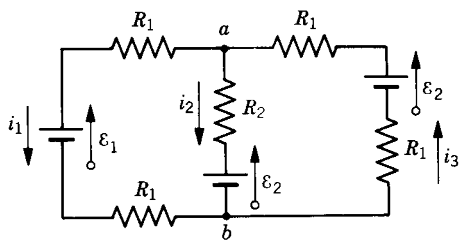
PHYSICS 271
ELECTRICITY AND MAGNETISM
SECOND EXAMINATION

20 November 2000

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

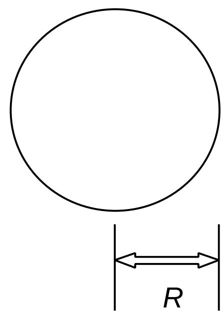
a) $V_a - V_b = iR_{eq}$

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

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

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

(25 pts) 2.) Consider the circular loop of radius R carrying a current i in the clockwise direction as shown below.



2.a.) What is the direction of the magnetic field at the center of the circular loop?

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, B, at the center of the circular loop is

a) $B = \frac{m_0 i}{2p\ R}$

c) $B = 0$, since P is a point of symmetry

b) $B = \frac{m_0 i}{4p\ R}$

d) $B = \frac{m_0 i}{2R}$

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

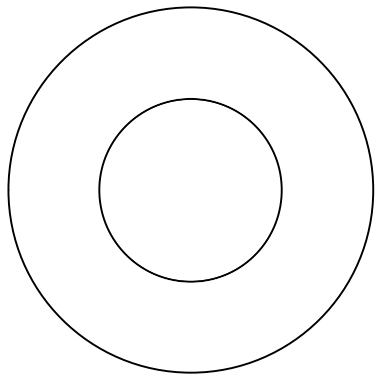
a) $ip R^2$, into the page

c) $m = 0$, since P is a point of symmetry

b) $\frac{m_0}{4p} i R^2$ **,** into the page

d) $\frac{m_0 i}{2p R}$, into the page

(25 pts) **3.)** Below is drawn a cross section of a hollow cylindrical conducting pipe of inner radius *a* and outer radius *R*, carrying a uniformly distributed current *i* flowing into the page.



3.a.) Determine the magnetic field for radius $r \geq R$.

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

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

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

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

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

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

b) $B = 0$

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

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

3.c.) Determine the magnetic field for radius $a \le r \le R$.

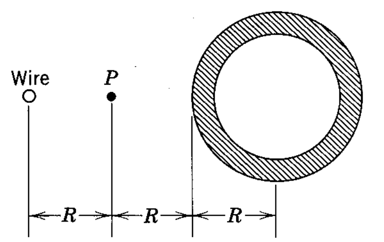
a) $B = \frac{m_0 i}{2p r} \frac{(r^2 - a^2)}{(R^2 - a^2)}$, tangent to circles in CW direction

b) $B = \frac{m_0 i}{2p r} \frac{(r^2 - a^2)}{(R^2 - a^2)}$, into the page

c) $B = \frac{m_0 i}{4p r} \frac{(r^2 - a^2)}{(R^2 - a^2)}$, tangent to circles in the CW direction

d) $B = \frac{m_0 i}{4p r} \frac{(r^2 - a^2)}{(R^2 - a^2)}$, into the page

3.d.-e.) A wire is placed to run parallel to the above described current carrying pipe at a distance *3R* from center to center, as drawn below. Current *I* flows in the wire so that the resultant magnetic field at the point *P* has the same magnitude, but opposite direction, as the resultant field at the center of the pipe.



3.d.) In what direction does *I* flow?

a) *I = 0, P* is a symmetry point

b) Out of the page

c) Into the page

3.e.) The magnitude of *I* is

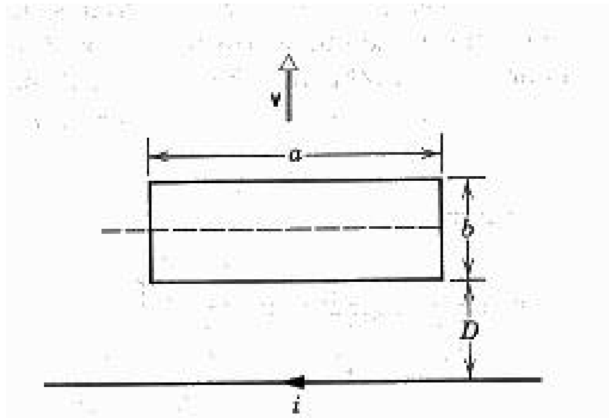
a) $I = \frac{3}{8} i$

b) $I = \frac{3}{4} i$

c) $I = \frac{3}{8} \frac{a}{R} i$

d) $I = \frac{3}{4} \frac{a}{R} i$

(25 **pts)** 4.) A rectangular loop of wire with length *a*, width *b*, and resistance *R* is placed near an infinitely long wire carrying current *i*, as shown below. The distance from the long wire to the loop is *D*.



4.a.) The magnetic flux, Φ_B, through the loop is

a) $\Phi_B = \dfrac{m_0 i}{2p\left[D + \dfrac{b}{2}\right]} ab$

c) $\Phi_B = \dfrac{m_0 i}{2p D} ab \ln\left[1 + \dfrac{b}{D}\right]$

b) $\Phi_B = \dfrac{m_0 i}{2p} a \ln\left[1 + \dfrac{b}{D}\right]$

d) $\Phi_B = \dfrac{m_0 i}{2p D} ab$

e) $\Phi_B = 0$

4.b.) The current *I* in the loop as it moves away from the long wire with speed *v* is

a) $I = \dfrac{m_0 i}{2p R D^2} abv$

c) $I = \dfrac{m_0 i}{2p R D^2} abv\left(\ln\left[1 + \dfrac{b}{D}\right] + \dfrac{b}{D+b}\right)$

b) $I = \dfrac{m_0 i}{2p R\left[D + \dfrac{b}{2}\right]^2} abv$

d) $I = \dfrac{m_0 i}{2p R} \dfrac{abv}{D(D+b)}$

e) $I = 0$

4.c.) The direction of the current *I* in the loop as it moves away from the long wire with speed *v* is

a) 0 **b)** CW **c)** CCW