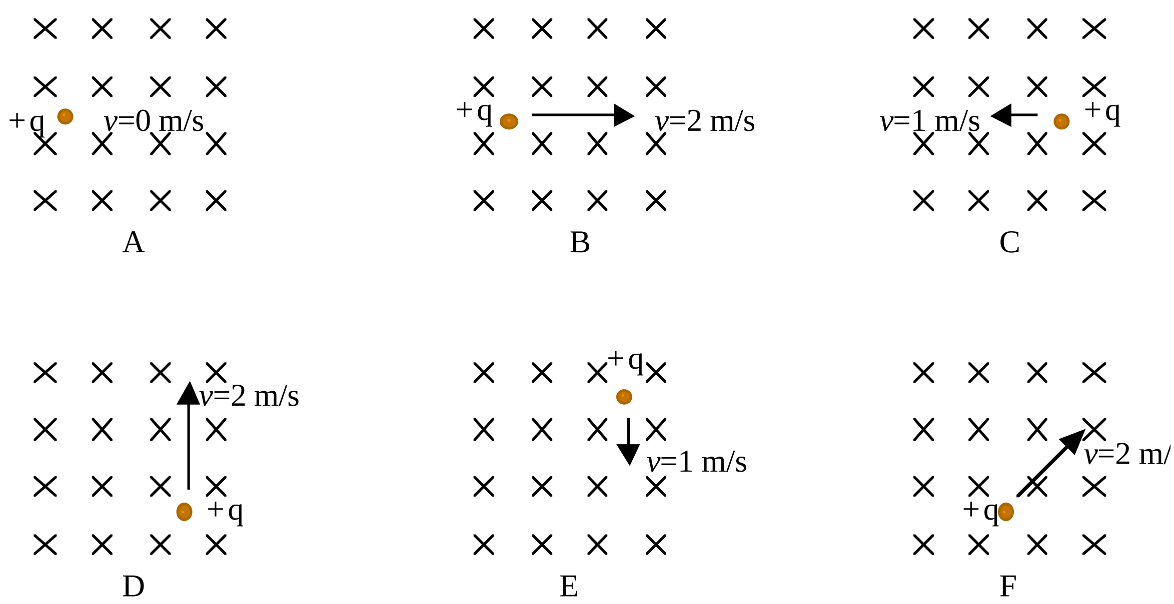
MFF 2A: CHARGED PARTICLE AND A UNIFORM MAGNETIC FIELD

MFF2a—RT1: Charged Particle and a Uniform Magnetic Field

The figures below show positively charged particles in a magnetic field. All magnetic fields are uniform and have the same strength. Magnetic fields whose directions are into the paper are represented by **x** and those that come out of the paper are represented by •.

Rank these situations from greatest to least on the basis of the strength (magnitude) of the magnetic force on each charge.



Greatest 1 ______ 2 ______ 3 ______ 4 ______ 5 ______ 6 ______ Least

Or, the force is the same for all six situations. ______

Or, the ranking for the forces cannot be determined. ______

Please carefully explain your reasoning.

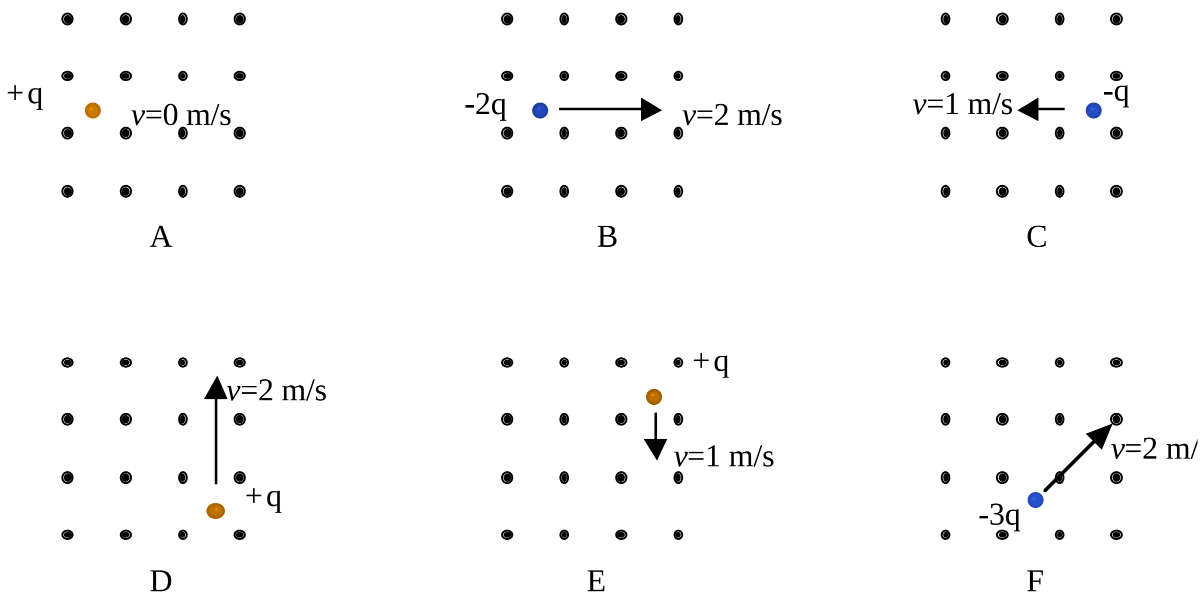
How sure were you of your ranking? (circle one)

Basically Guessed				Sure					Very Sure
1	2	3	4	5	6	7	8	9	10

MFF2a—RT2: Charged Particle and a Uniform Magnetic Field

The figures below show charged particles in a magnetic field. All magnetic fields are uniform and have the same strength. Magnetic fields whose directions are into the paper are represented by **x** and those that come out of the paper are represented by **•**.

Rank these situations from greatest to least on the basis of the strength (magnitude) of the magnetic force on each charge.



Greatest 1 ______ 2 ______ 3 ______ 4 ______ 5 ______ 6 ______ Least

Or, the force is the same for all six situations. ______

Or, the ranking for the forces cannot be determined. ______

Please carefully explain your reasoning.

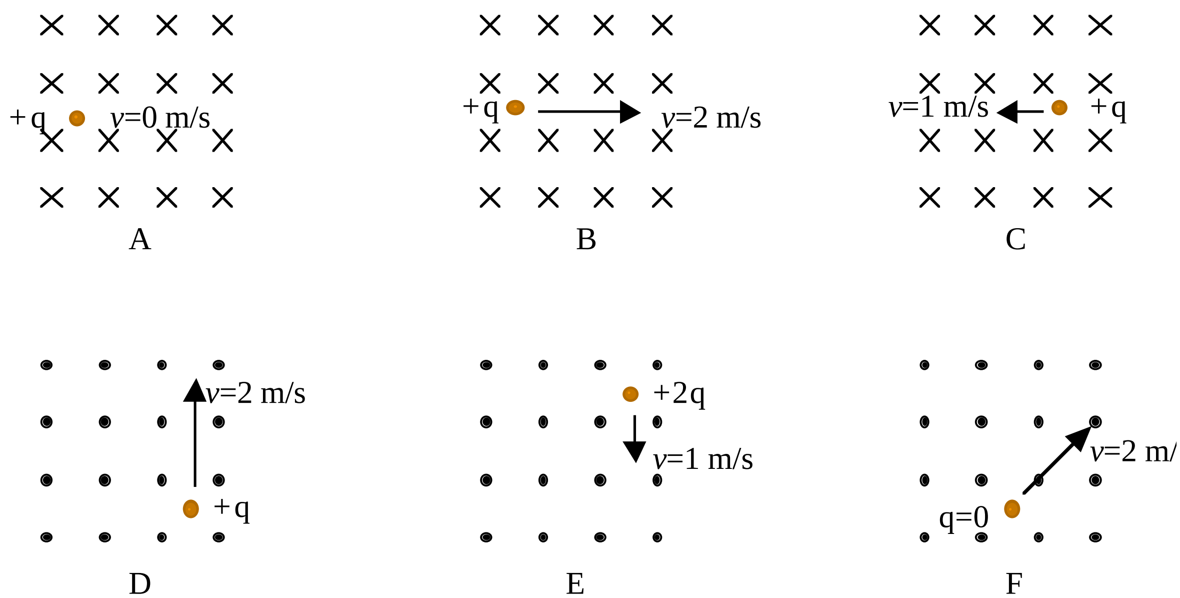
How sure were you of your ranking? (circle one)

Basically Guessed				Sure					Very Sure
1	2	3	4	5	6	7	8	9	10

MFF2a—RT3: Charged Particle and a Uniform Magnetic Field

The figures below show particles in a magnetic field. All magnetic fields are uniform and have the same strength. Magnetic fields whose directions are into the paper are represented by **x** and those that come out of the paper are represented by •.

Rank these situations from greatest to least on the basis of the strength (magnitude) of the magnetic force on each charge.



Greatest 1 _______ 2 _______ 3 _______ 4 _______ 5 _______ 6 _______ Least

Or, the force is the same for all six situations. _______

Or, the ranking for the forces cannot be determined. _______

Please carefully explain your reasoning.

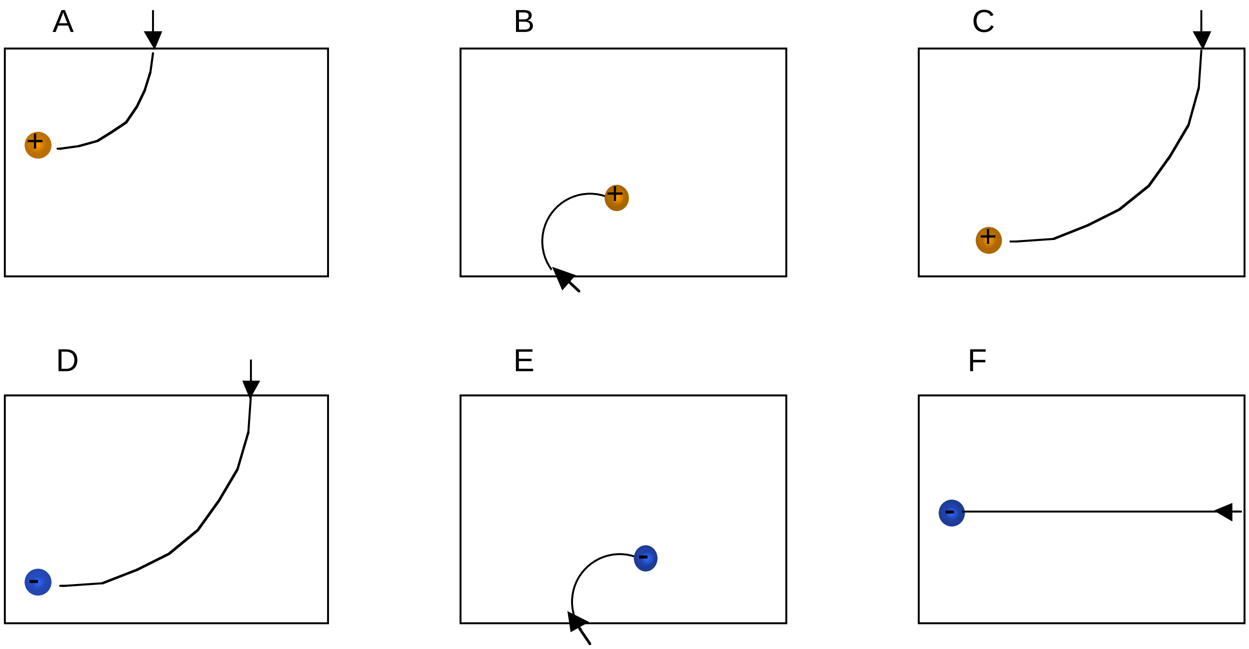
How sure were you of your ranking? (circle one)

Basically Guessed				Sure					Very Sure
1	2	3	4	5	6	7	8	9	10

MFF2a—RT4: Charged Particle and a Uniform Magnetic Field

Shown below are six situations where equal mass electrically charged particles are moving through regions of space in which there may be magnetic fields. In each figure, we are shown the sign of the charge and the path the charge follows through the region. (These are top views looking down on horizontally moving charges.) All of the charges start with the same initial velocity in the region.

Rank these situations, from greatest to least, on the basis of the strength of the upward directed magnetic field in the region. (Downward directed fields rank lower than upward directed fields.)



Greatest 1 _______ 2 _______ 3 _______ 4 _______ 5 _______ 6 _______ Least

OR, The magnetic field in all six of these cases has the same strength. _______

OR, The magnetic field is zero in all six of these cases. _______

Carefully explain your reasoning.

How sure were you of your ranking? (circle one)

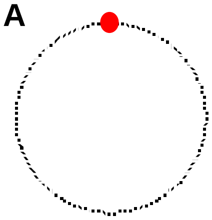
Basically Guessed					Sure				Very Sure
1	2	3	4	5	6	7	8	9	10

MFF2a—RT5: Charged Particle and a Uniform Magnetic Field

The figures below show the circular paths of six charged particles that have been injected into six different but uniform magnetic fields. The particles have the same mass, and they were all given the same initial speed before they entered the field. However, the charges on the particles and the radii of their paths vary.

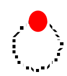
Rank these situations from greatest to least on the basis of the magnitude of the acceleration that each charge is experiencing.

A



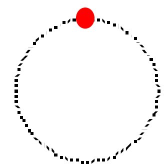
q = +7 nC
r = 4 cm

B



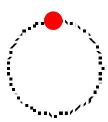
q = +15 nC
r = 1 cm

C



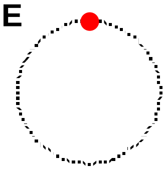
q = +9 nC
r = 3 cm

D



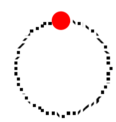
q = +5 nC
r = 2 cm

E



q = +15 nC
r = 3 cm

F



q = +8 nC
r = 2 cm

Greatest 1 ______ 2 ______ 3 ______ 4 ______ 5 ______ 6 ______ Least

Or, the acceleration is the same for all six situations. ______

Or, the ranking for the accelerations cannot be determined. ______

Please carefully explain your reasoning.

How sure were you of your ranking? (circle one)

Basically Guessed | Sure | Very Sure

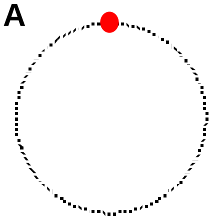
1 2 3 4 5 6 7 8 9 10

MFF2a—RT6: Charged Particle and a Uniform Magnetic Field

The figures below show the circular paths of six charged particles that have been injected into six different but uniform magnetic fields. The particles have the same mass, and they were all given the same initial speed before they entered the field. However, the charges on the particles and the radii of their paths vary.

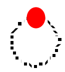
Rank these situations from greatest to least on the basis of the magnitude of the force on each charge.

A



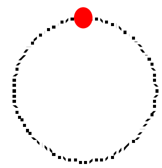
q = +7 nC
r = 4 cm

B



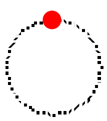
q = +15 nC
r = 1 cm

C



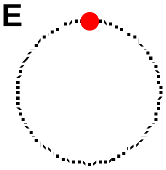
q = +9 nC
r = 3 cm

D



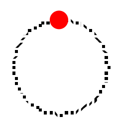
q = +5 nC
r = 2 cm

E



q = +15 nC
r = 3 cm

F



q = +8 nC
r = 2 cm

Greatest 1 ______ 2 ______ 3 ______ 4 ______ 5 ______ 6 ______ Least

Or, the force is the same for all six situations. ______

Or, the ranking for the forces cannot be determined. ______

Please carefully explain your reasoning.

How sure were you of your ranking? (circle one)

Basically Guessed				Sure					Very Sure
1	2	3	4	5	6	7	8	9	10

MFF2a—WBT1: Charged Particle and a Uniform Magnetic Field

Draw and describe a physical arrangement to which the equation below could apply.

$$6.49\text{x}10^{-12}\,\text{N} = (1.602\text{x}10^{-19}\,\text{C})(2.50\text{x}10^{7}\,\text{m/s})(1.62\text{T})$$

MFF2a—WBT2: Charged Particle and a Uniform Magnetic Field

Draw and describe a physical arrangement to which the equation below could apply.

$$-6.49\text{x}10^{-12}\,\hat{\mathbf{i}}\text{N} = (-1.602\text{x}10^{-19}\text{C})(2.50\text{x}10^{7}\,\hat{\mathbf{j}}\text{m/s})\,\mathbf{x}\,(1.62\hat{\mathbf{k}}\text{T})$$

MFF2a—WBT3: Charged Particle and a Uniform Magnetic Field

Draw and describe a physical arrangement to which the equation below could apply.

$$7.20\text{x}10^{-12}\,\text{N} = (3.20\text{x}10^{-19}\,\text{C})(1.50\text{x}10^{7}\,\text{m/s})(3.00\text{T})\sin 30^{\circ}$$

MFF2a—WBT4: Charged Particle and a Uniform Magnetic Field

Draw and describe a physical arrangement to which the equation below could apply.

$$r = \frac{(1.67\text{x}10^{-27}\,\text{kg})(5.00\text{x}10^{7}\,\text{m/s})}{(1.602\text{x}10^{-19}\,\text{C})(2.00\text{T})}.$$

MFF2a—WBT5: Charged Particle and a Uniform Magnetic Field

Draw and describe a physical arrangement to which the equation below could apply.

$$15\ \text{T} = \frac{(3.6\ \text{x}10^{-2}\ \text{kg} \bullet \text{m/s})}{(6.0\ \text{x}10^{-4}\ \text{C}) \bullet (4.0\ \text{m})}$$

MFF2a—WBT6: Charged Particle and a Uniform Magnetic Field

Draw and describe a physical arrangement to which the equation below could apply.

$$13.3\ \text{T} = \frac{(6.00\ \text{x}10^{-6}\ \text{kg}) \bullet (300.0\text{m/s})}{(9.00\ \text{x}10^{-6}\ \text{C}) \bullet (15.0\ \text{m})}$$

MFF2a—WBT7: Charged Particle and a Uniform Magnetic Field

Draw and describe a physical arrangement to which the equation below could apply.

$$6.3\ \text{T} = \frac{2\pi \bullet (6.0\ \text{x}10^{-9}\ \text{kg})}{(3.0\ \text{x}10^{-9}\ \text{C}) \bullet (2.0\ \text{s})}$$

MFF2a—WBT8: Charged Particle and a Uniform Magnetic Field

Draw and describe a physical arrangement to which the equation below could apply.

$$6.3\text{ T} = \frac{2\pi \bullet (5.0\text{Hz}) \bullet (6.0 \text{ x}10^{-9}\text{ kg})}{(3.0 \text{ x}10^{-8}\text{C})}$$

MFF2a—CCT1: Charged Particle and a Uniform Magnetic Field

Consider the following statements made by three students.

Student I: "For a particle to feel a magnetic force, it only needs to be within a magnetic field."

Student II: "For a particle to feel a magnetic force, it needs to be charged and within a magnetic field."

Student III: "For a particle to feel a magnetic force, the particle must be charged and moving within the magnetic field."

Which, if any, of these three students do you believe is correct? Explain fully why you chose as you did.

MFF2a—CCT2: Charged Particle and a Uniform Magnetic Field

Consider the following statements made by three students.

Student I: "For a particle to feel a magnetic force, it must be charged and moving in a magnetic field."

Student II: "For a particle to feel a magnetic force, it must be charged and moving in a magnetic field cutting across the magnetic field."

Student III: "A moving charged particle will experience a magnetic force only if it moves perpendicular to the field."

Which, if any, of these three students do you believe is correct? Explain fully why you chose as you did.

MFF2a—WWT1: Charged Particle and a Uniform Magnetic Field

"A proton moving to the east enters a magnetic field pointed up, i.e., away from the center of the Earth. The proton feels a magnetic force whose direction is toward the north."

What, if anything, is wrong with the above statement about this situation? If something is wrong, explain the error and how to correct it. If the statement is legitimate as it stands, explain why it is valid.

MFF2a—WWT2: Charged Particle and a Uniform Magnetic Field

"An electron moving to the east enters a magnetic field. Since the electron feels a magnetic force whose direction is north, the direction of the magnetic field must be (out of the horizontal plane.)"

What, if anything, is wrong with the above statement about this situation? If something is wrong, explain the error and how to correct it. If the statement is legitimate as it stands, explain why it is valid.

MFF2a—WWT3: Charged Particle and a Uniform Magnetic Field

What, if anything, is wrong with the following statement? If something is wrong, explain the error and how to correct it. If the statement is legitimate as it stands, explain why it is valid.

"A neutron moving to the west enters a magnetic field pointed up (out of the horizontal plane). The neutron feels no magnetic force while in the magnetic field."

MFF2a—WWT4: Charged Particles and a Uniform Magnetic Field

What, if anything, is wrong with the following statement? If something is wrong, explain the error and how to correct it. If the statement is valid as it stands, explain why it is valid.

"Two particles that have the same mass and electric charge enter the same uniform magnetic field traveling at the same speed. The distance between the two particles is so great that they do not affect each other. These particles will travel in circular paths of equal radius."

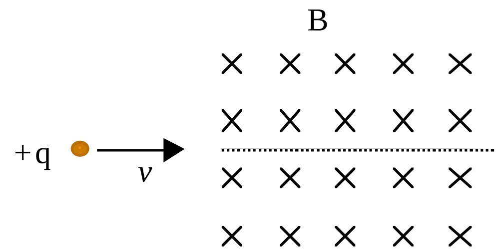
MFF2a—TT1: Charged Particle and a Uniform Magnetic Field

There is at least one error in the statement below. Identify the error(s) and explain how to correct it.

"A proton moving to the east enters a magnetic field. Since the proton feels a magnetic force whose direction is north, the direction of the magnetic force must be down (into the horizontal plane.)"

MFF2a—TT2: Charged Particle and a Uniform Magnetic Field

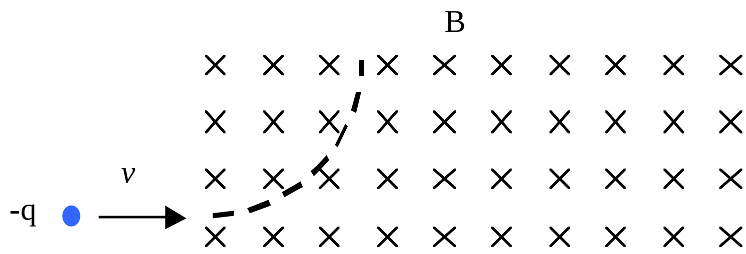
As shown in the figure below, a proton is moving to the right at a velocity v when it enters a magnetic field. The magnetic field is uniform and into the paper. (The magnetic field is indicated by x's). The path of the proton in the magnetic field is indicated by the dotted line.



There is at least one error in the diagram and/or statement above. Identify the error(s) and explain how to correct it.

MFF2a—TT3: Charged Particle and a Uniform Magnetic Field

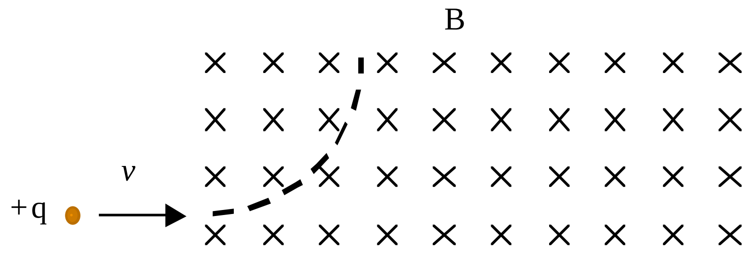
As shown in the figure below, an electron is moving to the right at a velocity v when it enters a magnetic field. The magnetic field is uniform and into the paper. (The magnetic field is indicated by x's.) The path of the electron in the magnetic field is indicated by the dotted curve.



There is at least one error in the diagram and/or statement above. Identify the error(s) and explain how to correct it.

MFF2a—LMCT1: Charged Particle and a Uniform Magnetic Field

The figure below shows a charged particle moving at a constant velocity about to enter a region in which there is a uniform magnetic field. The magnetic field is into the paper. When the charged particle enters the magnetic field, it feels a magnetic force.



A number of changes in this situation will be described below. For each change, you are to identify how the change will affect, if it will, the magnetic force felt by the particle shortly after entering the field.

The possible answers are:

A. This change will alter only the direction of the force felt by the particle.

B. This change will only increase the magnitude of the magnetic force felt by the particle.

C. This change will only decrease the magnitude of the magnetic force felt by the particle.

D. This change will alter both the magnitude and direction of the magnetic force felt by the particle.

E. This change will not affect the magnetic force felt by the particle.

Each change below refers to the original situation stated above:

The particle is replaced by a larger magnitude, positively charged particle. _______

The particle is replaced by a negatively charged particle. _______

The particle is replaced by an neutral particle. _______

The particle enters the region moving at a slower initial velocity. _______

The particle enters the region moving at a faster initial velocity. _______

The magnetic field is twice its original strength. _______

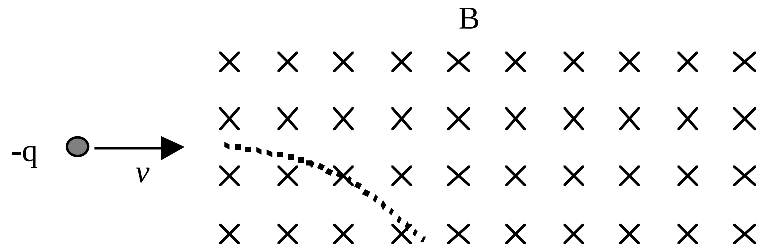
The magnetic field is one-third its original strength. _______

The direction of the magnetic field is parallel to the particle's initial velocity. _______

The direction of the magnetic field is 45˚ to the particle's initial velocity. _______

MFF2a—LMCT2: Charged Particle and a Uniform Magnetic Field

The figure below shows a charged particle moving at a constant velocity about to enter a region in which there is a uniform magnetic field. The magnetic field is into the paper. When the charged particle enters the magnetic field, it feels a magnetic force.



A number of changes in this situation will be described below. For each change, you are to identify how the change will affect, if it will, the magnetic force felt by the charged particle shortly after entering the field.

The possible answers are:

A. This change will only alter the direction of the force felt by the charged particle.
B. This change will only increase the magnitude of the magnetic force felt by the charged particle.
C. This change will only decrease the magnitude of the magnetic force felt by the charged particle.
D. This change will alter both the magnitude and direction of the magnetic force felt by the charged particle.
E. This change will not affect the magnetic force felt by the charged particle.

Each change below refers to the original situation stated above:

The particle is replaced by a larger magnitude, negatively charged particle. _______

The charged particle is replaced by a positive charged particle. _______

The charged particle enters the region moving at a slower constant velocity. _______

The charged particle enters the region moving at a faster constant velocity. _______

The magnetic field is twice its original strength. _______

The magnetic field is one-third its original strength. _______

The direction of the magnetic field is opposite to the charged particle's initial velocity. _______

The direction of the magnetic field is 45˚ to the charged particle's initial velocity. _______

MFF2a—PET1: Charged Particle and a Uniform Magnetic Field

A proton is moving at a constant speed toward the east. Along the path of the proton is a region in which the magnetic field is uniform and is directed towards the north.

What will happen to the proton when it enters the magnetic field? Explain fully.

MFF2a—PET2: Charged Particle and a Uniform Magnetic Field

An electron is moving at a constant speed toward the east. Along the path of the electron is a region in which the magnetic field is uniform and is directed towards the north.

What will happen to the electron when it enters the magnetic field? Explain fully.

MFF2a—PET3: Charged Particle and a Uniform Magnetic Field

A proton is placed at rest in a region in which the magnetic field is uniform and is directed towards the north.

What will happen to the proton when it is released? Explain fully.

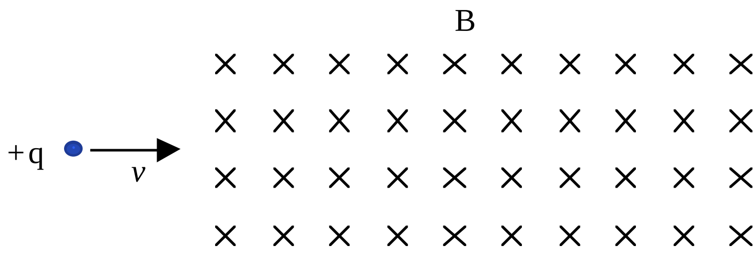
MFF2a—PET4: Charged Particle and a Uniform Magnetic Field

A proton is moving at a constant speed toward the east. Along the path of the proton is a region in which the magnetic field is uniform and is directed eastward as well.

What will happen to the proton when it enters the magnetic field? Explain fully.

MFF2a—M/MCT1: Charged Particle and a Uniform Magnetic Field

The figure below shows a proton moving at 5.00 x 10^7 m/s about to enter a region in which there is a uniform magnetic field of 200 mT.



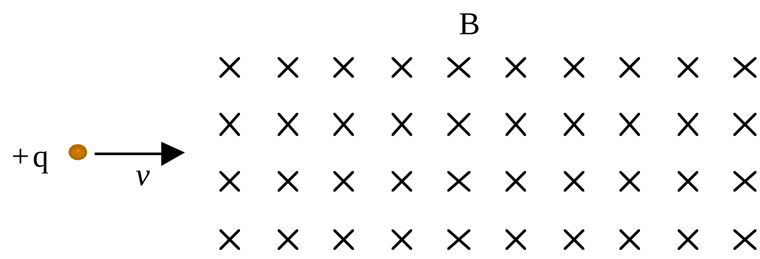
Given below is a student's calculation for the magnitude of the magnetic force on the proton once it enters the magnetic field.

$$F_B = (1.602x10^{-19}C)(5.00x10^7 m/s)(.200T)$$

Is this calculation meaningful (i.e., it tells us something legitimate about this situation) or is it meaningless (i.e., the value calculated is either nonsense, or it tells us nothing legitimate about this situation)?

MFF2A—QRT1: CHARGED PARTICLE AND A UNIFORM MAGNETIC FIELD

The figure below shows a proton entering a region of uniform magnetic field strength directed into the paper.



(1) What is the direction of the magnetic force acting on the proton when it enters the magnetic field?

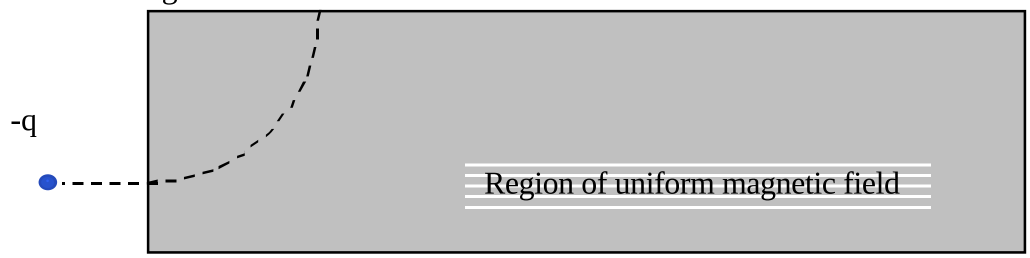
(2) What would be the path of the proton within the magnetic field?

(3) What would the direction of the magnetic force be when the proton enters the field if the direction of the magnetic field were out of the paper?

(4) What would happen to the direction of the magnetic force and the path if we changed the charged particle from a proton to an electron?

MFF2a—QRT2: Charged Particle and a Uniform Magnetic Field

The figure below shows the motion of a negatively charged particle in a region of uniform magnetic field strength.



(1) What is the direction of the magnetic field producing the force acting on the particle?

(2) If we double the speed of the original particle entering the uniform magnetic field, what will happen to the path of the particle in the uniform magnetic field?

(3) If we double the magnitude of the uniform magnetic field, what will happen to the path of the particle in the uniform magnetic field?

(4) If we change the original particle to a negatively charged particle of twice the charge of the original particle, what will happen to the path of this negatively charged particle in the uniform magnetic field?

(5) If we change the original particle to a positive particle, what would be the direction of the magnetic field acting on the positive particle?

MFF2a—CRT1: Charged Particle and a Uniform Magnetic Field

The equation below represents at an instant the magnetic force on a charged particle moving in a uniform magnetic field.

$$-6.49\text{x}10^{-12}\,\hat{\mathbf{j}}\text{N} = (1.602\text{x}10^{-19}\text{C})(2.50\text{x}10^{7}\,\hat{\mathbf{i}}\text{m/s})\,\mathbf{x}\,(1.62\hat{\mathbf{k}}\text{T})$$

Draw an appropriate diagram showing the magnetic field, the particle's velocity and the force on the particle at this instant.

Graph the magnitude of the acceleration of the charged particle versus time while it is in the magnetic field.

MFF2a—CRT2: Charged Particle and a Uniform Magnetic Field

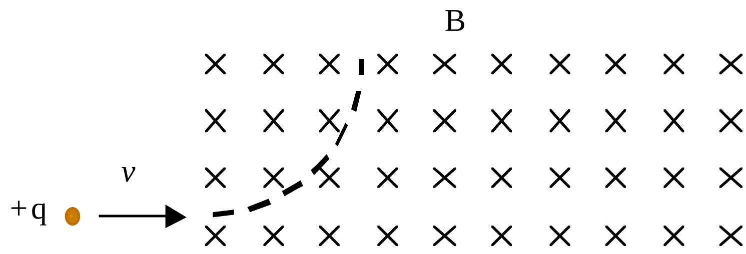
The equation below represents the radius of the circular path for a charged particle moving in a uniform magnetic field.

$$r = \frac{(1.67\text{x}10^{-27}\,\text{kg})(5.00\text{x}10^{7}\,\text{m/s})}{(1.602\text{x}10^{-19}\,\text{C})(2.00\text{T})}.$$

Draw a motion diagram, i.e., show the position, with the corresponding velocity and acceleration for four equally separated time intervals, for this particle in the field.

MFF2a—CRT3: Charged Particle and a Uniform Magnetic Field

Shown below is the path of a proton moving at 2 x 10^6 m/s in a magnetic field of uniform strength 2 T.



Draw an appropriate graph of the magnitude of the magnetic force on the proton versus time while the proton is in the magnetic field.