

Physics 222

2/3/05

name \_\_\_\_\_

$$\begin{aligned} \text{KE} &= \frac{1}{2} m v^2, & \mathbf{F} &= m \mathbf{a}, & v^2 - v_0^2 &= 2 a x, & v &= v_0 - a t, & x &= v_0 t + \frac{1}{2} a t^2, & a_c &= v r^2 / r \\ k &= \frac{1}{4 \pi \epsilon_0} = 9 \times 10^9 \text{ Nm}^2 / \text{C}^2 & \mu_0 &= 4 \pi \times 10^{-7} \text{ Tm/A} \end{aligned}$$



1a) Suppose the charge shown in the picture is stationary and positive and the field shown by the arrows is an electric field. Describe the motion of the charge.

1b) Suppose instead that the charge shown in the picture is stationary and positive and the field is a magnetic field. Describe the motion of the charge.

1c) Suppose instead the charge is positive and is moving away from you, into the page and the field is a magnetic field. Describe the motion of the charge.

1d) Suppose instead the charge is negative and is moving towards you, out of the page and the field is a magnetic field. Describe the motion of the charge.

1e) Suppose instead the charge is negative and is moving towards you, out of the page and the field is an electric field. Describe the motion of the charge.

2) A charge  $q$  is placed at the center of a spherical Gaussian surface. What happens to the flux through the surface under the following changes:

a) The radius is doubled.

b) The charge is moved off center.

c) The charge is doubled.

d) The charge is replaced with a charge of  $-q$ .

e) The spherical surface is replaced by a cubic Gaussian surface.

3) A piece of iron which originally unmagnetized is heated while oriented in a north-south direction. When it is cooled it is found to have a permanent magnetic field. Explain what happened, draw before and after pictures.

4) The earth's magnetic north pole is the south pole of an internal magnet. One hypothesis for explaining this magnetic field says that it is caused by a current flow in the iron core of the earth. What would have to be the orientation and direction of this current flow in order to get the earth's magnetic field as we measure it today?

5) Ink is transferred to a sheet of paper in a xerox machine by static electricity. Suppose a charge of  $+0.06 \mu\text{C}$  resides on the component of the machine which contains the ink and at a distance 2 cm away the paper has a charge of  $+0.08 \mu\text{C}$ .

a) Calculate the force between these two charges?

b) Calculate the electric field at a point located exactly halfway between the two charges?

6) A long hollow metal cylinder with inside radius of  $a$  and outside radius of  $b$  is charged with a static line charge of  $+\lambda$  per unit length. Using Gauss' Law, find the electric field

- a) inside the cylinder ( $r < a$ )
- b) inside the metal ( $a < r < b$ )
- c) outside the cable ( $r > b$ )

7) Suppose you are biologist and you suspect that a particular animal is using either the earth's magnetic field or the earth's electric field to navigate. You have discovered that these animals have a small amount of charge ( $2.1 \times 10^{-7}$  C) located in their heads. At the location of your field work the earth's magnetic field is parallel to the earth's surface with a magnitude of  $3 \times 10^{-5}$  T and points north while the earth's electric field is perpendicular to the surface and points down with a magnitude of 120 N/C.

- a) If the animal moves at  $3.0 \times 10^{-2}$  m/s westward, how large is the force due to the earth's electric field?

b) What direction is the electric force?

c) If the animal moves at  $3.0 \times 10^{-2}$  m/s westward, how large is the force due to the earth's magnetic field?

d) What direction is the magnetic force?

e) What direction and what speed would the animal have to move in order for the electric and magnetic forces to cancel?

8) Ampere's law is given by  $\oint \mathbf{B} \cdot d\mathbf{s} = \mu_0 I$ . Explain in words what each term in the equation means and what the law tells you.

9) A bolt of lightning strikes the ground perpendicular to the earth's surface.

a) Assume the current travels in a straight line and use Ampere's law to prove that the magnetic field at a distance  $r$  from the strike is given by  $B = \mu_0 I / 2\pi r$ . Be sure to explain all the steps in the proof.

b) Suppose the lightning strike has a current of  $6.02 \times 10^6$  Amps for its duration. What is the strength of the magnetic field 200m away?

10) The Biot and Savart is given by  $d\mathbf{B} = \frac{\mu_o I d\mathbf{s} \times \mathbf{r}}{4\pi r^2}$

a) Explain in words what each term in the equation means and what the law tells you.

b) Given the radius  $a$  and the current  $I$ , use the Biot Savart law find an expression for the magnetic field at point  $p$  on the figure below. Be sure to explain all your steps in words.

**Bonus**

What is the difference between resistance and resistivity?

Home outlet plugs are part of a parallel circuit. Why would connecting more and more devices be dangerous?