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Institution: Beijing-Dublin International College
Module: University Physics 2 (BDIC2008J)
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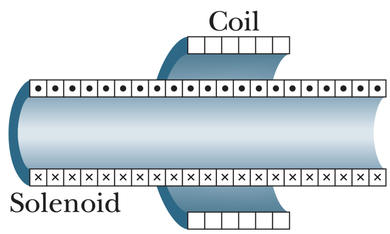
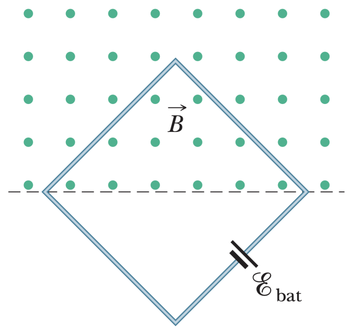
Problem Set 7

Electromagnetic Induction

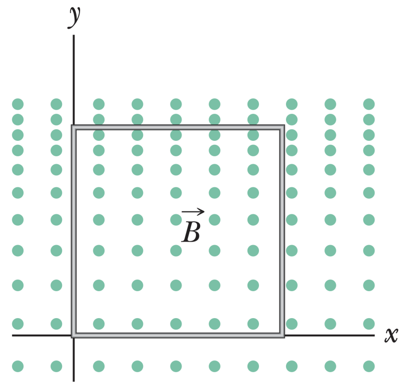
Problem 1. *In the Figure below, a* 120-turn *coil of radius* 1.8 cm *and resistance* 5.3 Ω *is coaxial with a solenoid of* 220 turns/cm *and diameter* 3.2 cm. *The solenoid current drops from* 1.5 A *to zero in the time interval* $\Delta t = 25\,\text{ms}$. *What current is induced in the coil during* Δt*?*



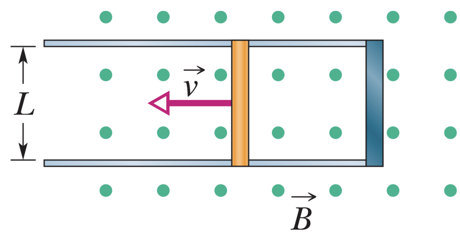
Problem 2. *A square wire loop with* $2.00\,\mathrm{m}$ *sides is perpendicular to a uniform magnetic field, with half the area of the loop in the field as shown in the Figure. The loop contains an ideal battery with emf* $\mathscr{E} = 20.0\,\mathrm{V}$*. If the magnitude of the field varies with time according to* $B = 0.0420 - 0.870\,t$*, 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?*



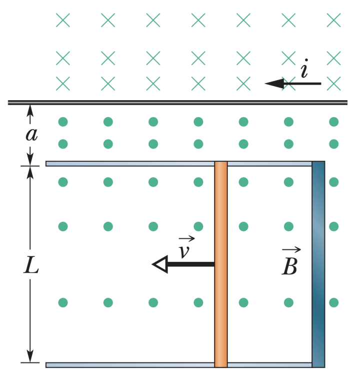
Problem 3. *As seen in the Figure, a square loop of wire has sides of length* $2.0\,\mathrm{cm}$. *A magnetic field is directed out of the page; its magnitude is given by* $B = 4.0t^2y$, *where* B *is in teslas,* t *is in seconds, and* y *is in meters. At* $t = 2.5\,\mathrm{s}$, *what are the* ***(a)*** *magnitude and* ***(b)*** *direction of the emf induced in the loop?*



Problem 4. *In the Figure below, a metal rod is forced to move with constant velocity* $\vec{v}$ *along two parallel metal rails, connected with a strip of metal at one end. A magnetic field of magnitude* $B = 0.350\,\mathrm{T}$ *points out of the page.* ***(a)*** *If the rails are separated by* $L = 25.0\,\mathrm{cm}$ *and the speed of the rod is* $55.0\,\mathrm{cm/s}$*, what emf is generated?* ***(b)*** *If the rod has a resistance of* $18.0\,\Omega$ *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?*

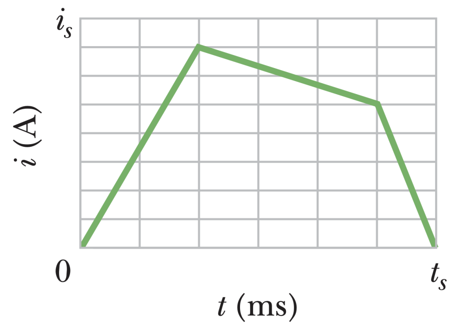


Problem 5. *The figure below shows a rod of length* $L = 10.0\,\text{cm}$ *that is forced to move at constant speed* $v = 5.00\,\text{m/s}$ *along horizontal rails. The rod, rails, and connecting strip at the right form a conducting loop. The rod has resistance* $0.400\,\Omega$*; the rest of the loop has negligible resistance. A current* $i = 100\,\text{A}$ *through the long straight wire at distance* $a = 10.0\,\text{mm}$ *from the loop sets up a (nonuniform) magnetic field through the loop. Find the* ***(a)*** *emf and* ***(b)*** *current induced in the loop.* ***(c)*** *At what rate is thermal energy generated in the rod?* ***(d)*** *What is the magnitude of the force that must be applied to the rod to make it move at constant speed?* ***(e)*** *At what rate does this force do work on the rod?*

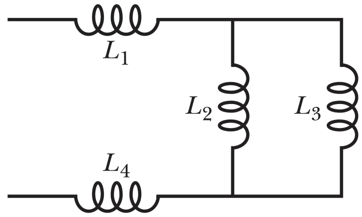


Problem 6. *A long solenoid has a diameter of* $12.0\,\mathrm{cm}$. *When a current* i *exists in its windings, a uniform magnetic field of magnitude* $B = 30.0\,\mathrm{mT}$ *is produced in its interior. By decreasing* i*, the field is caused to decrease at the rate of* $6.50\,\mathrm{mT/s}$. *Calculate the magnitude of the induced electric field* ***(a)*** $2.20\,\mathrm{cm}$ *and* ***(b)*** $8.20\,\mathrm{cm}$ *from the axis of the solenoid.*

Problem 7. *The current i through a* $4.6\,\mathrm{H}$ *inductor varies with time t as shown by the graph, where the vertical axis scale is set by is $i_s = 8.0\,\mathrm{A}$ and the horizontal axis scale is set by $t_s = 6.0\,\mathrm{ms}$. The inductor has a resistance of $12\,\Omega$. Find the magnitude of the induced emf ε during time intervals* ***(a)*** *0 to* $2\,\mathrm{ms}$, ***(b)*** $2\,\mathrm{ms}$ *to* $5\,\mathrm{ms}$, *and* ***(c)*** $5\,\mathrm{ms}$ *to* $6\,\mathrm{ms}$. *(Ignore the behaviour at the ends of the intervals.)*



Problem 8. *The inductor arrangement of the figure, with* $L_1 = 30.0\,\text{mH}$, $L_2 = 50.0\,\text{mH}$, $L_3 = 20.0\,\text{mH}$, *and* $L_4 = 15.0\,\text{mH}$, *is to be connected to a varying current source. What is the equivalent inductance of the arrangement?*



Problem 9. *A solenoid that is* $85.0\,\mathrm{cm}$ *long has a cross-sectional area of* $17.0\,\mathrm{cm}^2$*. There are 950 turns of wire carrying a current of* $6.60\,\mathrm{A}$*.* ***(a)*** *Calculate the energy density of the magnetic field inside the solenoid.* ***(b)*** *Find the total energy stored in the magnetic field there (neglect end effects).*

Problem 10. *A rectangular loop of N closely packed turns is positioned near a long straight wire as shown in the figure. What is the mutual inductance M for the loop-wire combination if $N = 100$, $a = 1.0\,\text{cm}$, $b = 8.0\,\text{cm}$, and $l = 30\,\text{cm}$?*