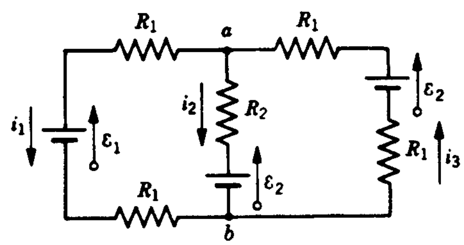
PHYSICS 271
ELECTRICITY AND MAGNETISM
SECOND EXAMINATION

20 November 1998

INSTRUCTIONS: Answer all questions. Explain what you are doing in the calculations, do not simply write formulae. Stating the answer is not sufficient, you will lose points if you do not show steps in finding the solution (excluding the multiple choice questions). Neatness and clarity of presentation count. This is a closed book exam.

(25 pts) **1.)** Calculate the current through each source of emf in the circuit below. Calculate V_a-V_b .



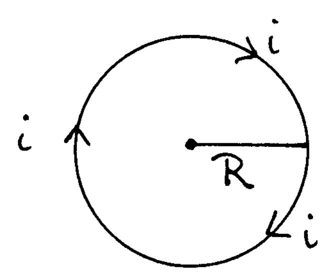
(20 pts) **2.a.)** A circular coil of wire of radius *R* carries a current *i* as shown below. The magnetic field ***B*** (magnitude and direction) at the center of the circle is

a) $\frac{\mu_0 i}{2\pi R}$, into the page

b) $\frac{\mu_0 i}{2R}$, into the page

c) $\frac{\mu_0 i}{4\pi R^2}$, into the page

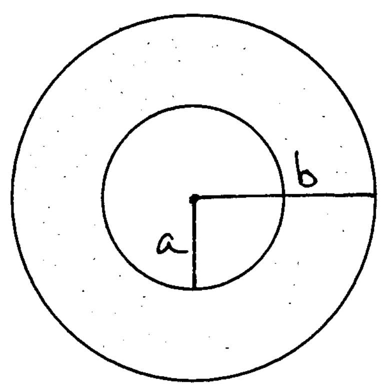
d) $\frac{\mu_0 i}{2\pi R}$, out of the page.



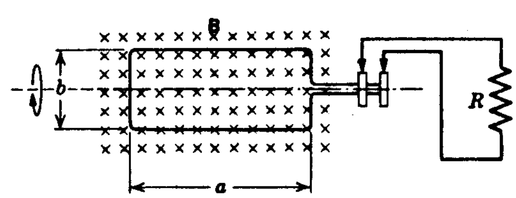
(5 pts) **2.b.)** The magnetic dipole moment μ of the above circular ring of current is

a) $i\pi R^2$, into the page
b) $2\pi \; iR$, into the page
c) $i\pi R^2$, out of the page
d) $2\pi \; iR$, out of 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. Find the magnetic field $\boldsymbol{B}$.



(25 pts) **4.)** A rectangular loop of N turns and of length a and width b is rotated at a frequency ν in a uniform magnetic field $\boldsymbol{B}$, as shown below. Determine the induced emf that appears in the loop. This is the principle of the commercial alternating current generator.



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: $R_{eq} = \sum_{i=1}^{N} R_i$

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

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

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

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

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

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