(b) The current is in the sense of the total emf (counterclockwise).

Problem 4

If 50.0 cm of copper wire (diameter =1mm) is formed into a circular loop and placed perpendicular to a uniform magnetic field that is increasing at the constant rate of 10.0 mT/s, at what rate is thermal energy generated in the loop? The resistivity of copper is $1.69 \times 10^{-8}\ \Omega \cdot \text{m}$. (01小題)

________W

06: **ANS:=3.68E-6**

$$R = \rho L/A, \qquad A_{\text{loop}} = \pi r_{\text{loop}}^2 = \pi\left(\frac{L}{2\pi}\right)^2 \qquad L = 0.500\ \text{m}$$

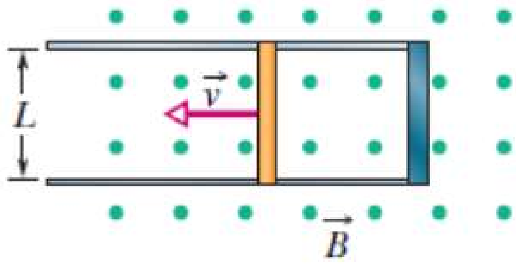
$$\varepsilon = \frac{d\Phi_B}{dt} = A_{\text{loop}}\frac{dB}{dt} = \frac{L^2}{4\pi}\frac{dB}{dt} \qquad dB/dt = 0.0100\ \text{T/s}.$$

$$P = \frac{\varepsilon^2}{R} = \frac{(L^2/4\pi)^2(dB/dt)^2}{\rho L/(\pi d^2/4)} = \frac{d^2L^3}{64\pi\rho}\left(\frac{dB}{dt}\right)^2 = \frac{(1.00\times10^{-3}\ \text{m})^2(0.500\ \text{m})^3}{64\pi(1.69\times10^{-8}\Omega\cdot\text{m})}(0.0100\ \text{T/s})^2$$

$$= 3.68\times10^{-6}\ \text{W}.$$

Problem 5

In the figure, a metal rod is forced to move with constant velocity v along two parallel metal rails, connected with a strip of metal at one end. A magnetic field of magnitude $B = 0.35$ T points out of the page. (a) If the rails are separated by $L = 25$ cm and the speed of the rod is 55.0 cm/s, what emf is generated? (b) If the rod has a resistance of 18 Ω and the rails and connector have negligible resistance, what is the current in the rod? (c) At what rate is energy being transferred to thermal energy? (03小題)



(a) the emf=________V

07: **ANS:=0.0481**

$$\varepsilon = BLv = (0.350\ \text{T})(0.250\ \text{m})(0.55\ \text{m/s}) = 0.0481\ \text{V}.$$

(b) the currrent=________A

08: **ANS:=0.00267**

$$i = 0.0481\ \text{V}/18.0\ \Omega = 0.00267\ \text{A}.$$

(c) ________W

09: **ANS:=0.000129**

$$P = i^2R = 0.000129\ \text{W}.$$

Problem 6

A long solenoid has a diameter of 12.0 cm. When a current i exists in its windings, a uniform magnetic field of magnitude $B = 30$ mT is produced in its interior. By decreasing i, the field is caused to decrease at the rate of 6.50 mT/s. Calculate the magnitude of the induced electric field (a) 2.20 cm and (b) 8.20 cm from the axis of the solenoid. (02小題)

(a) ________V/m

10: **ANS:=7.15E-5**

(b) ________V/m

11: **ANS:=1.43E-4**

Solution:

(a) $E = \frac{1}{2}\frac{dB}{dr}r = \frac{1}{2}(6.5 * 10^{-3}T/s)(0.0220m) = 7.15 * 10^{-5}V/m$

(b) $E = \frac{1}{2}\frac{dB}{dr}\frac{R^2}{r} = \frac{1}{2}(6.5 * 10^{-3}T/s)\frac{(0.06m)^2}{0.0820m} = 1.43 * 10^{-4}V/m$

Problem 7
The magnetic field of a cylindrical magnet that has a pole-face diameter of 3.3 cm can be varied sinusoidally between 29.6 T and 30.0 T at a frequency of 15 Hz. At a radial distance of 1.6 cm, what is the amplitude of the electric field induced by the variation? (01小題)

________V/m

12: **ANS:=<u>0.15</u>**

$$B(t) = B_0 + B_1 \sin(\omega t + \phi_0),$$

$$B_0 = (30.0\ \text{T} + 29.6\ \text{T})/2 = 29.8\ \text{T}$$

$$B_1 = (30.0\ \text{T} - 29.6\ \text{T})/2 = 0.200\ \text{T}.$$

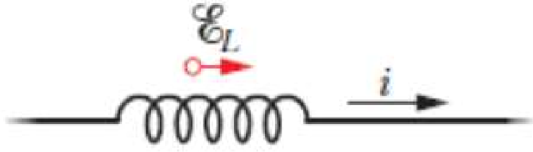
$$\omega = 2\pi f$$

$$E = \frac{1}{2}\left(\frac{dB}{dt}\right)r = \frac{r}{2}\frac{d}{dt}\left[B_0 + B_1 \sin(\omega t + \phi_0)\right] = \frac{1}{2}B_1 \omega r \cos(\omega t + \phi_0).$$

$$E_{max} = \frac{1}{2}B_1(2\pi f)r = \frac{1}{2}(0.200\,\text{T})(2\pi)(15\ \text{Hz})(1.6\times10^{-2}\ \text{m}) = 0.15\ \text{V/m}.$$

Problem 8

At a given instant the current and self-induced emf in an inductor are directed as indicated in the figure. (a) Is the current increasing or decreasing? (b) The induced emf is 17 V, and the rate of change of the current is 25 kA/s; find the inductance. (02小題)



(a) the current=________;increasing=1,decreasing=2

13: **ANS:=2**

(b) the inductance=________H

14: **ANS:=6.8e-4**

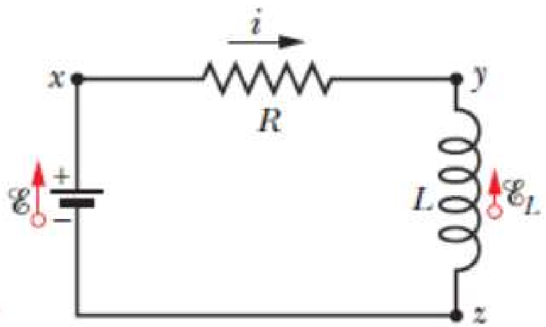
the coil wants to fight the changes

i must be in the process of decreasing.

$$L = \left|\frac{\varepsilon}{di/dt}\right| = \frac{17\,\text{V}}{2.5\,\text{kA/s}} = 6.8\times10^{-4}\ \text{H}.$$

Problem 9

For the circuit of the figure, assume that $\epsilon = 10V$,$R = 6.7\,\Omega$, and $L = 5.5$ H. The ideal battery is connected at time $t = 0$. (a) How much energy is delivered by the battery during the first 2.00 s? (b) How much of this energy is stored in the magnetic field of the inductor? (c) How much of this energy is dissipated in the resistor? (03小題)



(a) the energy=_________J

15: **ANS:=18.7**

(b) the energy=_________J

16: **ANS:=5.10**

(c) the energy=_________J

17: **ANS:=13.6**

Problem 10

Two coils are at fixed locations. When coil 1 has no current and the current in coil 2 increases at the rate 15.0 A/s, the emf in coil 1 is 25.0 mV. (a) What is their mutual inductance? (b) When coil 2 has no current and coil 1 has a current of 3.60 A, what is the flux linkage in coil 2? (02小題)

(a) the mutual inductance=__________mH

18: **ANS:=1.67**

(b) the flux=_________Wb

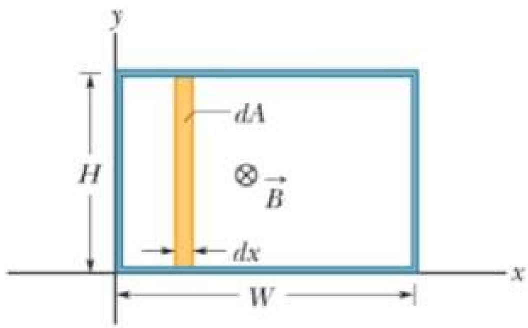
19: **ANS:=6E-3**

$$M = \frac{\varepsilon_1}{|di_2/dt|} = \frac{25.0\,\text{mV}}{15.0\,\text{A/s}} = 1.67\,\text{mH}\ .$$

$$N_2\Phi_{21} = Mi_1 = (1.67\,\text{mH})(3.60\,\text{A}) = 6.00\,\text{mWb}\ .$$

Problem 11

The figure shows a rectangular loop of wire immersed in a nonuniform and varying magnetic field that is perpendicular to and directed into the page. The field's magnitude is given by $B(t,x) = 4t^2x^2$. The loop has width W and height H.



(a)What is the magnetic flux through the loop as a function of t?

(b)What is the magnitude of the induced emf around the loop at t? (02小題)

(a)magnetic flux $\Phi(t)$=______ [t,H,W]

20: **ANS:=<u>4/3*H*W**3*t**2</u>**

(b)the induced emf, ε=_______ [t,H,W]

21: **ANS:=<u>8/3*H*W**3*t</u>**