Assignment 2

March 25, 2023 4:34 PM

Assignment-2

1 Assignment Prepared By (Individual Work)

Assignment Due: March 28th, 2023 – 11:59 pm
Please submit on Blackboard / email

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2 Questions

Q1 [Textbook 28.27] [20 pts]

S A strong magnet is placed under a horizontal conducting ring of radius r that carries current I as shown in Figure P28.27. If the magnetic field $\vec{B}$ makes an angle θ with the vertical at the ring's location, what are

(a) the magnitude and

(b) the direction of the resultant magnetic force on the ring?

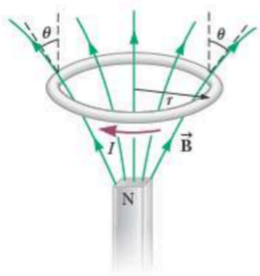

Figure [28.27]: Magnetic force acting on a current carrying conductor

$dF = i\,dl\,B\sin\theta\,\hat{j}$

$F_y = \int dF$

$= \int_0^{2\pi} i r\,d\phi\, B\sin\theta$

$= i r B\sin\theta \int_0^{2\pi} d\phi$

$F_y = 2\pi r i B\sin\theta$

$F_x = 0$ because symmetric ring
↑ component will be cancelled by opposite Portion

$\therefore$ Net $F = 2\pi r i B\sin\theta$

Q2 [Textbook 29.29] [20 pts]

V A solenoid of radius $r = 1.25$ cm and length $\ell = 30.0$ cm has 300 turns and carries 12.0 A.

(a) Calculate the flux through the surface of a disk-shaped area of radius $R = 5.00$ cm that is positioned perpendicular to and centered on the axis of the solenoid as shown in Figure P29.29a.

(b) Figure P29.29b shows an enlarged end view of the same solenoid. Calculate the flux through the tan area, which is an annulus with an inner radius of $a = 0.400$ cm and an outer radius of $b = 0.800$ cm.

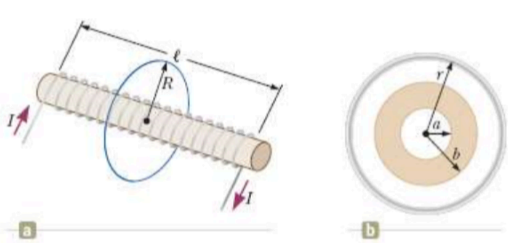

Figure [29.29]: Gauss's law in magnetism

a)

$r = 1.25$ cm
$\ell = 30$ cm
turn = 300

$\Phi = B \cdot A$

$\Phi = \frac{\mu_0 N i}{L} \cdot (\pi r^2)$

$\Phi = \left(\frac{(4\pi\times10^{-7})(300)(12)}{0.30}\right) \cdot (\pi \cdot 0.0125)^2$

B) $\Phi = B \cdot A$
$= (0.015)(0.00015)$
$= 2.3\times10^{-6}$ Wb

$A_1 = \pi r_1^2 = 0.0002$ m
$A_2 = \pi r_2^2 = 0.00005$ m
$A = A_1 - A_2 = 0.00015$ m

$\Phi = (0.015)(\pi)(0.0125)^2$

$\Phi = 7.4 \times 10^{-6}\ Wb$

Q3 [Textbook 30.35] [20 pts]

A conducting rod of length $\ell = 35.0$ cm is free to slide on two parallel conducting bars as shown in Figure P30.35. Two resistors $R_1 = 2.00\ \Omega$ and $R_2 = 5.00\ \Omega$ are connected across the ends of the bars to form a loop. A constant magnetic field $B = 2.50$ T is directed perpendicularly into the page. An external agent pulls the rod to the left with a constant speed of $v = 8.00$ m/s. Find

(a) the currents in both resistors,
(b) the total power delivered to the resistance of the circuit, and
(c) the magnitude of the applied force that is needed to move the rod with this constant velocity.

Hint: Find the EMF induced on the moving bar and apply Kirchhoff's voltage (loop) rule on two sides of the bar. Use Lenz's law as a guidance to assign the directions of currents in each loop.

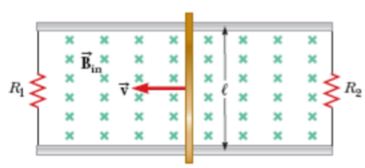

Figure [30.35]: Motional EMF

a)

$I_1 = \frac{Bvl}{R_1} = \frac{(2.50)(8.00)(0.35)}{2.00} = 3.5A$

$I_2 = \frac{Bv\ell}{R_2} = \frac{(2.50)(8.00)(0.35)}{5} = 1.4A$

$I = I_1 + I_2$

$I = 4.9A$

b) $P = \mathcal{E}I = Bv\ell(4.9A)$

$= (2.50)(8.00)(0.35)(4.9A)$

$= 34.3\ W$

c) $F_B = ILB$

$= (4.9)(0.35)(2.5)$

$= 4.29N$

Q4.a [Textbook 31.11] [10 pts]

A series RL circuit with $L = 3.00$ H and a series RC circuit with $C = 3.00\ \mu$F have equal time constants. If the two circuits contain the same resistance R,

(a) what is the value of R?
(b) What is the time constant?

a) $\frac{L}{R} = RC$

$R^2 = \frac{L}{C}$

$R = \sqrt{\frac{3}{3\times10^{-6}}} = 1000\Omega$

b) $= 1000\Omega \times 3\times10^{-6}$

$= 3\times10^{-3}$ sec

Q4.b [Textbook 31.12] [10 pts]

Show that $i = I_i e^{-t/\tau}$ is a solution of the differential equation

$$iR + L\frac{di}{dt} = 0$$

where I_i is the current at $t = 0$ and $\tau = L/R$.

$IR + L\frac{di}{dt} = 0$

$-\frac{IR}{L} = \frac{di}{dt}$

$\frac{I}{-L/R} = \frac{di}{dt}$

$\frac{-dt}{L/R} = \frac{di}{I}$

$-\int_0^t \frac{dt}{L/R} = \int_{I_1}^{I} \frac{di}{I}$

$\frac{-t}{L/R} = \ln\left(\frac{I}{I_1}\right)$

$e^{-Rt/L} = \frac{I}{I_1}$

$I = I_1 e^{-Rt/L}$

$\tau = \frac{L}{R}$

$I = I_i e^{-t/\tau}$

Q5 [Textbook 32.5] [20 pts]

In the AC circuit shown in Figure P32.3, $R = 70.0\ \Omega$ and the output voltage of the AC source is $\Delta V_{max} \sin \omega t$.

(a) If $\Delta V_R = 0.250\ \Delta V_{max}$ for the first time at $t = 0.010\ 0$ s, what is the angular frequency of the source?
(b) What is the next value of t for which $\Delta V_R = 0.250\ \Delta V_{max}$?

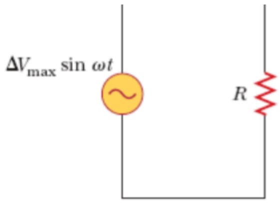

Figure [32.3]: Resistors in an AC circuit

a)

$V = V_{Max} \sin wt$

$0.250\, V_{max} = V_{max} \underbrace{\sin(w \cdot 0.0100)}_{0.250}$

$\sin^{-1}(0.260) = 14.48°$

$14.48° \cdot \frac{\pi}{180°} = 0.2527 \text{ rads}$

$w = 25.27 \text{ rads/sec}$

b)

$\omega t' = \pi - \omega t$

$t' = (\pi / w) - t$

$t' = \left(\frac{\pi}{25.27}\right) - 0.0100$

$= 0.1243 - 0.0100$

$= 0.1143 \text{ seconds}$