Teachers' notes

Lesson notes

Trajectories in Magnetic Fields

1) Students will be able to describe (qualitatively and quantitatively) the trajectories of charged particles in magnetic fields.

2) Students will be able to analyze q/m and mass spectrometer scenarios.

Teachers' notes

Lesson notes

Back

We've already examined the path followed by a charged particle in an initially perpendicular electric field.

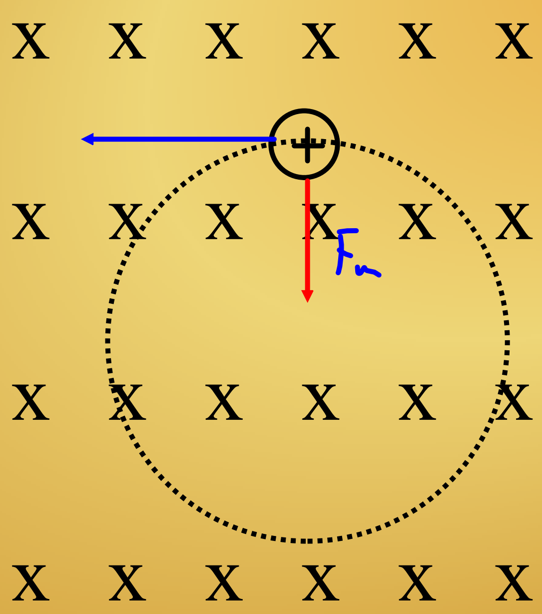
The shape of the path followed by a charged particle in an electric field is a.... parabola.

What two physics principles are necessary to analyze this parabolic motion in the electric field?

Balanced forces (uniform motion)	and	unbalanced forces (accelerated motion)

What might the trajectory of a charged particle in a perpendicular magnetic field look like?

The path of a charged particle moving through a perpendicular magnetic field is circular. the magnetic force acts as a center seeking, centripetal force.



$F_c = F_m$

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

The physics principle used here is unbalanced forces (causing circular motion).

i.e. $F_m = ma_c$

p. 600

2. Ions, with a charge of 1.60×10^{-19} C and a mass of 8.12×10^{-26} kg, travel perpendicularly through a region with an external magnetic field of 0.150 T. If the perpendicular speed of the ions is 8.00×10^{4} m/s, determine
   (a) the magnitude of the deflecting force on the ion
   (b) the radius of curvature of the motion of the deflected ion

$q = 1.60 \times 10^{-19}$ C
$m = 8.12 \times 10^{-26}$ kg
$B = 0.150$ T
$v = 8.00 \times 10^{4}$ m/s

a) $F_m = ?$ $F_m = qvB$

$F_m = (1.60 \times 10^{-19}\text{ C})(8.00 \times 10^{4}\text{ m/s})(0.150\text{ T})$

$F_m = 1.92 \times 10^{-15}$ N

b) $r = ?$

$F_c = F_m$

$\frac{mv^2}{r} = F_m$

$r = \frac{mv^2}{F_m}$

$r = \frac{(8.12 \times 10^{-26}\text{ kg})(8.00 \times 10^{4}\text{ m/s})^2}{(1.92 \times 10^{-15}\text{ N})} = 0.271$ m

Trajectories in Electric vs Magnetic Fields

Electric Fields	Magnetic Fields
[redacted] Direction of force stays the same [redacted]	Direction is always ⊥ to the velocity... will change

p. 601 Check and Reflect #9, 10

+ review booklet

9. Electrons in the picture tube of a television are accelerated to a speed of 1.30×10^6 m/s. As they travel through the tube, they experience a perpendicular magnetic field of magnitude 0.0700 T. What is the radius of deflection of the electrons in the tube?

$v = 1.30 \times 10^6$ m/s

$B = 0.0700$ T

$r = ?$

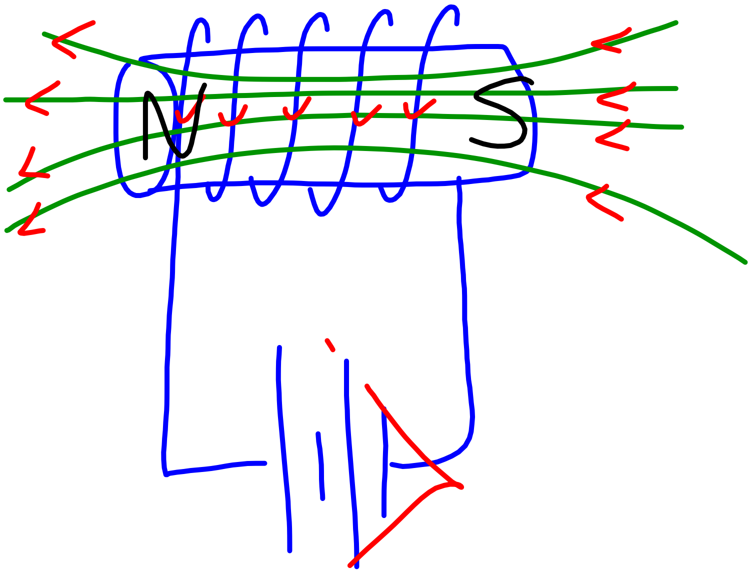
$F_c = F_m$

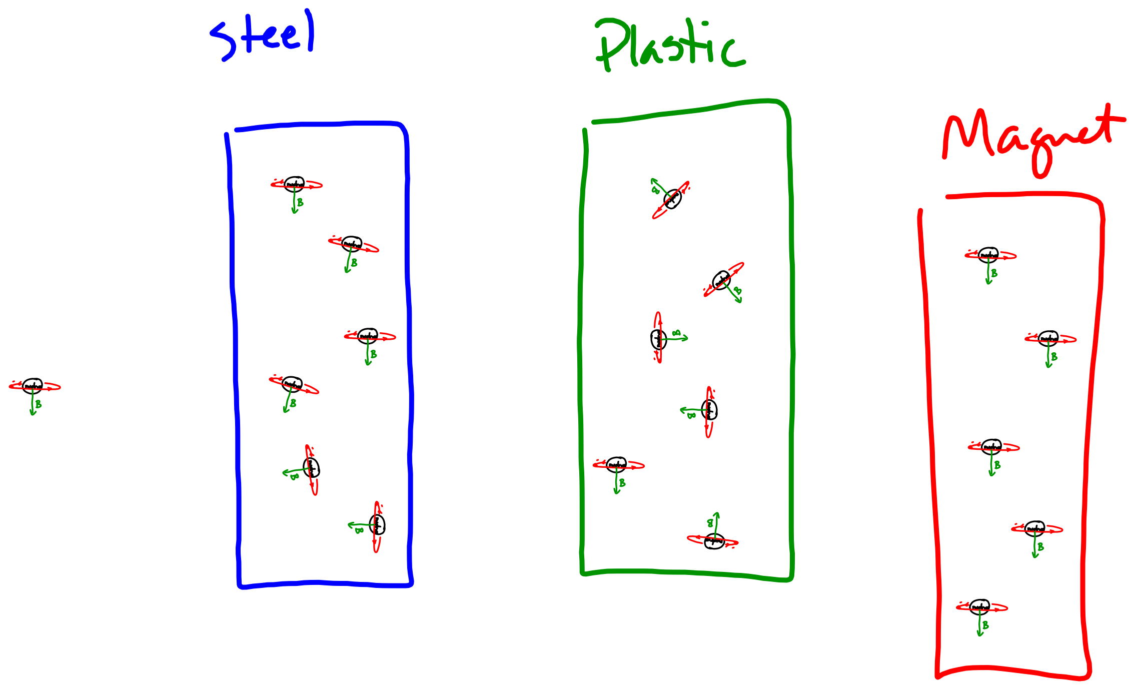
$$\frac{mv^2}{r} = qvB$$

$$r = \frac{mv}{qB}$$

$$r = \frac{(9.11 \times 10^{-31}\ \text{kg})(1.30 \times 10^6\ \text{m/s})}{(1.60 \times 10^{-19}\ \text{C})(0.0700\ \text{T})}$$

$r = 1.06 \times 10^{-4}$ m


N
S



Magnetic Domains

The Cathode Ray Tube (CRT)

Once scientists had developed an efficient vacuum pump, they started running high voltages across parallel plates in a vacuum. They found that a "ray" was emitted from the cathode (the negative plate). The properties of these cathode rays included:

...they were negatively charged.

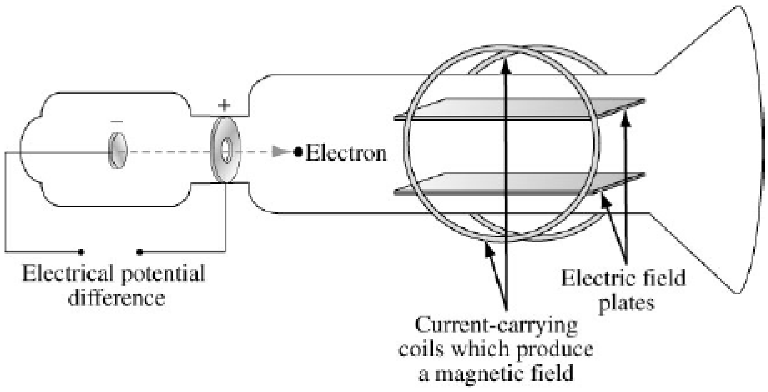
...they travelled in straight lines.

...they could be deflected by electric and magnetic fields.

What does a cathode ray consist of?

Electrons!

Thomson's Charge-to-mass (q/m) Experiment


+
–
Electron
Electrical potential difference
Electric field plates
Current-carrying coils which produce a magnetic field

Pictures of q/m apparatus at the U of A

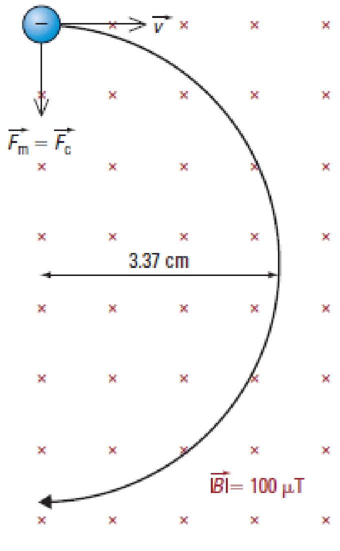
Example 15.1 p. 756

A beam of electrons passes undeflected through a 0.50-T magnetic field combined with a 50-kN/C electric field. The electric field, the magnetic field, and the velocity of the electrons are all perpendicular to each other. How fast are the electrons travelling?

Practice Problems: #1-3, p. 756

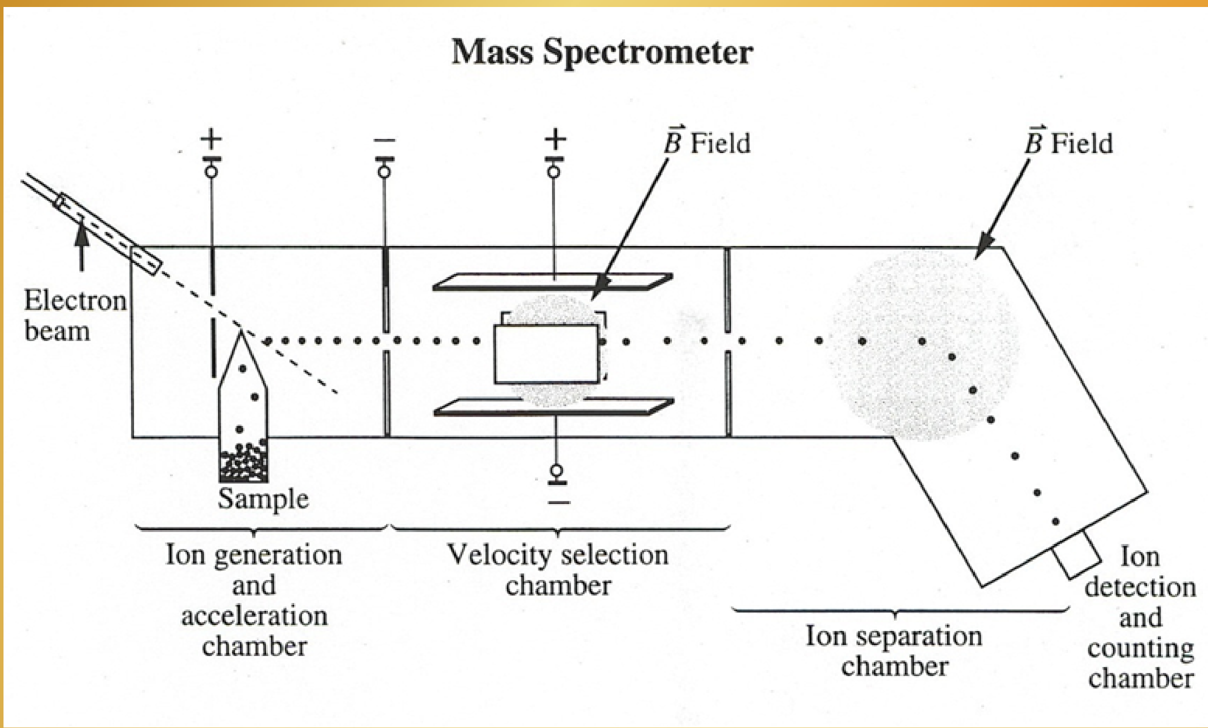
Example 15.2 p. 758

When a beam of electrons, accelerated to a speed of 5.93×10^5 m/s, is directed perpendicular to a uniform 100-μT magnetic field, they travel in a circular path with a radius of 3.37 cm (Figure 15.6). Determine the charge-to-mass ratio for an electron.



▲ Figure 15.6

Practice Problems: #1-3, p. 758

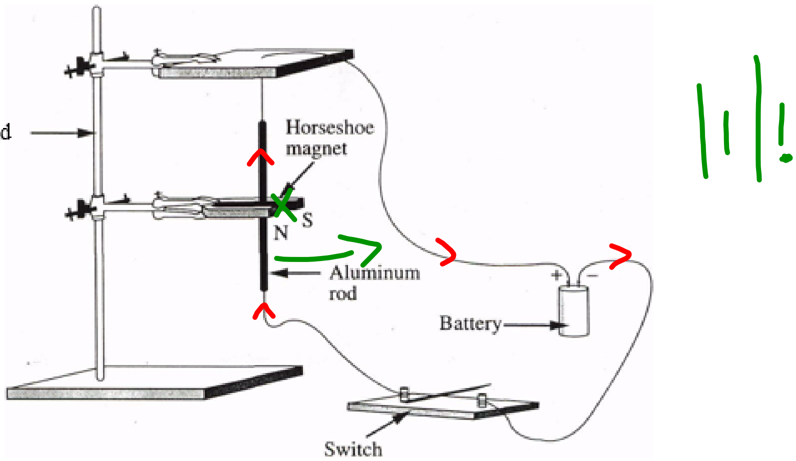

Mass Spectrometer
+
−
+
$\vec{B}$ Field
$\vec{B}$ Field
Electron beam
Sample
−
Ion generation and acceleration chamber
Velocity selection chamber
Ion separation chamber
Ion detection and counting chamber

Check and Reflect, p. 760

12.2eTest

Use the following information to answer the next question.

The diagram below shows an experimental design used to investigate the effect of a magnetic field on a vertical current-carrying conductor. The aluminum rod is able to swing freely.

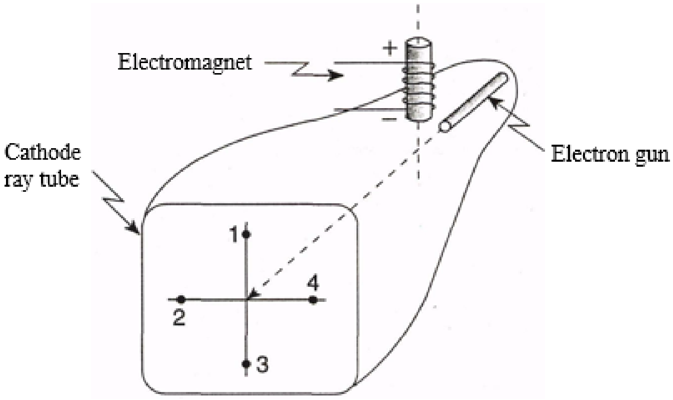


11. When the switch is closed, a current in the circuit causes the bottom end of the aluminum rod to swing

A. toward the retort stand
B. away from the retort stand
C. toward the south pole of the magnet
D. toward the north pole of the magnet

Use the following information to answer the next question.

With the electromagnet turned off, electrons in a cathode ray tube strike the centre of the screen as shown.

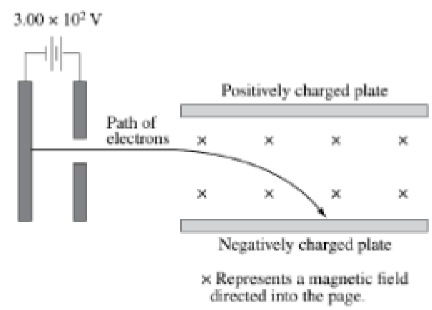


3. When the electromagnet is turned on, where will the electron beam now strike the screen?

A. 1
B. 2
C. 3
D. 4

Use the following information to answer the next two questions.

Electrons are accelerated from rest by an electric potential difference of 3.0×10^2 V. These electrons enter a region that contains mutually perpendicular electric and magnetic fields. The electric field has a magnitude of 8.5×10^5 N/C and the magnetic field has a magnitude of 2.0×10^{-1} T.



Numerical Response

8. The magnitude of the instantaneous acceleration experienced by an electron as it first enters the region containing the perpendicular fields, expressed in scientific notation, is $a.b \times 10^{cd}$ m/s^2. The values of **a, b, c,** and **d** are _________, _____, and _____.

(Record all **four digits** of your answer in the numerical-response section on the answer sheet.)

Attachments

carJumpS[1].dir

favicon[1].ico