Chapter 20 Practice Exam

Spring 2020

One $8\frac{1}{2} \times 11$ equation sheet written on one side permitted

IMPORTANT: Except for multiple-choice questions, you will receive no credit if you show only an answer, even if the answer is correct. Always show in the space on your answer sheet some sketches, words, or equations which clearly justify your answer. Show the equations you use and the values substituted into them whenever equations are necessary. If you go from a formula directly to an answer without showing the values used, you will lose points. Points will also be deducted for missing or erroneous units.

Each individual answer is weighted roughly evenly throughout the exam.

Name ____

elementary charge $e = 1.6 \times 10^{-19}$C

Chapter 20 Multiple Choice

For the next two items

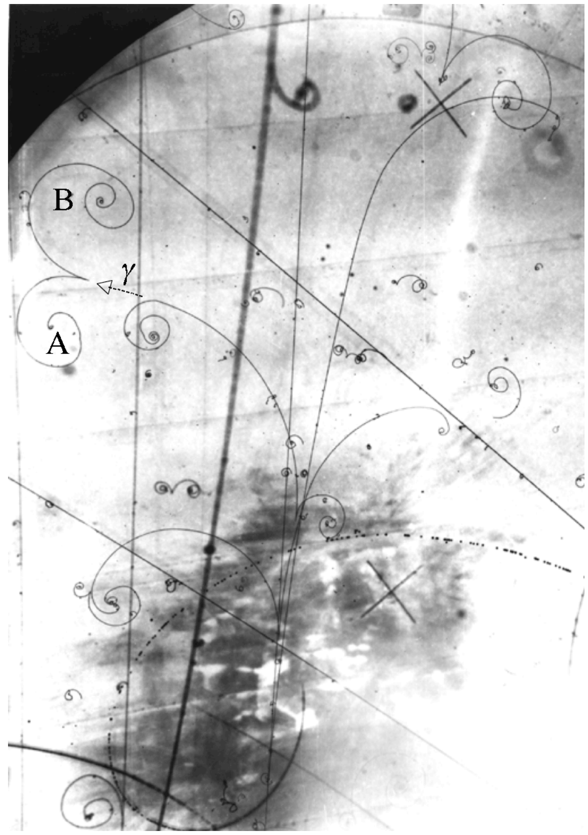
A magnetic field of 0.1 T causes a beam of protons to move in a circular path of radius 0.1 m. The plane of this circular path is perpendicular to the magnetic field.

1. Which of the following is the best estimate of the work done by the magnetic field on the protons during one complete orbit of the circle?

   (a) 0 J
   (b) 10^{-22} J
   (c) 10^{-5} J
   (d) 10^{2} J
   (e) 10^{20} J

2. Which of the following is the best value of the speed of a proton in the beam as it moves in the circular path?

   (a) $10^{-2}\,\frac{\text{m}}{\text{s}}$
   (b) $10^{3}\,\frac{\text{m}}{\text{s}}$
   (c) $10^{6}\,\frac{\text{m}}{\text{s}}$
   (d) $10^{8}\,\frac{\text{m}}{\text{s}}$
   (e) $10^{15}\,\frac{\text{m}}{\text{s}}$



3. A uniform magnetic field is directed into the page in this picture, which shows the things that occur when high energy particles collide. In one such collision a gamma ray (γ) is produced and travels along (as shown). Then an interaction occurs in which the γ disappears, its energy being used to create an electron and its antiparticle, a positron (a positively charged electron). These two particles, labeled A and B, make paths through this bubble chamber. Which is the positron and which is the electron?

   "A" is the positron; "B" is the electron.

FREE RESPONSE

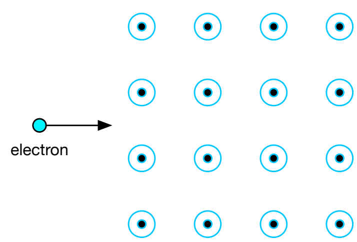
1. Use magnetic field lines to sketch the magnetic field produced by a

   (a) bar magnet
   See text for all of these diagrams.

   (b) solenoid

   (c) wire as seen from an "end view."

2. An electron is shot toward a uniform magnetic field as illustrated in the diagram below.

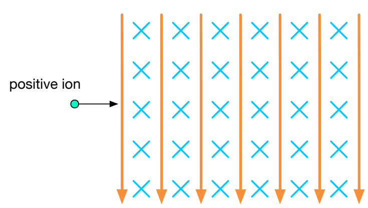


   (a) Sketch a possible path of the electron as it travels through the magnetic field.
   Counter-clockwise circular path

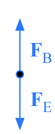
   (b) What are the magnitude and direction of the force exerted on the electron while it is in the magnetic field?
   F = qvB, to its left.

   (c) What is the radius of the path taken by the electron?
   $r = \dfrac{mv}{qB}$

3. A proton is shot into crossed electric and magnetic fields as shown. The electric field is represented by the arrows, and the magnetic field is illustrated by the tail feathers.

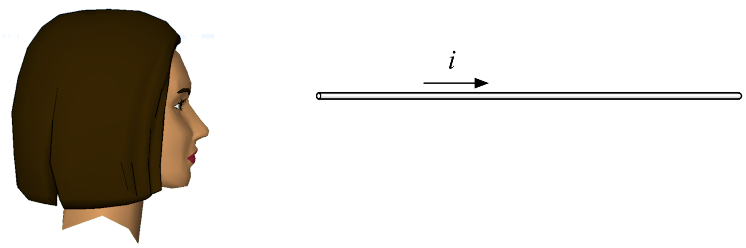


   (a) Sketch the force diagram for the proton once it enters the magnetic field.

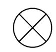


   (b) Determine the speed of protons that travel through these crossed fields with no deflection.
   $v = \dfrac{\mathbb{E}}{B}$

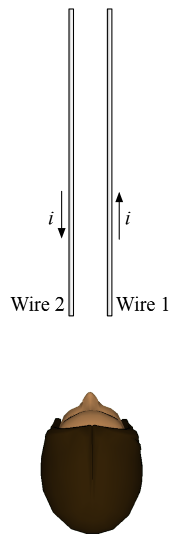
4. A woman observes a wire that has a conventional current flowing away from her.



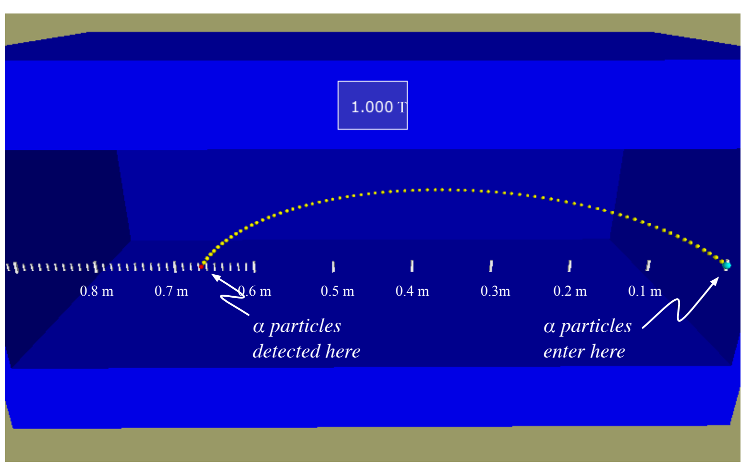
(a) Make a sketch of how the magnetic field is oriented around the wire from the point of view of the woman.



A second wire, Wire 2, is placed parallel to the first one as shown below.



(b) What effect does Wire 2 experience because of the current flowing through Wire 1?
Wire 2 experiences a repulsion, which in this case is a force to the left.



5. Polonium is a radioactive element that emits alpha particles, which are made of just two protons and two neutrons bound together, or, in other words, a helium nucleus. Your task is to find the kinetic energy of the alpha particles emitted by ${}^{210}_{84}$Po. You arrange for these α particles to project

horizontally into a mass spectrometer having a vertical magnetic field of magnitude 1.000 T. You measure the distance from the point where the α's enter the magnetic field to where they are detected to be 0.667 m as shown in the diagram above. (The mass of a proton is very nearly the same as the mass of a neutron: 1.67×10^{-27} kg.)

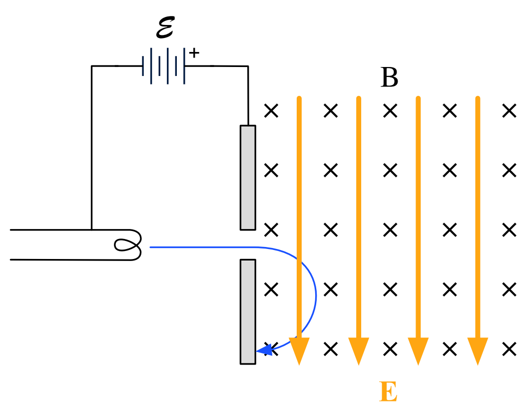
(a) What is the direction of the magnetic field **upward** or **downward**? (Circle one)

(b) What is the speed of these α particles?

$$v = \frac{qBr}{m}$$

3.3×10^{7} m/s

(c) What is the kinetic energy of the α particles?



6. An electron emitted from a hot wire in a cathode ray tube is accelerated through a potential difference $\mathcal{E}$ where it reaches a speed $v = 1 \times 10^{7}$ m/s . It then passes into a uniform magnetic field of strength $\mathbf{B}$ directed into the page as shown above. The mass of the electron is m and its charge has magnitude q.

(a) On the diagram above, sketch the path of the electron in the magnetic field.

(b) In terms of the mass m, speed v, charge q, and field strength B, develop a mathematical expression for r, the radius of the circular path of the electron.

$\Sigma F = ma$
$\Sigma F = qvB$
$a = \frac{v^2}{r}$
Therefore, $qvB = m\frac{v^2}{r}$
So, $r = \frac{mv}{qB}$

(c) An electric field is now established in the same region as the magnetic field, so that the electron passes through the region undeflected.

i. Determine $\mathbb{E}$, the strength of the field.

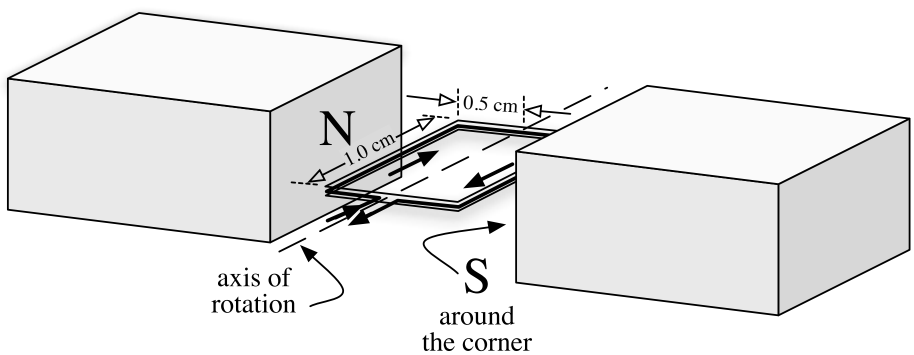
$\Sigma F = ma = 0$
$\Sigma F = F_{\mathbb{E}} - F_B = 0$
Therefore, $q\mathbb{E} = qvB$ or
$\mathbb{E} = vB$

ii. Indicate the direction of $\mathbb{E}$ in the diagram above. See diagram above.

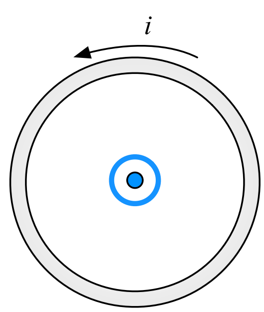
7. Discuss two ways to destroy a ferromagnetic permanent magnet. Describe just how it is that these two ways of destroying the magnet actually result in its destruction.

1) Heat it to more than its Curie temperature, the temperature at which all magnetic domains are destroyed. 2) Just beat it over and over with a sledgehammer. Jar the magnetic domains out of alignment that way.

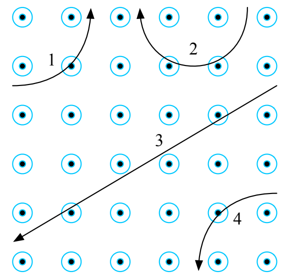
8. Describe how a motor works. In your description, discuss what would go on with the armature shown in the diagram below. The conventional electric current flows as shown by the arrows around the armature. The North pole of a magnet is on the left, and a South pole is on the right.



9. Describe the orientation of the magnetic field at the center of this loop of current. The conventional current flows as shown.



10. What are the signs of the charges on the four particles that travel through the magnetic field as shown?



1 −, 2 +, 3 neutral, 4 −

11. (a) State the meaning of the following terms.

    i. isotopes ______________________________ [1]

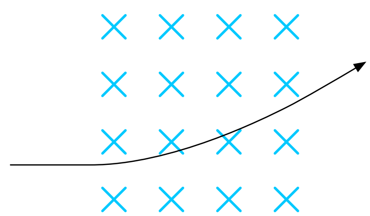
    ii. ion ______________________________ [1]

(b) A potassium source is used to produce a beam of potassium ions. The rate of production of the ions in the beam is 5.4×10^7 per second and the charge on each ion is $+1.6 \times 10^{-19}$ C. Calculate

    i. the electric current of the beam in Ampères.

    ii. the mass of a potassium ion, ${}^{39}_{19}$K.

(c) The potassium ions are accelerated to a speed of 5.0×10^5 m/s and then passed into a magnetic field of strength 0.84 T, as shown below.



Calculate the radius of the path of the ions in the magnetic field.

$$qvB = \frac{mv^2}{r}$$
$$r = \frac{mv}{qB}$$

$m = 39(1.66 \times 10^{-27})$ kg; other values are stated above. Calculate.

radius = ... m [4]

(d) In an actual experiment it is found that 93% of potassium ions follow the path calculated in (c). The remaining 7% of ions follow a different path with a slightly larger radius. Suggest why this happens. These other ions must have a bit more mass, because they are harder to turn (more inertia) as indicated by the bigger radius. [In fact, these are ${}^{40}_{19}$K ions. It's a different isotope of K.]