15. Electro-magnetism

Definitions

Magnetic Flux Density: Magnetic flux density of a magnetic field is the force per unit length that acts on a wire carrying unit current, lying at right angles to the magnetic field.

Tesla: 1 Tesla is defined as the magnetic flux density of a uniform magnetic field when a wire of length 1m, carrying a current of 1A, placed perpendicular to the field, experiences a force of 1N in a direction at right angles to both the field and the current.

Comparison between an Electric Field and a Magnetic Field

Similarities:

1. Both fields exert forces on moving charged particles.
2. They are non-contact forces / action-at-a-distance forces.
3. They are conservative fields

Differences:

1. Electric field will change the magnitude of the speed of charged particles whereas magnetic field can only change the direction, not magnitude of velocity of charged particles.
2. If the paths of the particles are not straight line, it will be parabolic and circular in electric fields and magnetic fields respectively.
3. The electric force is either parallel or anti-parallel to the electric field whereas the magnetic force is always mutually perpendicular to the magnetic field and the motion of the charged particle.
4. There will not be any magnetic force on stationary charged particles whilst there will be electric force on charged particles regardless of its state of motion.

- **NOTE: When helical motion in a solenoid, note that helix is formed on one side (one side of the diameter), not directly in the centre. IMPORTANT!!!**

Questions

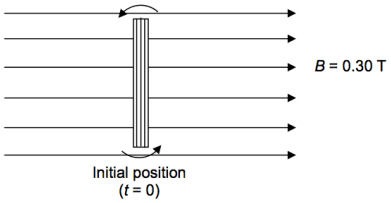
1. What happens to the magnetic flux density when the plastic tube (wrapped with coil to form a solenoid) is filled with iron filing?

Ans: The magnetic flux density increases significantly. The ferromagnetic (having high susceptibility to magnetism) property of iron filing causes the internal magnetic domains of the iron to line up with the smaller driving magnetic field produced by the current in the solenoid, thus multiplying the magnetic flux density produced by the solenoid by factors of tens to thousands.

2. A student noted that the current causes a change in the length of the spring (Q4 of supplementary). State and explain whether the change in the length of the spring is an extension or compression.

Ans: The current in each turn of the coil of the spring produces a magnetic field that is **perpendicular to the current in the adjacent coil**. Since the current in the adjacent coil is flowing in the same direction, an attractive force will be exerted on the coils towards each other. The spring coils will move towards one another and the length of the spring will thus shorten. The change in the length of the spring is therefore a compression.

1 A flat circular coil of wire of 25 turns, each of area 0.010 m^2, is rotated steadily at 60 rad s^{-1} in a uniform magnetic field of flux density 0.30 T as shown. What is the induced e.m.f. (in volts) at time t (in seconds)?



Top View

A $0.075\sin 60t$

B $0.075\cos 60t$

C $4.5\sin 60t$

D $4.5\cos 60t$

Ans is C.