MOVING CHARGES AND MAGNETISM

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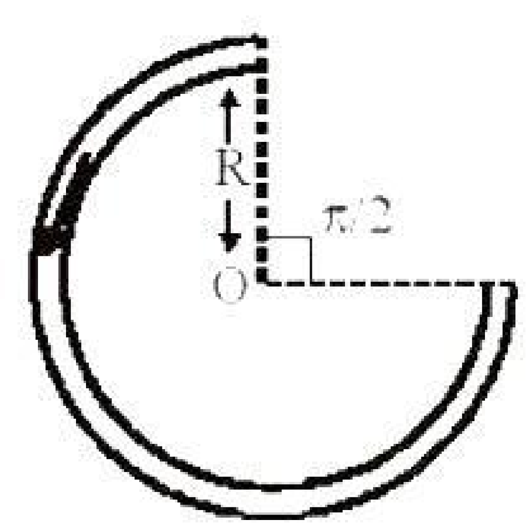
1. A proton (mass = 1.67×10^{-27} kg and charge = 1.6×10^{-19} C) enters perpendicular to a magnetic field of intensity 2 weber/m^2 with a velocity 3.4×10^7 m/sec. The acceleration of the proton should be
   (a) 6.5×10^{15} m/sec^2 (b) 6.5×10^{13} m/sec^2
   (c) 6.5×10^{11} m/sec^2 (d) 6.5×10^{9} m/sec^2

2. A uniform magnetic field acts at right angles to the direction of motion of electron. As a result, the electron moves in a circular path of radius 2cm. If the speed of electron is doubled, then the radius of the circular path will be
   (a) 2.0 cm (b) 0.5 cm
   (c) 4.0 cm (d) 1.0 cm

3. A charged particle of mass m and charge q travels on a circular path of radius r that is perpendicular to a magnetic field B. The time taken by the particle to complete one revolution is
   (a) $\frac{2\pi q^2 B}{m}$ (b) $\frac{2\pi mq}{B}$
   (c) $\frac{2\pi m}{qB}$ (d) $\frac{2\pi qB}{m}$

4. The magnetic induction at a point P which is at a distance of 4 cm from a long current carrying wire is 10^{-3} T. The field of induction at a distance 12 cm from the current will be
   (a) 3.33×10^{-4} T (b) 1.11×10^{-4} T
   (c) 3×10^{-3} T (d) 9×10^{-3} T

5. A current i ampere flows in a circular arc of wire whose radius is R, which subtends an angle $3\pi/2$ radian at its centre. The magnetic induction B at the centre is



   (a) $\frac{\mu_0 i}{R}$
   (b) $\frac{\mu_0 i}{2R}$
   (c) $\frac{2\mu_0 i}{R}$
   (d) $\frac{3\mu_0 i}{8R}$

6. A straight section PQ of a circuit lies along the X-axis from $x = -\frac{a}{2}$ to $x = \frac{a}{2}$ and carries a steady current i. The magnetic field due to the section PQ at a point $X = +a$ will be
   (a) proportional to a
   (b) proportional to a^2
   (c) proportional to $1/a$
   (d) zero

7. A long solenoid carrying a current produces a magnetic field B along its axis. If the current is double and the number of turns per cm is halved, the new value of the magnetic field is

(a) $4B$ (b) $B/2$
(c) B (d) $2B$

8. A straight wire of length 0.5 metre and carrying a current of 1.2 ampere is placed in uniform magnetic field of induction 2 tesla. The magnetic field is perpendicular to the length of the wire. The force on the wire is

(a) 2.4 N (b) 1.2 N
(c) 3.0 N (d) 2.0 N

9. Two long parallel wires are at a distance of 1 metre. Both of them carry 5 ampere of current. The force of attraction per unit length between the two wires is

(a) 50×10^{-7} N/m (b) 2×10^{-8} N/m
(c) 5×10^{-8} N/m (d) 10^{-7} N/m

10. A moving coil galvanometer has resistance of $10\,\Omega$ and full scale deflection of 0.01 A. It can be converted into voltmeter of 10 V full scale by connecting into resistance of

(a) $9.90\,\Omega$ in series (b) $10\,\Omega$ in series
(c) $990\,\Omega$ in series (d) $0.10\,\Omega$

11. The distance between the wires of electric mains is 12 cm. These wires experience 4 mg wt. per unit length. The value of current flowing in each wire will be
[assume equal current flows in both wires]

(a) 4.85 A (b) 0
(c) 4.85×10^{-2} A (d) 4.85×10^{-4} A

12. An electron moves in a circular arc of radius 10 m at a constant speed of 2×10^7 ms^{-1} with its plane of motion normal to a magnetic flux density of 10^{-5} T. What will be the value of specific charge of the electron?

(a) 2×10^4 C kg^{-1} (b) 2×10^5 C kg^{-1}
(c) 5×10^6 C kg^{-1} (d) 2×10^{11} C kg^{-1}

13. A beam of proton with velocity 4×10^5 ms^{-1} enters a uniform magnetic field of 0.3T. The velocity makes an angle 60° with magnetic field. The pitch of the helix path will be

(a) 4.4 cm (b) 5.8 cm
(c) 6.1 cm (d) 7.2 cm

14. A deuteron of kinetic energy 50 keV is describing a circular orbit of radius 0.5 metre in a plane perpendicular to the magnetic field B. The kinetic energy of the proton that describes a circular orbit of radius 0.5 metre in the same plane with the same B is

(a) 25 keV (b) 50 keV
(c) 200 keV (d) 100 keV

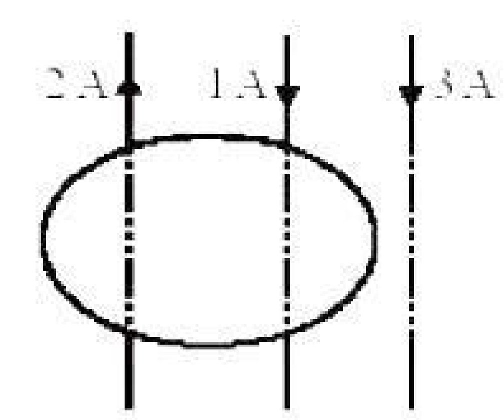
15. A particle of charge 16×10^{-16} C moving with velocity 10 ms^{-1} along x-axis enters a region where magnetic field of induction $\vec{B}$ is along the y-axis and an electric field of magnitude 10^4 Vm^{-1} is along the negative z-axis. If the charged particle continues moving along x-axis, the magnitude of $\vec{B}$ is :

(a) 16×10^3 Wb m^{-2} (b) 2×10^3 Wb m^{-2}
(c) 1×10^3 Wb m^{-2} (d) 4×10^3 Wb m^{-2}

16. A cyclotron's oscillator frequency is 10 MHz. If the radius of its **'dees'** is 60 cm, what is the kinetic energy of the proton beam produced by the accelerator ?
Given e = 1.60×10^{-19} C, m = 1.67×10^{-27} kg.
1 MeV = 1.6×10^{-13} J)

(a) 3.421 MeV (b) 4.421 MeV
(c) 5.421 MeV (d) 7.421 MeV

17. Two wires with currents 2 A and 1 A are enclosed in a circular loop. Another wire with current 3 A is situated outside the loop as shown. The $\oint \vec{B}.d\vec{l}$ around the loop is



(a) μ_0
(b) $3\mu_0$
(c) $6\mu_0$
(d) $2\mu_0$

18. The magnetic field due to a current carrying circular loop of radius 3 cm at a point on the axis at a distance of 4 cm from the centre is 54 μT. What will be its value at the centre of loop?

(a) 125 μT (b) 150 μT
(c) 250 μT (d) 75 μT

19. A current I flows in an infinitely long wire with cross section in the form of a semi-circular ring of radius R. The magnitude of the magnetic induction along its axis is:

(a) $\frac{\mu_0 I}{2\pi^2 R}$ (b) $\frac{\mu_0 I}{2\pi R}$

(c) $\frac{\mu_0 I}{4\pi R}$ (d) $\frac{\mu_0 I}{\pi^2 R}$

20. A wire in the form of a square of side 'a' carries a current i. Then the magnetic induction at the centre of the square wire is (Magnetic permeability of free space = μ_0)

(a) $\frac{\mu_0 i}{2\pi a}$ (b) $\frac{\mu_0 i\sqrt{2}}{\pi a}$

(c) $\frac{2\sqrt{2}\mu_0 i}{\pi a}$ (d) $\frac{\mu_0 i}{\sqrt{2}\pi a}$

21. A galvanometer having a coil resistance of 100 Ω gives a full scale deflection, when a currect of 1 mA is passed through it. The value of the resistance, which can convert this galvanometer into ammeter giving a full scale deflection for a current of 10 A, is :

(a) 0.1 Ω (b) 3Ω

(c) 0.01Ω (d) 2Ω

22. A square loop of side 2m carries a current of 5 A is suspended freely in a uniform magnetic field of strength 0.8T. Net force acting on the loop is

(a) 2×10^{-5}N (b) 4.8×10^{-5}N

(c) Zero (d) 2.6×10^{-7}N

23. Proton, deuteron and alpha particle of same kinetic energy are moving in circular trajectories in a constant magnetic field. The radii of proton, deuteron and alpha particle are respectively r_p, r_d and r_α. Which one of the following relation is correct?

(a) $r_\alpha = r_p = r_d$ (b) $r_\alpha = r_p < r_d$

(c) $r_\alpha > r_d > r_p$ (d) $r_\alpha = r_d > r_p$

24. If an electron and a proton having same momenta enter perpendicular to a magnetic field, then

(a) curved path of electron and proton will be same (ignoring the sense of revolution)

(b) they will move undeflected

(c) curved path of electron is more curved than that of the proton

(d) path of proton is more curved.

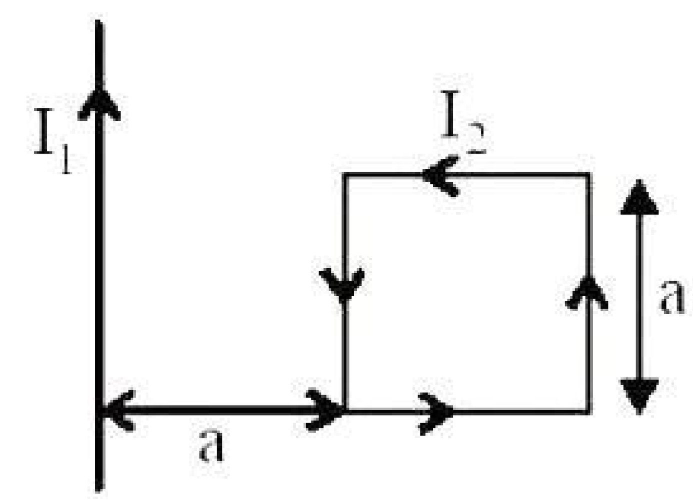
25. Two concentric coils each of radius equal to 2 π cm are placed at right angles to each other. 3 ampere and 4 ampere are the currents flowing in each coil respectively. The magnetic induction in Weber/m^2 at the centre of the coils will be

$(\mu_0 = 4\pi\times10^{-7}\,\text{Wb/A.m})$

(a) 10^{-5} (b) 12×10^{-5}

(c) 7×10^{-5} (d) 5×10^{-5}

26. A rigid square of loop of side 'a' and carrying current I_2 is lying on a horizontal surface near a long current I_1 carrying wire in the same plane as shown in figure. The net force on the loop due to the wire will be:



(a) Repulsive and equal to $\frac{\mu_o I_1 I_2}{2\pi}$

(b) Attractive and equal to $\frac{\mu_o I_1 I_2}{3\pi}$

(c) Repulsive and equal to $\frac{\mu_o I_1 I_2}{4\pi}$

(d) Zero

27. Two long conductors, separated by a distance d carry current I_1 and I_2 in the same direction. They exert a force F on each other. Now the current in one of them is increased to two times and its direction is reversed. The distance is also increased to $3d$. The new value of the force between them is

(a) $-\frac{2F}{3}$ (b) $\frac{F}{3}$

(c) $-2F$ (d) $-\frac{F}{3}$

28. A current of 1A is flowing on the sides of an equilateral triangle of side 4.5×10^{-2}m . The magnetic field at the centre of the triangle will be:

(a) 4×10^{-5}Wb/m^2 (b) Zero

(c) 2×10^{-5}Wb/m^2 (d) 8×10^{-5}Wb/m^2

29. If in a circular coil *A* of radius *R*, current *I* is flowing and in another coil *B* of radius 2*R* a current 2*I* is flowing, then the ratio of the magnetic fields B_A and B_B, produced by them will be

(a) 1 (b) 2

(c) 1/2 (d) 4

30. A moving coil galvanometer has a coil with 175 turns and area 1 cm^2. It uses a torsion band of torsion constant 10^{-6} N-m/rad. The coil is placed in a magnetic field B parallel to its plane. The coil deflects by 1° for a current of 1mA. The value of B (in Tesla) is approximately:

(a) 10^{-4} (b) 10^{-2}

(c) 10^{-1} (c) 10^{-3}

ANSWER KEY

1	(a)	4	(a)	7	(c)	10	(c)	13	(a)	16	(d)	19	(d)	22	(c)	25	(d)	28	(a)
2	(c)	5	(d)	8	(b)	11	(a)	14	(d)	17	(a)	20	(c)	23	(b)	26	(c)	29	(a)
3	(c)	6	(d)	9	(a)	12	(d)	15	(c)	18	(c)	21	(c)	24	(a)	27	(a)	30	(d)

18 Moving Charges and Magnetism

1. **(a)** $F = ma = qvB \Rightarrow a = \frac{qvB}{m}$

$$= \frac{1.6\times10^{-19}\times2\times3.4\times10^{7}}{1.67\times10^{-27}} = 6.5\times10^{15}\ \text{m/sec}^2$$

2. **(c)** $r = \frac{mv}{qB}$ or $r \propto v$

As v is doubled, the radius also becomes double. Hence radius $= 2\times2 = 4$ cm

3. **(c)** Equating magnetic force to centripetal force,

$$\frac{mv^2}{r} = qvB\sin 90^\circ$$

Time to complete one revolution,

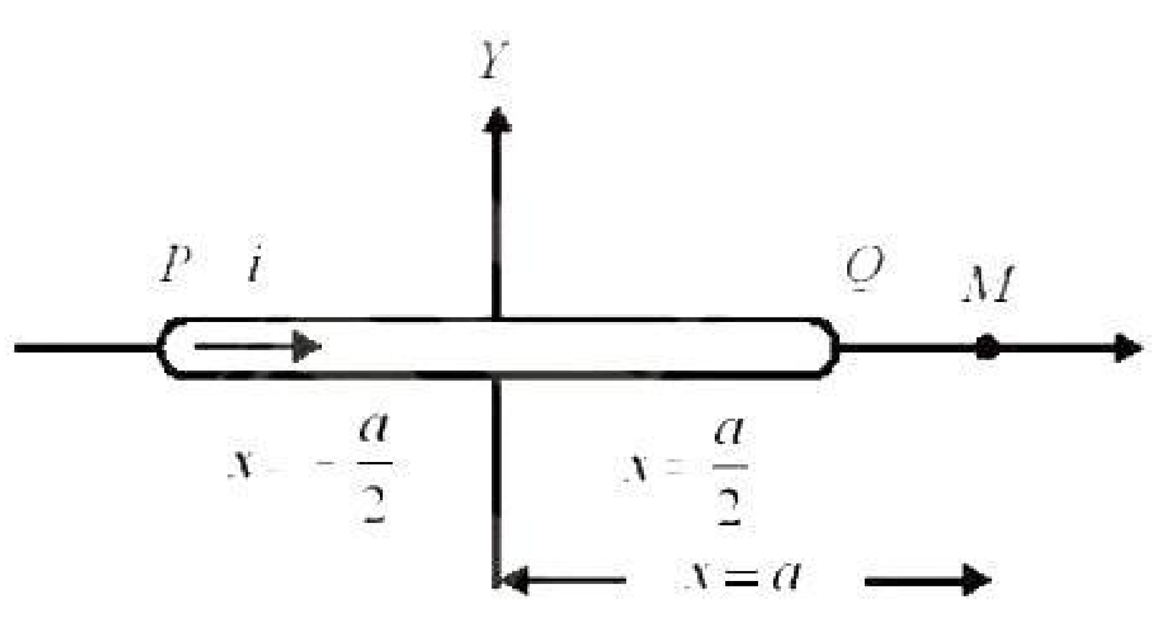
$$T = \frac{2\pi r}{v} = \frac{2\pi m}{qB}$$

4. **(a)** $B \propto \frac{1}{r}$

$$\therefore B' = \frac{1}{3}B = \frac{1}{3}\times10^{-3} = 3.33\times10^{-4}\,\text{T}$$

5. **(d)**

6. **(d)** Magnetic field at a point on the axis of a current carrying wire is always zero.



7. **(c)** $B = \mu_0 ni$

$$B_1 = (\mu_0)\left(\frac{n}{2}\right)(2\,i) = \mu_0 ni = B$$

$$\Rightarrow B_1 = B$$

8. **(b)** $F = Bi\ell = 2\times1.2\times0.5 = 1.2\,\text{N}$

9. **(a)** $F = \frac{\mu_0}{4\pi}\times\frac{2i_1 i_2}{r}$

$= 50\times10^{-7}$ N/m. Here F is force per unit length.

10. **(c)** $R = \frac{V}{I_g} - G = \frac{10}{0.01} - 10 = 990\,\Omega$ in series.

11. **(a)** $\frac{F}{\ell} = \frac{\mu_0 i^2}{2\pi d} = 9.8\times4\times10^{-6}$

$$\Rightarrow i = \sqrt{\frac{4\times10^{-6}\times9.8\times0.12}{2\times10^{-7}}} = 4.85\,\text{A}$$

12. **(d)** $Bqv = mv^2/r$ or $q/m = v/rB$.

13. **(a)**

14. **(d)** For a charged particle orbiting in a circular path in a magnetic field

$$\frac{mv^2}{r} = Bqv \Rightarrow v = \frac{Bqr}{m}$$

or $mv^2 = Bqvr$

Also,

$$E_K = \frac{1}{2}mv^2 = \frac{1}{2}Bqvr = Bq\frac{r}{2}.\frac{Bqr}{m} = \frac{B^2q^2r^2}{2m}$$

For deuteron, $E_1 = \frac{B^2q^2r^2}{2\times2m}$, For proton,

$$E_2 = \frac{B^2q^2r^2}{2m}$$

$$\frac{E_1}{E_2} = \frac{1}{2} \Rightarrow \frac{50\text{keV}}{E_2} = \frac{1}{2} \Rightarrow E_2 = 100\text{keV}$$

15. **(c)** Since particle is moving undeflected

So, $q_E = qvB \Rightarrow B = \frac{E}{V} = \frac{10^4}{10} = 10^3\ \text{wb/m}^2$

16. **(d)** $m = 1.67\times10^{-27}$ kg; $e = 1.60\times10^{-19}$ C; $v = 10\,\text{MHz} = 10^7$ Hz; $R = 60$ cm $= 0.6$ m

$$B=\frac{2\pi mv}{e}=\frac{2\pi\times1.67\times10^{-27}\times10^{7}}{1.60\times10^{-19}}$$

$= 0.656$ Tesla

$$E_{max}=\frac{B^2e^2R^2}{2m}$$

$$=\frac{(0.656)^2\times(1.60\times10^{-19})^2(0.6)^2}{2\times1.67\times10^{-27}}$$

$$=11.874\times10^{-13}\,J=\frac{11.874\times10^{-13}}{1.6\times10^{-13}}=7.421\,MeV$$

17. **(a)** According to Ampere's circuit law

$$\oint\vec{B}.d\vec{l}=\mu_0I_{enclosed}=\mu_0(2A-1A)=\mu_0$$

18. **(c)** The magnetic field at a point on the axis of a circular loop at a distance x from centre is,

$$B=\frac{\mu_0 i\,a^2}{2(x^2+a^2)^{3/2}}$$

$$B'=\frac{\mu_0 i}{2a}=\frac{B.(x^2+a^2)^{3/2}}{a^3}$$

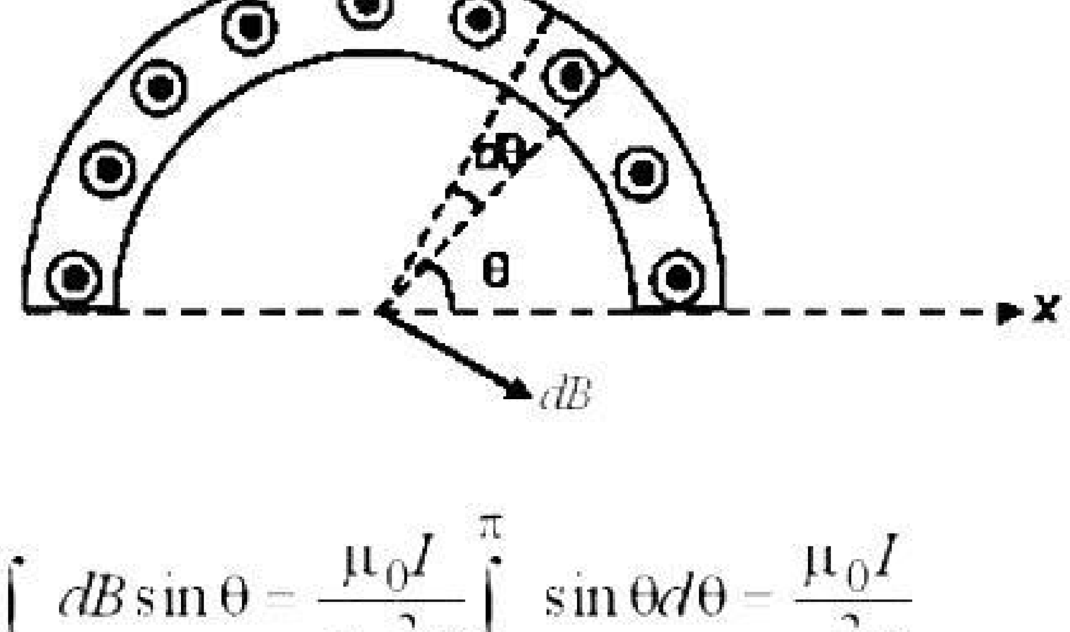
Put $x=4$ & $a=3\Rightarrow B'=\frac{54(5^3)}{3\times3\times3}=250\,\mu T$

19. **(d)** Current in a small element, $dI=\frac{d\theta}{\pi}I$

Magnetic field due to the element

$$dB=\frac{\mu_0}{4\pi}\frac{2dI}{R}$$

The component $dB\cos\theta$, of the field is cancelled by another opposite component.
Therefore,



$$B_{net}=\int dB\sin\theta=\frac{\mu_0 I}{2\pi^2R}\int_0^{\pi}\sin\theta d\theta=\frac{\mu_0 I}{\pi^2R}$$

20. **(c)**

21. **(c)** $I_gG=(I-I_g)S$

$\therefore 10^{-3}\times100=(10-10^{-3})\times S$

$\therefore S\approx0.01\,\Omega$

22. **(c)**

23. **(b)** The centripetal force is provided by the magnetic force

$$\therefore\frac{mv^2}{R}=qvB\Rightarrow r=\frac{mv}{Bq}\qquad\therefore r\propto\frac{\sqrt{m}}{q}$$

$$\therefore r_p:r_d:r_\alpha=\frac{\sqrt{m_p}}{q_p}:\frac{\sqrt{m_d}}{q_d}:\frac{\sqrt{m_\alpha}}{q_\alpha}=1:\sqrt{2}:1$$

Thus we have, $r_\alpha=r_p<r_d$

24. **(a)** When a moving charged particle is subjected to a perpendicular magnetic field, then it describes a circular path of radius.

$$r=\frac{p}{qB}$$

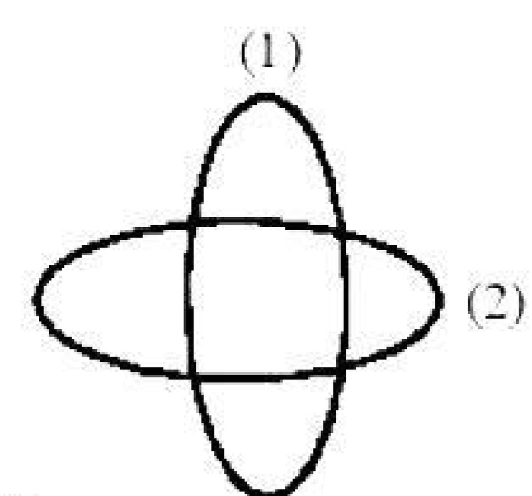
where q = Charge of the particle
p = Momentum of the particle
B = Magnetic field

Here p, q and B are constant for electron and proton, therefore the radius will be same.

25. **(d)** The magnetic field due to circular coil (1) is

$$B_1=\frac{\mu_0 i_1}{2r}=\frac{\mu_0 i_1}{2(2\pi\times10^{-2})}$$

$$=\frac{\mu_0\times3\times10^{2}}{4\pi}$$



Magnetic field due to coil (2)
Total magnetic field

$$B_2=\frac{\mu_0 i_2}{2(2\pi\times10^{-2})}=\frac{\mu_0\times4\times10^{2}}{4\pi}$$

Total magnetic field, $B=\sqrt{B_1^2+B_2^2}$

$$=\frac{\mu_0}{4\pi}\cdot5\times10^{2}$$

$\Rightarrow B=10^{-7}\times5\times10^{2}\Rightarrow B=5\times10^{-5}\,Wb/m^2$

26. **(c)** $F=\frac{\mu_0}{2\pi}\left(\frac{i_1i_2}{a}-\frac{i_1i_2}{2a}\right)\times a=\frac{\mu_0 i_1i_2}{4\pi}$

27. **(a)** Force acting between two long conductor carrying current,

$$F = \frac{\mu_0}{4\pi}\frac{2I_1I_2}{d} \times \ell \qquad \text{...(i)}$$

Where d = distance between the conductors
ℓ = length of conductor

In second case, $F' = -\frac{\mu_0}{4\pi}\frac{2(2I_1)I_2}{3d}\ell \qquad \text{...(ii)}$

From equation (i) and (ii), we have

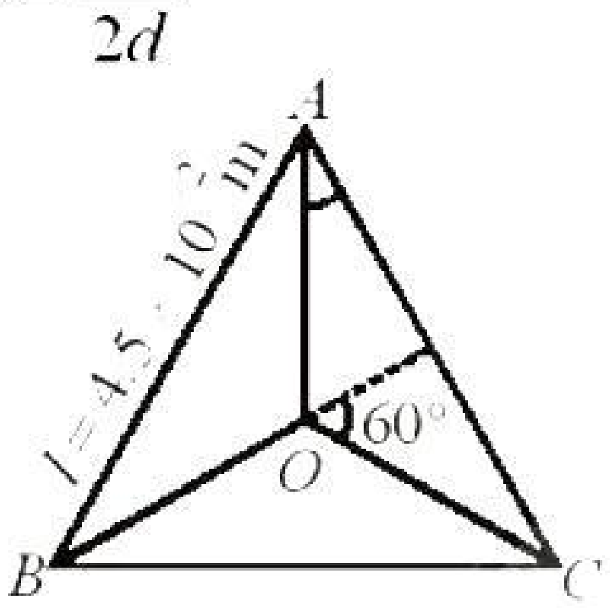
$$\therefore \frac{F'}{F} = \frac{-2}{3}$$

28. **(a)** Here, side of the triangle, $l = 4.5 \times 10^{-2}$ m, current, I = 1A
magnetic field at the centre of the triangle 'O' B = ?

From figure, $\tan 60° = \sqrt{3} = \frac{l}{2d}$

$$\Rightarrow \quad d = \frac{l}{2\sqrt{3}}$$

$$= \left(\frac{4.5 \times 10^{-2}}{2\sqrt{3}}\right) \text{m}$$



Magnetic field, $B = \frac{\mu_0 i}{4\pi d}(\cos\theta_1 + \cos\theta_2)$

Putting value of $\mu = 4\pi \times 10^{-7}$ and θ_1 and θ_2 we will get $B = 4 \times 10^{-5}$ Wb/m^2

29. **(a)** Magnetic field induction at the centre of current carrying circular coil of radius r is

$$B = \frac{\mu_0}{4\pi}\frac{I}{R} \times 2\pi$$

Here $B_A = \frac{\mu_0}{4\pi}\frac{I}{R} \times 2\pi$ and $B_B = \frac{\mu_0}{4\pi}\frac{2I}{2R} \times 2\pi$

$$\Rightarrow \frac{B_A}{B_B} = \frac{I/R}{2I/2R} = 1$$

30. **(d)** $C\theta = NBiA \sin 90°$

or $10^{-6}\left(\frac{\pi}{180}\right) = 175B(10^{-3}) \times 10^{-4}$

$\therefore B = 10^{-3}$T