SUMMARY HOMEWORK 4

Shown on the next page is a copy of what the front page of Exam 4 will look like.
After that are a bunch of problems for you to work out. Solutions to the problems are posted on the course website.
A wide variety of problems has been given to help you understand all the concepts. The exam will not be as long as this problem set.

Name:

Section:

The exam is closed book and closed notes. Write answers in the boxes provided. Show your methods and calculations for partial credit. Give numerical answers to 3 significant digits, and include units. Express vectors in ijk form unless otherwise indicated.

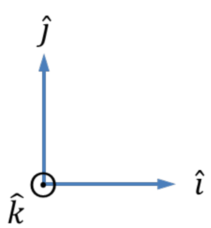
$$\epsilon_0 = 8.85 \times 10^{-12} \frac{C^2}{N\,m^2}, \qquad \mu_0 = 4\pi \times 10^{-7} \frac{T\,m}{A}$$
$$m_e = 9.1 \times 10^{-31}\,kg, \qquad m_p = 1.67 \times 10^{-27}\,kg, \qquad e = 1.60 \times 10^{-19}\,C$$

$$m = milli = 10^{-3}, \qquad \mu = micro = 10^{-6}, \qquad n = nano = 10^{-9}, \qquad p = pico = 10^{-12}$$

$$k = kilo = 10^3, \qquad M = mega = 10^6, \qquad G = giga = 10^9$$

$$\vec{F} = q\vec{v} \times \vec{B}, \qquad \vec{F} = I\,\vec{L} \times \vec{B}, \qquad F = \frac{\mu_0 I_1 I_2 L}{2\pi r}, \qquad F = ILB, \qquad P = ILBv$$
$$F = \frac{mv^2}{r}, \qquad r = \frac{mv}{qB}, \qquad \omega = \frac{2\pi}{T} = \frac{qB}{m}, \qquad v = \frac{E}{B}$$
$$\vec{B} = \frac{\mu_0}{4\pi}\frac{q\vec{v} \times \hat{r}}{r^2}, \qquad d\vec{B} = \frac{\mu_0}{4\pi}\frac{Id\vec{L} \times \hat{r}}{r^2}$$
$$B = \frac{\mu_0 I}{2\pi r}, \qquad B = \frac{\mu_0 N I a^2}{2(x^2 + a^2)^{3/2}}, \qquad B = \frac{\mu_0 N I}{2a}, \qquad B = \mu_0 n I, \qquad n = \frac{N}{L}$$
$$\Phi = \vec{B} \cdot \vec{A} = BA\cos\theta, \qquad \mathcal{E} = -\frac{d\Phi}{dt}$$

The following conventions for vectors apply throughout the exam:



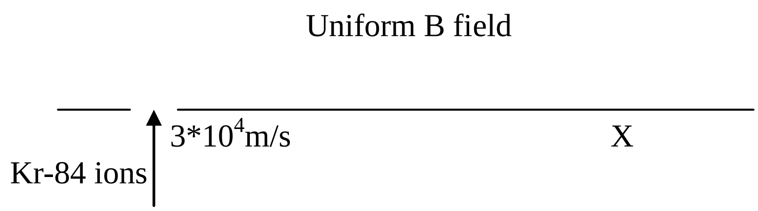
Vectors pointing out of the page and into the page are represented by

⊙ out of the page

⊗ into the page

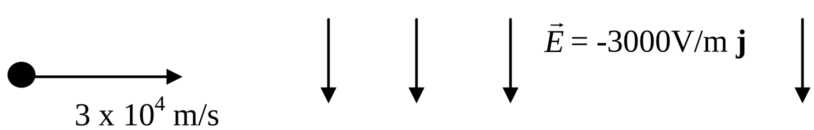
In all the problems below, take the unit vectors **i,j** and **k** to be as on the previous page
Magnetic fields and currents pointing into the page are denoted by the symbol ×
Magnetic fields and currents pointing out of the page are denoted by the symbol ●
These conventions will also be followed on the exam

1. Positively charged Kr-84 ions (mass = $1.4*10^{-25}$kg, charge = $+1.6*10^{-19}$C) pass through a mass spectrometer that selects ions of speed of $3*10^{4}$m/s and makes them enter a region with a uniform magnetic field (see sketch below). The ions are curved by the magnetic field and hit a photographic plate at a point X that is 0.075m directly to the right of their point of entry.



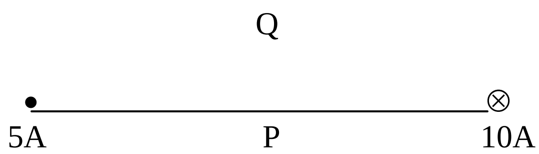
(a) Copy the above figure on your answer sheet and sketch the path followed by the ions on it.
(b) Calculate the magnitude and direction of the uniform magnetic field. Specify the direction in terms of the unit vectors defined above.
(c) Calculate the time taken by the ions to hit the plate after they enter the field.
(d) Some Kr-86 ions (same charge but larger mass) are present in the beam with the same speed as the Kr-84 ions. Will they hit the plate to the LEFT or RIGHT of X?

2. It is desired to construct a velocity selector for Kr-84 ions that will pick out ions of speed 3×10^{4} m/s, as needed in problem 1. Suppose the ions move horizontally from left to right so that their velocity is $\left(3\times10^{4}\,\text{m/s}\right)\mathbf{i}$, see sketch below. When they enter the velocity selector they encounter an electric field $\vec{E}=\left(-3000\text{V/m}\right)\mathbf{j}$, see sketch below.



(a) Calculate the magnitude and direction of the magnetic field in the velocity selector if the ions are to go straight through in the **i** direction without deflection.
(b) Suppose it is desired to use the above velocity selector to pick out Kr-86 ions of the same speed (these ions have the same charge as the Kr-84 but a slightly larger mass). How will the strength of the magnetic field have to be changed?
(c) If the Kr-84 ions were doubly ionized (i.e. had a charge of +2e), how would the magnetic field in part (a) have to be changed?

3. Shown below are two wires 100cm apart, the left carrying a current of 5A out of the page and the right a current of 10A into the page. The point P is midway between the wires.



(a) Calculate the magnetic field at P due to the left wire, expressing your answer in terms of the unit vectors **i,j,k.**
(b) Calculate the magnetic field at P due to the right wire (again express answer in terms of **i,j,k).**
(c) Calculate the total magnetic field at P due to both wires.
(d) Draw an arrow at Q, which is vertically above P, showing the approximate direction of the total magnetic field there. (You will get full credit if arrow is in the right quadrant).
(e) The magnetic field vanishes somewhere on the line joining the two wires. Where does this happen: to the left of 5A wire, in between the two wires or to the right of the 10A wire?
(f) As a followup to (e), calculate the exact place on the line joining the wires where the magnetic field vanishes.
(g) A long wire is placed at P, parallel to the other two wires, and carrying a current of 3A out of the page. Calculate the force experienced by a 1cm portion of this wire, expressing your answer in terms of the unit vectors **i,j,k.**

4. Problem 28.80

5. Problem 28.44

The problems below do not have to be submitted for grading. However they are excellent practice problems, of the type you could get on the exam. Their solutions will also be posted.

Exercises 28.27, 28.28 and 28.30

The following problems are all connected with Faraday's law and Lenz's law:

Ex. 29.2, 29.15, 29.19, 29.28

A rectangular loop of wire of dimensions 4cm x 5cm lies in the x-y plane, with the 4cm side being parallel to the x-axis and the 5cm side parallel to the y-axis. Take the normal to the loop to be along **k.** The loop is in a uniform magnetic field that changes with time according to the equation **B** = (-.05t **i** + .05t **k**) T, where the time t is to be taken in seconds. (a) Calculate the flux through the loop at t = 20s. (b) Calculate the emf induced in the loop. How does it change with time? (c) Determine the direction of the induced current in the loop if one looks down on it from a point on the positive z-axis.