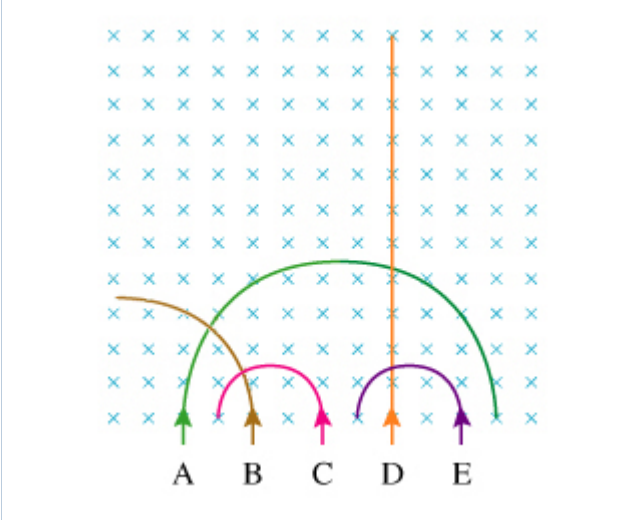
Description: Short conceptual problem to derive charge and relative speed of particles from their trajectories in a uniform magnetic field. (ranking task)

Five equal-mass particles (A–E) enter a region of uniform magnetic field directed into the page. They follow the trajectories illustrated in .



Part A

Which particle (if any) is neutral?

▼ **View Available Hint(s)** (1)

Hint 1. Neutral particles

Since the magnitude of the magnetic force acting on a particle is given by $F = qvB\sin\theta$, a neutral particle (with $q = 0$) will not experience a magnetic force.

ANSWER:

- ○ particle A
- ○ particle B
- ○ particle C
- ◉ particle D
- ○ particle E
- ○ none

Part B

Which particle (if any) is negatively charged?

View Available Hint(s) (1)

Hint 1. Find the direction of the magnetic force

The direction of the magnetic force is determined by the right-hand rule. With the given directions for velocity and magnetic field, what is the direction of the magnetic force on a positively charged particle?

ANSWER:

- (•) left
- ( ) right

ANSWER:

- (•) particle A
- ( ) particle B
- ( ) particle C
- ( ) particle D
- ( ) particle E
- ( ) none

Part C

Rank the particles on the basis of their speed.

Rank from largest to smallest. To rank items as equivalent, overlap them.

View Available Hint(s) (1)

Hint 1. Determining velocity based on particle trajectories

A charged particle moving in a uniform magnetic field follows a circular trajectory. By Newton's second law, the magnetic force acting on the particle must be equal to the product of its mass and acceleration:

$$qvB\sin\theta = ma.$$

In our scenario, the velocity and field vectors are perpendicular, so $\theta = 90$ degrees. Also, since the particle moves along a circular path, the acceleration must equal the expression for centripetal acceleration:

$$qvB = m\frac{v^2}{r}.$$

This can be solved for velocity to yield

$$v = \frac{qBr}{m}.$$

Thus, the speed of a particle can be determined by measuring the radius of its circular path in a known magnetic field, assuming that you also know the charge and mass of the particle.

ANSWER:

Reset Help

A B C D E

largest smallest

The correct ranking cannot be determined.

Part D

Now assume that particles A, B, C, and E all have the same magnitude of electric charge. Rank the particles A, B, C, and E on the basis of their speed.

Rank from largest to smallest. To rank items as equivalent, overlap them.

View Available Hint(s) (1)

Hint 1. Charged particle trajectories in magnetic fields

Particles A, B, C, and E are charged. A charged particle moving in a uniform magnetic field follows a circular trajectory. The speed of the particle has two distinct effects on the radius of its circular path. First, the faster the particle moves, the larger the magnetic force acting on it, by

$$F = qvB\sin\theta.$$

However, the faster it moves, the larger its centripetal acceleration, by

$$a_{\text{centripetal}} = \frac{v^2}{r},$$

and therefore the larger the force needed to keep it in its circular path.

ANSWER: