208 Mid-Term 1 POINTS TABLE	
Multiple Choice (out of 20)	
Problem 1 (out of 20)	
Problem 2 (out of 20)	
Problem 3 (out of 20)	
Problem 4 (out of 20)	
TOTAL SCORE (out of 100)	

Multiple Choice:

Ver. A

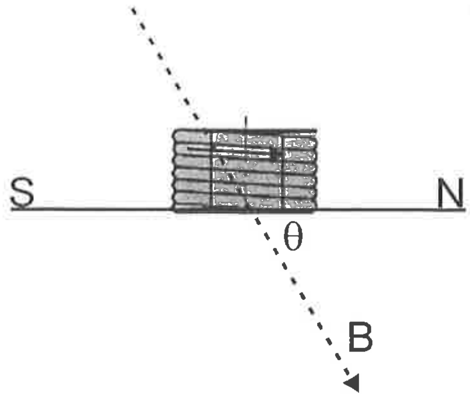
1. e.)
2. b.)
3. a.)
4. b.), b.)

Ver. B

1. f.)
2. a.)
3. b.)
4. b.), a.)

1. **(20 marks)** A circular coil 28.0 cm in diameter and containing 18 loops lies flat on the ground. The Earth's magnetic field at this location has magnitude 5.80×10^{-5} T and points into the earth at an angle of $\theta = 61.0°$ below a line pointing due north. If a 9.30-A counterclockwise (looking down on the coil) current passes through the coil, determine

16 a) the torque on the coil, and
4 b) which edge of the coil rises up, north, east, south or west.



a) $\vec{\tau} = \vec{\mu} \times \vec{B}$

$\vec{\mu} = NI\vec{A}$ — direction given by right hand rule - see figure

$= NI\pi r^2 \hat{j}$

$\vec{\tau} = NI\pi r^2 \hat{j} \times (B\cos 61° \hat{i} - B\sin 61° \hat{j})$

$= -NI\pi r^2 B\cos 61° \hat{k}$

$= -18 \times 9.30 \times \pi \times (.140)^2 \times 5.80 \times 10^{-5} \times \cos 61° \hat{k}$

$\vec{\tau} = -2.90 \times 10^{-4}$ Nm $\hat{k}$ (ie into the page)

b) With $\vec{\tau}$ into the page (pointing west), the right hand rule indicates that the **south edge of the coil rises up.**

X version: a) $\vec{\tau} = -15 \times 4.70 \times \pi \times (.210)^2 \times 5.80 \times 10^{-5} \times \cos 55° \hat{k}$

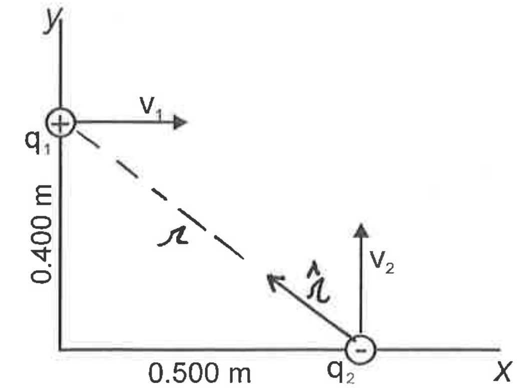
$\vec{\tau} = -3.25 \times 10^{-4}$ Nm $\hat{k}$ (ie into the page)

b) Same answer

2. **(20 marks)** A pair of point charges, $q_1 = 9.00\mu C$ and $q_2 = -6.00\mu C$, are moving as shown in the figure with speeds $v_1 = 6.50 \times 10^4$ m/s and $v_2 = 4.60 \times 10^4$ m/s. When the charges are at the location shown in the figure, find:

8 a) the magnitude and direction of the magnetic field produced at the origin, and

12 b) the magnitude and direction of the magnetic force that q_2 exerts on q_1.



a) $\vec{B} = \frac{\mu_0}{4\pi} \frac{q\vec{v}\times\hat{r}}{r^2}$

$\vec{B}_{origin} = \vec{B}_1 + \vec{B}_2$

$= -\frac{\mu_0}{4\pi}\left[\frac{q_1 v_1}{r_1^2} + \frac{q_2 v_2}{r_2^2}\right]\hat{k}$

$= -10^{-7}\left[\frac{9.00\times10^{-6}\times6.50\times10^4}{(0.400)^2} + \frac{6.00\times10^{-6}\times4.60\times10^4}{(0.500)^2}\right]\hat{k}$

$\boxed{\vec{B}_0 = -4.76\times10^{-7}\,T\,\hat{k}}$

b) See diagram

$\vec{F} = q_1 v_1 B_2 \hat{j} = q_1 v_1\left(\frac{\mu_0}{4\pi}\frac{q_2 v_2 \sin\theta}{r^2}\right)\hat{j}$ where $\sin\theta = \frac{0.500}{r}$

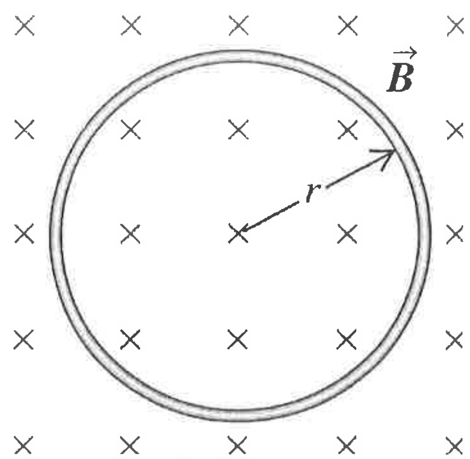
$= 9.00\times10^{-6}\times6.50\times10^4\times10^{-7}\times\frac{6.00\times10^{-6}\times4.60\times10^4\times.500}{(0.400^2+0.500^2)^{3/2}}\hat{j}$

$\boxed{\vec{F} = 3.08\times10^{-8}\,N\,\hat{j}}$

3. (20 marks) A circular coil containing 50 loops of wire with radius $r = 35$ cm and resistance $R = 0.460\ \Omega$ is in a region of spatially uniform magnetic field directed into the plane of the figure. At $t = 0$, $B = 0$. The magnetic field then begins increasing, with $B(t) = (0.560\ \text{T/s}^3)\ t^3$.

16 a) What is the current in the loop (magnitude and direction) at the instant when B = 1.56T?

4 b) What is the power being dissipated in the loop at that instant?



a) $\mathcal{E} = -N\dfrac{d\Phi_B}{dt} = -N\dfrac{d(BA)}{dt} = -NA\dfrac{dB}{dt}$

$= -NA\,(3t^2 \times 0.560)$

$= -50 \times \pi(0.035)^2 \times 3 \times 0.560\, t^2$

$= -0.3233\, t^2$

but $B = 1.56 = 0.560\,t^3 \Rightarrow t^3 = 2.786$

or $t = 1.407$ s

$\therefore |\mathcal{E}| = +0.3233 \times 1.407^2 = 0.6401$ V

$I = \dfrac{\mathcal{E}}{R} = \dfrac{0.6401\text{V}}{0.460\Omega} = 1.39\text{A}$ counterclockwise

b) $P = \mathcal{E}I = 0.6401 \times 1.391 = 0.891$ W

4. **(20 marks)** A 1200-pF capacitor is charged to 100 V and then quickly connected to an inductor. The frequency of the subsequent oscillation is 720 kHz. Determine

6 a) the inductance *L* of the inductor
7 b) the peak value of the current in the inductor, and
7 c) the maximum energy stored in its magnetic field.

a) $\omega = 2\pi f = \frac{1}{\sqrt{LC}} \Rightarrow LC = \frac{1}{(2\pi f)^2}$

$\therefore L = \frac{1}{C(2\pi f)^2} = \frac{1}{1200 \times 10^{-12} F\,(2\pi \times 720 \times 10^3 Hz)^2}$

$\boxed{L = 40.7 \mu H}$

b) Initially, all energy is in electric field of the capacitor

$U_E = \frac{1}{2}CV^2 = \frac{1}{2} \times 1200 \times 10^{-12} F\,(100V)^2 = 6.00 \mu J$

The peak value of current occurs when all energy is stored in magnetic field of inductor

$\therefore U_B = \frac{1}{2}LI^2 = U_E$

$\therefore I^2 = \frac{2U_E}{L} = \frac{2 \times 6.00 \times 10^{-6} J}{40.7 \times 10^{-6} H} = 0.2948 A^2$

$\boxed{I = 543 mA}$

c) Maximum energy is U_B as defined above

$\boxed{U_B = U_E = 6.00 \mu J}$

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x version: a) $L = \frac{1}{800 \times 10^{-12} F\,(2\pi \times 940 \times 10^3 Hz)^2}$

$\boxed{L = 35.8 \mu H}$

b) $U_E = \frac{1}{2} \times 800 \times 10^{-12} F \times (110V)^2 = 4.84 \mu J$

$I = \sqrt{\frac{2 \times 4.84 \times 10^{-6} J}{35.8 \times 10^{-6} H}}$

$\boxed{I = 520 mA}$

c) $\boxed{U_B = U_E = 4.84 \mu J}$