Exam 3 - Solutions

1/ (a) $R_{eq} = \left(\frac{1}{3+1} + \frac{1}{8}\right)^{-1} + 2$

$= \left(\frac{3}{8}\right)^{-1} + 2 = \frac{8}{3} + 2 = \frac{14}{3}\,\Omega$

(b) $P_A = I_A^2 R_A = (11)^2(2) = 242\,W$

(c) R_d has same I as R_c ; in series

$\Delta V_d = I_d R_d = (4)(1) = 4V$

(d) use the junct rule $11 = 4 + 7$

so R_b has 7A thgh it

* My apologies for my mistake — above #'s are not consistent.

the crnt thgh R_c should have been $\frac{22}{3}$ A

leading to $\Delta V_d = \left(\frac{22}{3}\right)(1) = \frac{22}{3}\,V$

R_b has $11 = \frac{22}{3} + \frac{11}{3}$ so $I_d = \frac{11}{3}$ A

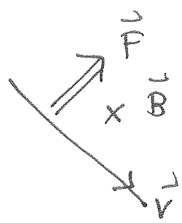
2/ Use the outer (big) loop

$$+\mathcal{E}_1 - 4(4) - 20 + 4(6) - 4(4) = 0$$

$$-\mathcal{E}_1 - 16 - 20 + 24 - 16 = 0$$

$$\mathcal{E}_1 = 28\,V$$

3/



$$\vec{F} = q\vec{v}\times\vec{B}$$

$F = qvB\sin\theta$ here, $\theta = 90^\circ$

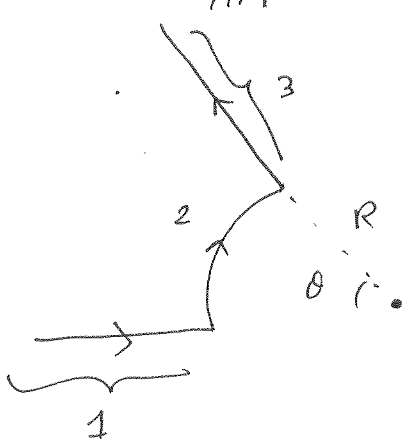
$$= qvB$$

$$= (1.6\cdot 10^{-19})(100)(2)$$

$$F = 3.2\cdot 10^{-17}\,N$$

4/ Use Biot-Savart law. (finding B from Ampere's law only works simply for highly symmetric distributions)

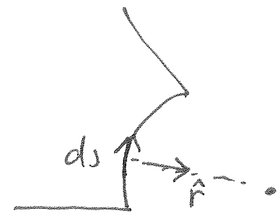
$$d\vec{B} = \frac{\mu_0 I}{4\pi r^2}\, d\vec{s}\times\hat{r} \qquad \text{where } |d\vec{s}\times\hat{r}| = ds\sin\theta$$



Segments 1 + 3 have $\sin\theta = \sin(0^\circ) = 0$ since $d\vec{s}$ and $\hat{r}$ point in same direction.

only segment 2 creates $\vec{B}$ at P

$$dB = \frac{\mu_0 I}{4\pi r^2} ds \sin\theta$$



here, $r = R$
$ds = ds$, along arc
$\sin\theta = \sin(90) = 1$

$$dB = \frac{\mu_0 I}{4\pi R^2} ds$$

$$B = \int \frac{\mu_0 I}{4\pi R^2} ds = \frac{\mu_0 I}{4\pi R^2} \int ds \qquad ds = R\,d\theta$$

$$= \frac{\mu_0 I R}{4\pi R^2} \int d\theta$$

$$B = \frac{\mu_0 I \theta}{4\pi R}$$

into the page, ⊗ or $-\hat{z}$
by the RHR

5/ $V(t) = V_0 e^{-t/\tau}$ $\qquad \tau = RC$

here, $V(40ms) = 0.05\,V_0$

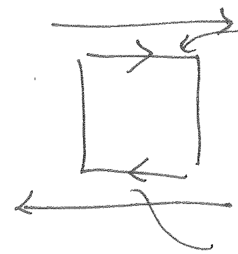
$$0.05\,V_0 = V_0 e^{-t/RC}$$

$$\ln(0.05) = -t/RC$$

$$R = \frac{-t}{C} \ln(0.05) = \frac{-(40 \cdot 10^{-3})}{150 \cdot 10^{-6}} \ln(0.05)$$

$$= 800\,\Omega$$

6/ (a) negative (b) zero (c) positive



here, $\vec{B}$ + $d\vec{s}$ point in the same dir

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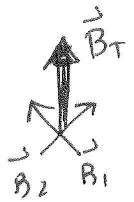
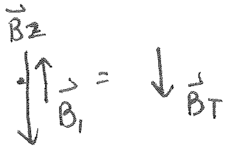


7/

(a) $\odot$ 1 $\otimes$ 2



(b) at A:

by RHR $\vec{F} \Rightarrow$

8/ (a) $B = \mu_0 \frac{N I}{l}$

$$N = \frac{B l}{\mu_0 I} = \frac{(2.4)(0.3)}{4\pi \cdot 10^{-7}(12)} = \frac{3}{2\pi} \cdot 10^5 \text{ turns}$$

(b) $\mathcal{E} = IR$

$$I_{ind} = \frac{\mathcal{E}_{ind}}{R} = \frac{N}{R}\frac{d\phi_B}{dt}$$

where $\phi_B = BA\cos\theta$; A → 0.2, $\cos\theta$ → 1, B → changing

$$I = \frac{N}{R} A \frac{dB}{dt} = \frac{400}{4}(0.2)\frac{(2.4)}{30} = 1.6A$$

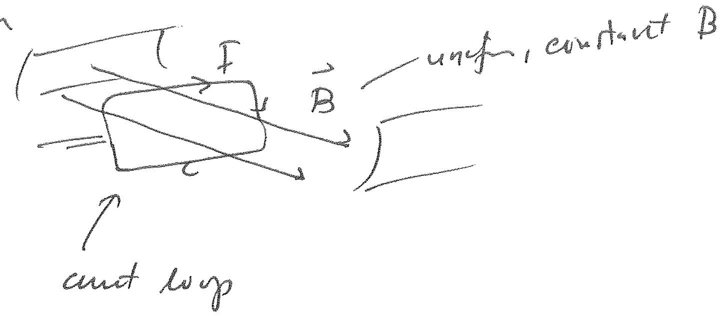
9/ Points to cover in explanation

- current loop in a magnetic field is subject to a net torque $\vec{\tau} = \vec{\mu} \times \vec{B}$

- or current in a magnetic field is subject to a force $\vec{F} = I\vec{l} \times \vec{B}$; opp. segments of loop have opposite $\vec{F}$'s leading to net torque

- changes electrical energy (current) into mechanical energy (torque)

typical diagram



10/ (a) $B_{wire} = \dfrac{\mu_0 I}{2\pi R} = \dfrac{\mu_0 (10)}{2\pi (0.5)}$

(b) $B_{loop} = \dfrac{\mu_0 I}{2R} = \dfrac{\mu_0 (10)}{2 (0.5)}$

(c) $B_{dipole} = \dfrac{\mu_0 \mu}{4\pi z^3} = \dfrac{\mu_0 (0.1\pi)}{4\pi (0.5)^3}$

dipole < wire < loop