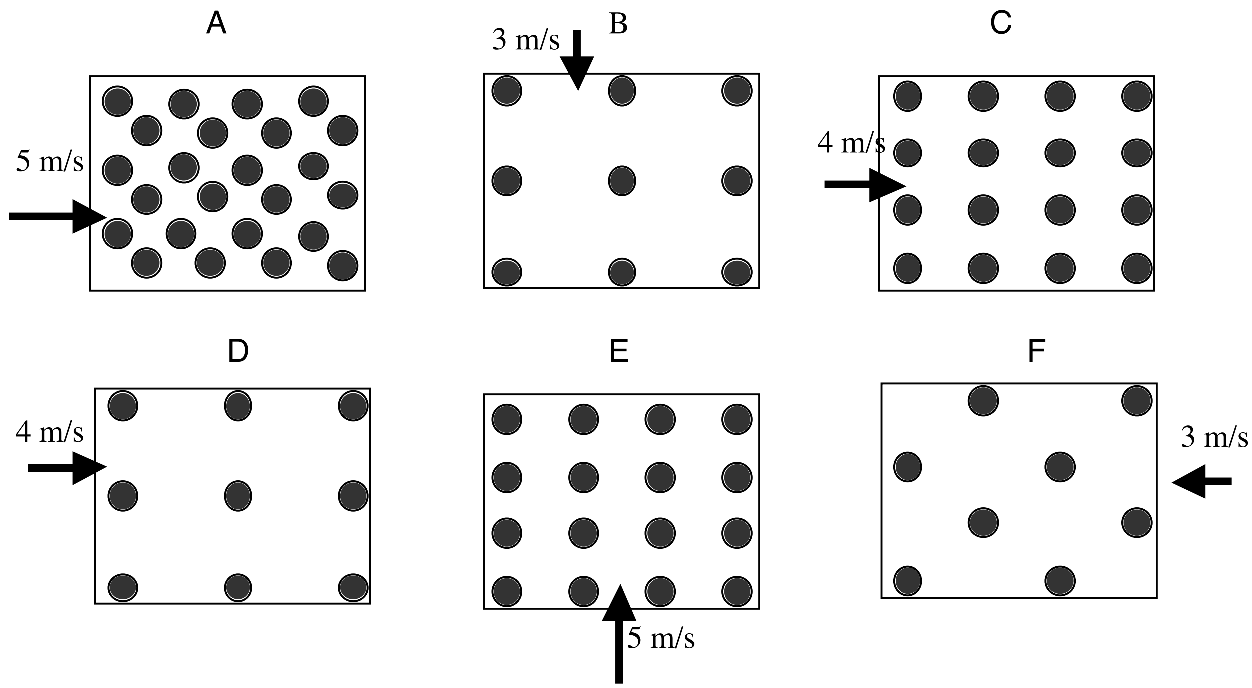
MFF 10a: MOVING CHARGE IN A TIME-CONSTANT, UNIFORM MAGNETIC FIELD

MFF10A—RT1: MOVING CHARGE AND A UNIFORM MAGNETIC FIELD

The six situations below involve electrically charged particles that are moving through uniform magnetic fields. For each situation, we are told the initial speed of the particle as it entered the field and the strength of the magnetic field, which remains constant over time. All of the charges are positive with the same magnitude, all of the particles have the same mass, and all are moving perpendicular to the magnetic fields, which are all directed out of the page. All particles remain within the field region during the three seconds.

Rank these situations, from greatest to least, on the change in kinetic energy the particles will experience during their first three seconds in the fields.



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

OR, The change in kinetic energy will be the same for all SIX of these situations. _______

OR, There will be NO change in kinetic energy for any of these SIX situations. ____*X*___

Carefully explain your reasoning.

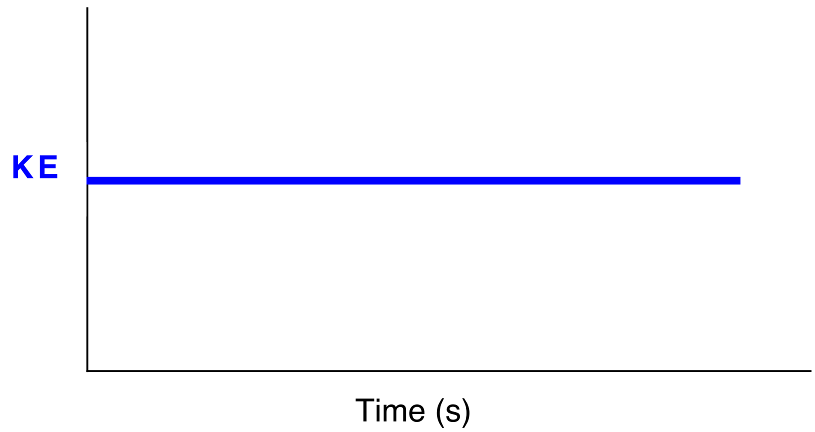
There is no change in the kinetic energy for the charged particle in any of the six cases.

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

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

MFF10A—WBT1: MOVING CHARGE AND A UNIFORM MAGNETIC FIELD

A charged particle moves into a region in which there is a uniform magnetic field, which is also constant in time. The graph of the particle's kinetic energy-versus-time for the period while the particle is in the field region is given below.



Describe a physical situation that could produce this graph.

This will work for any particle moving in, or through, a region that has a uniform magnetic field, but no electric field. Particle can be moving in any direction relative to the field.

MFF10a—CCT1: Moving Charge and a Uniform Magnetic Field

Given below are statements, from three students, about the work done by the magnetic force on electric charges moving in magnetic fields that are constant over time. **With which, if any, of these students do you agree?**

Student A: "Electric charges moving through regions in which there are magnetic fields never have work done on them by the magnetic force."

Student B: "Electric charges moving through regions in which there are magnetic fields will only have work done on them if they are moving perpendicular to the field."

Student C: "Electric charges moving through regions in which there are magnetic fields will have work done on them if they experience a magnetic force."

I agree with:

Student A __*X*___ Student B _____ Student C _____ None of them_____

Carefully explain your reasoning.

Constant magnetic fields cannot do work on moving charges since the force will always be perpendicular to the velocity.

MFF10a—WWT1: Moving Charge and a Uniform Magnetic Field

What, if anything, is wrong with the following situation? If something is wrong, explain what is wrong and how it can be corrected. If nothing is wrong, explain why the situation works as it does.

If a charged particle moving through a region in which there is a magnetic field that is constant over time experiences no change in its kinetic energy, then the particle must be moving parallel to the magnetic field.

This is wrong. The charge is not going to have any change in kinetic energy no matter what direction of motion in the magnetic field. The magnetic force is always perpendicular to the velocity, so no work is done.

MFF10a—TT1: Moving Charge and a Uniform Magnetic Field

There is something wrong with the following situation. Identify what is wrong and explain how to correct it.

If no work is done on a charged particle as it moves through a region in which there is a uniform magnetic field that is constant over time, the particle is moving parallel, or anti-parallel, to the magnetic field.

It does not matter what direction the particle is moving in the uniform magnetic field. There is no work done on the charge particle, because the magnetic force is perpendicular to the velocity.

MFF10a—BCT1: Moving Charge and a Uniform Magnetic Field

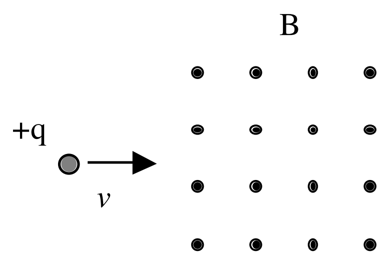
Shown below is a bar chart describing the initial kinetic energy for a charged particle that is just entering a region in which there is a uniform magnetic field that is constant over time. The particle's velocity is perpendicular to the magnetic field.

Complete the bar chart below to show the final kinetic energy of this particle 2 sec after entering the magnetic field.

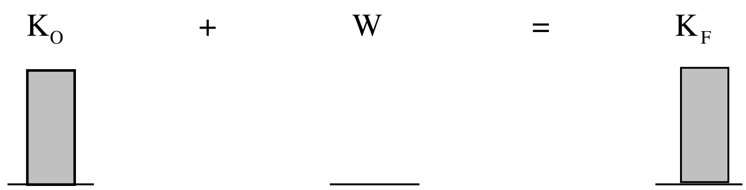
The magnetic field does not change the kinetic energy of the moving particle, because the magnetic force is always perpendicular to the velocity.

MFF10a—BCT2: Moving Charge and a Uniform Magnetic Field

The figure below shows a proton moving at a constant velocity that is just about to enter a region where there is a uniform magnetic field, which is constant over time, directed out of the plane of the paper.



Complete the bar chart below, by putting in the appropriate values for the initial and final potential energies and for any work done, for the electron from just before it enters the magnetic field to when it has traveled into the magnetic field a short distance.

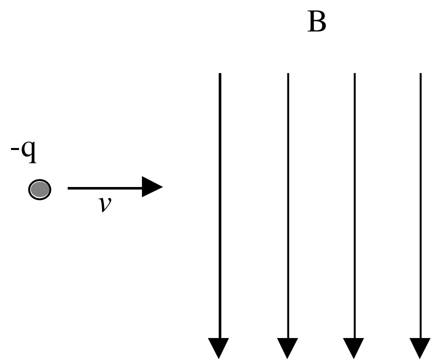


Explain the reasoning behind your bar chart:

The magnetic field does no work on the moving charge; thus, the final kinetic energy is the same as the initial kinetic energy.

MFF10a—BCT3: Moving Charge and a Uniform Magnetic Field

The figure below shows an electron moving at a constant velocity that is just about to enter a region where there is a uniform magnetic field directed toward the bottom of the page.



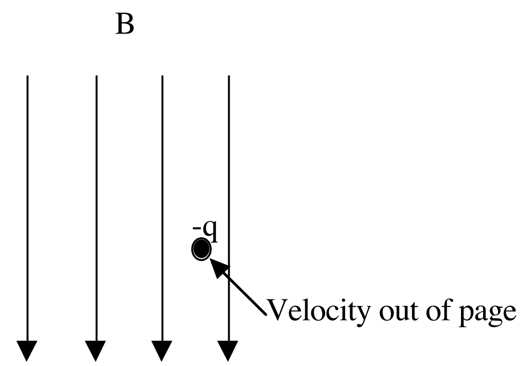
Complete the bar chart below, by putting in the appropriate values for the final kinetic energy, the initial and final potential energies and for any work done, for the electron from just before it enters the magnetic field to when it has traveled into the magnetic field a short distance.

Explain the reasoning behind your bar chart:

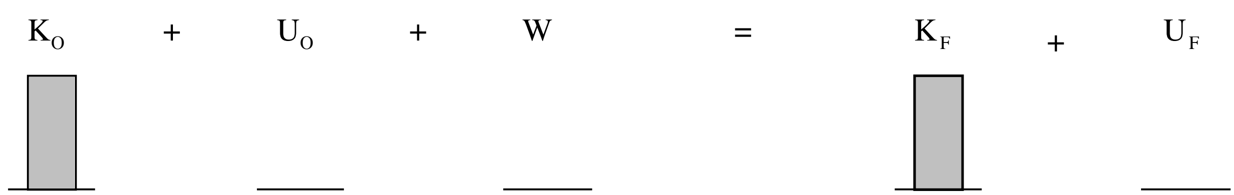
The magnetic field does no work on the moving charge because the magnetic force is always perpendicular to the velocity.

MFF10a—BCT4: Moving Charge and a Uniform Magnetic Field

The figure below shows an electron moving within a region where there is a uniform magnetic field, which is constant over time, directed toward the bottom of the page. Initially, the electron was moving with some velocity before it entered the region with the uniform magnetic field.



Complete the bar chart below, by putting in the appropriate values for the initial kinetic energy, the initial and final potential energies and for any work done, for the electron from just before it enters the magnetic field to when it has traveled into the magnetic field a short distance.



Explain the reasoning behind your bar chart.

The magnetic field does no work on the moving charge because the magnetic force is always perpendicular to the velocity.

MFF10a—PET1: Moving Charge and a Uniform Magnetic Field

A negatively charged particle is projected into a region in which there is a uniform magnetic field that is constant over time. The particle's initial velocity is perpendicular to the field.

What will happen to the particle's kinetic energy and why?

The particle's kinetic energy will not change since the magnetic force cannot do any work on the charge because the magnetic force is perpendicular to the velocity.

MFF10a—LMCT1: Moving Charge and a Uniform Magnetic Field

Described below are a variety of situations where positively charged particles are projected into regions in which there are uniform magnetic fields that are constant over time and there are no electric fields. **Identify what will happen to the direction of the particle's velocity and its kinetic energy as it moves in the magnetic field for each of these cases.**

The options are:

a) Direction of velocity and KE will remain constant.
b) Direction of velocity will change, but KE will remain constant.
c) Direction of velocity will change, and KE will increase.
d) Direction of velocity will change, and KE will decrease.
e) Direction of velocity will remain constant, but KE will increase.
f) Direction of velocity will remain constant, and KE will decrease.

1) The particle is positively charged and projected into the field parallel to the field. __***A***__

2) The particle is negatively charged and projected into the field perpendicular to the field. _***B***___

3) The particle is negatively charged and projected into the field at an angle of 40º relatively to the direction of the magnetic field. _***B***___

4) The particle is positively charged and projected into the field at an angle of 130º relatively to the direction of the magnetic field. _***B***___

5) The particle is positively charged and projected into the field perpendicular to the field. _***B***___

MFF10A—M/MCT1: MOVING CHARGE AND A UNIFORM MAGNETIC FIELD

A charged particle, q = 7 mC, with an initial velocity of 4 m/s enters a region in which there is a uniform magnetic field of 750 mT directed vertically upward. The particle has a mass of 64 g and is in the field for 10 seconds. A student carries out the following calculations.

$$a = \frac{(7 \times 10^{-3}\ C\ )(4\ \text{m/s})(750 \times 10^{-3}\ T\ )}{0.064\ \text{kg}} = 3.28 \times 10^{-1}\ \text{m/s}^2$$

$$v_f = 4\ \text{m/s} + (3.28 \times 10^{-1}\ \text{m/s}^2)(10\ \text{s})$$

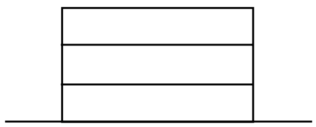
$$\text{Change in } KE = (0.5)(0.064\ \text{kg})(7.28\ \text{m/s})^2 - (0.5)(0.064\ \text{kg})(4\ \text{m/s})^2$$

Are these calculations meaningful or meaningless for this situation? Explain fully.

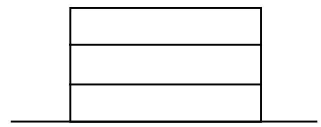
Meaningless. While there is an acceleration, it does not change the magnitude of the velocity because it is perpendicular to the velocity so there is no change in kinetic energy.

MFF10a—CRT1: Moving Charge and a Uniform Magnetic Field

The two bar charts below show the kinetic energy of a particle just as it enters a region in which there is a uniform magnetic field, which is constant over time, and 4 seconds after entering the field.



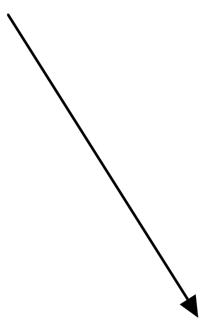
Initial KE

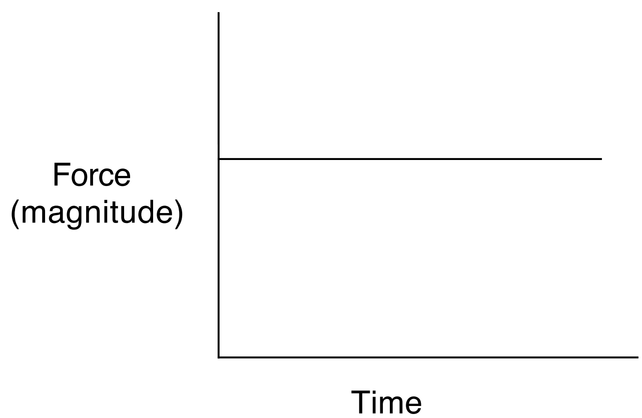


KE after 4sec

Shown below is an arrow representing the particle's initial velocity and a set of axes for a force magnitude-versus-time graph. (What is plotted on the vertical axis is the magnitude of the force without regard to the direction.)

Below the velocity arrow, draw an arrow showing a reasonable direction for the magnetic field to produce the above kinetic energy bar charts. On the axes, draw what the magnetic force-versus-time graph will look like for this situation.





Explain fully your reasoning.

The magnetic field can be drawn at any angle. The velocity will probably change direction, but the magnitude of the force will have a constant magnitude.

MFF10a—QRT1: Moving Charge and a Uniform Magnetic Field

A negatively charged particle is shot into a region in which there is a uniform magnetic field that is constant over time. The particle has an initial speed, v_o, and is initially moving perpendicular to the field.

Explain how each of the changes described below would affect the particle's change of kinetic energy (KE) during the first 3 seconds it is in the field.

(a) Initial speed of the particle is three times as large.

No effect.

(b) Magnetic field direction is reversed.

No effect.

(c) Mass of the particle is doubled.

No effect.

(d) Particle is initially moving at an angle of 60º relative to the direction of the magnetic field.

No effect.