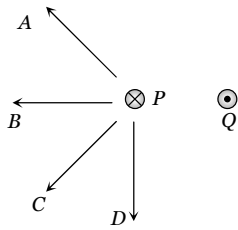


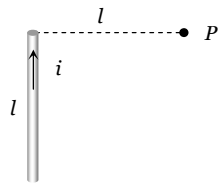
# Magnetic Effect of Current

## SET Self Evaluation Test - 21

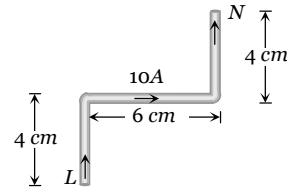
- In the hydrogen atom, the electron is making  $6.6 \times 10^{15}$  r.p.s. If the radius of the orbit is  $0.53 \times 10^{-10}$  metre, then magnetic field produced at the centre of the orbit is  
 (a) 140 Tesla (b) 12.5 Tesla  
 (c) 1.4 Tesla (d) 0.14 Tesla
- A coil carrying a heavy current and having large number of turns mounted in a N-S vertical plane and a current flows in clockwise direction. A small magnetic needle at its centre will have its north pole in  
 (a) East-north direction (b) West-north direction  
 (c) East-south direction (d) West-south direction
- A charged particle is projected in a plane perpendicular to a uniform magnetic field. The area bounded by the path described by the particle is proportional to  
 (a) The velocity (b) The momentum  
 (c) The kinetic energy (d) None of these
- In figure shows three long straight wires P, Q and R carrying currents normal to the plane of the paper. All three currents have the same magnitude. Which arrow best shows the direction of the resultant force on the wire P



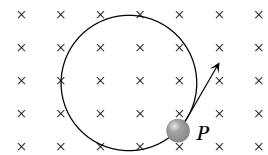
- (a) A (b) B  
(c) C (d) D
- A moving coil galvanometer has 48 turns and area of coil is  $4 \times 10^{-2} \text{ m}^2$ . If the magnetic field is  $0.2 \text{ T}$ , then to increase the current sensitivity by 25% without changing area (A) and field (B) the number of turns should become  
 (a) 24 (b) 36  
 (c) 60 (d) 54
  - Figure shows a straight wire of length  $l$  current  $i$ . The magnitude of magnetic field produced by the current at point P is  
 (a)  $\frac{\sqrt{2}\mu_0 i}{\pi l}$   
 (b)  $\frac{\mu_0 i}{4\pi l}$   
 (c)  $\frac{\sqrt{2}\mu_0 i}{8\pi l}$   
 (d)  $\frac{\mu_0 i}{2\sqrt{2}\pi l}$



- A winding wire which is used to frame a solenoid can bear a maximum 10 A current. If length of solenoid is 80 cm and it's cross sectional radius is 3 cm then required length of winding wire is ( $B = 0.2 \text{ T}$ )  
 (a)  $1.2 \times 10^2 \text{ m}$  (b)  $4.8 \times 10^2 \text{ m}$   
 (c)  $2.4 \times 10^3 \text{ m}$  (d)  $6 \times 10^3 \text{ m}$
- A current carrying wire LN is bent in the form shown below. If wire carries a current of 10 A and it is placed in a magnetic field of 5 T which acts perpendicular to the paper outwards then it will experience a force



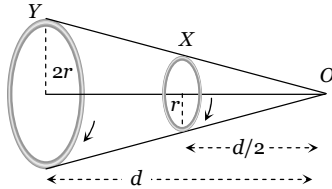
- (a) Zero (b) 5 N  
(c) 30 N (d) 20 N
- A wire of length  $L$  is bent in the form of a circular coil and current  $i$  is passed through it. If this coil is placed in a magnetic field then the torque acting on the coil will be maximum when the number of turns is  
 (a) As large as possible (b) Any number  
 (c) 2 (d) 1
  - A particle having a charge of  $10.0 \mu\text{C}$  and mass  $1 \mu\text{g}$  moves in a circle of radius 10 cm under the influence of a magnetic field of induction  $0.1 \text{ T}$ . When the particle is at a point P, a uniform electric field is switched on so that the particle starts moving along the tangent with a uniform velocity. The electric field is  
 (a)  $0.1 \text{ V/m}$   
 (b)  $1.0 \text{ V/m}$   
 (c)  $10.0 \text{ V/m}$   
 (d)  $100 \text{ V/m}$



- Two parallel long wires carry currents  $i_1$  and  $i_2$  with  $i_1 > i_2$ . When the currents are in the same direction, the magnetic field midway between the wires is  $10 \mu\text{T}$ . When the direction of  $i_2$  is reversed, it becomes  $40 \mu\text{T}$ . the ratio  $i_1 / i_2$  is  
 (a) 3 : 4 (b) 11 : 7  
 (c) 7 : 11 (d) 5 : 3

12. Two circular coils  $X$  and  $Y$ , having equal number of turns, carry equal currents in the same sense and subtend same solid angle at point  $O$ . If the smaller coil,  $X$  is midway between  $O$  and  $Y$ , then if we represent the magnetic induction due to bigger coil  $Y$  at  $O$  as  $B_Y$  and that due to smaller coil  $X$  at  $O$  as  $B_X$ , then

- (a)  $\frac{B_Y}{B_X} = 1$
- (b)  $\frac{B_Y}{B_X} = 2$
- (c)  $\frac{B_Y}{B_X} = \frac{1}{2}$
- (d)  $\frac{B_Y}{B_X} = \frac{1}{4}$

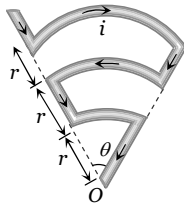


13. A fixed horizontal wire carries a current of 200 A. Another wire having a mass per unit length  $10^{-2} \text{ kg/m}$  is placed below the first wire at a distance of 2 cm and parallel to it. How much current must be passed through the second wire if it floats in air without any support? What should be the direction of current in it

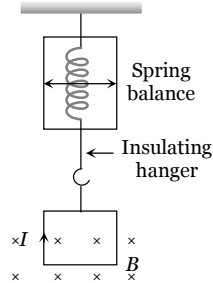
- (a) 25A (direction of current is same to first wire)
- (b) 25A (direction of current is opposite to first wire)
- (c) 49 A (direction of current is same to first wire)
- (d) 49 A (direction of current is opposite to first wire)

14. Find magnetic field at  $O$

- (a)  $\frac{5\mu_0 i \theta}{24\pi r}$
- (b)  $\frac{\mu_0 i \theta}{24\pi r}$
- (c)  $\frac{11\mu_0 i \theta}{24\pi r}$
- (d) Zero



15. A square loop of side  $a$  hangs from an insulating hanger of spring balance. The magnetic field of strength  $B$  occurs only at the lower edge. It carries a current  $I$ . Find the change in the reading of the spring balance if the direction of current is reversed



- (a)  $IaB$
- (b)  $2IaB$
- (c)  $\frac{IaB}{2}$
- (d)  $\frac{3}{2}IaB$

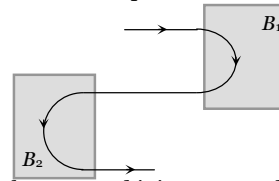
16. A charge of  $2.0 \mu\text{C}$  moves with a speed of  $3.0 \times 10^6 \text{ ms}^{-1}$  along  $+ve$   $X$ -axis. A magnetic field of strength  $\vec{B} = -0.2 \hat{k}$  Tesla exists in space. What is the magnetic force ( $\vec{F}_m$ ) on the charge

- (a)  $F_m = 1.2 \text{ N}$  along  $+ve$   $x$  - direction
- (b)  $F_m = 1.2 \text{ N}$  along  $-ve$   $x$  - direction
- (c)  $F_m = 1.2 \text{ N}$  along  $+ve$   $y$  - direction
- (d)  $F_m = 1.2 \text{ N}$  along  $-ve$   $y$  - direction

17. Five very long, straight wires are bound together to form a small cable. Currents carried by the wires are  $I_1 = 20 \text{ A}$ ,  $I_2 = -6 \text{ A}$ ,  $I_3 = 12 \text{ A}$ ,  $I_4 = -7 \text{ A}$ ,  $I_5 = 18 \text{ A}$ . The magnetic induction at a distance of 10 cm from the cable is

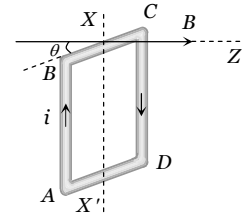
- (a)  $34 \mu\text{T}$
- (b)  $74 \text{ mT}$
- (c)  $34 \text{ mT}$
- (d)  $74 \mu\text{T}$

18. Following figure shows the path of an electron that passes through two regions containing uniform magnetic fields of magnitudes  $B_1$  and  $B_2$ . It's path in each region is a half circle, choose the correct option



- (a)  $B_1$  is into the page and it is stronger than  $B_2$
- (b)  $B_1$  is in to the page and it is weaker than  $B_2$
- (c)  $B_1$  is out of the page and it is weaker than  $B_2$
- (d)  $B_1$  is out of the page and it is stronger than  $B_2$

19. The square loop  $ABCD$ , carrying a current  $i$ , is placed in uniform magnetic field  $B$ , as shown. The loop can rotate about the axis  $XX'$ . The plane of the loop makes an angle  $\theta$  ( $\theta < 90^\circ$ ) with the direction of  $B$ . Through what angle will the loop rotate by itself before the torque on it becomes zero



- (a)  $\theta$
- (b)  $90^\circ - \theta$
- (c)  $90^\circ + \theta$
- (d)  $180^\circ - \theta$

20. A cylindrical conductor of radius ' $R$ ' carries a current ' $i$ '. The value of magnetic field at a point which is  $R/4$  distance inside from the surface is  $10 \text{ T}$ . Find the value of magnetic field at point which is  $4R$  distance outside from the surface

- (a)  $\frac{4}{3} \text{ T}$
- (b)  $\frac{8}{3} \text{ T}$
- (c)  $\frac{40}{3} \text{ T}$
- (d)  $\frac{80}{3} \text{ T}$

21. Three long straight wires are connected parallel to each other across a battery of negligible internal resistance. The ratio of their resistances are  $3 : 4 : 5$ . What is the ratio of distances of middle wire from the others if the net force experienced by it is zero

- (a)  $4 : 3$
- (b)  $3 : 1$
- (c)  $5 : 3$
- (d)  $2 : 3$

# AS Answers and Solutions

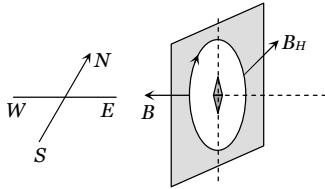
(SET -21)

1. (b)  $i = qv$

$$B = \frac{\mu_0 i}{2r} = \frac{\mu_0 qv}{2r} = \frac{4\pi \times 10^{-7} \times 1.6 \times 10^{-19} \times 6.6 \times 10^{15}}{2 \times 0.53 \times 10^{-10}}$$

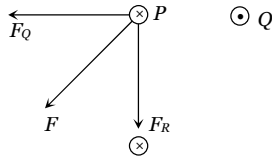
$$= \frac{2\pi \times 1.6 \times 6.6}{5.3} = 12.518 \text{ Tesla}$$

2. (b)



3. (c)  $r = \frac{\sqrt{2mK}}{qB}$  and  $A = \pi r^2 \Rightarrow A = \frac{\pi(2mK)}{q^2 B^2} \Rightarrow A \propto K.$

4. (c) The forces  $F_Q$  and  $F_R$  are the forces applied by wires Q and R respectively on the wire P as shown in figure. Their resultant force  $F$  is best shown by C.



5. (c) As we know

$$\text{Current sensitivity } S_i = \frac{NBA}{C}$$

$$\Rightarrow S_i \propto N \Rightarrow \frac{(S_i)_1}{(S_i)_2} = \frac{N_1}{N_2} \Rightarrow \frac{100}{125} = \frac{48}{N_2} \Rightarrow N_2 = 60.$$

6. (c) The given situation can be redrawn as follow.

As we know the general formula for finding the magnetic field due to a finite length wire

$$B = \frac{\mu_0}{4\pi} \cdot \frac{i}{r} (\sin \phi_1 + \sin \phi_2)$$

Here  $\phi_1 = 0^\circ$ ,  $\phi_2 = 45^\circ$

$$\therefore B = \frac{\mu_0}{4\pi} \cdot \frac{i}{r} (\sin 0^\circ + \sin 45^\circ) = \frac{\mu_0}{4\pi} \cdot \frac{i}{\sqrt{2}l} \Rightarrow B = \frac{\sqrt{2}\mu_0 i}{8\pi l}$$

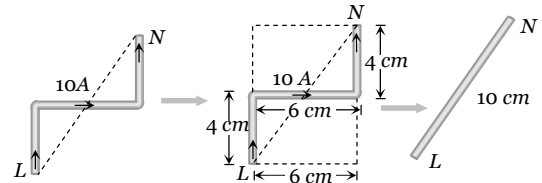
7. (c)  $B = \frac{\mu_0 Ni}{l}$  where  $N$  = Total number of turns,  $l$  = length of the solenoid

$$\Rightarrow 0.2 = \frac{4\pi \times 10^{-7} \times N \times 10}{0.8} \Rightarrow N = \frac{4 \times 10^4}{\pi}$$

Since  $N$  turns are made from the winding wire so length of the wire ( $L$ ) =  $2\pi \times N$  [ $2\pi r$  = length of each turns]

$$\Rightarrow L = 2\pi \times 3 \times 10^{-2} \times \frac{4 \times 10^4}{\pi} = 2.4 \times 10^3 \text{ m}$$

8. (b) The given wire can be replaced by a straight wire as shown below



Hence force experienced by the wire

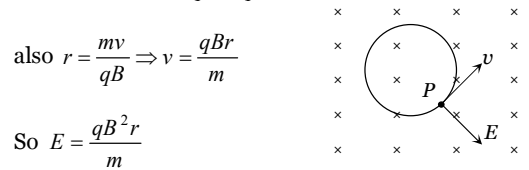
$$F = Bil = 5 \times 10 \times 0.1 = 5 \text{ N}$$

9. (d)  $\tau_{\max} = MB$  or  $\tau_{\max} = ni\pi r^2 B$ . Let number of turns in

length  $l$  is  $n$  so  $l = n(2\pi r)$  or  $\alpha = \frac{l}{2\pi r}$

$$\Rightarrow \tau_{\max} = \frac{ni\pi Bl^2}{4\pi^2 n^2} = \frac{l^2 iB}{4\pi n_{\min}} \Rightarrow \tau_{\max} \propto \frac{1}{n_{\min}} \Rightarrow n_{\min} = 1$$

10. (c) When the particle moves along a circle in the magnetic field  $B$ , the magnetic force is radially inward. If an electric field of proper magnitude is switched on which is directed radially outwards, the particle may experience no force. It will then move along a straight line with uniform velocity. This will be the case when  $qE = qvB \Rightarrow E = vB$



$$\text{also } r = \frac{mv}{qB} \Rightarrow v = \frac{qBr}{m}$$

$$\text{So } E = \frac{qB^2 r}{m}$$

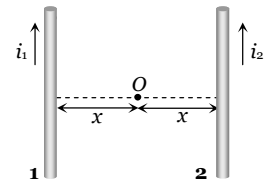
$$= \frac{(10 \times 10^{-6}) \times (0.1)^2 \times 10 \times 10^{-2}}{1 \times 10^{-3} \times 10^{-6}} = 10 \text{ V/m}$$

11. (d) Initially when wires carry currents in the same direction as shown.

Magnetic field at mid point O due to wires 1 and 2 are respectively

$$B_1 = \frac{\mu_0}{4\pi} \cdot \frac{2i_1}{x} \otimes$$

$$\text{and } B_2 = \frac{\mu_0}{4\pi} \cdot \frac{2i_2}{x} \otimes$$



Hence net magnetic field at  $O$   $B_{net} = \frac{\mu_0}{4\pi} \times \frac{2}{x} \times (i_1 - i_2)$

$$\Rightarrow 10 \times 10^{-6} = \frac{\mu_0}{4\pi} \cdot \frac{2}{x} (i_1 - i_2) \dots (i)$$

If the direction of  $i_2$  is reversed then

$$B_1 = \frac{\mu_0}{4\pi} \cdot \frac{2i_1}{x} \otimes$$

$$\text{and } B_2 = \frac{\mu_0}{4\pi} \cdot \frac{2i_2}{x} \otimes$$

$$\text{So } B_{net} = \frac{\mu_0}{4\pi} \cdot \frac{2}{x} (i_1 + i_2)$$

$$\Rightarrow 40 \times 10^{-6} = \frac{\mu_0}{4\pi} \cdot \frac{2}{x} (i_1 + i_2) \dots (ii)$$

$$\text{Dividing equation (ii) by (i)} \quad \frac{i_1 + i_2}{i_1 - i_2} = \frac{4}{1} \Rightarrow \frac{i_1}{i_2} = \frac{5}{3}$$

12. (c) Magnetic field at  $O$  due to bigger coil  $Y$ , is

$$B_Y = \frac{\mu_0}{4\pi} \cdot \frac{2\pi i (2r)^2}{\{d^2 + (2r)^2\}^{3/2}} = \frac{\mu_0}{4\pi} \cdot \frac{8\pi i r^2}{(d^2 + 4r^2)^{3/2}}$$

Magnetic field at  $O$  due to smaller coil  $X$  is

$$B_X = \frac{\mu_0}{4\pi} \cdot \frac{2\pi i r^2}{\left\{\left(\frac{d}{2}\right)^2 + r^2\right\}^{3/2}} = \frac{\mu_0}{4\pi} \cdot \frac{16\pi i r^2}{(d^2 + 4r^2)^{3/2}}$$

$$\Rightarrow \frac{B_Y}{B_X} = \frac{1}{2}$$

13. (c) For floating the second wire

$$\left| \begin{array}{l} \text{Down ward weight} \\ \text{of second wire} \end{array} \right| = \left| \begin{array}{l} \text{Magnetic force} \\ \text{on it} \end{array} \right|$$

$$\Rightarrow mg = \frac{\mu_0}{4\pi} \cdot \frac{2i_1 i_2}{a} \times l$$

$$\Rightarrow \left(\frac{m}{l}\right)g = \frac{\mu_0}{4\pi} \cdot \frac{2i_1 i_2}{a}$$

$$\Rightarrow 10^{-2} \times 9.8 = 10^{-7} \times \frac{2 \times 200 \times i}{2 \times 10^{-2}} \Rightarrow i = 49 \text{ A}$$

(Direction of current is same to first wire)

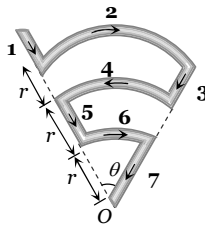
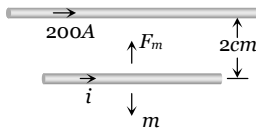
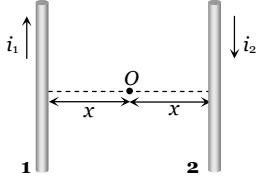
14. (a)  $B_1 = B_3 = B_5 = 0$

$$B_2 = \frac{\mu_0}{4\pi} \cdot \frac{\theta i}{3r} \otimes, B_4 = \frac{\mu_0}{4\pi} \cdot \frac{\theta i}{2r} \otimes$$

$$\text{and } B_6 = \frac{\mu_0}{4\pi} \cdot \frac{\theta i}{r} \otimes$$

$\therefore$  Net magnetic field at  $O$ ,

$$B_{net} = B_2 - B_4 + B_6 = \frac{\mu_0}{4\pi} \cdot \frac{\theta i}{r} \left( \frac{1}{3} - \frac{1}{2} + 1 \right) = \frac{5\mu_0 \theta i}{24\pi r}$$



15. (b) Initially  $F_1 = mg + IaB$  (down wards)

when the direction of current is reversed

$$F_2 = mg - IaB \text{ (down wards)} \Rightarrow \Delta F = 2IaB$$

16. (c) By using  $\vec{F}_m = q(\vec{v} \times \vec{B})$

$$\Rightarrow \vec{F}_m = 2 \times 10^{-6} \{3 \times 10^6 \hat{i} \times (-0.2) \hat{k}\} = -1.2(\hat{i} \times \hat{k}) = +1.2 \hat{j}$$

i.e., 1.2 N in positive  $y$  direction.

17. (d)  $i_{net} = 20 - 6 + 12 - 7 + 18 = 37 \text{ A}$  so  $B = \frac{\mu_0}{4\pi} \cdot \frac{2i}{a}$

$$= 10^{-7} \times \frac{2 \times 37}{10 \times 10^{-2}} = 74 \times 10^{-6} \text{ T} = 74 \mu\text{T}$$

18. (a) Direction of field can be find using Fleming left hand rule and  $r \propto \frac{1}{B}$ .

19. (c) In the position shown,  $AB$  is outside and  $CD$  is inside the plane of the paper. The Ampere force on  $AB$  acts into the paper. The torque on the loop will be clockwise, as seen from above. The loop must rotate through an angle  $(90^\circ + \theta)$  before the plane of the loop becomes normal to the direction of the direction of  $B$  and the torque becomes zero.

20. (b) Magnetic field inside the cylindrical conductor

$$B_{in} = \frac{\mu_0}{4\pi} \cdot \frac{2ir}{R^2} \text{ (R=Radius of cylinder, } r = \text{distance of observation point from axis of cylinder)}$$

Magnetic field out side the cylinder at a distance  $r'$  from it's axis  $B_{out} = \frac{\mu_0}{4\pi} \cdot \frac{2i}{r'}$

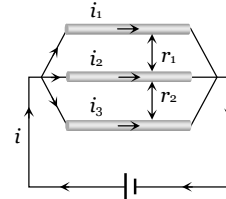
$$\Rightarrow \frac{B_{in}}{B_{out}} = \frac{rr'}{R^2} \Rightarrow \frac{10}{B_{out}} = \frac{\left(R - \frac{R}{4}\right)(R + 4R)}{R^2} \Rightarrow B_{out} = \frac{8}{3} T$$

21. (c) The wires are in parallel and ratio of their resistances are 3 : 4 : 5, Hence currents in wires are in the ratio  $\frac{1}{3} : \frac{1}{4} : \frac{1}{5}$

$$i_1 = \frac{k}{3}$$

$$i_2 = \frac{k}{4}$$

$$i_3 = \frac{k}{5}$$



Force between top and middle wire  $F_1 = \frac{\mu_0}{4\pi} \cdot \frac{2i_1 i_2}{r_1}$

$$= \frac{\mu_0}{4\pi} \times \frac{2\left(\frac{1}{3}\right)\left(\frac{1}{4}\right)k^2}{r_1}$$

Force between bottom and

middle wire  $F_2 = \frac{\mu_0}{4\pi} \cdot \frac{\left(\frac{1}{4}\right)\left(\frac{1}{5}\right)k^2}{r_2}$ . As the forces are

equal and opposite so  $F_1 = F_2 \Rightarrow \frac{r_1}{r_2} = \frac{5}{3}$ .

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