Physics 116b

Second Partial Examination October 12, 2000

Name: Key

I.D.#:

Please circle your section:

Section 1 Section 2 Section 3 Section 4

Instructions

This is a one hour, closed book examination. Put answers in the boxes provided, or circle the best answer. If numerical answers are needed, you must include units. If required, any work needed to justify the answer must be shown in the space provided. A correct answer without the necessary justifying work may not receive any credit. You may use the formula sheet on the back of the exam.

Total point scores for each problem will appear in the table below and in ( ) beside each problem number. Do what is easiest first. AVOID glancing at anyone else's paper during the exam! The honor code is in effect.

Point Tallies for the Exam Problems

Problem	Description	Max Score	Actual Score
1	Short Answer	25	
2	Magnetic Fields	35	
3	Total		

(Problem 1: Circle the Correct Response, or Make a Sketch):
(Showing your work can get you partial credit!)

a) What is the *resistivity* of a conducting wire of length 2.0 m, cross–sectional area of 1.0 mm^2, and resistance of 1.0Ω? (2 pts.)

I) 20 $\Omega \cdot m$
II) 2.0×10^6 $\Omega \cdot m$
[✓ III) 0.50×10^{-6} $\Omega \cdot m$]
IV) 2.0×10^7 $\Omega \cdot m$
V) 2.0 $\Omega \cdot m$

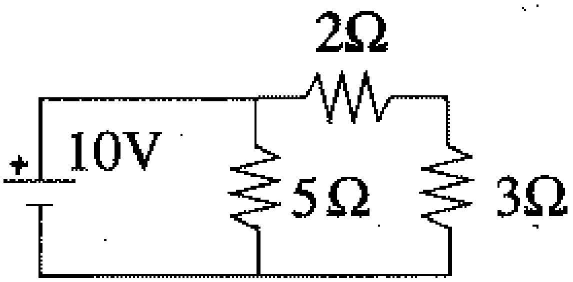
$$R = \rho \frac{l}{A}$$

$$\rho = \frac{AR}{l} = \frac{(1.0\,mm^2)\left(\frac{1m}{1{,}000mm}\right)^2 1.0\Omega}{2.0m}$$

$$= 5 \times 10^{-7} \Omega m$$

b) How much current passes through the 3 Ω resistor? (3 pts.)

I) 1 A
[✓ II) 2 A]
III) 3 A
IV) 4 A
V) 5 A



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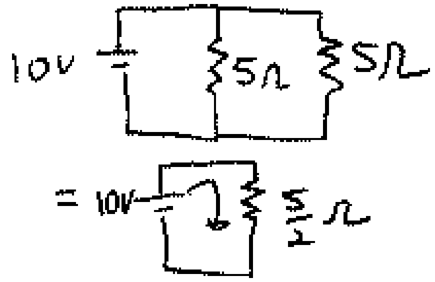
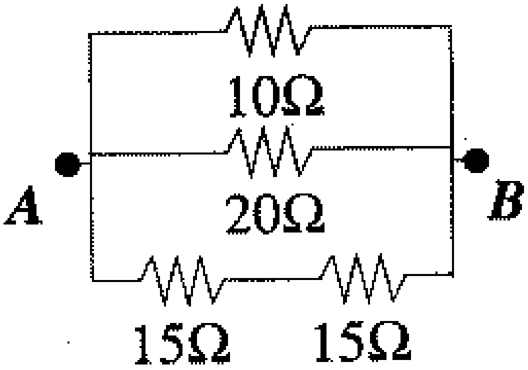


$$I = \frac{10V}{(5/2\,\Omega)} = 4A$$

each leg gets 2 A

c) Calculate the resistance between points A and B.(2 pts.)



I) 60 Ω
II) 17 Ω
III) 10 Ω
IV) 8.3 Ω
[✓ V) 5.5 Ω]

$$\frac{1}{R_{AB}} = \frac{1}{10} + \frac{1}{20} + \frac{1}{30}$$

$$= \frac{6}{60} + \frac{3}{60} + \frac{2}{60}$$

$$R_{AB} = \frac{60}{11} = 5.45\Omega$$

(Circle the Correct Response, or Make a Sketch):

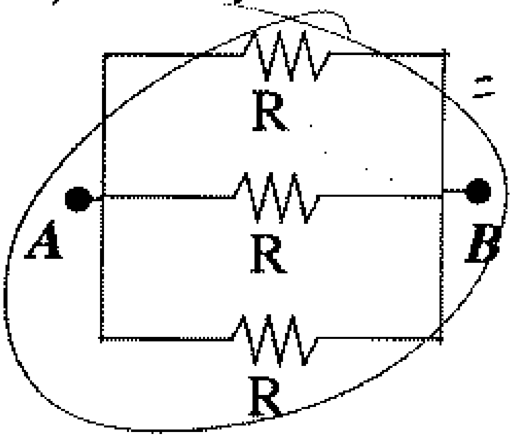
d) A 12 Ω resistor dissipates 100 *Watts* when current flows through it. This resistor has how much voltage across it? (2 pts.)

I) 4.0 *Volts*
II) 8.3 *Volts*
[✓ III) 35 *Volts*]
IV) 49 *Volts*
V) 2400 *Volts*

$P = \frac{V^2}{R} \Rightarrow \sqrt{PR} = V$

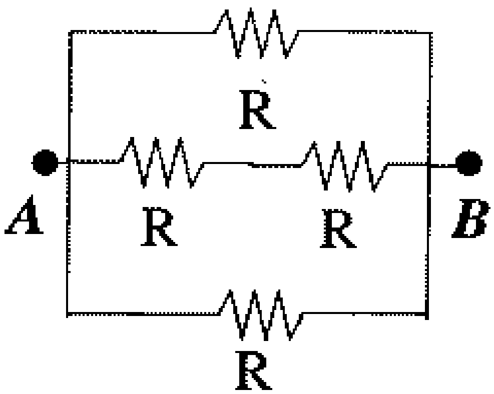
$\sqrt{1200} = 34.6V$

e) Circle the system of resistors that has the *Lowest* resistance.(2 pts)



$= \frac{1}{3}R$

$.33R$



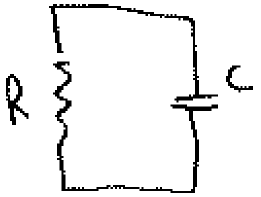
$\frac{1}{R} + \frac{1}{2R} + \frac{1}{R}$

$= \frac{5}{2R} = \frac{2}{5}R$

$= .4R$

f) A circuit contains a resistor and a charged capacitor. If the voltage across the capacitor decreases from 3.0 V to 1.0 V in 10.0 s when a switch is closed, what is the time constant of this resistor–capacitor combination? (2 pts)

I) 1.1*s*
II) 11*s*
III) 1.0*s*
IV) 10.0*s*
[✓ V) 9.1*s*]



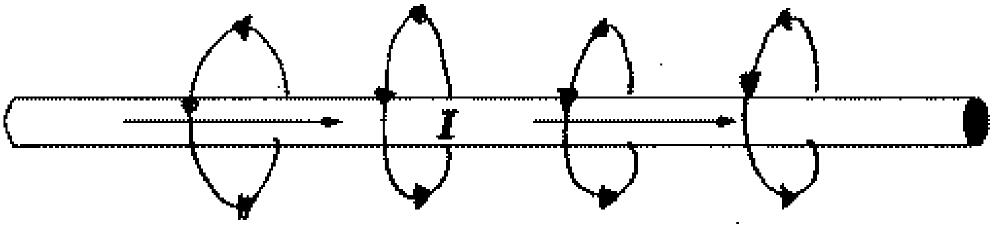
$\frac{Q(t)}{C} = \frac{Q_0}{C} e^{-t/RC}$

$1.0V = 3.0V e^{-t/RC}$

$\ln\left(\frac{1}{3}\right) = \frac{-10s}{\tau}$

$-\tau = \frac{-10s}{\ln\left(\frac{1}{3}\right)} = 9.1s$

g) Sketch the magnetc field of a wire carrying a current I.(2 pts)



(Circle the Correct Response, or Make a Sketch):

h) A magnetic field of 0.52 T makes an angle with respect to the velocity of a particle with charge 1.0×10^{-12} C traveling at 1000 m/s. If the magnitude of the force on the particle due to the magnetic field is $1.0 \times 10^{-10} N$, which of these angles best describes the angle of the magnetic field with respect to the particle velocity? (2 pts)

I) 1^0
~~II) 5^0~~
[✓ III) 11^0]
IV) 20^0
V) 34^0

$$|F| = |qvB| \sin\theta$$

$$\sin\theta = \frac{|F|}{|qvB|}$$

$$\theta = \sin^{-1}\left(\frac{1.0\times10^{-10} N}{10^{-12} C \; 1000 \, m/s \; 0.52}\right)$$

$$= 11.08°$$

i) An electron is in a circular orbit in a magnetic field of 0.0000010 T. What is the magnitude of the angular frequency(ω) with which this particle rotates? (2 pts)

I) 6.0×10^{10} *rads/sec*
II) 0.11 *rads/sec*
III) 8.8 *rads/sec*
IV) 1.0×10^{-6} *rads/sec*
[✓ V) 1.8×10^{5} *rads/sec*]

$$\frac{m v^{\cancel{2}}}{r} = q \cancel{v} B$$

$$\frac{v}{r} = \frac{qB}{m} = \frac{(1.6\times10^{-19} C) 0.000001 \, T}{9.1\times10^{-31} \, Kg}$$

$$= 175824 \text{ rads/sec}$$

j) At what location from a very long wire is the magnetic field 0.000040 T if the wire carries a current of 10.0 A? (2 pts)

[✓ I) $r = 0.05$ m]
~~II) $r = 0.31$ m~~
III) $r = 20$ m
IV) $r = 2000$ m
V) $r = 0.016$ m

$$B = \frac{\mu_0 I}{2\pi r}$$

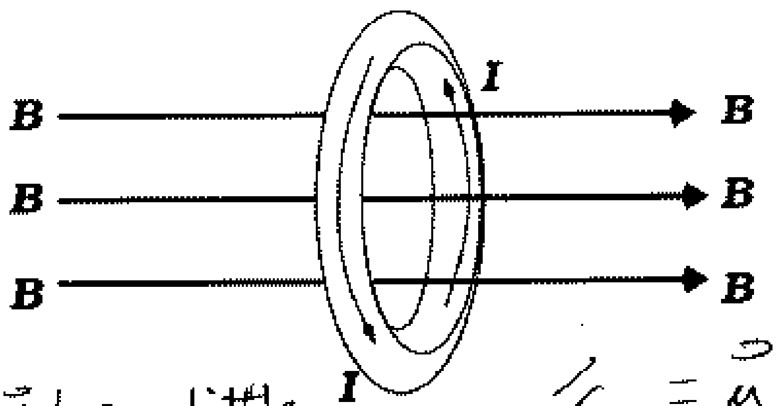
$$r = \frac{\mu_0 I}{2\pi B} = \frac{\overset{2}{\cancel{4\pi}} \times 10^{-7} \, \cancel{T}m/\cancel{A} \; 10.0 \, \cancel{A}}{\cancel{2\pi} \, (.00004 \, \cancel{T})}$$

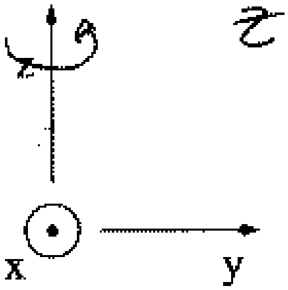
0.05 m

(Circle the Correct Response, or Make a Sketch):

k) About which axis will this ring of current rotate? Clockwise or [✓ Counter-Clockwise?] (2 pts) [✓ z]

rotates ccw about z





$\vec{\mu}$ has a little in $\hat{x}$ and a lot in $\hat{y}$

guess $\vec{\mu} = \hat{x} + 10\hat{y}$

$$\vec{\tau} = \vec{\mu} \times \vec{B}$$
$$= (\hat{x} + 10\hat{y}) \times B\hat{y} = B(\hat{x} \times \hat{y}) = B\hat{z}$$

l) What is the magnetic field in the center of a 0.25 m long solenoid with 5000 turns that carries 2.0 A?(2 pts)

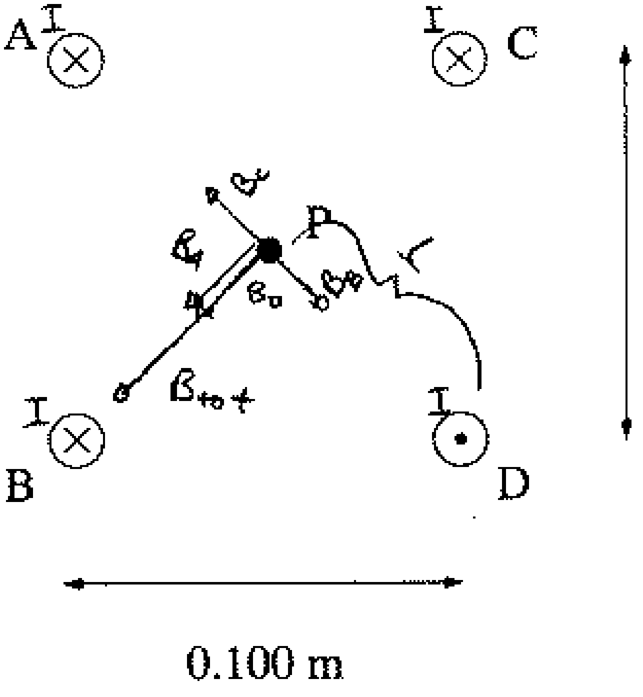
~~I) $0.06T$~~
[✓ II) $0.05T$]
~~III) $130000T$~~
IV) $5 \times 10^{-6}T$
V) $1.3T$

$$B = \mu_0 n I$$
$$= \left(4\pi \times 10^{-7} \frac{Tm}{\cancel{A}}\right)\left(\frac{5000}{0.25}\right) 2.0\cancel{A}$$
$$= 0.05\ T$$

2) Magnetic Fields(35 points total)

Four long, parallel conductors carry equal currents of I = 2.00 A. The figure below is an end view of the conductors. The current direction is into the page at points A, B, and C (indicated by the crosses) and out of the page at D (indicated by the dot). Calculate the magnitude and direction of the magnetic field at point P, located at the center of the square of edge length 0.100 m.

(indicate the B field direction at P with an arrow on the figure (5 pts.))



$$\vec{B}_{tot} = \vec{B}_A + \vec{B}_D + \overbrace{\vec{B}_C + \vec{B}_B}^{0}$$

$$= 2\vec{B}_D$$

$$|\vec{B}_D| = \frac{\mu_0 I}{2\pi r} = \frac{\cancel{4}^{2}\pi\times10^{-7}\frac{Tm}{A}\,2.00A}{\cancel{2}\pi(\sqrt{2})(\frac{0.100m}{2})}$$

$$= 5.656\times10^{-6}T$$

$$= 5.66\mu T$$

$$|\vec{B}_{tot}| = 2(5.66T)\times10^{-6}$$

$$= 11.32T\times10^{-6}$$

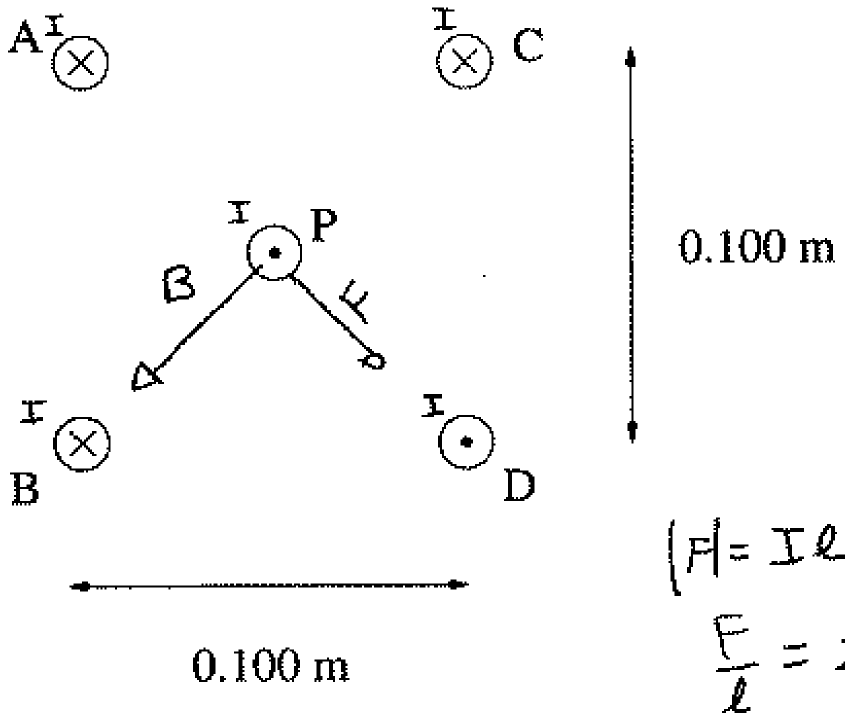
$$\boxed{B = 11.32\mu T}$$

(10 pts.)

2) Magnetic Fields (contd.)

Suppose I add a fifth wire in the center. This wire has identical current to the other wires and the current points out of the page (indicated by the dot). What is the force/length on this center wire? In which direction does this force point?
(Indicate the direction of the force on the figure below. If you did not do the first part of the problem, assume a direction for the B field (up, down, left or right), assume a magnitude for the B field (pick one) and proceed)

(5 pts.)



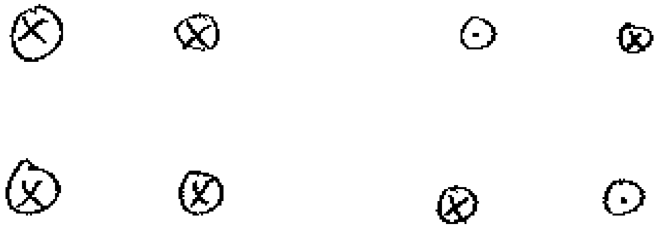
$|F| = I\ell B = (2A)\ell(11.32\mu T)$

$\frac{F}{\ell} = 22.64\ N/m$

F/length = $22.64\ \frac{N}{m}$

(10 pts.)

Suppose you could change the direction of the current in ONE of the wires: A, B, C or D. Which one should you change so that there is no force on the wire in the center? Is there more than one answer? (5 pts.) yes



Equations

$$I = \frac{dq}{dt}, \quad I = \int \vec{J} \cdot d\vec{A}, \quad V = IR, \quad R = \frac{\rho l}{A}, \quad \rho = \frac{1}{\sigma}$$

$$\rho - \rho_0 = \rho_0 \alpha (T - T_0), \quad \rho = \frac{m}{e^2 n \tau}, \quad P = IV$$

$$R = R_1 + R_2 + R_3 ... \;, \quad \frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + ...$$

$$(charging) \quad Q = Q_0(1 - e^{-\frac{t}{RC}}), \quad \tau = RC, \quad CV = Q, \quad I = \frac{V}{R} e^{-\frac{t}{RC}}$$

$$(discharging) \quad Q = Q_0 e^{-\frac{t}{RC}}, \quad I = -\frac{Q_0}{RC} e^{-\frac{t}{RC}}$$

$$\vec{F} = q\vec{v} \times \vec{B}, \quad n = \frac{BI}{Vle}, \quad qvB = \frac{mv^2}{r}, \quad \omega = 2\pi f, \quad \omega = \frac{v}{r}$$

$$\vec{F} = I\vec{l} \times \vec{B}, \quad d\vec{F} = Id\vec{l} \times \vec{B}, \quad \vec{\tau} = \vec{\mu} \times \vec{B}, \quad \vec{\tau} = \vec{r} \times \vec{F}$$

$$d\vec{B} = \left(\frac{\mu_0}{4\pi}\right) \frac{Id\vec{l} \times \vec{r}}{r^3} = \left(\frac{\mu_0}{4\pi}\right) \frac{Id\vec{l} \times \hat{r}}{r^2}, \qquad \oint \vec{B} \cdot d\vec{s} = \mu_0 I_{enclosed}$$

$$B = \frac{\mu_0 I}{2\pi r} \quad (infinite\ wire)$$

$$B = \frac{\mu_0 I \phi}{4\pi R} \quad (center\ of\ circular\ arc\ of\ angle = \phi)$$

$$B = \frac{\mu_0 I}{2R} \quad (center\ of\ whole\ loop)$$

$$B = \mu_0 n I \quad (solenoid)$$

$$B = \frac{\mu_0 N I}{2\pi r} \quad (toroid)$$

Constants

$\mu_0 = 4\pi \times 10^{-7} \frac{Tm}{A}$

$\epsilon_0 = 8.85 \times 10^{-12} \frac{C^2}{Nm^2}$

$e = 1.60 \times 10^{-19}\ C$

$M_{electron} = 9.11 \times 10^{-31}\ kg$