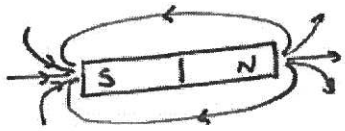
KEY

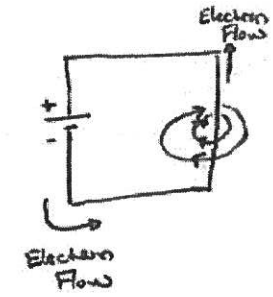
First Name:_____ Last Name:_____

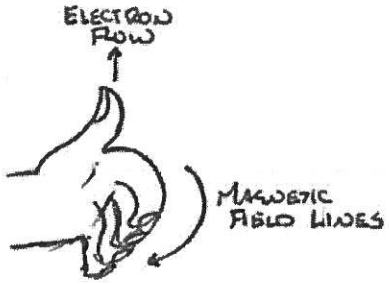
L13 – Worksheet – Motor Effect on a Point Charge

Concept Review

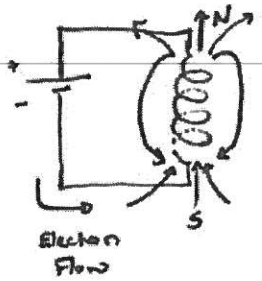
Hand Rules #1 & #2

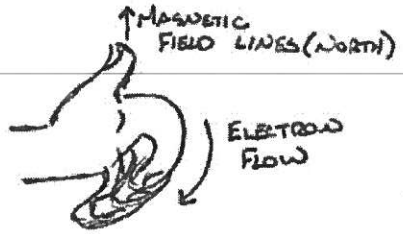






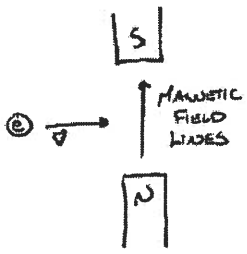
LEFT-HAND RULE → FOR MOVING NEGATIVE CHARGES ONLY!!!





Motor Effect (Hand Rule #3)

VECTOR DIAGRAMS → Going Left ← Going Right ⊙ Coming towards you ⊗ Going away from you.



$\vec{v}$ of negative charge.

FINGERS are bumpy ($\vec{B}$ for magnetic field)
PALM "slaps" a downward force.
THUMB represents movement (like hitch-hiking)

LEFT-HAND RULE → FOR MOVING NEGATIVE CHARGES ONLY!!!

$$|\vec{F}_m| = qv_\perp|\vec{B}|$$

KEY

Textbook Questions

Pg 601 #3: An electron and a proton, both with the same perpendicular velocity, enter a region with a uniform external magnetic field. What can you state about the deflections of both particles?

Electron → Use left-hand rule to determine direction of force / deflection.
Proton → Use right-hand rule.

Pg 601 #4: Describe the key differences in how magnetic and electric fields affect a moving charged particle.

Electric fields can do work → Change energy (E_K, or speed) of particle.
Magnetic fields apply force perpendicular to direction of motion, and therefore cannot do work. They cannot speed up or slow down (change E_K) particle, and can only change direction.

Pg 601 #6a: A proton with a speed of 2.00×10^5 m/s enters an external magnetic field of magnitude 0.200T. Calculate the magnitude of the deflecting force if the proton enters perpendicular to the magnetic field.

$v_\perp = 2.00 \times 10^5 \text{ m/s}$
$|\vec{B}| = 0.200 \text{ T}$
$|\vec{F}_m| = ?$
$q = +1.60 \times 10^{-19} \text{ C}$

$$|\vec{F}_m| = q v_\perp |\vec{B}|$$
$$= (1.60 \times 10^{-19} \text{C})(2.00 \times 10^5 \text{ m/s})(0.200 \text{ T})$$
$$= 6.40 \times 10^{-15} \text{ N}$$

Pg 601 #7: A 0.020g metal ball with a charge of -3.0μC is thrown horizontally along Earth's equator. How fast must the ball be thrown so that it maintains the same height, during tis motion tangential to Earth's surface, if the magnitude of Earth's magnetic field is 5.0×10^{-5} T?

$m = 2.0 \times 10^{-5} \text{ kg}$
$q = -3.0 \times 10^{-6} \text{ C}$
$|\vec{B}| = 5.0 \times 10^{-5} \text{ T}$

$$|\vec{F}_m| = |\vec{F}_g|$$
$$q v_\perp |\vec{B}| = mg$$
$$(3.0 \times 10^{-6} \text{C}) v_\perp (5.0 \times 10^{-5} \text{T}) = (2.0 \times 10^{-5} \text{kg})(9.81 \text{ m/s}^2)$$
$$v_\perp = 1{,}308{,}000 \text{ m/s}$$

KEY

Diploma Worksheet Questions – Motor Effect (Basic Definitions)

Q257: The force experienced by a charged particle moving in a magnetic field is independent of

$|\vec{F}_m| = qv_\perp|\vec{B}|$

(a.) Its mass
b. Its charge
c. Its velocity
d. The magnetic field strength

Q260: The charged particles in the Van Allen radiation belts most probably have been trapped there by

a. An electric field
(b.) A magnetic field
c. A scalar light field
d. A gravitational field

Q271: A magnetic field exerts no force on

$|\vec{F}_m| = qv_\perp|\vec{B}|$

If $v_\perp$ is $\emptyset$, then $|\vec{F}_m| = \emptyset$.

a. A magnet
b. An iron bar
c. An electric current
(d.) A stationary electric charge

Diploma Worksheet Questions – Motor Effect (Moving Point Charge)

Q273: A particle experiences a deflecting force of 2.5×10^{-6} N as it passes perpendicularly across a magnetic field of strength 0.050 T. If the particle has a charge of 8.0×10^{-4} C, its speed is

a. 1.6×10^{-4} m/s
b. 6.2×10^{-3} m/s
(c.) 6.2×10^{-2} m/s
d. 1.6×10^{-1} m/s

$F_m = qvB$

$2.5\times10^{-6} = (8.0\times10^{-4})v(0.05)$

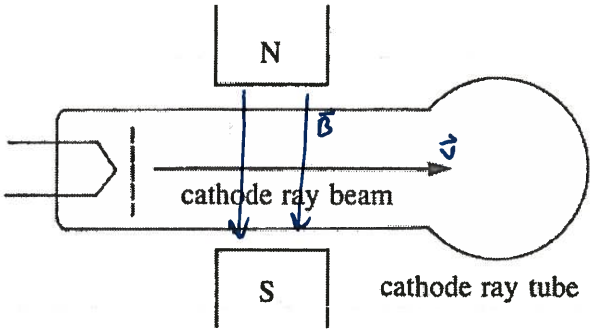
$v_\perp = 0.0625$ m/s

$= 6.25\times10^{-2}$ m/s

SHEET

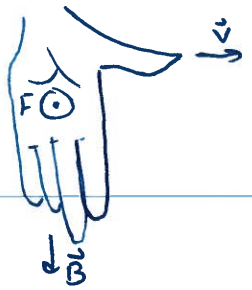
Use the following information to answer Q275:

A Beam of Electrons Travels Through a Magnetic Field



Q275: The cathode rays are deflected

a. Toward S
b. Toward N
c. Into the page
d. Out of the page



Q277: If a proton moves perpendicularly across a magnetic field of strength 2.0×10^{-2} T at a speed of 5.0×10^{6} m/s, it would experience a force of

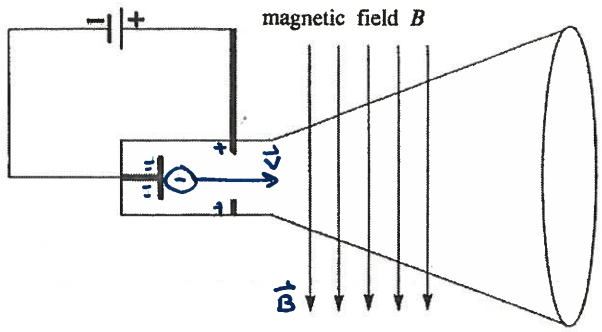
a. 1.7×10^{-22} N
b. 1.7×10^{-20} N
c. 1.6×10^{-14} N
d. 1.6×10^{-12} N

$F_m = qvB$
$= (1.60 \times 10^{-19})(5.0 \times 10^{6})(2.0 \times 10^{-2})$
$= 1.60 \times 10^{-14}$ N

KEY

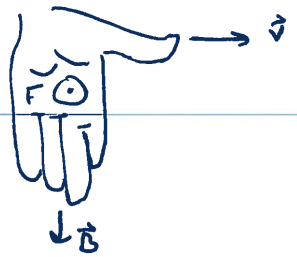
Use the following information to answer Q282:

A Cathode-Ray Tube in an External Magnetic Field

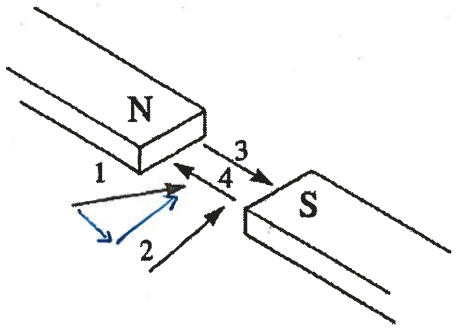


Q282: The particles in the cathode-ray tube will be deflected in the direction

a. Into the page
b. Out of the page
c. Toward the top of the page
d. Toward the bottom of the page



Use the following information to answer Q283:



This diagram shows the directions of motion of four charged particles in a magnetic field.

Q283: The magnetic field will deflect the particles labelled

a. 1 and 2
b. 1 and 3
c. 2 and 4
d. 4 and 3

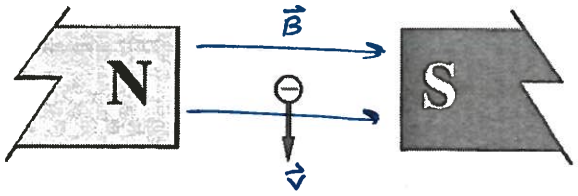
$|\vec{F}_m| = qv_\perp|\vec{B}|$

Need $v_\perp$ to magnetic field.
So 1 and 2.

KEY

Use the following information to answer Q286:

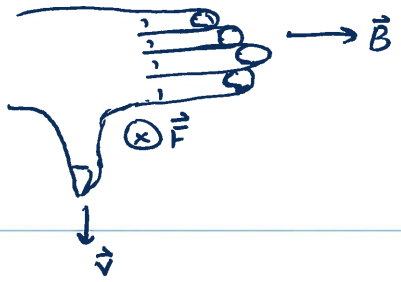
Charge in a Magnetic Field



A negative charge moves through a magnetic field.

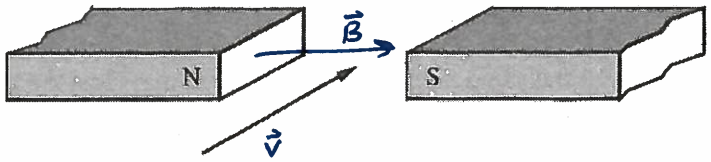
Q286: The charge will be deflected

a. Toward the left side of the page
b. Toward the right side of the page
c. Out of the page
d. Into the page



Use the following information to answer Q288:

Alpha Particles in Magnetic Fields



A horizontal beam of alpha particles is projected perpendicularly between a pair of magnetic poles.

Positive charge means RIGHT hand rule!

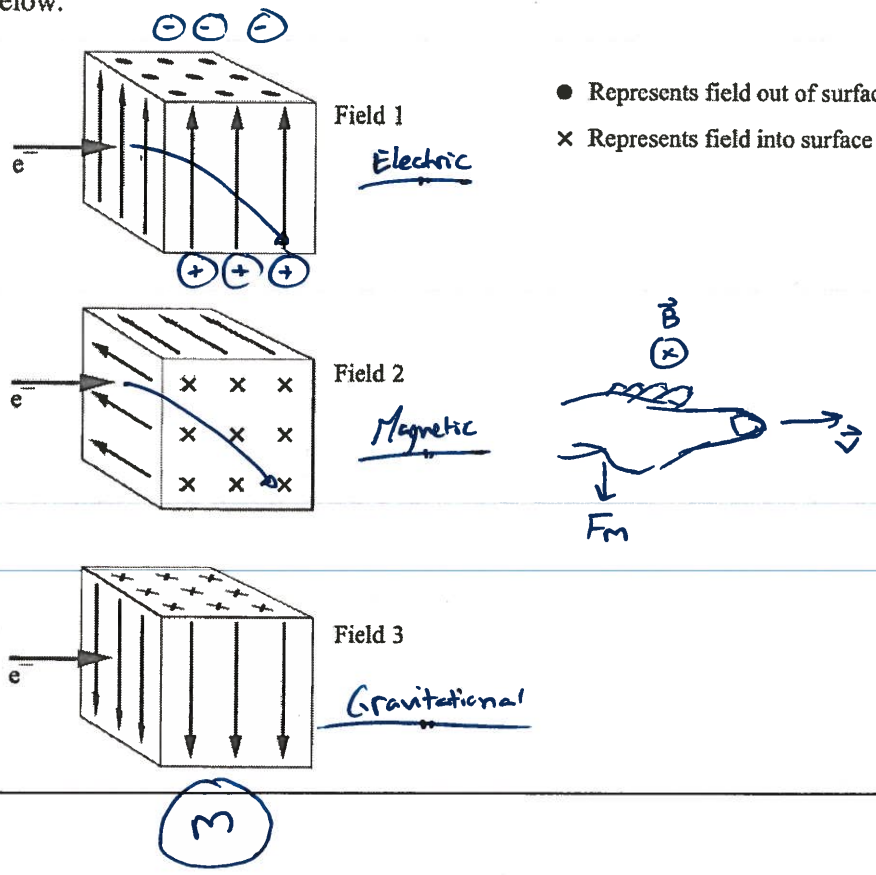
Q288: The ions will be deflected

a. Upward
b. Downward
c. Toward the north pole
d. Toward the south pole

KEY

Use the following information to answer Q295:

Moving electrons can be deflected by electric fields, gravitational fields, and magnetic fields. One electron is allowed to enter each type of field, as shown below.



Q295: If the electron is deflected downward in each field, then field 1, field 2, and field 3 are, respectively,

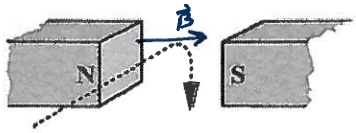
a. Electric, magnetic, and gravitational
b. Gravitational, magnetic, and electric
c. Magnetic, gravitational, and electric
d. Magnetic, electric, and gravitational

KEY:

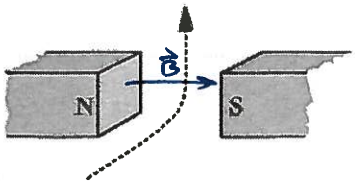
Q296: The path followed by a moving proton in an external magnetic field is shown in

Positive charge so RIGHT hand rule.

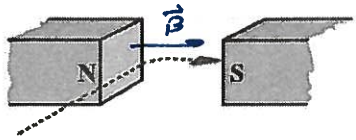
A. vertically down



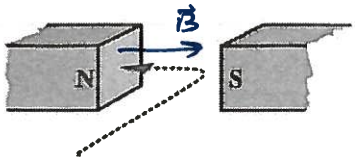
B. vertically up



C. horizontally right



D. horizontally left



Challenge Questions

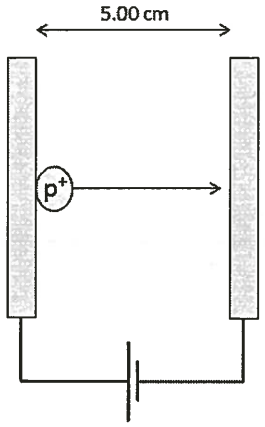
None

KEY

Cumulative Review from Previous Units

Use the following information to answer Q1:

A proton is placed between two parallel plates.



Q1: The impulse imparted to the proton is ***a.b*** x 10^{-cd} Ns, where ***a, b, c,*** and ***d*** are ___, ___, ___, and ___.

*(Record your **four digit** answer in the Numerical Response boxes below)*

1	3	2	2

EASY OPTION

$q\Delta V = \frac{1}{2}mv^2$

$(1.60\times10^{-19})(30) = \frac{1}{2}(1.67\times10^{-27})v^2$

$v^2 = 5,748,502,994.01$

$v = 75,818.8828328\ m/s$

$p = mv$

$= (1.67\times10^{-27})(75,818.8828328)$

$= 1.26617\ldots\times10^{-22}$

$\approx 1.27\times10^{-22}\ kg\ m/s$

$F\Delta t = m\Delta v$

$F\Delta t = 1.27\times10^{-22}\ Ns$

$F\Delta t \approx 1.3\times10^{-22}\ Ns$

HARD OPTION

$|\vec{E}| = \frac{\Delta V}{\Delta d} = \frac{30}{0.05} = 600\ N/C$

$\vec{F} = q\vec{E} = 9.60\times10^{-17}\ N$

$a = \frac{F_{net}}{m} = \frac{9.60\times10^{-17}}{1.67\times10^{-27}} = 5.7485\ldots\times10^{10}\ m/s^2$

$d = v_i t + \frac{1}{2}at^2$

$0.05 = (0)t + \frac{1}{2}(5.7485\times10^{10})t^2$

$t^2 = 1.739583\ldots\times10^{-12}$

$t = 1.3189\ldots\times10^{-6}\ s$

$F\Delta t = (9.60\times10^{-17}\ N)(1.3189\ldots\times10^{-6}\ s)$

$F\Delta t = 1.266\ldots\times10^{-22}\ Ns$

$F\Delta t = 1.3\times10^{-22}\ Ns$