Physics 202 Exam 2
October 30, 2006

Name: Key

Section:

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Instructions:

1. Don't forget to write down your name and section number.
2. Only one answer is allowed for each multiple-choice question.
3. **Except for the multiple-choice problems, a reasonable amount of work is required to receive full credit.**
4. Be aware that intermediate steps earn points even if the final answer is incorrect.
5. Erase (or cross out) any mistakes or you will be marked down. Grading is based on everything you have written down.
6. Sig. figure rules are not tested in this exam.

Scores:

Problem 1 _______________/30

Problem 2 _______________/20

Problem 3 _______________/15

Problem 4 _______________/10

Problem 5 _______________/15

Problem 6 _______________/10

Total _______________/100

Problem 1: multiple-choice questions (30 points, 3 points each):

Please circle the correct answer for each question below. Only one correct answer per question is expected. Answering with more than one choice earns zero credit.

(1) Which of the following statement is true?

- (a) A magnetic field can never change the velocity of a charged particle,
- (b) A uniform magnetic field can never change the velocity of a charged particle but certain non-uniform magnetic field can.
- (c) <u>A magnetic field can never change the speed of a charged particle,</u>
- (d) A uniform magnetic field can never change the speed of a charged particle but certain non-uniform magnetic field can.

(2) The acceleration of a charged particle due to a magnetic field

- (a) is always zero.
- (b) is zero as long as the magnetic field is uniform.
- (c) is zero as long as the field is uniform and the charged particle moves in perpendicular to the field.
- (d) <u>None of above.</u>

(3) A parallel plate capacitor, initially with no dielectrics in between plates, has a capacitance of C_0. With insertion of certain dielectrics, its capacitance becomes C_κ.

- (a) C_κ is less than C_0.
- (b) <u>C_κ is larger than C_0.</u>
- (c) Not sure, it depends on the type of dielectrics filled.
- (d) Not sure, it depends on the polarization of the dielectrics.

(4) The SI unit of the magnetic field is

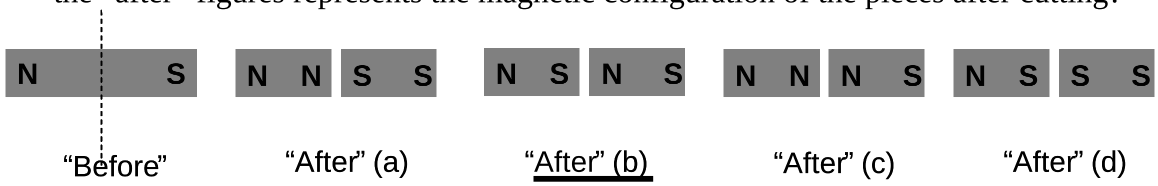
- (a) Gauss; (b) Faraday; (c) Ampere; (d) <u>Tesla.</u>

(5) Which of the following statements is true?

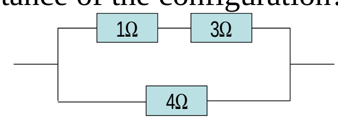
- (a) <u>An electric dipole tends to align in the direction of electric field; similarly a magnetic dipole tends to align in the direction of magnetic field.</u>
- (b) An electric dipole tends to align in the opposite direction of electric field; similarly a magnetic dipole tends to align oppositely to the magnetic field.
- (c) An electric dipole tends to align in the direction of electric field; but a magnetic dipole tends to align in the opposite direction of magnetic field.
- (d) None of above is correct. The magnetic dipole tends to align perpendicularly to the magnetic field according to the right hand rule.

(6) Magnetic field can be produced by
   (a) a magnetic charge or an electric current
   (b) an electric current only
   (c) a magnetic dipole only
   (d) none of above statements is true.

(7) A bar magnet is to be cut into two pieces along the dashed line as shown, which of the "after" figures represents the magnetic configuration of the pieces after cutting?



(8) What is the equivalent resistance of the configuration?



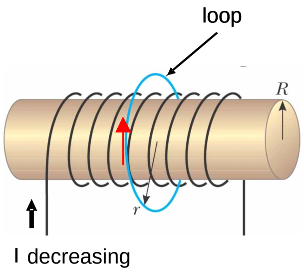
   (a) 8Ω.
   (b) 4Ω.
   (c) 2Ω.
   (d) None of above.

(9) In a lighting circuit, a 10W incandescent light bulb is connected in series with a 5W bulb (also of incandescent type). Which one is brighter?
(Note 1: "Brighter" means consumes more power.)
(Note 2: Incandescent bulbs can be treated as resistors.)
   (a) The 10W bulb.
   (b) The 5W bulb.
   (c) Both are the same.

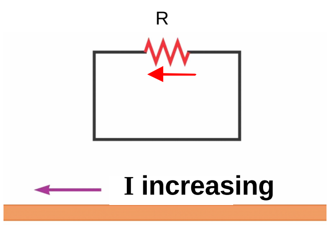
(10) The induced magnetic field inside a magnetic material is
   (a) Always in the same direction of the external magnetic field.
   (b) Always in the opposite direction of the external magnetic field.
   (c) Always smaller than the external magnetic field.
   (d) None of above is necessarily true.

Problem 2 (20 points): Apply Lentz's law to each case. (Arguments not necessary) .

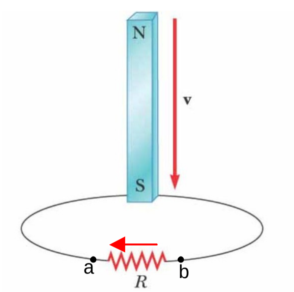
a) What is the direction of the induced emf in the loop? (5 points)



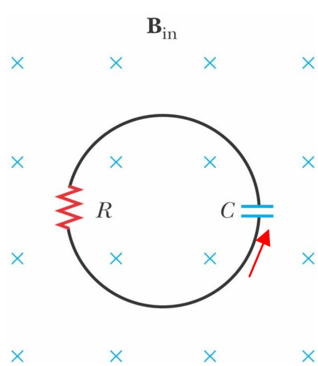
b) What is the direction of the current passing through R? (5 points)



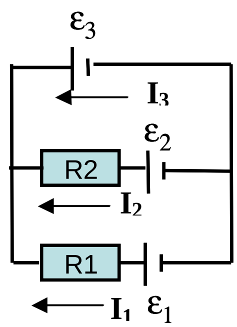
c) What is the direction of the current passing through R? (5 points)



d) Which plate of the capacitor is accumulating positive charge when B starts to increase? (5 points)



Problem 3 (15 points): In the circuit shown, R1=1Ω, R2=2Ω, ε_1= 3V, ε_2= 1V, ε_3= 2V.



a) Use Kirchhoff's rules to find the current (magnitude and direction) passing resistor R1.(5 points)

b) What is the current (magnitude and direction) passing resistor R2.(5 points)

c) What is the total power consumed in the circuit? (5points)

Solutions:

For currents with assumed directions as shown:

a):Loop rule for loop R1-ε_3–ε_1: $\varepsilon_1 - I_1 R1 - \varepsilon_3 = 0$

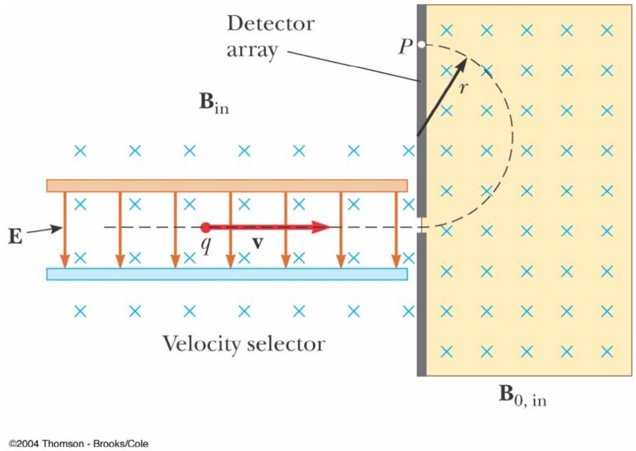
è $I_1 = (\varepsilon_1 - \varepsilon_3)/R1$ = 1A, direction as assigned.

b):Loop rule for loop R2-ε_3–ε_2: $\varepsilon_2 - I_2 R2 - \varepsilon_3 = 0$

è $I_2 = (\varepsilon_2 - \varepsilon_3)/R2$ = -0.5A, actual direction opposite to assigned.

c): $P = P_1 + P_2 = I_1^2 R1 + I_2^2 R2$ = 1W+0.5W =1.5W

Problem 4 (10 points): The schematic of a mass selector is shown in the figure.



For given E and B ,

a) What is the speed of a charged particle that can enter field B_0 ? (5points)

Solution:

For a particle to keep moving horizontally, $F_B=F_E$ à qvB=qE è v=E/B

b) If a particle of charge q moves inside field B_0 in a semicircle of radius r as shown, what are the mass and the sign of charge of this particle? (5points)

Solution:

$r=mv/qB_0$ à $m= rqB_0/v = rq\ B_0B/E$

q>0 in this case per right hand rule.

Problem 5 (15 points): An infinite straight thin wire carries a current I as shown.

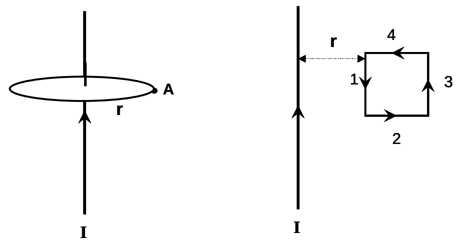


Fig. a Fig. b

a) Use Ampere's law to find the magnetic field at point A which is at distance r from the wire (as shown in Fig a.) (5 point).

Solution:

Draw a horizontal circle passing point A with the wile at the center, by symmetry argument, B must be tangent to the circle with same magnitude along the circle.

Ampere's Law: $\oint_{circle} \vec{B} \bullet \vec{dS} = \mu_0 I \rightarrow 2\pi r B = \mu_0 I \rightarrow B = \frac{\mu_0 I}{2\pi r}$ into the page.

b) A square loop which has a side length L and carries a current I, is placed near the above straight current as shown in fig b.

b.1) what is the sum of forces on sides 1 and 3? (5 points)

Solution: F=I**L**x**B**

on side 1: $F_1 = IL\mu_0 I/(2\pi r) = \mu_0 I^2 L/(2\pi r)$ to the right

on side 2: $F_2 = \mu_0 I^2 L/(2\pi(r+L))$ to the left

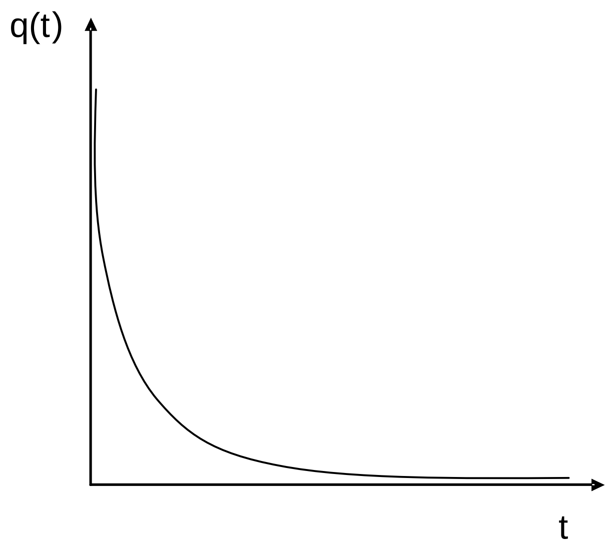
Total force $F_{12} = \mu_0 I^2 L/(2\pi)\ (1/r-1/(r+L)) = \mu_0 I^2 L^2/(2\pi)\ (1/(r(r+L)))$ to the right.

b.2) what is the sum of forces on sides 2 and 4? (5 points)

By symmetry, total forces on sides 2 and 4 is zero.

Problem 6 (10 points): A capacitor C holding a charge Q is connected in series with a resistor R and a switch K which is open initially. At t=0, the switch is closed.

a) Draw a q(t) vs. t curve for this discharge process. (5 points)



b) How long does it take to discharge the capacitor to 10% of its original charge? (5 points)

Solution:

$q(t)= Q e^{-t/RC} = 0.1Q$ à $e^{-t/RC} = 0.1$ à $t= RC\ln 10$