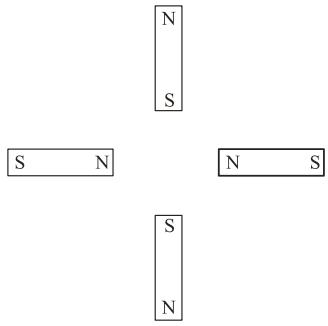
Magnetic Fields and Forces

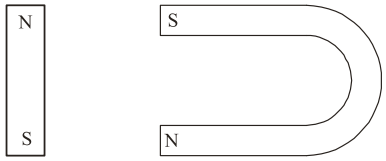
Basic Problems

1. Sketch the magnetic field for the following arrangements of bar and horseshoe magnets:

a)

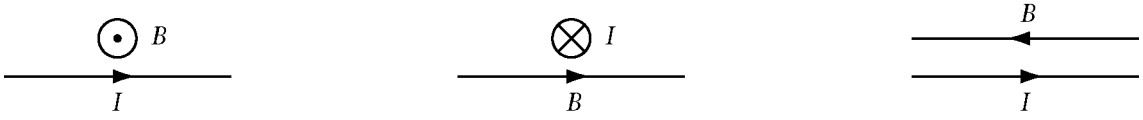


b)



2. Calculate the vertical component of the Earth's magnetic field in Geneva. Find the direction and the acceleration of the acceleration experienced by an α particle moving to the north at 3.4 % of the speed of light.

3. For the following situations, determine the direction of the force acting on the current in the magnetic field.



4. The current flowing through a 50 cm long piece of wire in a homogeneous magnetic field of 50 mT has magnitude 40 A. The force acting on the wire is 0.5 N. Determine the angle between field lines and current.

5. How is it possible for a charged particle to pass through a magnetic field without being deflected?

6. Between the sides of a 2.5 cm wide metal foil in a magnetic field of magnitude 0.28 T a potential difference of 12 μV can be measured. How fast are the electrons in the metal?

7. Electrons enter a homogeneous magnetic field of magnitude 25 mT at 10 % of the speed of light. The angle between the electron beam and the magnetic field lines is 45°. Determine the direction and magnitude of an additional electric field which compensates the effect of the Lorentz force.

8. An α particle is injected into a homogeneous magnetic field of magnitude 15 mT at the speed $5 \cdot 10^6$ m/s. Calculate the radius of its circular path. What is the frequency of the circular motion?

9. In a particle accelerator, electrons move at 10 % of the speed of light on a circular path with radius 10 m. Calculate the magnitude of the magnetic field perpendicular to the electron's motion. What would be the radius for protons moving at the same speed in the same magnetic field?

Supplementary Problems

10. A magnetic field of magnitude 0.3 T runs horizontally from north to south. A 2.5 m long copper wire (cross sectional area 2 mm^2) carrying an electric current is floating in the magnetic field. Choose a possible orientation for the wire and calculate the current necessary to allow for this phenomenon.

11. The write head of a hard disc drive produces a magnetic field of 95 mT. The disc has a radius of 3.5 inches and rotates at 7'200 rpm (*rotations per minute*). Calculate the Lorentz force acting on an electron near the edge of the disc. Compare the result to the electron's weight.

12. The electrons leave the electron gun of an old TV tube at the speed of some 30'000 km/s. After running perpendicularly through a nearly homogeneous magnetic field of magnitude 0.52 mT, they hit the screen, which has a distance of 25 cm to the electron gun. Determine the electrons' deflection with a construction.

13. A cyclotron with radius 0.8 m is used to accelerate protons. The magnitude of the magnetic field is 0.3 T. What are the protons' final speed and energy?

Solutions: 2. 41.46 μT, $2.0 \cdot 10^{10}$ m/s² to the west; 4. 30°; 6. 1.7 mm/s; 7. 530 kV/m; 8. 7.0 m, 110 kHz; 9. 17 μT, 18 km; 10. 0.6 A; 11. $7.3 \cdot 10^{-20}$ N; 12. 10.5 cm; 13. 0.077 c, 2.8 MeV