GPN2-LC11

Problem 1

A coil is connected in series with a 10.0 kΩ resistor. An ideal 50.0 V battery is applied across the two devices, and the current reaches a value of 2.00 mA after 5.00 ms. (a)Find the time constant τ_L. (b) Find the inductance of the coil. (c) How much energy is stored in the coil at this same moment? (03小題)

(a)τ_L=_______ s

01: **ANS:=9.79E-3**

(b)L=______ H

02: **ANS:=97.9**

(c)U_B=______ J

03: **ANS:=1.96E-4**

Solution:

(a) If the battery is applied at time $t = 0$ the current is given by

$$i = \frac{\varepsilon}{R}\left(1 - e^{-t/\tau_L}\right),$$

where ε is the emf of the battery, R is the resistance, and τ_L is the inductive time constant (L/R). This leads to

$$e^{-t/\tau_L} = 1 - \frac{iR}{\varepsilon} \Rightarrow -\frac{t}{\tau_L} = \ln\left(1 - \frac{iR}{\varepsilon}\right).$$

Since

$$\ln\left(1 - \frac{iR}{\varepsilon}\right) = \ln\left[1 - \frac{(2.00\times10^{-3}\,\text{A})(10.0\times10^{3}\,\Omega)}{50.0\,\text{V}}\right] = -0.5108,$$

the inductive time constant is

$$\tau_L = t/0.5108 = (5.00\times10^{-3}\ \text{s})/0.5108 = 9.79\times10^{-3}\ \text{s}$$

and the inductance is

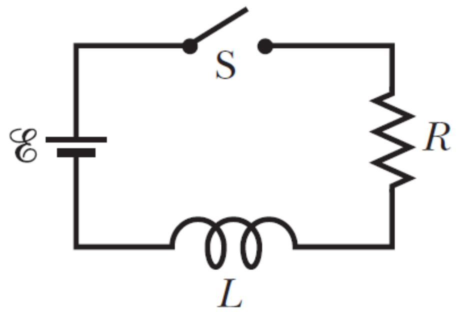
$$L = \tau_L R = (9.79\times10^{-3}\,\text{s})(10.0\times10^{3}\,\Omega) = 97.9\,\text{H}.$$

(b) The energy stored in the coil is

$$U_B = \frac{1}{2}Li^2 = \frac{1}{2}(97.9\,\text{H})(2.00\times10^{-3}\,\text{A})^2 = 1.96\times10^{-4}\,\text{J}.$$

Problem 2

In the figure, a 12.0 V ideal battery, a 20.0Ω resistor, and an inductor are connected by a switch at time $t = 0$. At what rate is the battery transferring energy to the inductor's field at $t = 1.61\tau_L$? (01小題)



$\frac{dU_B}{dt}$ =______ W

04: **ANS:=1.15**

Solution:

The energy stored when the current is i is

$$U_B = \frac{1}{2}Li^2$$

where L is the self-inductance. The rate at which this is developed is

$$\frac{dU_B}{dt} = Li\frac{di}{dt}$$

where i is given by Eq. 30-41 and di/dt is obtained by taking the derivative of that equation (or by using Eq. 30-37). Thus, using the symbol V to stand for the battery voltage (12.0 volts) and R for the resistance (20.0 Ω), we have, at $t = 1.61\tau_L$,

$$\frac{dU_B}{dt} = \frac{V^2}{R}\left(1 - e^{-t/\tau_L}\right)e^{-t/\tau_L} = \frac{(12.0\text{ V})^2}{20.0\Omega}\left(1 - e^{-1.61}\right)e^{-1.61} = 1.15\text{ W}.$$

Problem 2

In the figure above, assume that $R = 4.0k\Omega$, $L = 8.0\mu H$, and the ideal battery has $\mathscr{E} = 20V$. How long after switch S is closed is the current 2.0 mA? (01小題)

the time t=______ s

05: **ANS:=1.02**

Problem 3

A coil with 150 turns has a magnetic flux of 50.0 nT.m^2 through each turn when the current is 2.00 mA. (a) What is the inductance of the coil? What are the (b) inductance and (c) flux through each turn when the current is increased to 4.00 mA? (d) What is the maximum emf $\mathscr{E}$ across the coil when the current through it is given by $i = (3.00 \times 10^{-3})\cos(377t)$, with all quantities in SI units? (04小題)

(a)L=_____ H

06: **ANS:=3.75E-3**

when the current is increased to 4.00 mA :
(b)L=_____ H

07: **ANS:=3.75E-3**

(c)flux through each turn=_____ Wb

08: **ANS:=100E-9**

(d)maximum emf $\mathscr{E}$=_____ V

09: **ANS:=0.00424**

Solution:

(a) $$L = \frac{N\Phi}{i} = \frac{(150)(50\times10^{-9}\ \text{T}\cdot\text{m}^2)}{2.00\times10^{-3}\ \text{A}} = 3.75\ \text{mH}.$$

(b) The answer for L does not change; it is still 3.75 mH.

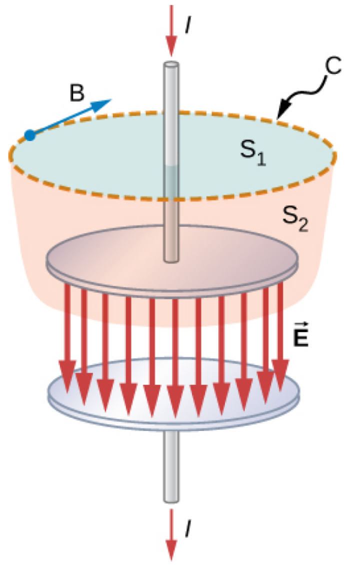
(c) The equations of Chapter 28 display a simple proportionality between magnetic field and the current that creates it. Thus, if the current has doubled, so has the field (and consequently the flux). The answer is 2(50) = 100 nWb.

(d) The magnitude of the induced emf is (from Eq. 30-35)

$$L\left.\frac{di}{dt}\right|_{\max} = (0.00375\ \text{H})(0.0030\ \text{A})(377\ \text{rad/s}) = 0.00424\ \text{V}.$$

Problem 4

A parallel-plate capacitor with capacitance C whose plates have area A and separation distance d is connected to a resistor R and a battery of voltage V_0. The current starts to flow at $t = 0$. Find (a)the voltage $V_C(t)$ between the plates, (b)the charge on the capacitor $Q(t)$ and (c)the displacement current $I_d(t)$ between the capacitor plates at time t. (03小題)



(a)$V_C(t)$=________ [R,C,V_0,t]

10: **ANS:=V_0*(1-exp(-t/(R*C)))**

(b)$Q(t)$=________ [R,C,V_0,t]

11: **ANS:=C*V_0*(1-exp(-t/(R*C)))**

(c)$I_d(t)$=________ [R,C,V_0,t]

12: **ANS:=(V_0/R)*exp(-t/(R*C))**

Problem 5

What is the maximum strength of the B field in an electromagnetic wave that has a maximum E-field strength of 1000 V/m? (01小題)

B=_______ T

13: **ANS:=3.33E-6**

Solution:

$$B = \frac{E}{c} = \frac{1000}{3 \times 10^8} = 3.33 \times 10^{-6}$$

Problem 5

The beam from a small laboratory laser typically has an intensity of about 1.0×10^{-3} W/m^2. Assuming that the beam is composed of plane waves, calculate the amplitudes of the (a)electric E_0 and (b)magnetic fields B_0 in the beam. (02小題)

(a)E_0=______ V/m

14: **ANS:=0.87**

(b)B_0=______ T

15: **ANS:=2.9E-9**

Solution:

$$I = \frac{1}{2} c\varepsilon_0 E_0^2$$

$$\text{(a)}E_0 = \sqrt{\frac{2I}{c\varepsilon_0}} = \sqrt{\frac{2(1.0 \times 10^{-3}}{(3 \times 10^8)(8.85 \times 10^{-12}}} = 0.87$$

$$\text{(b)}B_0 = E_0/c = 2.9 \times 10^{-9}$$

Problem 6

A light bulb emits 5.00 W of power as visible light. What are the average electric and magnetic fields from the light at a distance of 3.0 m? (02小題)

(a)E_0=_______ V/m

16: **ANS:=5.77**

(b)B_0=_______ T

17: **ANS:=1.92E-8**

Solution:

$$I = dfracP4\pi r^2 = \frac{1}{2}c\varepsilon_0 E_0^2$$

$$\text{(a)}E_0 = \sqrt{2P}4\pi r^2 c\varepsilon_0 = \sqrt{2(5)}4\pi(3^2)(3\times 10^8)(8.85\times 10^{-12} = 5.77$$

$$\text{(b)}B_0 = E_0/c = 1.92\times 10^{-8}$$

Problem 6

A 60-kW radio transmitter on Earth sends its signal
to a satellite 100 km away (figure). At what distance in the same direction would the signal have the same maximum field strength if the transmitter's output power were increased to 90 kW? (01小題)

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distance r_2=_____ km

18: **ANS:=<u>122</u>**

Problem 7

On February 9, 1986, Comet Halley was at its closest point to the Sun, about 9.0×10^{10} m from the center of the Sun. The average power output of the Sun is 3.8×10^{26} W. (a) Calculate the radiation pressure on the comet at this point in its orbit. Assume that the comet reflects all the incident light. (b) Suppose that a 10-kg chunk of material of cross-sectional area 4.0×10^{-2} m^2 breaks loose from the comet. Calculate the force on this chunk due to the solar radiation. Compare this force with the gravitational force of the Sun. (02小題)

(a)radiation pressure, p=______ N/m^2

19: **ANS:=2.5E-5**

(b) the force on chunk=_______ N

20: **ANS:=1.0E-6**

Solution:

$$I = S_{\text{avg}} = \frac{3.8 \times 10^{26}}{4\pi(9.0 \times 10^{10})^2} = 3.7 \times 10^3$$

$$p = \frac{2I}{c} = \frac{2(3.7 \times 103}{3 \times 10^8} = 2.5 \times 10^{-5}$$

$$F = pA = (2.5 \times 10^{-5})(4.0 \times 10^{-2}) = 1.0 \times 10^{-6}$$

Problem 7

The intensity of energy from sunlight at a distance of 1 AU from the Sun is 1370 W/m^2. The LightSail spacecraft has sails with total area of 32 m^2 and a total mass of 5.0 kg. Calculate the maximum acceleration LightSail spacecraft could achieve from radiation pressure when it is about 1 AU($= 1.5 \times 10^{11}$ m) from the Sun. (01小題)

The maximum acceleration, a=______ m/s^2

21: **ANS:=5.8E-5**

Solution:

$$F = pA = 2uA = \frac{2I}{c}A = \frac{2(1370)(32)}{3 \times 10^8} = 2.92 \times 10^{-4}$$

$$a = \frac{F}{m} = \frac{2.92 \times 10^{-4}}{5} = 5.8 \times 10^{-5}$$

Problem 8

The microwaves in a microwave oven reflect off the walls of the oven, so that the superposition of waves produces standing waves, similar to the standing waves of a vibrating guitar or violin string (see Normal Modes of a Standing Sound Wave). A rotating fan acts as a stirrer by reflecting the microwaves in different directions, and food turntables, help spread out the hot spots. How far apart are the hotspots in a 2.45-GHz microwave oven? (01小題)

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distance between nearest hot spots, d=______ cm

22: **ANS:=6.02**