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MFF 1A: ELECTRIC CHARGE AND A BAR MAGNET

MFF1A—WBT1: ELECTRIC CHARGE AND A BAR MAGNET

Construct a physical situation, involving a permanent magnet, for which the following equation for the magnetic force could apply.

$$\left| \vec{F}_B \right| = (88 \times 10^{-6} \text{ C})(0 \text{ m / s})(45 \times 10^{-3} \text{ T})$$

Draw a diagram and carefully explain your reasoning.



A 88 mC charge placed at rest near a bar magnet of strength 45 mT at the position of the charge. The bar magnet would still exert 0 force on the charged particle. This is an expression that could be used in this case although it somewhat of a stretch.

MFF1A—CCT1: ELECTRIC CHARGE AND A BAR MAGNET

Consider the following students' statements about the magnetic force on a positively charged particle placed near a permanent magnet.

Student A: "A positively charged particle placed near the N pole of a permanent magnet will experience a MAGNETIC repulsion."

Student B: "A positively charged particle placed near the N pole of a permanent magnet will experience a MAGNETIC attraction."

Student C: "A positively charged particle placed near either the N or S pole of a permanent magnet will not experience any magnetic force"

With which, if any, student do you agree?

Student A _____ Student B _____ Student C X None of them _____

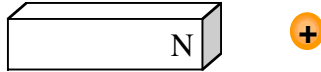
Carefully explain your reasoning.

Charge particles have to be moving in a magnetic field to feel a magnetic force.

MFF1A—WWT1: ELECTRIC CHARGE AND A BAR MAGNET

Determine what, if anything, is wrong with the situation presented below. If something is wrong, identify it and explain how to correct it. If nothing is wrong, explain why the situation is correct.

A positively charged particle placed at the position shown in the figure below will start moving to the right because it will be repelled by the N pole of the magnet.



The statement is incorrect. A positively charged particle placed at the position in the figure would not feel any magnetic force and hence would not move at all.

MFF1A—TT1: ELECTRIC CHARGE AND A BAR MAGNET

Something is wrong with the situation described below. **Identify what is wrong and explain how to correct it.**

“A positively charged particle placed at rest near the S pole of a permanent magnet will be repelled by the magnet.”

What is wrong is that the positively charged particle will not feel a magnetic force due to the magnet (and hence will not be repelled by the magnet).

MFF1A—PET1: ELECTRIC CHARGE AND A BAR MAGNET

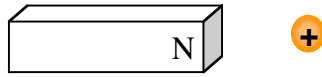
A positively charged Styrofoam packing “peanut” is suspended from a thread and hangs freely. The N pole of a permanent magnet is placed near the peanut. The peanut swings toward the magnet indicating that it is attracted to the magnet.

Suppose that the S pole of the magnet is placed near the peanut. What will the peanut do and why?

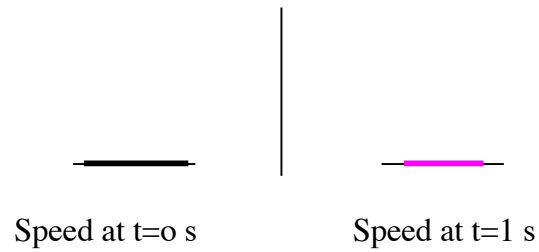
The peanut will also swing toward the magnet indicating it is attracted. The peanut will cause the surface charges on the magnet to be polarized and will create an attraction between unlike electrical charges to occur. The instructor may want to explain, or show, that the same thing will happen with any metal object, and has nothing to do with magnetism.

MFF1A—BCT1: ELECTRIC CHARGE AND A BAR MAGNET

The figure below shows a positively charged particle that is placed at rest near the N pole of a permanent magnet and released. The particle is released at $t = 0$ s and allowed to move freely.



Complete the bar chart below showing the particle's speed 1 second after being released.

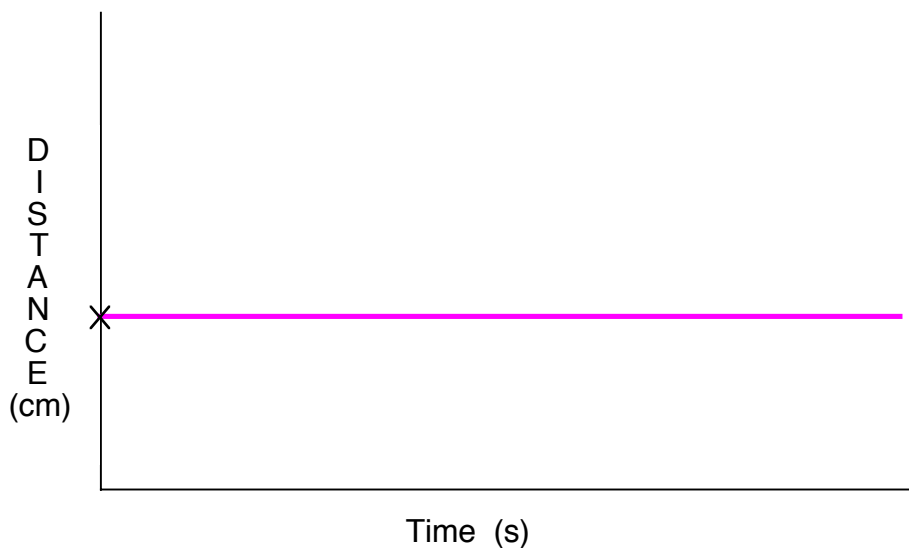


Explain your answer fully.

Since the particle will feel no magnetic force due to the magnet, it will not move and hence its speed will always be zero.

MFF1A—CRT1: ELECTRIC CHARGE AND A BAR MAGNET

A positively charged particle is placed at rest near the N pole of a permanent magnet and released. **On the axes below, plot the distance of the particle from the magnet versus time starting from the initial position marked by an X.**

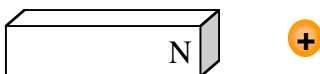


Explain fully why the graph looks as you have drawn it.

Since the particle will not feel a magnetic force, its distance from the magnet does not change; hence, it will be a constant value.

MFF1A—LMCT1: ELECTRIC CHARGE AND A BAR MAGNET

A positively charged particle is placed at rest 3 cm from the N pole of a permanent magnet. Several modifications to this initial situation are described below. For each modification **identify how the magnetic force exerted on the particle will change, if it does.**



The same possible answers are available for all changes, they are:

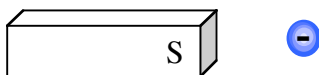
- This change will increase the force.
- This change will decrease the force.
- This change will reverse the direction of the force.
- This change will have no effect on the force.
- There was no force and this change will not alter that.

All of the modifications are to the original situation.

- 1) The strength of the magnet is doubled.** *E*
- 2) The particle is placed 7 cm from the N pole.** *E*
- 3) The magnet is reversed so the particle is located 3 cm from the S pole.** *E*
- 4) The charge on the particle is tripled.** *E*
- 5) The mass of the particle is doubled.** *E*
- 6) A second magnet is placed 3 cm on the other side of the charge with its S pole facing the charge.** *E*

MFF1A—M/MCT1: ELECTRIC CHARGE AND A BAR MAGNET

A 74 nC negatively charged particle is placed 3.5 cm from the N pole of a permanent magnet of strength 0.66 T.



A student calculates the force on the particle 3 seconds after the particle is put in place in the following way:

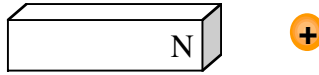
$$\left| \vec{F} \right| = \frac{(74 \times 10^{-9} \text{C})(3.5 \times 10^{-2} \text{m})(0.66 \text{T})}{3 \text{s}}$$

Is this calculation meaningful, i.e., it actually tells us something about a physical quantity relevant to the situation, or is it meaningless, i.e., it is not a legitimate calculation?

This is a meaningless calculation. In the relation $F = qvB$ the v stands for velocity, but the 3.5 cm is not the distance moved in the 3 s. There is no MAGNETIC force felt by the negatively charged particle.

MFF1A—QRT1: ELECTRIC CHARGE AND A BAR MAGNET

The figure below shows a positively charged particle at a certain position relative to the N pole of a permanent magnet. A number of modifications are going to be made to this situation, in each case **explain how the modification will affect, if it does, the force exerted on the particle.**



- a) The charge on the particle is tripled.

No change (no magnetic force).

- b) The strength of the magnet is decreased.

No change (no magnetic force) assuming the strength is decreased and remains a constant.

- c) The charge is placed closer to the magnet.

No change (no magnetic force).

- d) The magnet is reversed so the particle is sitting near the S pole.

No change (no magnetic force).

- e) The positive charge is replaced by a negative charge of the same magnitude.

No change (no magnetic force).

- f) The mass of the particle is doubled.

No change (no magnetic force).

MFF1A—CODT1: ELECTRIC CHARGE AND A BAR MAGNET

A permanent magnet is placed near a hanging negatively charged ball with the S pole of the magnet near the ball. The ball swings toward the magnet.

What will happen if we place the magnet near the ball but with the N pole near the ball?

Actually conduct the experiment and ask them to explain any discrepancies between their predictions and what actually occurred.

What students would hopefully see is the ball swinging toward the N pole of the magnet as it did toward the S pole of the magnet. The ball will cause the surface charges on the magnet to be polarized and will create an attraction between unlike electrical charges to occur. The instructor may want to explain, or show, that the same thing will happen with any metal object, and has nothing to do with magnetism.