DEGREE IN COMPUTER ENGINEERING

PHYSICS **EXERCISES CH 9**

Magnetic fields

Mass of the proton m= 1.67 $\times$ 10^{-27} kg
Mass of the electron m= 9.11 $\times$ 10^{-31} kg

1. A proton travelling with a velocity $\vec{v} = 2\cdot 10^6 \vec{i}\,(m/s)$ forms an angle of 30º with a magnetic field $\vec{B} = 3.46\vec{i} + 2\vec{j}\,(mT)$

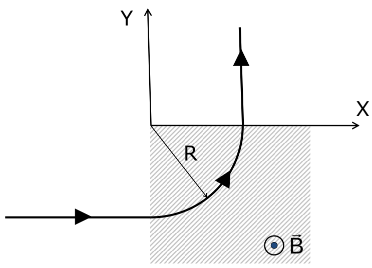
Find:

a) The magnetic force acting on the proton
b) The acceleration of the proton

2. A proton travelling with a constant velocity $5\times10^6\vec{i}$ m/s enters a region with a uniform and constant magnetic field $\vec{B} = -\vec{k}$ T.
a) Draw the forces acting on the proton.
b) Calculate the acceleration of the proton after entering the field.
c) Find the trajectory described by the proton.

3. An electron and a proton travelling with a kinetic energy of 100 eV enter a region in which there is a uniform magnetic field of magnitude 300 G. The magnetic field is perpendicular to the direction of motion. Find the radii of the circular trajectories described by the particles.

4. A particle of mass m and charge q moving with a velocity $\vec{v} = v_0\,\vec{i}$ enters the shadowed region (see figure), in which there is a uniform magnetic field $\vec{B} = B_0\,\vec{k}$. The particle describes an arc of circumference of radius R. Find:

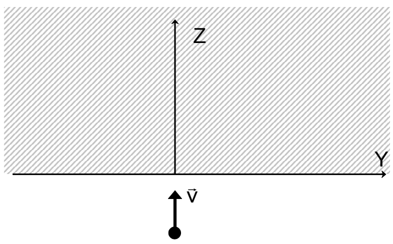


a) The charge of the particle
b) The time spent by the particle in the shadowed region
c) The kinetic energy of the particle when leaving the shadowed region.

DATA: m= 3 $\times$ 10^{-25} kg; v_0= 2 $\times$ 10^5 m/s; B_o= 0.3 T; R= 7.4 mm

5. A proton travelling at a speed of $2\text{x}10^5$ (m/s) along the Z axis (see figure) enters the shadowed area (Z>0) where there is a uniform magnetic field $\vec{B}$. The proton leaves the shadowed area at point (0,-2.45$\times10^{-3}$,0) m.

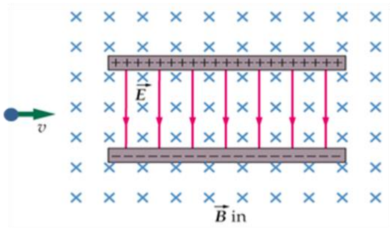
a) What is the magnetic field?
b) Find the kinetic energy of the proton when leaving the shadowed area.
c) After leaving the shadowed area, the proton enters a region in which there is a constant electric field along the -Z direction. Find the electric field so that the proton increases its kinetic energy in a factor of 10 when travelling a distance of 1 m.



Magnetic fields

6. A proton travelling at a speed of 100 km/s enters a region with a uniform magnetic field of magnitude 0.5 T that forms an angle of 30° with the proton. Find:
a) the radius of the helical trajectory described by the proton
b) the linear frequency of rotation
c) the distance advanced by the proton in a single revolution

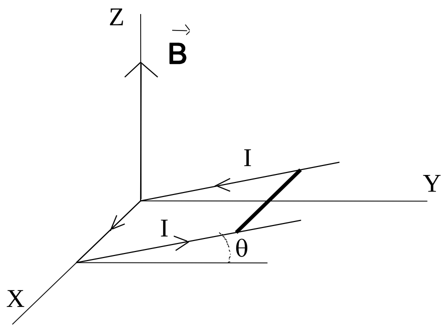
7. A parallel electron beam travelling with different speeds enters a parallel-plate capacitor where there is an electric field of magnitude 10^6 V/m. There is also a magnetic field of magnitude 0.1 T perpendicular to this electric field, see figure.
a) Find the speed of the electrons that pass through without deviating.
b) Find the kinetic energy of those electrons in eV.
c) In what direction will the electrons travelling with two times that speed deviate?



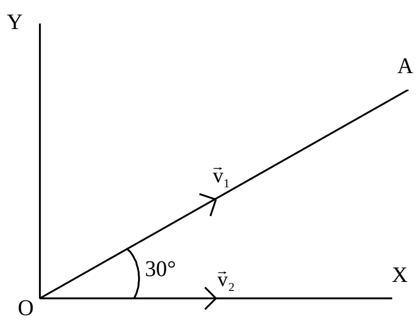
8. A 2.8 *m* length straight wire carries a current of 5*A* in a region where a uniform magnetic field has a magnitude of 0.39 *T*. Find the magnitude of the magnetic force on the wire knowing that the angle between B and the direction of the current is: 0º, 60°, 90° and 120° respectively.

9. A wire in a magnetic field is carrying a current of 2 *A* on the positive X direction and has a linear mass density λ_m = 0.5 *g*/cm. Find the direction and minimum magnitude of the magnetic field in order to lift the wire (consider the gravitational force acting on the wire).

10. A rectangular loop in a magnetic field $\vec{B} = B\vec{k}$ has a mobile side of length *L* and mass *m*. A constant current *I* circulates along the loop. The plane of the loop forms an angle θ with the XY plane (see figure). Find the magnitude of *B* so that the mobile side does not slide down.



11. A proton moves in a magnetic field with v = 5 × 10^5 m/s. When moving in the OA direction (forming an angle of 30° with the X axis), the trajectory of the proton is not affected by the magnetic field. However, the same proton moving with the same speed on the positive X direction experiments a magnetic force of 2 × 10^{-16} N on the positive Z direction.
a) Find $\vec{B}$.
b) Find the electric field applied so that the proton moving along the X axis does not deviate.
c) Find the magnetic force on a straight wire of length 50 cm located along the Y axis knowing that the current circulating along it is 6 A on the positive direction.



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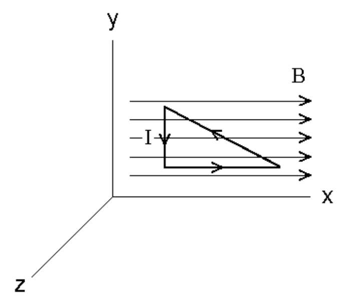
12. A triangular loop carries a current of 4 A. The loop is immersed in a magnetic field of magnitude 75 mT and direction parallel to the plane of the loop. The loop has sides of length 50 cm, 120 cm and 130 cm. Find:

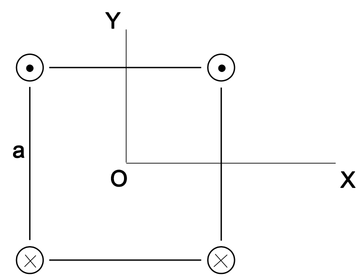
a) The force acting on each side of the loop.
b) The net force on the loop.
c) What happens to the loop in the presence on this B?



13. Two straight, parallel, very long conducting wires carrying currents I_1=15 A and I_2=5 A are separated by 20 cm. Find the regions of space in which the magnetic field due to these currents is zero.

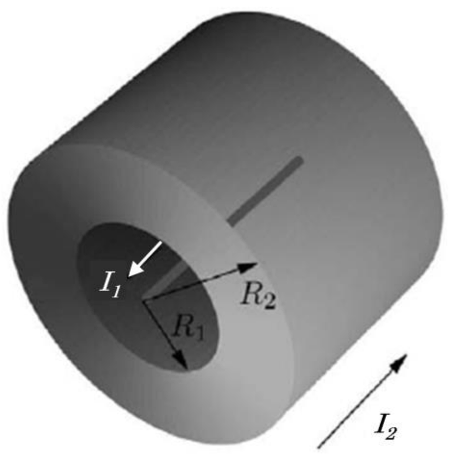
14. Four long parallel conductors each carry a current I. The figure shows a cross sectional view of the system, which forms a square of length a. Determine the magnetic field at point *O* in these two cases:

a) The directions of the currents are the ones indicated in the figure.
b) All the currents circulate along the same direction.



15. A coaxial cable is made by a very long conducting wire carrying a current I_1 and a solid hollow cylindrical conductor concentric with the wire (see figure), carrying a uniform current I_2. I_1 and I_2 circulate along opposite directions.

a) Find the magnetic field in all regions of space.
b) Find the relation between the two intensities that cancels the magnetic field outside the coaxial cable ($r>R_2$).
c) Find the relation between the intensities and radii that cancels the magnetic field inside the cylindrical cable ($R_1<r<R_2$).
d) Is it possible to cancel the magnetic field in the region $r<R_1$?



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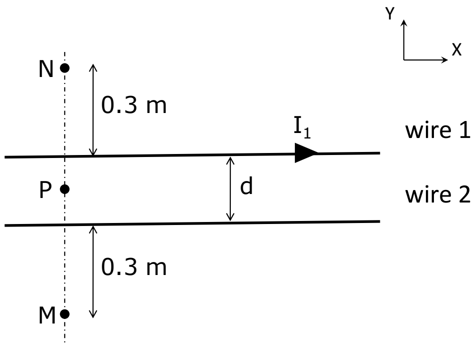
16. Two straight infinite parallel wires are separated by a distance d= 0.2 m. The 1st wire carries a current I_1 = 5 A along the direction indicated in the figure.

a) Find the intensity and direction of the current circulating along the 2nd wire (I_2) knowing that the magnetic field $\vec{B}$ is zero at point M.
b) Find the magnetic field $\vec{B}$ at point N.
c) Find the magnetic field $\vec{B}$ at point P, located at the midpoint between the two wires.



17. Find the magnetic field at the centre of a 1 *m* long closely wound solenoid with 1000 turns knowing that its radius is 10 *cm* and the current circulating along it is 1 *A*.

ANSWERS

1. a) **F**=6.4 x 10^{-16} **k** (N) b) **a**=4 x 10^{11} **k** (m/s^2)

2. b) a=4.8x10^{14} m/s^2 c) Circular trajectory, radius r = 5.2 cm

3. R_e = 1.12 mm R_p = 49 mm

4. a) q = - 2.7 $\times$ 10^{-17} C

b) t = 5.8 $\times$ 10^{-8} s

c) E_c = 6 $\times$ 10^{-15} J

5. a) $\vec{B} = -1.7\ \vec{\imath}\ T$

b) E_c = 3.34 $\times$ 10^{-17} J

c) $\vec{E} = -1.88 \times 10^3\ \vec{k}\ \ V/m$

6. a) R=1.05 mm b) f=7.6x10^6 Hz c) 11 mm

7. a) v = 10^7 m/s b) E_c = 281 eV c) downwards

8. 0 N, 4.73 N, 5.46 N and 4.73 N respectively.

9. $\vec{B} = -0.245\ \vec{k}\ \ T$

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10. $B = \dfrac{m\,g\,tg\,\theta}{I\,L}$

11. a) $\vec{B} = 4.3\times10^{-3}\,\vec{i} + 2.5\times10^{-3}\,\vec{j}$ (T)

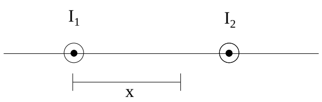
b) $\vec{E} = -1250\,\vec{k}$ (V/m)

c) $\vec{F} = -0.013\,\vec{k}$ (N)

12. a) $\vec{F_1} = 0$ $\quad \vec{F_2} = 0.15\,\vec{k}\ (N)$ $\quad \vec{F_3} = -\,0.15\,\vec{k}\ (N)$

b) $\vec{F}_{espira} = 0$ c) The loop rotates due to the torque until it is perpendicular to B.

13.



x = 15 cm

x = 10 cm

14. a) $\vec{B} = \dfrac{2\,\mu_0\,I}{\pi\,a}\,\vec{i}$

b) $\vec{B} = 0$

15. a) $\vec{B} = \dfrac{\mu_o}{2\pi r}(I_1 - I_2)\vec{u}_\theta (r > R_2)$; $\vec{B} = \dfrac{\mu_o}{2\pi r}(I_1 - I_2\dfrac{r^2 - R_1^2}{R_2^2 - R_1^2})\vec{u}_\theta (R_1 < r < R_2)$; $\vec{B} = \dfrac{\mu_o I_1}{2\pi r}\vec{u}_\theta (r < R_1)$

b) $I_1 = I_2$

c) $I_1 = I_2\dfrac{r^2 - R_1^2}{R_2^2 - R_1^2}$

d) No.

16. a) I_2 = 3 A along the $-\vec{i}$ direction.

b) $\vec{B}\,(N) = 2.1\times10^{-6}\,\vec{k}\quad (T)$

c) $\vec{B}\,(P) = -1.6\times10^{-5}\,\vec{k}\quad (T)$

17. $B = 1.23\times10^{-3}$ T