# Physics 227– Exam II
November 12, 2006
Prof. Coleman and Prof. Rabe

Your name sticker with exam code ⇒ 591

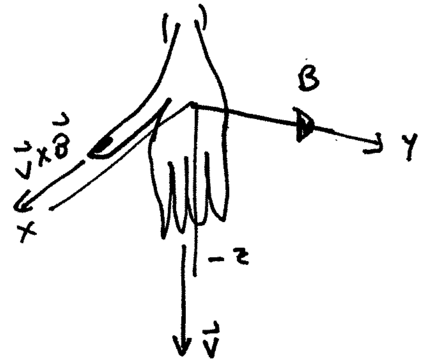
**SIGNATURE:** ______________

1. The exam will last from 3:00 p.m. to 4:20 p.m. Use a #2 pencil to make entries on the answer sheet. Enter the following ID information now, before the exam starts.
2. In the section labelled NAME (Last, First, M.I.) enter your last name, then fill in the empty circle for a blank, then enter your first name, another blank, and finally your middle initial.
3. Under STUDENT # enter your 9-digit Identification Number.
4. Enter 227 under COURSE, and your section number (see label above) under SEC.
5. Under CODE enter the exam code given above.
6. During the exam, you may use pencils, a calculator, and one **handwritten** 8.5 x 11 inch sheet with formulas and notes, without attachments.
7. There are 15 multiple-choice questions on the exam. For each question, mark only one answer on the answer sheet. There is no deduction of points for an incorrect answer, so even if you cannot work out the answer to a question, you should make an educated guess. At the end of the exam, **hand in the answer sheet and the cover page**. Retain this question paper for future reference and study.
8. When you are asked to open the exam, make sure that your copy contains all 15 questions. Raise your hand if this is not the case, and a proctor will help you. Also raise your hand during the exam if you have a question.
9. Please SIGN the cover sheet under your name sticker. A proctor will check your name sticker and your student ID sometime during the exam. Please have them ready.

## Useful Information

c = speed of light = $3.00 \times 10^8$ m/s
$q_e = -e$ = charge on an electron = -1.602 $\times 10^{-19}$ Coulombs
$q_p = +e$ = charge on a proton = +1.602 $\times 10^{-19}$ Coulombs
$m_e$ = electron mass = $9.11 \times 10^{-31}$ kg
$m_p$ = proton mass = $1.67 \times 10^{-27}$ kg
$k = 9 \times 10^9$ N m$^2$/C$^2$
$\epsilon_0 = 8.85 \times 10^{-12}$ C$^2$/(Nm$^2$)
$\mu_0 = 4\,\pi \times 10^{-7}$ Tm/A
$g = 9.80$ m/s$^2$
1 $eV = 1.602 \times 10^{-19}$ J
1 mC = $10^{-3}$ C    1 $\mu$C = $10^{-6}$ C
1 nC = $10^{-9}$ C    1 pC = $10^{-12}$ C

1.



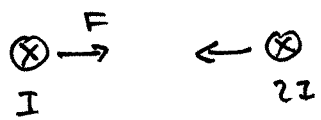

$\vec{v}\times\vec{B}$ points in $+\hat{x}$ direction by R.H. rule

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

$= -e\,\vec{v}\times\vec{B}$ in $-\hat{x}$ direction.

↑ −ve charged $e^-$

2.

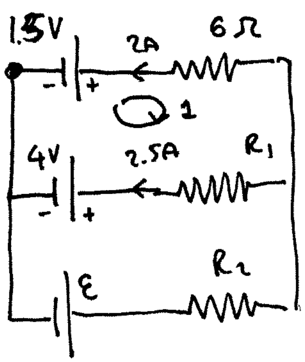



Like currents attract.

Field due to 2I is in +y direction @ origin.

$\vec{F} = i\,\vec{\ell}\times\vec{B}$ in $+\hat{x}$ direction.

3.

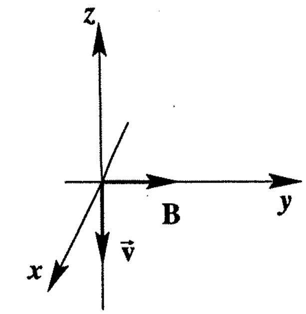



(1) $1.5 + 2\times 6 - 2.5\times R_1 - 4 = 0$

$13.5 - 4 = 2.5\,R_1$

$R_1 = 9.5/2.5 = 3.8\,\Omega$

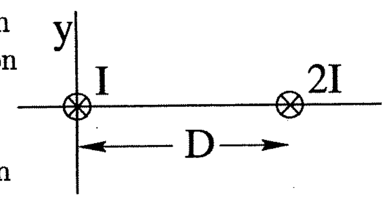
1. Consider an electron in a uniform magnetic field of magnitude 2 T in the $+y$ direction. When the velocity of the electron is $5\times10^6$ m/s in the $-z$ direction, the magnetic force on the electron is in the




a) $+z$ direction
b) $-x$ direction
c) $+x$ direction
d) $+y$ direction
e) $-y$ direction

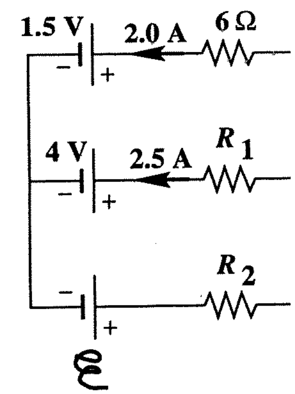
2. At $x = 0$ a long straight wire carries current I into the plane of the paper. At $x = D$, another long straight wire carries current $2I$ into the plane of the paper. What is the direction of the force on the wire at the origin?

a. towards the positive y-direction
b. towards the negative x-direction
c. out of the plane of the paper
d. towards the positive x-direction
e. None of the other answers




3. What is the resistance of $R_1$ in the circuit shown?

a) None of the other answers
b) 5.8 Ω
c) 3.8 Ω
d) 7.0 Ω
e) 2.6 Ω



4. $\frac{mv^2}{r} = qvB \Rightarrow r = \frac{mv}{qB}$

$r_p = \frac{m_p v_p}{qB} = 2r_D = \frac{2m_D v_D}{qB} = \frac{4 m_p v_D}{qD}$

$\Rightarrow 4 m_p v_D = m_p v_p \Rightarrow \underline{\underline{4v_D = v_p}}$ c

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5 $qvB = qE \Rightarrow E = vB$

$E = \frac{\Delta V}{d} \Rightarrow d = \frac{\Delta V}{E} = \frac{400 \text{ Volts}}{1.2\times10^7 \times 4\times10^{-3}}$

$= 8.33\times10^{-3}$ m

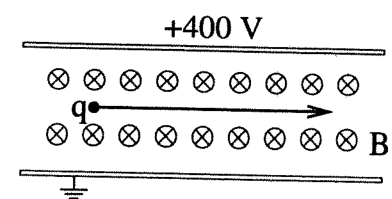
$= 8.33$ mm

4. A proton (charge = +e; mass = M) and a deuteron (charge = +e; mass = 2M) enter the same magnetic field, and both move in circular paths. The radius of the proton's path is twice that of the deuteron's. It follows that the proton's speed is

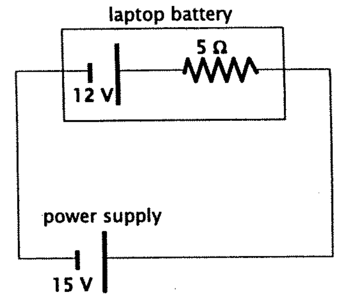
a) eight times that of the deuteron's
b) twice that of the deuteron's
c) four times that of the deuteron's
d) one-quarter of the deuteron's
e) half that of the deuteron's

5. A charged particle moves in a straight line as shown between the metal plates, through a uniform magnetic field $B = 4 \times 10^{-3}$ T. The velocity of the particle is $1.2 \times 10^7$ m/s, and the potential difference between the plates is 400 V. The separation between the plates is therefore

a) 133.3 mm
b) 1.2 m
c) 8.33 mm
d) impossible to state without knowing the charge $q$.
e) 120 m

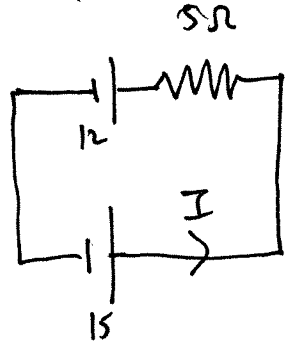


6. A 15V DC power supply is used to charge a laptop battery that has a maximum output EMF of 12V and an internal resistance of 5 Ω, as shown in the figure. At what rate is energy being stored inside the battery?




a) 45 W
b) 9 W
c) 1.8 W
d) 28.8 W
e) 7.2 W

6.




$15 - 5I - 12 = 0$

$\Rightarrow 3 = 5I \Rightarrow I = 0.6A$

Rate of power conversion in battery

$= 0.6A \times 12V = \underline{7.2W}$ e

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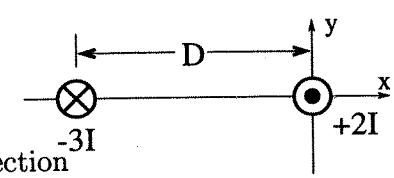
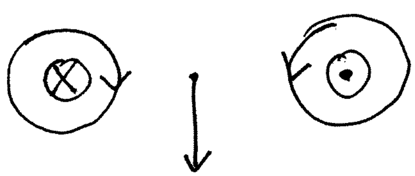
7. At $x = 0$, a long straight wire carries current $2I$ **out** of the plane of the paper. At $x = -D$, another long straight wire carries current $3I$ **into** the plane of the paper. Midway between them, i.e. at $x = -D/2$, what is the magnetic field?

a) Zero
b) $5\mu_0 I/\pi D$ in the positive $y$-direction
c) $\mu_0 I/\pi D$ in the negative $y$-direction
d) $5\mu_0 I/\pi D$ in the negative $y$-direction
e) $\mu_0 I/\pi D$ in the positive $y$-direction




7.

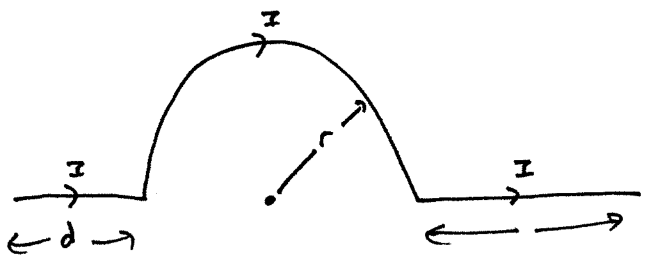


$B = B_L + B_R$

$= \frac{\mu_0}{2\pi}\frac{(3I)}{D/2} + \frac{\mu_0}{2\pi}\frac{(2I)}{D/2}$

$= \frac{\mu_0 I}{2\pi D} \times 10 = \frac{5\mu_0 I}{\pi D}$ d

8



Biot Savart : $\vec{B} = \frac{\mu_0 I}{4\pi} \int \frac{d\vec{l} \times \hat{r}}{r^2}$

Contributions from straight sections cancel

Semicircular section $B = \frac{\mu_0 I}{4\pi} \times \frac{\pi r}{r^2} = \frac{\mu_0 I}{4r}$

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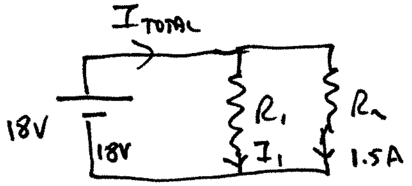
9.



$I_{TOTAL} = \frac{18V}{5\Omega} = 3.6A$

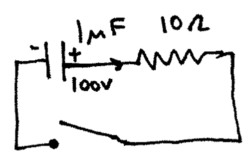
$I_1 = I_{TOTAL} - 1.5A$

$= 3.6 - 1.5 = 2.1A$

$2.1R_2 = 18V$

$\Rightarrow R_1 = \frac{18}{2.1} = 8.6\,\Omega$ (e)

10.



$I = I_0 e^{-t/\tau}$

$I_0 = \frac{100V}{10\Omega} = 10A$

$\tau = CR = 10^{-6} \times 10 = 10\mu s$ $\quad I(30\mu s) = 10 \times e^{-30/10} = \underline{0.497A}$ (d)

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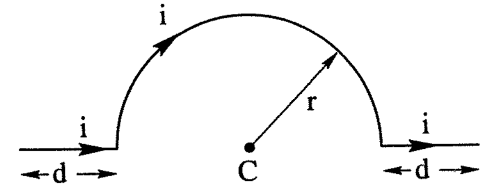
11. $P = V^2/R \Rightarrow R = V^2/P = \frac{(110)^2}{1000} = 12.1\,\Omega$ . (e)

8. The wire shown carries a current $i$. The magnitude of the magnetic field at $C$ is

a) $\mu_0 i/4r + 2\mu_0 i/d$
b) $\mu_0 i/4r$
c) $\mu_0 i/2\pi r$
d) $\mu_0 i/2r$
e) $\mu_0 i/4r + \mu_0 i/d$



9. Resistors $R_1$ and $R_2$ are connected in parallel to an 18 V battery. This combination of the two resistors has an equivalent resistance of 5 $\Omega$. If the current in the resistor $R_2$ is 1.5 A, which of the following statements is true?

a) $10\,\Omega \le R_1 < 16\,\Omega$
b) $4\,\Omega \le R_1 < 8\,\Omega$
c) $R_1 < 4\,\Omega$
d) $R_1 \ge 16\,\Omega$
e) $8\,\Omega \le R_1 < 10\,\Omega$

10. A 1 $\mu$F capacitor is charged up to a voltage of 100V. The capacitor is discharged through a 10 $\Omega$ resistor. What is the current flowing after 30 microseconds?

a) 0 A  b) 0.05A  c) 9.5 A  d) 0.50 A
e) 4.97 A

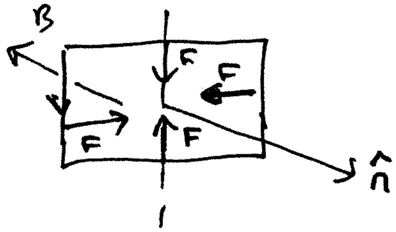
11. The working element of a toaster is a nichrome wire which acts as a resistor. All other wires have negligible resistance. The toaster heats up the bread by consuming 1000 W of power when plugged into a DC voltage source of 110 V. What is the resistance of the nichrome wire?

a) $1.1 \times 10^5\,\Omega$
b) $8.3 \times 10^{-2}\,\Omega$
c) $9.1\,\Omega$
d) The information given is not sufficient — we need to be given the current drawn as well.
e) $12.1\,\Omega$

2. $\vec{\tau} = \vec{\mu} \times \vec{B}$  $\vec{\mu} = IA\hat{n}$

$\vec{\tau} = IA\,\hat{n} \times \vec{B}$  But $\hat{n} \parallel \vec{B}$

$\Rightarrow \hat{n} \times \vec{B} = 0 \quad \vec{\tau} = 0$




All the forces on the wire produce no torque

(a)

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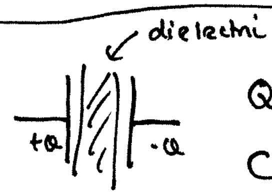
13.




Q fixed

C increases $= Q/V$

$\Rightarrow$ V decreases $\Rightarrow$ E decreases

(b)

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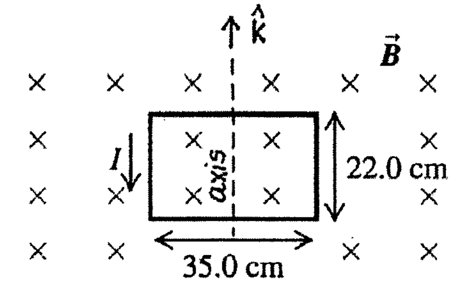
14. $R_A = \dfrac{\rho \ell}{\pi r_A^2} = \dfrac{4 \rho \ell}{\pi r_B^2} = 4R_B$

$\Rightarrow \dfrac{1}{r_A^2} = \dfrac{4}{r_B^2} \Rightarrow r_B = 2r_A$ (c)

PHYSICALLY $R_A = 4R_B \therefore R_A$ must have $1/4$ the area, $\frac{1}{2}$ the radius.

12. A rectangular coil of wire, 22.0 cm by 35.0 cm and carrying a counterclockwise current of 1.40 A, is oriented with the plane of its loop perpendicular to a uniform magnetic field pointing into the paper $\vec{B}$ = -1.50 T $\hat{\imath}$ and its axis along $\hat{k}$, as shown in the figure. The torque exerted by the magnetic field on the loop is

a) $0\hat{\jmath}$ Nm
b) $-0.16\hat{k}$ Nm
c) $+0.16\hat{k}$ Nm
d) $-0.16\hat{\jmath}$ Nm
e) $+0.16\hat{\jmath}$ Nm




13. A parallel-plate capacitor is charged and then disconnected from the charging battery. A dielectric slab is inserted in the gap between the capacitor plates. As a result,

a) the capacitance increases, while the electric field decreases
b) the capacitance stays the same, while the electric field decreases
c) the capacitance stays the same, while the electric field increases
d) the capacitance and electric field both increase
e) the capacitance and electric field both decrease

14. Two straight wires A and B of circular cross-section are made of the same metal and have equal lengths, but the resistance of wire A is four times greater than that of wire B. How do their radii compare?

a) $r_A = 2r_B$
b) $r_A = r_B/4$
c) $r_A = r_B/2$
d) $r_A = r_B/16$
e) $r_A = 4r_B$

5. Which of the following statements about the magnetic force on a moving charge is TRUE?

   a) The magnetic force on a moving charge is qvB$\sin\theta$, which vanishes when the charge moves perpendicular to the magnetic field.
   b) The magnetic force acts parallel to the magnetic lines of force, and is a maximum when a particle is moving perpendicular to the field.
   c) The magnetic force per unit charge is equal to the product of the magnetic field strength and the component of the velocity perpendicular to the field.
   d) The magnetic force changes sign when both the velocity and magnetic field are reversed.
   e) The magnetic force per unit charge is equal to the product of the magnetic field strength and the component of the velocity parallel to the field.

$F = q v_{\perp} B$ (c).