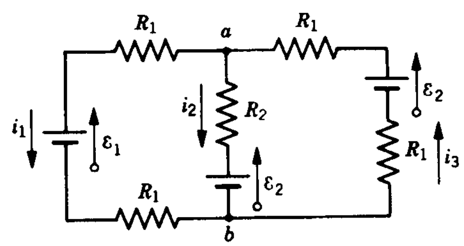
PHYSICS 271
ELECTRICITY AND MAGNETISM
SECOND EXAMINATION

19 November 1999

INSTRUCTIONS: Answer all questions on the answer sheet provided, it will be the only paper that is collected. This is a closed book exam.

(25 pts) **1.)** For the circuit drawn below:



1.a.) What does the junction rule yield?

a) $\mathcal{E}_1 + 2\mathcal{E}_2 = 0$

b) $i_1 + i_2 + i_3 = 0$
$2i_1R_1 + i_2R_2 = \mathcal{E}_1 + \mathcal{E}_2$
$i_2R_2 + 2i_3R_1 = 0$

c) $i_1 + i_2 = i_3$

d) $i_1 + i_2 = i_3$
$-2i_1R_1 + i_2R_2 = \mathcal{E}_1 - \mathcal{E}_2$
$i_2R_2 + 2i_3R_1 = 0$

1.b.) What does the loop rule yield?

a) $i_1 + i_2 = i_3$

b) $i_1 + i_2 + i_3 = 0$
$2i_1R_1 + i_2R_2 = \mathcal{E}_1 + \mathcal{E}_2$
$i_2R_2 + 2i_3R_1 = 0$

c) $-2i_1R_1 + i_2R_2 = \mathcal{E}_1 - \mathcal{E}_2$
$i_2R_2 + 2i_3R_1 = 0$

d) $2i_1R_1 + i_2R_2 = \mathcal{E}_1 + \mathcal{E}_2$
$i_2R_2 + 2i_3R_1 = 0$

1.c.) What is the current through the source of emf in the left branch?

a) $i_1 = \dfrac{(2R_1 + R_2)(\mathcal{E}_2 - \mathcal{E}_1)}{4R_1(R_1 + R_2)}$

c) $i_1 = \dfrac{(2R_1 + R_2)(\mathcal{E}_1 - \mathcal{E}_2)}{4R_1(R_1 + R_2)}$

b) $i_1 = \dfrac{(\mathcal{E}_2 - \mathcal{E}_1)}{2(R_1 + R_2)}$

d) $i_1 = \dfrac{(2R_1 + R_2)(\mathcal{E}_1 + \mathcal{E}_2)}{4R_1(R_1 + R_2)}$

1.d.) What is the current through the source of emf in the right branch?

a) $i_3 = \dfrac{R_2(\mathcal{E}_1 - \mathcal{E}_2)}{4R_1(R_1 + R_2)}$

c) $i_3 = \dfrac{(2R_1 + R_2)(\mathcal{E}_1 - \mathcal{E}_2)}{4R_1(R_1 + R_2)}$

b) $i_3 = \dfrac{(\mathcal{E}_1 - \mathcal{E}_2)}{2(R_1 + R_2)}$

d) $i_3 = \dfrac{R_2(\mathcal{E}_2 - \mathcal{E}_1)}{4R_1(R_1 + R_2)}$

1.e.) What is the current through the source of emf in the center branch?

a) $i_2 = \dfrac{(2R_1 + R_2)(\mathcal{E}_2 - \mathcal{E}_1)}{4R_1(R_1 + R_2)}$

c) $i_2 = \dfrac{(\mathcal{E}_1 - \mathcal{E}_2)}{2(R_1 + R_2)}$

b) $i_2 = \dfrac{(\mathcal{E}_2 - \mathcal{E}_1)}{2(R_1 + R_2)}$

d) $i_2 = \dfrac{(2R_1 + R_2)(\mathcal{E}_1 + \mathcal{E}_2)}{4R_1(R_1 + R_2)}$

1.f.) The potential difference V_a-V_b is equal to

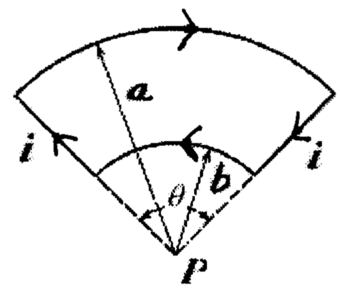
a) $V_a - V_b = iR_{eq}$

c) $V_a - V_b = \dfrac{(2R_1 + R_2)\,\mathcal{E}_2 + R_2\,\mathcal{E}_1}{2(R_1 + R_2)}$

b) $V_a - V_b = \dfrac{\mathcal{E}_2}{2(R_1 + R_2)}$

d) $V_a - V_b = \dfrac{-\mathcal{E}_2}{2(R_1 + R_2)}$

(25 pts) **2.)** Consider the circuit drawn below. The curved segments are arcs of circles of radii a and b. The straight segments are along the radii. Assume current i flows in the circuit.



2.a.) The direction of the magnetic field at P is

a) B points up

b) B points down

c) B points to the right

d) B points to the left

e) B points into the page

f) B points out of the page

g) B =0

2.b.) The magnitude of the magnetic field at P is

a) $B = \frac{\mu_0}{4\pi} i \frac{1}{2}\left(\frac{1}{a} + \frac{1}{b}\right)$

b) $B = \frac{\mu_0}{4\pi} i\theta \left(\frac{1}{b} - \frac{1}{a}\right)$

c) $B = 0$, since P is outside the loop

d) $B = \frac{\mu_0 i}{\left[(a-b) + \theta(a+b)\right]}$

2.c.) The magnetic dipole moment μ of the above current loop is

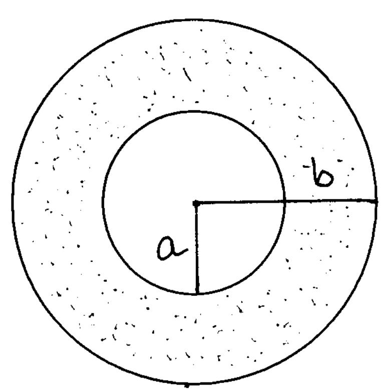
a) $i\pi(a^2-b^2)$, into the page

b) $\frac{\mu_0}{4\pi} i \left(a^2 - b^2\right)$, into the page

c) $\mu = 0$, since P is outside the loop

d) $i\theta \frac{1}{2}\left(a^2 - b^2\right)$, into the page

(25 pts) **3.)** Below is drawn a cross section of a hollow cylindrical conductor of radii a and b, carrying a uniformly distributed current i flowing out of the page.



3.a.) Determine the magnetic field for radius $r>b$.

a) $B=\dfrac{\mu_0 i}{4\pi\ r}$, tangent to circles in CCW direction

b) $B=\dfrac{\mu_0 i}{4\pi\ r}$, out of the page

c) $B=\dfrac{\mu_0 i}{2\pi\ r}$, tangent to circles in the CCW direction

d) $B=\dfrac{\mu_0 i}{2\pi\ r}$, out of the page

3.b.) Determine the magnetic field for radius $r<a$.

a) $B=\dfrac{\mu_0 i}{4\pi\ a}$, tangent to circles in CCW direction

b) $B=0$

c) $B=\dfrac{\mu_0 i}{4\pi\ r}$, tangent to circles in the CCW direction

d) $B=\dfrac{\mu_0 i}{4\pi\ r}$, out of the page

3.c.) Determine the magnetic field for radius $a<r<b$.

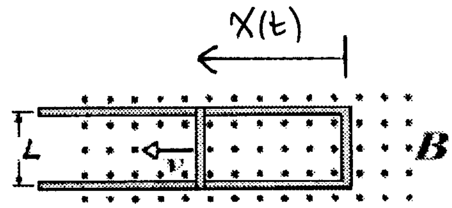
a) $B=\dfrac{\mu_0 i\ (r^2-a^2)}{2\pi\ r\ (b^2-a^2)}$, tangent to circles in CCW direction

b) $B=\dfrac{\mu_0 i\ (r^2-a^2)}{2\pi\ r\ (b^2-a^2)}$, out of the page

c) $B=\dfrac{\mu_0 i\ (r^2-a^2)}{4\pi\ r\ (b^2-a^2)}$, tangent to circles in the CCW direction

d) $B=\dfrac{\mu_0 i\ (r^2-a^2)}{4\pi\ r\ (b^2-a^2)}$, out of the page

(25 pts) 4.) A rod lies across frictionless rails in a uniform magnetic field ***B***, as shown. The rod moves to the left with constant speed v and at $t=0$ its position is $x(t=0)=x_0$.



4.a.) In order for the emf around the circuit to be zero, the magnitude of the magnetic field should

a) not change

b) increase linearly with time

c) decrease inversely with time

d) increase quadratically with time

e) decrease quadratically with time

4.b.) A rod with resistance R lies across frictionless conducting rails in a constant uniform magnetic field ***B***, as drawn above. Assume the rails have negligible resistance. The force that must be applied by a person to pull the rod to the left at constant speed v is

a) 0

b) BLv

c) $\frac{BLv}{R}$

d) $\frac{B^2L^2v}{R}$

e) $\frac{B^2Lxv}{R}$

Physics 271 Electricity and Magnetism
Examination 2: Equation Sheet

$$i = \frac{dq}{dt} \quad ; \quad \vec{j} = Nq\vec{v}_d \quad ; \quad i = \int_S \vec{j} \cdot d\vec{A} \tag{1}$$

$$\int_V \frac{\partial \rho}{\partial t} dV + \oint_S \vec{j} \cdot d\vec{A} = 0 \tag{2}$$

$$\vec{j} = \sigma \vec{E} \quad ; \quad V = iR \quad ; \quad R = \frac{\rho L}{A} \tag{3}$$

$$P = iV \quad ; \quad P = i^2 R = \frac{V^2}{R} \tag{4}$$

Kirchhoff's First Rule: At any junction, the sum of the currents leaving the junction equals the sum of the currents entering the junction.

Kirchhoff's Second Rule: The algebraic sum of the changes in potential encountered in a complete traversal of any closed circuit is zero.

Parallel Resistors: $\frac{1}{R_{eq}} = \sum_{i=1}^{N} \frac{1}{R_i}$ Series Resistors: $R_{eq} = \sum_{i=1}^{N} R_i$

$$\vec{F} = q\left(\vec{E} + \vec{v} \times \vec{B}\right) \quad ; \quad \oint_S \vec{B} \cdot d\vec{A} = 0 \tag{5}$$

$$d\vec{F} = i d\vec{s} \times \vec{B} \quad ; \quad \vec{F} = i\vec{L} \times \vec{B} \tag{6}$$

$$\vec{\mu} = NiA\hat{n} \quad ; \quad \vec{\tau} = \vec{\mu} \times \vec{B} \quad ; \quad U = -\vec{\mu} \cdot \vec{B} \tag{7}$$

$$d\vec{B} = \frac{\mu_0}{4\pi} \frac{i d\vec{s} \times \vec{r}}{r^3} \quad ; \quad \vec{B} = \frac{\mu_0}{4\pi} \int_C \frac{i d\vec{s} \times \vec{r}}{r^3} \tag{8}$$

$$\oint_C \vec{B} \cdot d\vec{s} = \mu_0 i_{\text{enclosed}} \quad ; \quad \mathcal{E} = -\frac{d\Phi_B}{dt} \tag{9}$$

$$\Phi_B = \int_S \vec{B} \cdot d\vec{A} \quad ; \quad \mathcal{E} = \oint_C \vec{E} \cdot d\vec{s} = -\frac{d}{dt} \int_S \vec{B} \cdot d\vec{A} \tag{10}$$