Answers

Biot-Savart's Law and Amperes Law

1	c	2	b	3	c	4	b	5	d
6	c	7	b	8	d	9	b	10	d
11	b	12	a	13	a	14	c	15	c
16	a	17	b	18	a	19	b	20	d
21	c	22	c	23	a	24	d	25	b
26	d	27	c	28	a	29	b	30	d
31	b	32	a	33	a	34	d	35	d
36	d	37	b	38	c	39	a	40	c
41	c	42	b	43	d	44	b	45	d
46	b	47	a	48	a	49	b	50	d
51	c	52	b	53	c	54	b	55	d
56	a	57	b	58	a	59	d	60	d
61	c	62	c	63	d	64	b	65	a
66	c	67	a	68	c	69	a	70	b
71	c	72	c	73	b	74	b	75	d
76	b	77	b	78	b	79	c	80	b
81	d	82	c	83	c	84	d	85	c
86	b	87	d	88	a	89	a	90	b
91	c	92	d	93	d	94	a	95	b
96	b	97	a	98	d	99	c	100	d
101	b	102	c	103	b	104	d	105	a
106	c	107	b	108	a	109	a	110	c
111	d	112	a	113	b	114	a	115	b
116	d	117	c	118	b	119	a	120	a
121	a	122	a	123	c	124	d	125	c
126	b								

Motion of Charged Particle In Magnetic Field

1	abd	2	d	3	c	4	a	5	b
6	b	7	c	8	c	9	c	10	d
11	c	12	d	13	d	14	b	15	a
16	c	17	c	18	a	19	c	20	b
21	c	22	c	23	d	24	b	25	d
26	a	27	c	28	a	29	d	30	d
31	d	32	b	33	c	34	a	35	c
36	b	37	d	38	a	39	a	40	d
41	c	42	a	43	d	44	a	45	b
46	c	47	d	48	b	49	c	50	d
51	b	52	c	53	b	54	a	55	a
56	d	57	d	58	b	59	d	60	a
61	c	62	c	63	b	64	a	65	a
66	b	67	b	68	a	69	bd	70	b
71	c	72	b	73	b	74	a	75	d
76	d	77	d	78	b	79	a	80	d
81	a	82	a	83	c	84	b	85	b
86	c	87	c	88	b	89	a	90	b
91	a	92	a	93	c	94	d	95	c
96	a	97	c	98	b	99	a	100	b
101	d	102	c	103	d	104	d	105	c
106	c	107	d	108	d	109	d	110	d
111	a	112	b	113	d	114	c	115	c
116	c	117	c	118	c				

Force and Torque on a Current Carrying Conductor

1	b	2	c	3	b	4	c	5	b
6	a	7	b	8	b	9	a	10	a
11	c	12	a	13	c	14	c	15	a
16	c	17	b	18	b	19	b	20	b
21	d	22	b	23	d	24	a	25	a
26	b	27	d	28	b	29	c	30	c
31	c	32	d	33	d	34	d	35	b
36	a	37	a	38	a	39	c	40	d
41	c	42	a	43	a	44	c	45	d
46	a	47	d	48	a	49	a	50	c
51	b	52	a	53	abc	54	a	55	c
56	b	57	a	58	d	59	c	60	a
61	b	62	b	63	d	64	b	65	c
66	a	67	b	68	a	69	a	70	a
71	c	72	a	73	a	74	d	75	d
76	c	77	a	78	a	79	b	80	c
81	b	82	c	83	c	84	b	85	a
86	d	87	c	88	b	89	c	90	c
91	d								

Critical Thinking Questions

1	b	2	a	3	a	4	c	5	c
6	c	7	cd	8	c	9	d	10	a
11	abd	12	ac	13	c	14	c	15	b
16	b	17	c	18	a	19	b	20	d
21	c	22	b	23	b	24	c	25	b
26	c	27	a	28	a	29	a	30	d
31	b	32	c	33	b	34	d	35	b
36	d	37	a	38	c	39	c	40	a
41	d	42	a	43	a	44	b	45	b
46	b	47	b	48	b	49	a	50	d

51	d								

Graphical Questions

1	c	2	a	3	b	4	a	5	c
6	a	7	a	8	b	9	c	10	a
11	c	12	a	13	bc	14	b	15	b
16	b								

Assertion and Reason

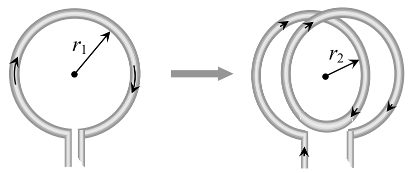
1	a	2	c	3	a	4	e	5	a
6	c	7	a	8	c	9	a	10	b
11	d	12	e	13	b	14	b	15	b
16	d	17	b	18	d	19	a		

Answers and Solutions

Biot-Savart's Law and Amperes Law

1. (c) Magnetic field at the centre of current carrying coil is given by $B=\frac{\mu_0}{4\pi}\cdot\frac{2\pi Ni}{r}$ $\Rightarrow$ $B\propto\frac{N}{r}$ $\Rightarrow\frac{B_1}{B_2}=\frac{N_1}{N_2}\times\frac{r_2}{r_1}$.

The following figure shows that single turn coil changes to double turn coil.



$N_1=1$ $\quad$ $N_2=2$

$r_1=r$ $\quad$ $r_2=r/2$

$B_1=B$ $\quad$ $B_2=?$

$\Rightarrow\frac{B}{B_2}=\frac{1}{2}\times\frac{r/2}{r}=\frac{1}{4}\Rightarrow B_2=4B$

Short trick : For such type of problems remember $B_2=n^2B_1$

2. (b) If distance is same field will be same $\left(\because B=\frac{\mu_0}{4\pi}\cdot\frac{2i}{r}\right)$

3. (c) Magnetic field lies inside as well as outside the solid current carrying conductor.

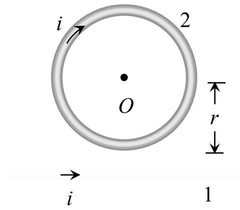
4. (b) Because for inside the pipe $i=0$

$\therefore B=\frac{\mu_0 i}{2\pi r}=0$

5. (d) $dB=\frac{\mu_0}{4\pi}\cdot\frac{idl\sin\theta}{r^2}\Rightarrow\vec{dB}=\frac{\mu_0}{4\pi}\cdot\frac{i(\vec{dl}\times\vec{r})}{r^3}$

6. (c) The magnetic field at the centre of the circle $=\frac{\mu_o}{4\pi}\times\frac{2\pi i}{r}=10^{-7}\times\frac{2\pi(nq)}{r}=\frac{2\pi nq}{r}\times10^{-7}\,N/Am$

7. (b) The given shape is equivalent to the following diagram

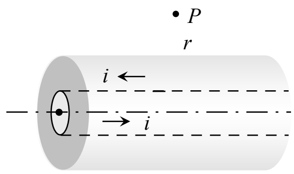


The field at O due to straight part of conductor is $B_1=\frac{\mu_o}{4\pi}\cdot\frac{2i}{r}\odot$. The field at O due to circular coil is $B_2=\frac{\mu_0}{4\pi}\cdot\frac{2\pi i}{r}\otimes$. Both fields will act in the opposite direction, hence the total field at O.

i.e. $B=B_2-B_1=\left(\frac{\mu_o}{4\pi}\right)\times(\pi-1)\frac{2i}{r}=\frac{\mu_o}{4\pi}\cdot\frac{2i}{r}(\pi-1)$

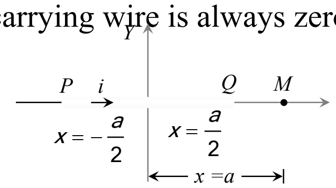
8. (d) $B=\frac{\mu_0}{4\pi}\frac{(2\pi-\theta)i}{R}=\frac{\mu_0}{4\pi}\frac{\left(2\pi-\frac{\pi}{2}\right)\times i}{R}=\frac{3\mu_0 i}{8R}$

9. (b) The respective figure is shown below



Magnetic field at P due to inner and outer conductors are equal and opposite. Hence net magnetic field at P will be zero.

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



11. (b) $i=\frac{q}{T}=\frac{2\times1.6\times10^{-19}}{2}=1.6\times10^{-19}A$

$\therefore B=\frac{\mu_o i}{2r}=\frac{\mu_o\times1.6\times10^{-19}}{2\times0.8}=\mu_o\times10^{-19}$

12. (a) $B=\mu_o ni=4\pi\times10^{-7}\times5\times1000=2\pi\times10^{-3}$ *Tesla*

13. (a) $B = \frac{\mu_0}{4\pi} \cdot \frac{2i}{r} \Rightarrow \frac{B_1}{B_2} = \frac{r_2}{r_1} \Rightarrow \frac{10^{-8}}{B_2} = \frac{12}{4}$

$\Rightarrow B_2 = 3.33 \times 10^{-9}$ *Tesla*

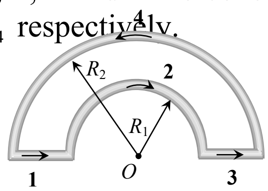
14. (c) $B \propto \frac{1}{r} \Rightarrow \frac{B_1}{B_2} = \frac{r_2}{r_1} \Rightarrow \frac{B}{B_2} = \frac{r/2}{r} \Rightarrow B_2 = 2B$

15. (c) Field at the centre of a circular coil of radius r is $B = \frac{\mu_o I}{2r}$

16. (a) $B = \frac{\mu_0 Ni}{2r} = \frac{4\pi \times 10^{-7} \times 100 \times 0.1}{2 \times 5 \times 10^{-2}} = 4\pi \times 10^{-5}$ *Tesla*

17. (b) Magnetic field inside the solenoid $B_{in} = \mu_0 ni$

18. (a) In the following figure, magnetic fields at O due to sections 1, 2, 3 and 4 are considered as B_1, B_2, B_3 and B_4 respectively.



$B_1 = B_3 = 0$

$B_2 = \frac{\mu_0}{4\pi} \cdot \frac{\pi i}{R_1} \otimes$

$B_4 = \frac{\mu_0}{4\pi} \cdot \frac{\pi i}{R_2} \odot$ As $|B_2| > |B_4|$

So $B_{net} = B_2 - B_4 \Rightarrow B_{net} = \frac{\mu_0 i}{4}\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \otimes$

19. (b) $B = \mu_o ni$

20. (d) The magnetic induction at O due to the current in portion AB will be zero because O lies on AB when extended.

21. (c) The induction due to AB and CD will be zero. Hence the whole induction will be due to the semicircular part BC. $B = \frac{\mu_o i}{4r}$

22. (c) The magnetic induction due to both semicircular parts will be in the same direction perpendicular to the paper inwards.

$\therefore B = B_1 + B_2 = \frac{\mu_0 i}{4r_1} + \frac{\mu_0 i}{4r_2} = \frac{\mu_0 i}{4}\left(\frac{r_1 + r_2}{r_1 r_2}\right) \otimes$

23. (a) Field at a point x from the centre of a current carrying loop on the axis is

$B = \frac{\mu_0}{4\pi} \cdot \frac{2M}{x^3} = \frac{10^{-7} \times 2 \times 2.1 \times 10^{-25}}{(10^{-10})^3}$

$= 4.2 \times 10^{-32} \times 10^{30} = 4.2 \times 10^{-2}\, W/m^2$

24. (d) At these points, the resultant field $= 0$

25. (b) $i = \frac{q}{t} = 100 \times e$

$B_{centre} = \frac{\mu_o}{4\pi} \cdot \frac{2\pi i}{r} = \frac{\mu_o}{4\pi} \cdot \frac{2\pi \times 100 e}{r}$

$= \frac{\mu_o \times 200 \times 1.6 \times 10^{-19}}{4 \times 0.8} = 10^{-17} \mu_o$

26. (d) $B = \frac{\mu_o}{4\pi} \cdot \frac{2\pi NiR^2}{r^3} \Rightarrow B \propto \frac{1}{r^3}$

27. (c) $B = \frac{\mu_0}{4\pi} \cdot \frac{2\pi(qv)}{r}$

$= 10^{-7} \times \frac{2 \times 3.14 \times (1.6 \times 10^{-19} \times 6.6 \times 10^{15})}{0.53 \times 10^{-10}} = 12.5\, Wb/m^2$

28. (a)

29. (b)

30. (d) Two coils carrying current in opposite direction, hence net magnetic field at centre will be difference of the two fields.

i.e. $B_{net} = \frac{\mu_0}{4\pi} \cdot 2\pi N\left[\frac{Ni_1}{r_1} - \frac{i_2}{r_2}\right]$

$= \frac{10\mu_0}{2}\left[\frac{0.2}{0.2} - \frac{0.3}{0.4}\right] = \frac{5}{4}\mu_0$

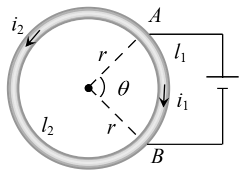
31. (b) Because $B = \mu_0 ni \Rightarrow B \propto ni$.

32. (a) See solution 34.

33. (a) $B = \mu_0 ni \Rightarrow i = \frac{B}{\mu_0 n} = \frac{20 \times 10^{-3}}{4\pi \times 10^{-7} \times 20 \times 100}$

$= 7.9\, amp = 8\, amp$

34. (d) Directions of currents in two parts are different, so directions of magnetic fields due to these currents are opposite. Also applying Ohm's law across AB



$i_1 R_1 = i_2 R_2 \Rightarrow i_1 l_2 = i_2 l_2$

$\left(\because R = \rho \frac{l}{A}\right)$

Also $B_1 = \frac{\mu_o}{4\pi} \times \frac{i_1 l_1}{r^2}$ and $B_2 = \frac{\mu_o}{4\pi} \times \frac{i_2 l_2}{r^2}$ $(\because l = r\theta)$

$\therefore \frac{B_2}{B_1} = \frac{i_1 l_1}{i_2 l_2} = 1$

Hence, two field induction's are equal but of opposite direction. So, resultant magnetic induction at the centre is zero and is independent of θ.

35. (d) The magnetic field at any point on the axis of wire be zero.

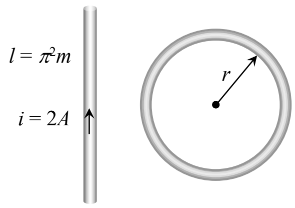
36. (d) Magnetic field inside the hollow conductor (tube) is zero.

37. (b) If a wire of length l is bent in the form of a circle of radius r

then $2\pi r = l \Rightarrow$

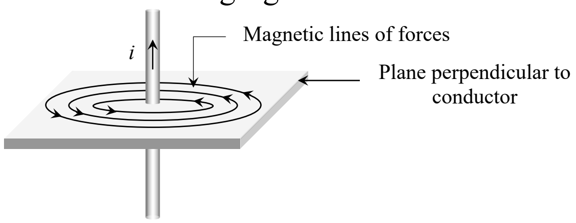
$r = \frac{l}{2\pi}$

$r = \frac{l}{2\pi} = \frac{\pi^2}{2\pi} = \frac{\pi}{2}$



Magnetic field due to straight wire $B_1 = \frac{\mu_0}{4\pi} \cdot \frac{2i}{r} = \frac{\mu_0}{4\pi} \times \frac{2 \times 2}{1 \times 10^{-2}}$ also magnetic field due to circular loop $B_2 = \frac{\mu_0}{4\pi} \cdot \frac{2\pi i}{r} = \frac{\mu_0}{4\pi} \cdot \frac{2\pi \times 2}{\pi / 2} \Rightarrow \frac{B_2}{B_1} = \frac{1}{50}$

38. (c) See the following figure



39. (a) $B = \frac{\mu_0}{4\pi} \cdot \frac{2i}{r} \Rightarrow 10^{-5} = 10^{-7} \times \frac{2i}{(10 \times 10^{-2})} \Rightarrow i = 5A$

40. (c) $B = \frac{\mu_0}{4\pi} \cdot \frac{2\pi Ni}{r}$

$\Rightarrow 3.14 \times 10^{-3} = \frac{10^{-7} \times 2 \times 3.14 \times N \times 10}{(10 \times 10^{-2})} \Rightarrow N = 50$

41. (c) The magnetic field in the solenoid along its axis (i) At an internal point $= \mu_o ni$

$= 4\pi \times 10^{-7} \times 5000 \times 4 = 25.1 \times 10^{-3}\, Wb/m^2$

(Here $n = 50\ turns/cm = 5000\ turns/m$)

(ii) At one end

$B_{end} = \frac{1}{2} B_{in} = \frac{\mu_0 ni}{2} = \frac{25.1 \times 10^{-3}}{2} = 12.6 \times 10^{-3}\, Wb/m^2$

42. (b) Magnetic field at the centre of solenoid $(B) = \mu_0 ni$

Where n = Number of *turns /meter*

$\therefore B = 4\pi \times 10^{-7} \times 4250 \times 5 = 2.7 \times 10^{-2}\, Wb/m^2$

43. (d) Use Right hand palm rule, or Maxwell's Cork screw rule or any other.

44. (b) $B = n^2 B \Rightarrow B = (4)^2 B = B = 16B$

45. (d) $B = \frac{\mu_0}{4\pi} . \frac{2\pi i}{r} \Rightarrow 12.56 = 10^{-7} \times \frac{2\pi \times i}{5.2 \times 10^{-11}}$

$\Rightarrow i = 1.04 \times 10^{-3}\ A$

46. (b) $B = \frac{\mu_0}{4\pi} \frac{\theta i}{r} = \frac{\mu_0}{4\pi} \times \frac{\pi}{2} \times \frac{i}{R} = \frac{\mu_0 i}{8R}$

47. (a) $B \propto \frac{1}{r} \Rightarrow \frac{B_1}{B_2} = \frac{r_2}{r_1} \Rightarrow \frac{0.04}{B_2} = \frac{40}{10} \Rightarrow B_2 = 0.01\ T$

48. (a) See solution 34.

49. (b) $B = \frac{\mu_0 i}{2\pi r}$ or $B \propto \frac{1}{r}$

50. (d) $B = \mu_0 ni = \mu_0 \frac{N}{L} i$

51. (c) Here $B = \mu_0 ni$

where n is number of turns per unit length $= \frac{N}{l}$

52. (b) $\frac{\mu_0}{4\pi} \times \frac{2\pi i}{r} = H \Rightarrow \frac{(10^{-7}) \times 2 \times 3.142 \times i}{0.05} = 7 \times 10^{-5}$

$\therefore i = \frac{7 \times 0.05 \times 10^{-5}}{2 \times 3.142 \times 10^{-7}} = \frac{35}{2 \times 3.142} = 5.6$ *amp*

53. (c) $B = \frac{\mu_0 Ni}{2r} = \frac{4\pi \times 10^{-7} \times 1000 \times 0.1}{2 \times 0.1} = 6.28 \times 10^{-4}\ T$

54. (b) $B = \frac{\mu_0 Ni}{2r} = \frac{4\pi \times 10^{-7} \times 50 \times 2}{2 \times 0.5} = 1.25 \times 10^{-4}\ T$

55. (d) $B \propto \frac{i}{r}$

56. (a) $B = \frac{\mu_0 i}{2\pi r}$ *i.e.* $B \propto \frac{1}{r}$ *i.e.* when r is doubled, B is halved.

57. (b) Applying Ampere's law $\oint B.dl = \mu_0 i$ to any closed path inside the pipe we find no current is enclosed. Hence $B = 0$.

58. (a) Magnetic field at the centre of current carrying coil is

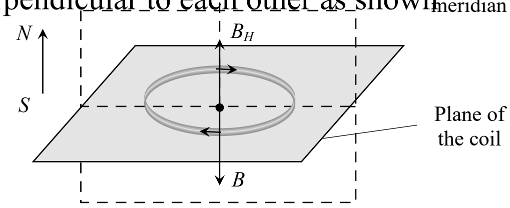
$B = \frac{\mu_0}{4\pi} \cdot \frac{2\pi ni}{r} = \frac{\mu_0 ni}{2r}$

59. (d) The magnetic field is given by $B = \frac{\mu_0}{4\pi} \frac{2i}{r}$.

It is independent of the radius of the wire.

60. (d) Magnetic meridian is a vertical *N-S* plane, the earth's magnetic field (B_H) lies in it. (For more details see magnetism).

To obtain neutral point at the centre of coil, magnetic field due to current (B) and B_H must cancel each other. Hence plane of the coil and magnetic meridian must be perpendicular to each other as shown.



61. (c) 1 *Tesla* $=10^4$ *Gauss*

62. (c)

63. (d)

64. (b) $B=\frac{\mu_0}{4\pi}\times\frac{2i}{r}=10^{-7}\times\frac{2\times 1}{10^{-2}}=2\times 10^{-5}$ *Tesla*

65. (a) Magnetic field due to one side of the square at centre O

$$B_1=\frac{\mu_0}{4\pi}.\frac{2i\sin 45^o}{a/2}\Rightarrow B_1=\frac{\mu_0}{4\pi}.\frac{2\sqrt{2}\,i}{a}$$

Hence magnetic field at centre due to all side

$$B=4B_1=\frac{\mu_0(2\sqrt{2}i)}{\pi a}$$

Magnetic field due to n turns

$$B_{net}=nB=\frac{\mu_0 2\sqrt{2}ni}{\pi a}=\frac{\mu_0 2\sqrt{2}ni}{\pi(2l)}=\frac{\sqrt{2}\mu_0 ni}{\pi l}$$

$(\because a=2l)$

66. (c)

67. (a)

68. (c) Magnetic field on the axis of circular current

$$B=\frac{\mu_0}{4\pi}\cdot\frac{2\pi nir^2}{(x^2+r^2)^{3/2}}\Rightarrow B\propto\frac{nr^2}{(x^2+r^2)^{3/2}}$$

69. (a) $r_1:r_2=1:2$ and $B_1:B_2=1:3$ We know that

$$B=\frac{\mu_0}{4\pi}.\frac{2\pi ni}{r}\Rightarrow\frac{i_1}{i_2}=\frac{B_1r_1}{B_2r_2}=\frac{1\times 1}{3\times 2}=\frac{1}{6}$$

70. (b) $B=10^{-7}\frac{2i}{r}=10^{-7}\times\frac{2\times 2}{5}=8\times 10^{-8}\ T$

71. (c) $B=\frac{\mu_0}{4\pi}\times\frac{\pi i}{r}\Rightarrow B=10^{-7}\times\frac{\pi\times 10}{5\times 10^{-2}}=6.28\times 10^{-5}\ T$

72. (c) Magnetic field due to solenoid is independent of diameter (Because $B=\mu_0 ni$).

73. (b) $B=\frac{\mu_0}{4\pi}\frac{2\pi i}{r}=10^{-7}\times\frac{2\pi\times 2}{0.0157}=8\times 10^{-5}\ Wb/m^2$

74. (b) $B=\mu_0 ni=4\pi\times 10^{-7}\times\frac{200}{10^{-2}}\times 2.5=6.28\times 10^{-2}\ Wb/m^2$

75. (d) Magnetic field at centre due to smaller loop

$B_1=\frac{\mu_0}{4\pi}.\frac{2\pi i_1}{r_1}$ ..... (i)

Due to Bigger loop $B_2=\frac{\mu_0}{4\pi}.\frac{2\pi i_2}{r_2}$ So net magnetic field at centre

$$B=B_1-B_2=\frac{\mu_0}{4\pi}\times 2\pi\left(\frac{i_1}{r_1}-\frac{i_2}{r_2}\right)$$

According to question $B=\frac{1}{2}\times B_1$

$$\Rightarrow\frac{\mu_0}{4\pi}.2\pi\left(\frac{i_1}{r_1}-\frac{i_2}{r_2}\right)=\frac{1}{2}\times\frac{\mu_0}{4\pi}.\frac{2\pi i_1}{r_1}$$

$$\frac{i_1}{r_1}-\frac{i_2}{r_2}=\frac{i_1}{2r_1}\Rightarrow\frac{i_1}{2r_1}=\frac{i_2}{r_2}\Rightarrow\frac{i_1}{i_2}=1\qquad\{r_2=2r_1\}$$

76. (b)

77. (b) $B=\frac{\mu_0}{4\pi}\times\frac{2\pi NiR^2}{(R^2+x^2)^{3/2}}\Rightarrow B\propto\frac{1}{(r^2+x^2)^{3/2}}$

$$\Rightarrow\frac{8}{1}=\frac{(R^2+x_2^2)^{3/2}}{(R^2+x_1^2)^{3/2}}\Rightarrow\left(\frac{8}{1}\right)^{2/3}=\frac{R^2+0.04}{R^2+0.0025}$$

$\Rightarrow\frac{4}{1}=\frac{R^2+0.04}{R^2+0.0025}$. On solving $R=0.1m$

78. (b) $B=10^{-7}\frac{2i}{r}\Rightarrow\frac{B}{B}=\frac{20}{5}\Rightarrow B=B/4$

79. (c) $B=10^{-7}\frac{2\pi ni}{r}=10^{-7}\times\frac{2\times\pi\times 25\times 4}{5\times 10^{-2}}=1.257\times 10^{-3}\ T$

80. (b) $F=Bil\Rightarrow[B]=\frac{[F]}{[i][l]}=\frac{MLT^{-2}}{AL}=MT^{-2}A^{-1}$

81. (d) Magnetic field on the axis of conductor is zero.

82. (c) $B\propto\frac{1}{r}\Rightarrow\frac{B_1}{B_2}=\frac{r_2}{r_1}=\frac{2r}{r}=2$

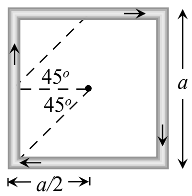
83. (c) $B=10^{-7}\times\frac{2i}{r}=10^{-7}\times\frac{2\times 1}{1}=2\times 10^{-7}\ T$

84. (d) At midpoint, magnetic fields due to both the wires are equal and opposite. So $B_{Net}=0$.

85. (c) $B_0=4\times\frac{\mu_0}{4\pi}\times\frac{i}{(a/2)}(\sin 45^\circ+\sin 45^\circ)$

$$=4\times\frac{\mu_0}{4\pi}\times\frac{2i}{a}\times\frac{2}{\sqrt{2}}$$

$$=\frac{\mu_0 i 2\sqrt{2}}{\pi a}$$



86. (b) $B=10^{-7}\frac{2\pi i}{r}$; according to question $B_H=B$

$$\Rightarrow 5\times 10^{-5}=10^{-7}\times\frac{2\times 3.14\times i}{5\times 10^{-2}}\Rightarrow i=4A$$

87. (d) $B=\frac{\mu_0}{4\pi}.\frac{2\pi Ni}{r}=\frac{10^{-7}\times 2\pi\times 100\times 0.1}{5\times 10^{-2}}=4\pi\times 10^{-5}\ T$

88. (a) Corresponding current $i=en$

So $B=\frac{\mu_0}{4\pi}.\frac{2\pi(en)}{r}=\frac{\mu_0 ne}{2r}$

89. (a) B at ends of solenoid is $\frac{\mu_0}{2} ni$

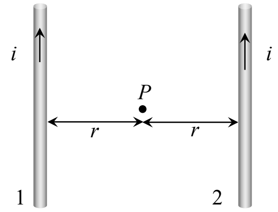
90. (b) Use Right hand palm rule or Maxwell's Cork screw rule.

91. (c) At P

$\Rightarrow B_{net} = B_1 - B_2$

Since $|B_1| = |B_2|$

So, $B_{net} = 0$



92. (d) A moving charge and changing electric field both produces magnetic field.

93. (d)

94. (a) $B = \frac{\mu_0}{2\pi}\frac{i}{r} \Rightarrow 5\times10^{-5} = \frac{\mu_0}{2\pi}\times\frac{\pi}{r} \Rightarrow r = 10^4 \mu_0$ metre

95. (b) $B' = n^2 B = (3)^2 B = 9B$

96. (b) B represents the magnetic field.

97. (a)

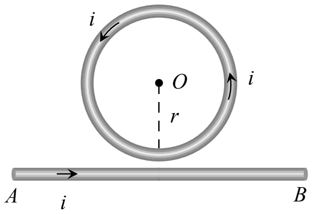
98. (d) $\frac{B_c}{B_a} = \left(1+\frac{x^2}{a^2}\right)^{3/2} = \left(1+\frac{a^2}{a^2}\right)^{3/2} = (1+1)^{3/2} = 2\sqrt{2}$

99. (c) The given circuit can be considered as follows

$B_{loop} = \frac{\mu_0 i}{2r} \odot$

$B_{conductor} = \frac{\mu_0 i}{2\pi r} \odot$

$B_{net} = \frac{\mu_0 i}{2\pi r}(\pi + 1) \odot$



100. (d) $B = \frac{\mu_0 \mu_r N i}{2\pi r} \Rightarrow 1 = \frac{4\pi\times10^{-7}\times\mu_r\times400\times2}{0.4} \Rightarrow \mu_r = 400$

101. (b)

102. (c)

103. (b) $B = 10^{-7}\times\frac{\pi\times i}{r} = 10^{-7}\times\frac{\pi\times10}{20\times10^{-2}} = B = 5\pi\mu T$

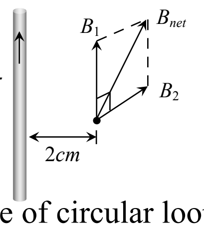
104. (d) $B = n^2 B = (2)^2 B = 4B$

105. (a) $B = \mu_0 n i \Rightarrow \frac{B}{B'} = \frac{n}{n'}\times\frac{i}{i'} = \frac{1}{(1/2)}\times\frac{1}{2} = 1 \Rightarrow B' = B$

106. (c) $B_1 = 4\times10^{-4}\,T$

$B_2 = 10^{-7}\times\frac{2\times30}{2\times10^{-2}} = 3\times10^{-4}\,T$

$\therefore\ B_{net} = \sqrt{B_1^2 + B_2^2} = 5\times10^{-4}\,T$



107. (b) Magnetic field at the centre of circular loop

$B = \frac{\mu_0}{4\pi}\frac{2\pi i}{r} \Rightarrow 0.5\times10^{-5} = \frac{10^{-7}\times2\times3.14\times i}{5\times10^{-2}}$

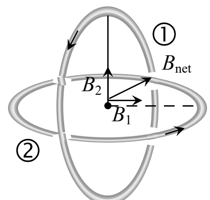
$i = 0.4\,A$

108. (a)

109. (a) $B_1 = B_2 = B = \frac{\mu_0}{4\pi}\times\frac{2\pi i}{r}$

$B_{net} = \sqrt{2}B$

$\Rightarrow \frac{B}{B_{net}} = \frac{1}{\sqrt{2}}$



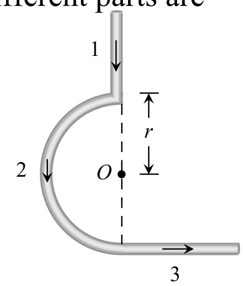
110. (c) Magnetic field due to different parts are

$B_1 = 0$

$B_2 = \frac{\mu_0}{4\pi}\cdot\frac{\pi i}{r} \odot$

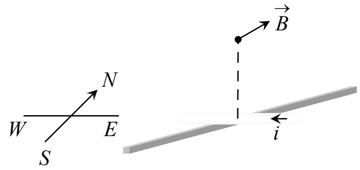
$B_3 = \frac{\mu_0}{4\pi}\cdot\frac{i}{r} \odot$

$\therefore B_{net} = B_2 + B_3 = \frac{\mu_0 i}{4r} + \frac{\mu_0 i}{4\pi r}$



111. (d) $M = niA = n(\pi r^2) \Rightarrow M \propto r^2$

112. (a)



113. (b) Magnetic field at the center of single turn loop $B = \frac{\mu_0}{4\pi}\cdot\frac{2\pi i}{r}$, magnetic field at the center of n-turn loop

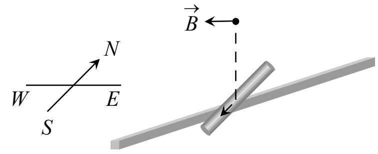
$B_n = \left(\frac{\mu_0}{4\pi}\cdot\frac{2\pi i}{r/n}\right)\times n \Rightarrow B_n = n^2 B$

114. (a) $\frac{B_{center}}{B_{axis}} = \left(1+\frac{x^2}{r^2}\right)^{3/2} \Rightarrow \frac{B_{center}}{54} = \left(1+\left(\frac{4}{3}\right)^2\right)^{3/2} = \frac{125}{27}$

$B_{center} = 250\mu T$

115. (b) $B = \frac{\mu_0}{4\pi}\cdot\frac{2\pi i}{r} \Rightarrow B \propto \frac{1}{r}$

116. (d)

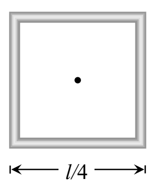


117. (c) Suppose length of each wire is l.

$A_{square} = \left(\frac{l}{4}\right)^2 = \frac{l^2}{16}$

$A_{circle} = \pi r^2 = \pi\left(\frac{l}{2\pi}\right)^2 = \frac{l^2}{4\pi}$

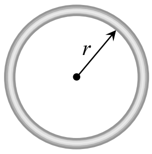
$\because$ Magnetic moment



$M = iA$

$\Rightarrow \frac{M_{square}}{M_{circle}} = \frac{A_{square}}{A_{circle}}$

$= \frac{l^2/16}{l^2/4\pi} = \frac{\pi}{4}$



118. (b) $B = \frac{\mu_0}{4\pi}.\frac{2\pi ni}{r} \Rightarrow B \propto ni$

119. (a) Magnetic field due to revolution of electron

$$B = \frac{\mu_0}{4\pi}.\frac{2\pi i}{r} = \frac{\mu_0}{4\pi}.\frac{2\pi.\left(\frac{e\omega}{2\pi}\right)}{r} = 10^{-7} \times \frac{e\omega}{r}$$

$$\Rightarrow 16 = 10^{-7} \times \frac{1.6 \times 10^{-19}\omega}{1 \times 10^{-10}} \Rightarrow \omega = 10^{17}\ rad/\text{sec.}$$

120. (a) $B = \frac{\mu_0}{4\pi}.\frac{2i}{r} = 10^{-7} \times \frac{2 \times 20}{10 \times 10^{-2}} = 4 \times 10^{-5}\ Wb/m^2$

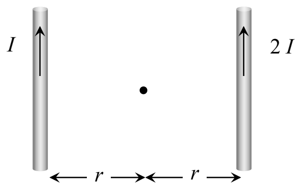
121. (a) $B = \frac{\mu_0}{4\pi}.\frac{2i}{r} \Rightarrow B \propto i$

122. (a) $B_{net} = \sqrt{B_1^2 + B_2^2} = \frac{\mu_0}{4\pi}.\frac{2\pi}{r}\sqrt{i_1^2 + i_2^2}$

$$= 10^{-7} \times \frac{2\pi}{2\pi \times 10^{-2}}\sqrt{(3)^2 + (4)^2} = 5 \times 10^{-5}\ wb/m^2$$

123. (c) When two parallel conductors carrying current I and $2I$ in same direction, then magnetic field at the midpoint is

$$B = \frac{\mu_0 2I}{2\pi r} - \frac{\mu_0 I}{2\pi r} = \frac{\mu_0 I}{2\pi r}$$



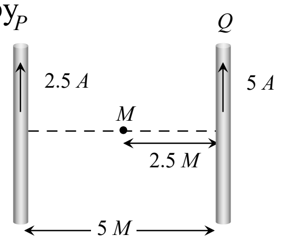
When current $2I$ is switched off then magnetic field due to conductor carrying current I is $B = \frac{\mu_0 I}{2\pi r}$.

124. (d) In the following figure magnetic field at mid point M is given by

$B_{net} = B_Q - B_P$

$= \frac{\mu_0}{4\pi}.\frac{2}{r}(i_Q - i_P)$

$= \frac{\mu_0}{4\pi} \times \frac{2}{2.5}(5 - 2.5) = \frac{\mu_0}{2\pi}$



125. (c)

126. (b) The magnetic field due to small element of conductor of length is given by

$dB = \frac{\mu_0}{4\pi}\frac{Idl\sin\theta}{r^2}$

This value will be maximum when

$\sin\theta = 1 = \sin 90°$ or, $\theta = 90°$

Motion of Charged Particle in Magnetic Field

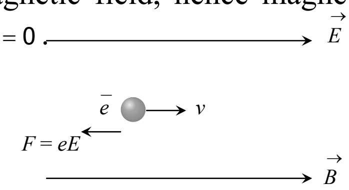
1. (a, b, d)

Here the proton has no acceleration so $E = B = 0$.

When $E = 0$ but $B \neq 0$, but parallel to the motion of proton, there will be no force acting.

When $E \neq 0$ and $B \neq 0$ and E, B and motion of proton (v) are mutually perpendicular, there may be no net force. Forces due to E and B cancel each other.

2. (d) Since electron is moving is parallel to the magnetic field, hence magnetic force on it $F_m = 0$



The only force acting on the electron is electric force which reduces it's speed.

3. (c) $r = \frac{\sqrt{2mk}}{qB} = \frac{1}{B}\sqrt{\frac{2mV}{q}} \Rightarrow r \propto \sqrt{m} \Rightarrow \frac{m_1}{m_2} = \left(\frac{R_1}{R_2}\right)^2$

4. (a) $r = \frac{mv}{Bq} = \frac{v}{(q/m)B} = \frac{2 \times 10^5}{5 \times 10^7 \times 4 \times 10^{-2}} = 0.1m$

5. (b) $r = \frac{p}{qB} \Rightarrow r \propto p$

6. (b) $B = \frac{mv}{qr} = \frac{9 \times 10^{-31} \times 10^6}{1.6 \times 10^{-19} \times 0.1} = 5.6 \times 10^{-5}\ T$

7. (c) $r = \frac{\sqrt{2mK}}{qB}$ i.e. $r \propto \frac{\sqrt{m}}{q}$

Here kinetic energy K and B are same.

$\therefore \frac{r_p}{r_\alpha} = \frac{\sqrt{m_p}}{\sqrt{m_\alpha}}.\frac{q_\alpha}{q_p} = \frac{\sqrt{m_p}}{\sqrt{4m_p}}.\frac{2q_p}{q_p} = 1$

8. (c) $\vec{F} = q\vec{v} \times \vec{B}$

9. (c)

10. (d)

11. (c) East, (By $\vec{F} = q(\vec{v} \times \vec{B})$) or by applying Fleming's left hand rule.

12. (d) $F = qvB = 1.6 \times 10^{-19} \times \left[\sqrt{\frac{2E}{m}}\right] 2.5$

$= 4 \times 10^{-19} \sqrt{\frac{2 \times 2 \times 1.6 \times 10^{-19} \times 10^{6}}{1.66 \times 10^{-27}}} = 7.6 \times 10^{-12} N$

13. (d) $\vec{F} = q(\vec{v} \times \vec{B})$; if $\vec{v} \parallel \vec{B}$ then $\vec{F} = 0$

14. (b) This is according to the cross product $\vec{F} = q(\vec{v} \times \vec{B})$ otherwise can be evaluated by the left-hand rule of Fleming.

15. (a) $r = \frac{\sqrt{2mK}}{qB} \Rightarrow K \propto \frac{q^2}{m} \Rightarrow \frac{K_p}{K_\alpha} = \left(\frac{q_p}{q_\alpha}\right)^2 \times \frac{m_\alpha}{m_p}$

$\Rightarrow \frac{1}{K_\alpha} = \left(\frac{q_p}{2q_p}\right)^2 \times \frac{4m_p}{m_p} = 1 \Rightarrow K_\alpha = 1\, MeV.$

16. (c) $r \propto \frac{1}{B}$ *i.e.* $\frac{r_1}{r_2} = \frac{B_2}{B_1} \Rightarrow r_2 = \frac{B_1}{B_1/2} \times r = 2r$

17. (c) Time period of proton $T_p = \frac{25}{5} = 5\mu \sec$

By using $T = \frac{2\pi m}{qB} \Rightarrow \frac{T_\alpha}{T_p} = \frac{m_\alpha}{m_p} \times \frac{q_p}{q_\alpha}$

$= \frac{4m_p}{m_p} \times \frac{q_p}{2q_p}$

$\Rightarrow T_\alpha = 2T_p = 10\mu$ sec.

18. (a) $F = ma = qvB \Rightarrow$

$a = \frac{qvB}{m} = \frac{1.6 \times 10^{-19} \times 2 \times 3.4 \times 10^{7}}{1.67 \times 10^{-27}}$

$= 6.5 \times 10^{15} m/sec^2$

19. (c) $T = \frac{2\pi m}{qB} = \frac{2\pi r}{v} = \frac{2 \times 3.14 \times 0.45}{2.6 \times 10^{7}} = 1.08 \times 10^{-7}$ sec

20. (b) $F = qvB$ and $K = \frac{1}{2}mv^2 \Rightarrow F = qB\sqrt{\frac{2k}{m}}$

$= 1.6 \times 10^{-19} \times 1.5 \sqrt{\frac{2 \times 5 \times 10^{6} \times 1.6 \times 10^{-19}}{1.7 \times 10^{-27}}}$

$= 7.344 \times 10^{-12} N$

21. (c) Magnetic force acts on a moving charge.

22. (c) $r = \frac{mv}{qB} \Rightarrow r \propto v, \Rightarrow r_2 = 2r_1 = 2 \times 2 = 4cm$

23. (d) $r = \frac{\sqrt{2mK}}{qB} \Rightarrow K \propto \frac{q^2}{m}$

$\Rightarrow \frac{K_p}{K_d} = \left(\frac{q_p}{q_d}\right)^2 \times \frac{m_d}{m_p} = \left(\frac{1}{1}\right)^2 \times \frac{2}{1} = \frac{2}{1}$

$\Rightarrow K_p = 2 \times 50 = 100\, keV.$

24. (b) Maximum force will act on proton so it will move on a circular path. Force on electron will be zero because it is moving parallel to the field.

25. (d) Fleming's left hand rule is used to the determine the direction of force.

26. (a) Lorentz force is given by

$\vec{F} = \vec{F_e} + \vec{F_m} = q\vec{E} + q(\vec{v} \times \vec{B}) = q[\vec{E} + (\vec{v} \times \vec{B})]$

27. (c) $\vec{F} = q\vec{v} \times \vec{B}$

28. (a) $F = qvB\sin\theta$

$= 1.6 \times 10^{-19} \times 2 \times 10^{7} \times 1.5 \sin 30^{o}$

$= 1.6 \times 10^{-19} \times 2 \times 10^{7} \times 1.5 \times \frac{1}{2} = 2.4 \times 10^{-12} N$

29. (d) $F = qvB\sin\theta \Rightarrow B = \frac{F}{qv\sin\theta}$

$B_{\min} = \frac{F}{qv}$ (when $\theta = 90^{o}$)

$\therefore B_{\min} = \frac{F}{qv} = \frac{10^{-10}}{10^{-12} \times 10^{5}} = 10^{-3}$ *Tesla* in $\hat{z}$-direction.

30. (d) Kinetic energy in magnetic field remains constant and it is $K = qV \Rightarrow K \propto q$ (V = constant)

$\therefore K_p : K_d : K_\alpha = q_p : q_d : q_a = 1 : 1 : 2$

31. (d) When charged particle enters perpendicularly in a magnetic field, it moves on a circular path with a constant speed. Hence it's kinetic energy also remains constant.

32. (b) $r = \frac{\sqrt{2mK}}{qB}$ *i.e.* $r \propto \frac{\sqrt{m}}{q}$

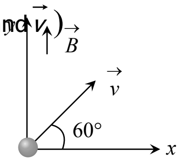
Here kinetic energy K and B are same.

$\therefore \frac{r_e}{r_p} = \sqrt{\frac{m_e}{m_p}} \times \frac{q_p}{q_e} \Rightarrow \frac{r_e}{r_p} = \sqrt{\frac{m_e}{m_p}}$ $(\because q_e = q_p)$

Since $m_e < m_p$, therefore $r_e < r_p$

33. (c) Path of the proton will be a helix of radius $r = \frac{mv\sin\theta}{qB}$

(where θ = Angle between $\vec{B}$ and $\vec{v}$)



$\Rightarrow r=\dfrac{1.67\times10^{-27}\times2\times10^{6}\times\sin30^{o}}{1.6\times10^{-19}\times0.104}$

$=0.1m$

Time period $T=\dfrac{2\pi m}{qB}=\dfrac{2\pi\times1.67\times10^{-27}}{1.6\times10^{-19}\times0.104}$

$=2\pi\times10^{-7}\,sec$

34. (a) $\dfrac{mv^2}{R}=qvB$. For proton $R_p=\dfrac{mv}{qB}=\dfrac{\sqrt{2m_pE}}{qB}$

and for deutron $R_d=\dfrac{\sqrt{2m_dE}}{qB}$

$\Rightarrow \dfrac{R_d}{R_p}=\sqrt{\dfrac{m_d}{m_p}}=\sqrt{2}\Rightarrow R_d=\sqrt{2}R_p$

35. (c) In this case $|\vec{F_e}|=|\vec{F_m}|$ and both forces are opposite to each other.

36. (b) We know that time period $T=\dfrac{2\pi m}{qB}$ i.e. $T\propto m$

(Since q and B are same)

$\because$ Mass of proton > Mass of electron

$\therefore$ Time period of proton > Time period of electron

37. (d) According to Fleming's right hand rule.

38. (a) $r=\dfrac{mv}{eB}\Rightarrow\dfrac{e}{m}=\dfrac{v}{rB}$

39. (a) Using $eE = evB$

$\Rightarrow E=vB=5\times10^{6}\times0.02=10^{5}\,Vm^{-1}$

40. (d) $F = evB=1.6\times10^{-19}\times4\times10^{6}\times2\times10^{-1}$

$=1.28\times10^{-13}\,N$

Also $\dfrac{mv^2}{r}=evB\Rightarrow r=\dfrac{mv}{eB}$

$\Rightarrow r=\dfrac{9\times10^{-31}\times4\times10^{6}}{1.6\times10^{-19}\times2\times10^{-1}}=1.1\times10^{-4}\,m$

41. (c) Force acts perpendicular to the velocity in a magnetic field, so speed of electron will remain same.

42. (a) By Fleming left hand rule.

43. (d) Direction of motion of proton is same as that of direction of magnetic field.

44. (a) Time period is given by $T=\dfrac{2\pi m}{qB}$

$\Rightarrow$ Frequency $\nu=\dfrac{1}{T}=\dfrac{qB}{2\pi m}$

45. (b) $r=\dfrac{\sqrt{2mK}}{qB}=\dfrac{1}{B}\sqrt{\dfrac{2mV}{q}}$

$=\dfrac{1}{10^{-3}}\sqrt{\dfrac{2\times9\times10^{-31}\times12000}{1.6\times10^{-19}}}=0.367\ m = 36.7\ cm$

46. (c) $r=\dfrac{1}{B}\sqrt{\dfrac{2mV}{q}}\Rightarrow r\propto\sqrt{\dfrac{m}{q}}\Rightarrow\dfrac{r_x}{r_y}=\sqrt{\dfrac{m_x}{q_x}\times\dfrac{q_y}{m_y}}$

$\Rightarrow\dfrac{R_1}{R_2}=\sqrt{\dfrac{m_x}{m_y}\times\dfrac{2}{1}}\Rightarrow\dfrac{m_x}{m_y}=\dfrac{R_1^2}{2R_2^2}$

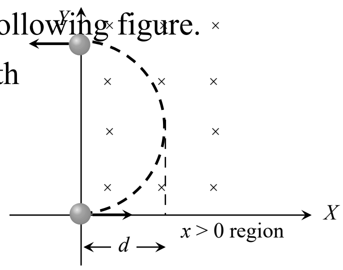
47. (d) $\vec{F}=q(\vec{v}\times\vec{B})=10^{-11}(10^{8}\hat{j}\times0.5\hat{i})$

$=5\times10^{-4}(\hat{j}\times\hat{i})=5\times10^{-4}\,N(-\hat{k})$

48. (b) It is easy to understand the given problem, along with the following figure.

d = radius of path

$=\dfrac{mv}{qB}$



49. (c) Lorentz force $F=q(v\times B)$ or $|F|=qvB\sin\theta$

F will be maximum. when $\theta=90^{o}$

50. (d) The component of velocity perpendicular to H will make the motion circular while that parallel to H will make it move along a straight line. The two together will make the motion helical.

51. (b) We have $qvB=\dfrac{mv^2}{r}$ or $r=\dfrac{mv}{qB}=\dfrac{\sqrt{2mK}}{qB}$

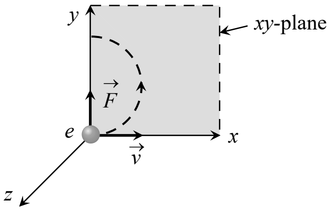
For same kinetic energy K, we have $r\propto\sqrt{m}$

Hence path of proton will have larger r and is therefore less curved.

52. (c) When particle enters at angle other than 0° or 90° or 180°, path followed is helix.

53. (b) To move the electron in xy plane, force on it must be acting in the y-direction initially. The direction of $\vec{F}$ is known, and the direction of v is known, hence by applying

Fleming's left hand rule, the direction of magnetic field is also determined.



54. (a) A moving charge gains energy in electric field only because in magnetic field energy remains constant.

55. (a) Given that $K_p = K_d = K_\alpha = K$ (say)

We know that $m_p = m$, $m_d = 2m$ and $m_\alpha = 4m$ and $q_p = e$, $q_d = e$ and $q_\alpha = 2e$

Further $r = \frac{\sqrt{2mK}}{qB} \Rightarrow r_p = \frac{\sqrt{2mK}}{eB}$,

$r_d = \frac{\sqrt{2(2m)K}}{eB} = \sqrt{2}r_p$

and $r_\alpha = \frac{\sqrt{2(4m)K}}{(2e)B} = r_p$. Hence $r_\alpha = r_p < r_d$

56. (d) Since force is perpendicular to direction of motion. energy and magnitude of momentum remains constant.

57. (d) $T = \frac{2\pi m}{qB} \Rightarrow T \,\alpha\, v^o$

58. (b) $F = qvB$ also Kinetic energy $K = \frac{1}{2}mv^2$

$\Rightarrow v = \sqrt{\frac{2K}{m}}$

$\therefore\ F = q\sqrt{\frac{2K}{m}}B$

$= 1.6 \times 10^{-19}\sqrt{\frac{2 \times 200 \times 10^6 \times 1.6 \times 10^{-19}}{1.67 \times 10^{-27}}} \times 5$

$= 1.6 \times 10^{-10}\,N$

59. (d) The deflection produced by the electric field may be nullified by that produced by magnetic field.

60. (a) $\vec{F_m} = q(\vec{v} \times \vec{B})$

When the angle between $\vec{v}$ and $\vec{B}$ is 180°, $F_m = 0$

61. (c) $r = mv / qB$

Since both have same momentum, therefore the circular path of both will have the same radius.

62. (c) When particle enters perpendicularly in a magnetic field, it moves along a circular path with constant speed.

63. (b) For motion of a charged particle in a magnetic field, we have $r = mv/qB$ *i.e.* $r \propto v$

64. (a) The charged particle moving in a magnetic field does not gain energy. However, the direction of its velocity changes continuously. Hence momentum changes.

65. (a) $F = qvB\sin\theta = qvB\sin 0 = 0$

66. (b) $r = \frac{mv}{qB} = \frac{10^7}{10^{11} \times 10^{-4}} = 1m\ (\because q/m = 10^{11}\,C/kg)$

67. (b) $\omega = \frac{2\pi}{T} = \frac{qB}{m} \Rightarrow \omega \propto v^o \quad \left(\because T = \frac{2\pi m}{qB}\right)$

68. (a) $r = \frac{\sqrt{2mK}}{qB} \Rightarrow r \propto \sqrt{K} \Rightarrow \frac{R}{R_2} = \sqrt{\frac{K}{2K}} \Rightarrow R_2 = R\sqrt{2}$

69. (b, d) $r = \frac{mv}{qB} = \frac{P}{qB}$

70. (b) $F = qvB\sin\theta = 1.6 \times 10^{-19} \times 2.5 \times 2.5 \times 10^7 \sin 30^o$

$F = 1.6 \times 10^{-19} \times 6.25 \times 10^7 \times \frac{1}{2} = 5 \times 10^{-12}\,N$

71. (c) $K_{max} = \frac{1}{2}mv^2$ and $r_0 = \frac{mv}{qB} \Rightarrow v = \frac{qBr_0}{m}$

$\Rightarrow K_{max} = \frac{1}{2}m\left(\frac{qBr_0}{m}\right)^2 = \frac{q^2B^2r_0^2}{2m}$

72. (b) $F = qvB\sin\theta$; Independent of mass

73. (b) By Fleming left hand rule.

74. (a) $F = qBv = 1 \times 0.5 \times 10 = 5\,N$

75. (d) $r = \frac{mv}{qB} \Rightarrow \frac{r_1}{r_2} = \frac{v_1}{v_2} \times \frac{B_2}{B_1} \Rightarrow \frac{r_1}{r_2} = \frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$

$r_2 = 4r_1$

76. (d) Magnetic force on charge will be zero.

77. (d)

78. (b) Apply Fleming's left hand rule.

79. (a) $T = \frac{2\pi m}{qB} = \frac{2 \times 3.14 \times 9 \times 10^{-31}}{1.6 \times 10^{-19} \times 1 \times 10^{-4}} = 3.5 \times 10^{-7}\,sec$

80. (d) $\vec{F} = q(\vec{v} \times \vec{B}) = 0$ as $\vec{v}$ and $\vec{B}$ are parallel.

81. (a) Here magnetic force is zero, but the velocity increases due to electric force.

82. (a)

83. (c)

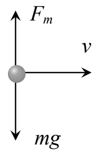
84. (b) $r=\frac{mv}{qB}\Rightarrow r\propto mv$ (q and B are constant)

$\because r_A>r_B\Rightarrow m_Av_A>m_Bv_B$

85. (b) $r=\frac{p}{qB}\Rightarrow p\propto q$ ($\because$ r and B are constant)

$\frac{p_p}{p_\alpha}=\frac{q_p}{q_\alpha}=\frac{q_p}{(2q_p)}=\frac{1}{2}$

86. (c) Particle will move with uniform velocity when it's acceleration is zero.



i.e. $|F_m|=mg\Rightarrow mg=qvB$

$\Rightarrow B=\frac{mg}{qv}=\frac{0.6\times10^{-3}\times10}{25\times10^{-9}\times1.2\times10^{4}}=20\ T$

87. (c) $r=\frac{mv}{qB}\Rightarrow\frac{r_\alpha}{r_p}=\frac{m_\alpha}{m_p}\times\frac{q_p}{q_\alpha}=\frac{4}{1}\times\frac{1}{2}=\frac{2}{1}$

88. (b) When field is parallel to the direction of motion of charge, magnetic force on it is zero.

89. (a) Since $\vec{F}$ and $\vec{v}$ are perpendicular to each other work done by force is zero. Hence K.E. is constant.

90. (b)

91. (a) Charged particles deflects in magnetic field.

92. (a) $\nu=\frac{qB}{2\pi m}\Rightarrow\nu\propto\frac{q}{m}$

$\left(\frac{q}{m}\right)_{Li^+}$ is minimum so ν_{Li^+} is minimum.

93. (c) $r=\frac{\sqrt{2mK}}{qB}\Rightarrow r\propto\frac{\sqrt{m}}{q}\Rightarrow\frac{r_{He^+}}{r_{O^{++}}}=\sqrt{\frac{m_{He^+}}{m_{O^{++}}}}\times\frac{q_{O^{++}}}{q_{He^+}}$

$=\sqrt{\frac{4}{16}}\times\frac{2}{1}=\frac{1}{1}$. Then will deflect equally.

94. (d) $r=\frac{\sqrt{2mE}}{qB}=\frac{\sqrt{2\times9\times10^{-31}\times7.2\times10^{-18}}}{1.6\times10^{-19}\times9\times10^{-5}}$

$=0.25\ m=25\ cm$

95. (c) $v=\frac{E}{B}=\frac{20}{5}=4\,m/\sec$

96. (a) Because magnetic force on charge will be zero.

97. (c) $W=F.d\cos90^o=0$

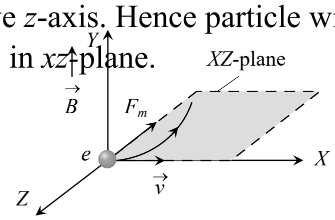
98. (b) Since particle is moving undeflected.

So $qE=qvB\Rightarrow B=E/v=\frac{10^4}{10}=10^3\,Wb/m^2$

99. (a) $r=\frac{mv}{qB}\Rightarrow\frac{r_1}{r_2}=\frac{m_1v_1}{m_2v_2}\times\frac{q_2}{q_1}=\frac{1\times2}{1\times3}\times\frac{2}{1}=\frac{4}{3}$

100. (b) $\vec{F}=-e(\vec{v}\times\vec{B})\Rightarrow\vec{F}=-e[v\hat{i}\times B\hat{j}]=evB[-\hat{k}]$

i.e. Force on electron is acting towards negative z-axis. Hence particle will move on a circle in xz-plane.



101. (d) Particles entering perpendicularly, hence they will describe circular path. Since their masses are different so they will describe path of different radii.

102. (c) $r=\frac{mv}{qB}=\frac{6\times10^7}{1.7\times10^{11}\times1.5\times10^{-2}}=2.35\ cm$

103. (d) Cyclotron frequency $\nu=\frac{Bq}{2\pi m}$

$\Rightarrow\nu=\frac{1\times1.6\times10^{-19}}{2\times3.14\times9.1\times10^{-31}}=2.79\times10^{10}\ H_z$

$=27.9\times10^9\ HZ\cong28\ GHZ$

104. (d) By Fleming's left hand rule.

105. (c) $r=\frac{\sqrt{2mK}}{qB}\Rightarrow q\propto\sqrt{mK}\Rightarrow K\propto\frac{q^2}{m}$

$\Rightarrow\frac{K_\alpha}{K_p}=\left(\frac{q_\alpha}{q_p}\right)^2\times\frac{m_p}{m_\alpha}\Rightarrow\frac{K_\alpha}{8}=\left(\frac{2q_p}{q_p}\right)^2\times\frac{m_p}{4m_p}=1$

$\Rightarrow K_\alpha=8\ eV$

106. (c) By using $r=\frac{mv}{qB}=\frac{v}{\left(\frac{q}{m}\right)B}\Rightarrow r\propto\frac{1}{(q/m)}$

$\because\left(\frac{q}{m}\right)_{e^-}>\left(\frac{q}{m}\right)_{p^+}>\left\{\left(\frac{q}{m}\right)_d=\left(\frac{q}{m}\right)_\alpha\right\}$

$\therefore R_d=R_\alpha$

107. (d) By using Fleming's left hand rule.

108. (d) Along the axis of coil. $\vec{v}$ and $\vec{B}$ are parallel, so $F=0$

109. (d) $F_m=qvB\sin\theta$, if $v=0\Rightarrow F_m=0$

110. (d) $T=\frac{2\pi m}{qB}=\frac{2\times3.14\times9.1\times10^{-31}}{1.6\times10^{-19}\times3.534\times10^{-5}}$

$=1\times10^{-6}\,sec=1\mu sec$

111. (a)

112. (b)

113. (d) Magnetic field produced by wire at the location of charge is perpendicular to the paper inwards. Hence by applying Fleming's left hand rule, force is directed along *OY*.

114. (c) From Fleming's left hand rule the force on electron is towards the east means it is deflected towards east.

115. (c) Electric current corresponds to the revolution of electron is $i = \frac{ev}{2\pi r}$

Magnetic field due to circular current at the centre $B = \frac{\mu_0}{4\pi}.\frac{2\pi i}{r} = \frac{\mu_0}{4\pi}.\frac{ev}{r^2} \Rightarrow \quad r = \sqrt{\frac{\mu_0}{4\pi}.\frac{ev}{B}} \Rightarrow$

$r \propto \sqrt{\frac{v}{B}}$.

116. (c) When electron moves in both electric and magnetic field then $qE = qvB$.

$\therefore \; v = \frac{E}{B} = \frac{1500}{0.40} = 3750 \; m/s = 3.75 \times 10^3 m/s$.

117. (c) For no deflection in mutually perpendicular electric and magnetic field $v = \frac{E}{B} = \frac{3.2 \times 10^5}{2 \times 10^{-3}} = 1.6 \times 10^8 \; m/s$.

If electric field is removed then due to only magnetic field radius of the path described by electron $r = \frac{mv}{qB} = \frac{9.1 \times 10^{-31} \times 1.6 \times 10^8}{1.6 \times 10^{-19} \times 2 \times 10^{-3}} = 0.45 \, m$

118. (c) $r = \frac{mv}{qB} \Rightarrow r \propto v$

Force and Torque on Current Carrying Conductor

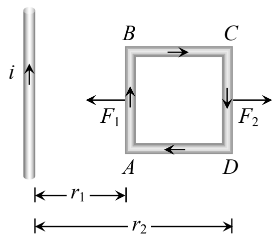
1. (b) Two wires, if carries current in opposite direction, they repel each other.

2. (c) $\because r_1 < r_2$

So $F_1 > F_2$

$\Rightarrow F_{net} = (F_1 - F_2)$

towards the wire.



3. (b) $M = NiA = 20 \times \frac{22}{7}(4 \times 10^{-2})^2 3 = 0.3 \; A - m^2$

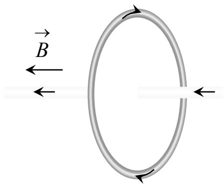
4. (c) Net force on a current carrying closed loop is always zero, if it is placed in an uniform magnetic field.

5. (b) Force per unit length $= \frac{\mu_0}{4\pi}.\frac{2i_1 i_2}{r} = \frac{\mu_0}{2\pi}.\frac{i^2}{b}$

6. (a) $F = \frac{\mu_0}{4\pi}.\frac{2i_1 i_2}{a} \times l \Rightarrow F = 10^{-7} \times \frac{2 \times 10 \times 2}{(10 \times 10^{-2})} \times 2 = 8 \times 10^{-5} \, N$

7. (b) For charge particles, if they are moving freely in space, electrostatic force is dominant over magnetic force between them. Hence due to electric force they repel each other.

8. (b) As shown in the following figure straight wire is placed parallel to the magnetic field produced by circular current. Hence force on wire $F = 0$



9. (a) Two straight conductors carry current in same direction, then attractive force acts between them.

10. (a) $F = \frac{\mu_0}{4\pi}\frac{2 \times i_1 i_2}{a} = \frac{10^{-7} \times 2 \times 5 \times 5}{0.1} = 5 \times 10^{-5} \, N/m$

11. (c) $F = \frac{\mu_0}{4\pi}\frac{2i_1 i_2}{a} = 10^{-3} \, N$

When current in both the wires is doubled, then

$F = \frac{\mu_0}{4\pi}\frac{2(2i_1 \times 2i_2)}{a} = 4 \times 10^{-3} \, N$

12. (a) The magnetic moment of current carrying loop

$M = niA = ni(\pi r^2)$

Hence the work done in rotating it through 180°

$W = MB(1 - \cos\theta) = 2MB = 2(ni\pi r^2)B$

$= 2 \times (50 \times 2 \times 3.14 \times 16 \times 10^{-4}) \times 0.1 = 0.1 J$

13. (c) $F = Bil\sin\theta$

$= 500 \times 10^{-4} \times 3 \times (40 \times 10^{-2}) \times \frac{1}{2} = 3 \times 10^{-2} \, N$

14. (c) $M = i\pi r^2$

15. (a) Because $\tau = NiAB\cos\theta$

16. (c)

17. (b) $\theta = \frac{NiAB}{C} \Rightarrow \theta \propto N$ (Number of turns)

18. (b) Magnet provides damping.

19. (b) $i = \frac{C\theta}{NAB} \Rightarrow i \propto \theta$

20. (b) Force per unit length on two parallel current carrying conductor is given by $\frac{F}{l} = 10^{-7} \times 2\frac{i_1 i_2}{a}$

$\Rightarrow \frac{F}{l} = 10^{-7} \times 2 \times \frac{1 \times 1}{1} = 2 \times 10^{-7}\ N/m$

21. (d) $\tau = MB\sin\theta \Rightarrow \tau_{max} = NiAB$, ($\theta = 90°$)

22. (b) $W = MB(\cos\theta_1 - \cos\theta_2)$

$= (NiA)\,B(\cos 0° - \cos 180°) = 2NAIB$

23. (d) Magnetic dipole moment of coil = *NIA*

24. (a) $F = Bil\sin\theta \Rightarrow \sin\theta = \frac{F}{Bil} = \frac{15}{2 \times 10 \times 1.5} = \frac{1}{2} \Rightarrow$

$\theta = 30°$

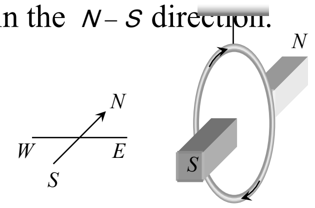
25. (a)

26. (b) $M = i(\pi r^2) = \frac{ev}{2\pi r} \times \pi r^2 \Rightarrow M = \frac{1}{2}evr$

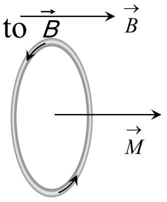
27. (d) Couple of force on loop *S* will be maximum because for same perimeter the area of loop will be maximum and magnetic moment of loop $= i \times A$. So, it will also be maximum for loop *S*.

28. (b) According to the definition.

29. (c) Current carrying loop, behaves as a bar magnet. A freely suspended bar magnet stays in the $N - S$ direction.



30. (c) In equilibrium angle between $\vec{M}$ and $\vec{B}$ is zero. It is happened, when plane of the coil is perpendicular to $\vec{B}$



31. (c)

32. (d)

33. (d) Sensitivity $S = \frac{\theta}{i} = \frac{nBA}{C}$

34. (d)

35. (b) By Fleming left hand rule.

36. (a) Force on wire *Q* due to wire *P* is

$F_P = 10^{-7} \times \frac{2 \times 30 \times 10}{0.1} \times 0.1 = 6 \times 10^{-5}\ N$ (Towards left)

Force on wire *Q* due to wire *R* is

$F_R = 10^{-7} \times \frac{2 \times 20 \times 10}{0.02} \times 0.1 = 20 \times 10^{-5}\ N$ (Towards right)

Hence $F_{net} = F_R - F_P = 14 \times 10^{-5}\ N = 1.4 \times 10^{-4}\ N$

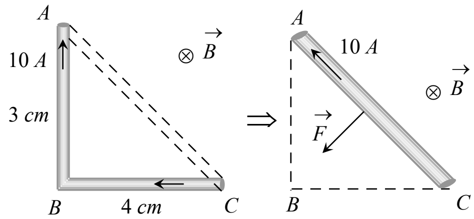
(Towards right)

37. (a) $\tau = NBiA = 100 \times 0.2 \times 2 \times (0.08 \times 0.1) = 0.32\ N \times m$

Direction can be found by Fleming's left hand rule.

38. (a) $F = Bil\sin\theta \Rightarrow 7.5 = 2 \times 5 \times 1.5\sin\theta \Rightarrow \theta = 30°$

39. (c) According to the question figure can be drawn as shown below.



Force on the conductor *ABC* = Force on the conductor *AC*

$= 5 \times 10 \times (5 \times 10^{-2}) = 2.5\ N$

40. (d) Current sensitivity $\frac{\theta}{i} = \frac{NBA}{C}$

$\Rightarrow \frac{\theta}{i} = \frac{100 \times 5 \times 10^{-4}}{10^{-8}} = 5\ rad/\mu\ Amp$

41. (c) $\tau = NBiA = 100 \times 0.5 \times 1 \times 400 \times 10^{-4} = 2\ N - m$

42. (a) When current is passed through a spring, it gets compressed.

43. (a) $M = iA \Rightarrow i = M/A$

44. (c) $i = 6.6\times10^{15}\times1.6\times10^{-19} = 10.5\times10^{-4}\,amp$

$A = \pi R^2 = 3.142\times(0.528)^2\times10^{-20}\,m^2$

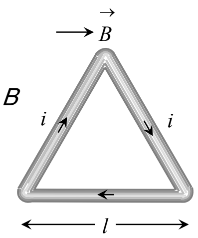
$\Rightarrow M = iA = 10.5\times10^{-4}\times3.142\times(0.528)^2\times10^{-20}$

$= 10\times10^{-24}\,units = 1\times10^{-23}\,units$

45. (d) Since $\theta = 90°$

Hence $\tau = NIAB = 1\times I\times\left(\frac{\sqrt{3}}{4}l^2\right)B$

$= \frac{\sqrt{3}}{4}l^2 B$



46. (a) For no force on wire *C*, force on wire *C* due to wire *D*= force on wire *C* due to wire *B*

$\Rightarrow \frac{\mu_0}{4\pi}\times\frac{2\times15\times5}{x}\times l = \frac{\mu_0}{4\pi}\times\frac{2\times5\times10}{(15-x)}\times l \Rightarrow x = 9cm$

47. (d) By Fleming's left hand rule.

48. (a)

49. (a)

50. (c) Force on the wire = *Bil*

Force per unit length $= Bi = 10^{-4}\times10 = 10^{-3}\,N$

51. (b) $F = Bil = 2\times1.2\times0.5 = 1.2N$

52. (a) $F = \frac{\mu_0}{4\pi}\frac{2i_1i_2}{a} = 10^{-7}\times\frac{2\times10\times10}{0.1} = 2\times10^{-4}\,N$

Direction of current is same, so force is attractive.

53. (a,b,c) Sensitivity $\frac{\theta}{i} = \frac{NAB}{C}$

54. (a) $M = NiA = 24\times0.75\times3.14\times(3.5\times10^{-2})^2$

$= 6.9\times10^{-2}\,A\text{-}m^2$

55. (c) $\frac{F}{l} = \frac{\mu_0}{4\pi}\times\frac{2i_1i_2}{a} = \frac{\mu_0}{4\pi}\frac{2i^2}{a}$ $(\because i_1 = i_2 = i)$

$\Rightarrow 2\times10^{-7} = 10^{-7}\times\frac{2i^2}{1} \Rightarrow i = 1A$

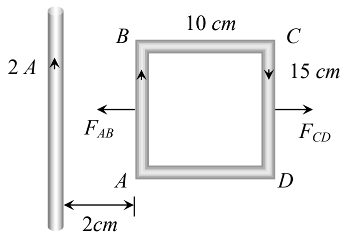
56. (b)

57. (a) $\tau = NiAB\sin\theta = 0$ $\quad(\because \theta = 0^o)$

58. (d) $M = NiA$

59. (c)

60. (a) Force on side *BC* and *AD* are equal but opposite so their net will be zero.



But $F_{AB} = 10^{-7}\times\frac{2\times2\times1}{2\times10^{-2}}\times15\times10^{-2} = 3\times10^{-6}\,N$

and $F_{CD} = 10^{-7}\times\frac{2\times2\times1}{(12\times10^{-2})}\times15\times10^{-2} = 0.5\times10^{-6}\,N$

$\Rightarrow F_{net} = F_{AB} - F_{CD} = 2.5\times10^{-6}\,N$

$= 25\times10^{-7}\,N$, towards the wire.

61. (b) $F = 10^{-7}\frac{2i_1i_2}{a} = 10^{-7}\times\frac{2\times5\times5}{0.5} = 10^{-5}\,N$ (repulsive)

62. (b) Sensitivity $= \frac{NAB}{C}$

63. (d) $M = iA = 0.1\times\pi\times(0.05)^2$

$= (0.1)\times3.14\times25\times10^{-4} = 7.85\times10^{-4}\,amp\text{-}m^2$

64. (b) $B = \frac{\mu_0 i}{2R} \Rightarrow i = \frac{B\times2R}{\mu_0}$

Now, $M = i\times A = i\pi R^2 = \frac{B\times2R}{\mu_0}\times\pi R^2 = \frac{2\pi BR^3}{\mu_0}$

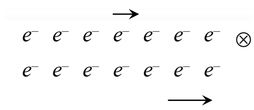
65. (c) $M = NiA \Rightarrow M\propto A \Rightarrow M\propto r^2$ $\quad(\text{As } l = 2\pi r \Rightarrow l\propto r)$

$\Rightarrow M\propto l^2$

66. (a)

$F = \frac{\mu_0}{4\pi}\frac{2i_1i_2}{a} = 10^{-7}\times\frac{2\times10\times5}{0.1} = 10^{-4}\,N$ (Repulsive)

67. (b) According to Fleming's left hand rule, magnetic force on electrons will be downward.

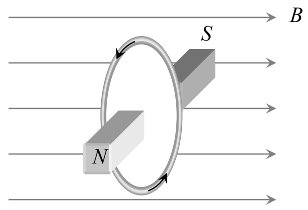


68. (a) $\sigma_i = \frac{\theta}{i} = \frac{\theta}{iG}\cdot G = \sigma_V G \Rightarrow \frac{\sigma_i}{G} = \sigma_V$

69. (a)

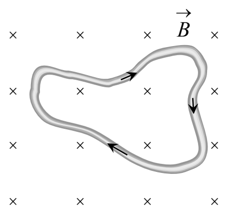
70. (a) $F = Bil\sin30^o = 1.5\times10\times1\times\frac{1}{2} = 7.5N$

71. (c) As shown in the following figure, the given situation is similar to a bar magnet placed in a uniform magnetic field perpendicularly. Hence torque on it



$\tau = MB\sin 90° = (i\pi r^2)B$

72. (a) As shown in figure, since $\vec{L} = 0$



Hence according to $\vec{F} = i(\vec{L} \times \vec{B}) \Rightarrow \vec{F} = 0$

73. (a) Because $\tau_{max} = BiNA \Rightarrow \tau \propto N$.

74. (d)

75. (d) $F = \frac{\mu_0}{4\pi}\frac{2i_1i_2}{a}$

$F_1 = \frac{\mu_0}{4\pi} = \frac{2i^2}{x}$ (Attraction)

$F_2 = \frac{\mu_0}{4\pi} = \frac{2i \times 2i}{2x} = \frac{\mu_0}{4\pi}\frac{2i^2}{x}$ (Repulsion)

Thus $F_1 = -F_2$

76. (c) Magnetic field produced by wire is perpendicular to the motion of electron and it is given by

$B = \frac{\mu_0}{4\pi}\cdot\frac{2i}{a} = 10^{-7} \times \frac{2 \times 5}{0.1} = 10^{-5}\ Wb/m^2$

Hence force on electron

$F = qvB = (1.6 \times 10^{-19}) \times 5 \times 10^6 \times 10^{-5} = 8 \times 10^{-18}\ N$

77. (a) Sensitivity (S) $= \frac{\theta}{i} \Rightarrow \frac{S_A}{S_B} = \frac{i_B}{i_A} = \frac{5}{3} \Rightarrow S_A > S_B$

78. (a)

$F = 10^{-7}\frac{2i_1i_2}{a} = 10^{-7} \times \frac{2 \times 5 \times 8}{0.5} = 1.6 \times 10^{-5}$ (Attractive)

79. (b) In moving coil galvanometer $i \propto \theta$.

80. (c)

81. (b) $F \propto i_1i_2$, so force on B due to C will be greater than that due A. Hence net force on B acts towards C.

82. (c) $F \propto \frac{i_1i_2}{a}$; Since one of the current increase two times and distance increases three times, so force become $\frac{2}{3}$ times. Also due to the reversal of direction of current force becomes negative.

83. (c) Neon molecule is diatomic, so it's net magnetic moment is zero.

84. (b) $F = Bil \Rightarrow 1 \times 9.8 = 0.98 \times i \times 1 \Rightarrow i = 10A$

85. (a)

86. (d) $F = 10^{-7} \times \frac{2i^2}{a} \times l \Rightarrow 30 \times 10^{-7} = 10^{-7} \times \frac{2i^2}{0.15} \times 9$

$\Rightarrow i = 0.5A$

87. (c) $\tau_{max} = NiAB = 1 \times i \times (\pi r^2) \times B$

$\left(2\pi r = L, \Rightarrow r = \frac{L}{2\pi}\right)$

$\tau_{max} = \pi i\left(\frac{L}{2\pi}\right)^2 B = \frac{L^2 iB}{4\pi}$

88. (b)

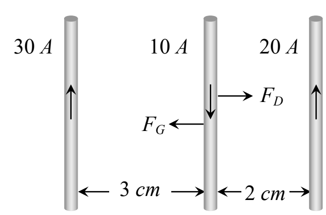
89. (c) $\left(\frac{F}{l}\right) = \frac{\mu_0}{4\pi}.\frac{2i_1i_2}{a} \Rightarrow \left(\frac{F}{l}\right) = \frac{\mu_0}{4\pi}.\frac{2i^2}{d} = \frac{\mu_0 i^2}{2\pi d}$

(Attractive)

90. (c) Force on wire C due to wire D

$F_D = 10^{-7} \times \frac{2 \times 30 \times 10}{2 \times 10^{-2}} \times 25 \times 10^{-2} = 5 \times 10^{-4}\ N$

(towards right)



Force on wire C due to wire G

$F_G = 10^{-7} \times \frac{2 \times 20 \times 10}{2 \times 10^{-2}} \times 25 \times 10^{-2} = 5 \times 10^{-4}\ N$

(towards left)

$\Rightarrow$ Net force on wire C is $F_{net} = F_D - F_G = 0$

91. (d) Since $\theta = 0°$ so $\tau = 0$ $(\because \tau = NiAB\sin\theta)$

Critical Thinking Questions

1. (b) $\frac{B_{centre}}{B_{axis}} = \left(1+\frac{x^2}{R^2}\right)^{3/2}$, also $B_{axis} = \frac{1}{8}B_{centre}$

$\Rightarrow \frac{8}{1} = \left(1+\frac{x^2}{R^2}\right)^{3/2} \Rightarrow 2 = \left(1+\frac{x^2}{R^2}\right)^{1/2}$

$\Rightarrow 4 = 1+\frac{x^2}{R^2} \Rightarrow 3 = \frac{x^2}{R^2} \Rightarrow x^2 = 3R^2 \Rightarrow x = \sqrt{3}R$

2. (a) Field at the centre $B_1 = \frac{\mu_0}{4\pi}\times\frac{2\pi i n}{r} = \frac{\mu_0}{2}.\frac{ni}{r}$

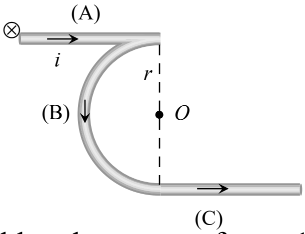
Field at a distance h from the centre

$B_2 = \frac{\mu_0}{4\pi}.\frac{2\pi n i r^2}{(r^2+h^2)^{3/2}} = \frac{\mu_0}{2}.\frac{nir^2}{r^3\left(1+\frac{h^2}{r^2}\right)^{3/2}}$

$= B_1\left(1+\frac{h^2}{r^2}\right)^{-3/2} = B_1\left(1-\frac{3}{2}.\frac{h^2}{r^2}\right)$ (By binomial theorem)

Hence B_2 is less than B_1 by a fraction $= \frac{3}{2}\frac{h^2}{r^2}$

3. (a) ***Case 1 :*** $B_A = \frac{\mu_0}{4\pi}.\frac{i}{r}\otimes$



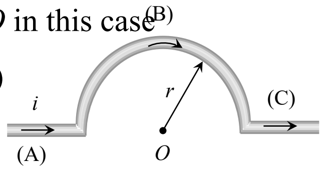
$B_B = \frac{\mu_0}{4\pi}.\frac{\pi i}{r}\odot$

$B_C = \frac{\mu_0}{4\pi}.\frac{i}{r}\odot$

So net magnetic field at the centre of case 1

$B_1 = B_B - B_C - B_A \Rightarrow B_1 = \frac{\mu_0}{4\pi}.\frac{\pi i}{r}\odot$ ..... (i)

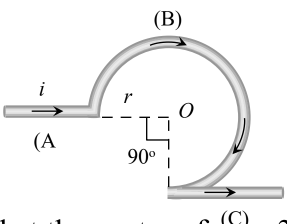
Case 2 : As we discussed before magnetic field at the centre O in this case



$B_2 = \frac{\mu_0}{4\pi}.\frac{\pi i}{r}\otimes$ ..... (ii)

Case 3 : $B_A = 0$

$B_B = \frac{\mu_0}{4\pi}.\frac{(2\pi - \pi/2)i}{r}\otimes$



$B_C = \frac{\mu_0}{4\pi}.\frac{i}{r}\odot$

$= \frac{\mu_0}{4\pi}.\frac{3\pi i}{2r}\otimes$

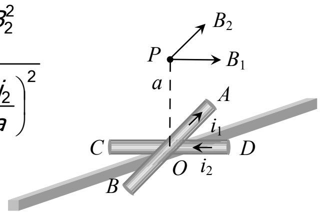
So net magnetic field at the centre of case 3

$B_3 = \frac{\mu_0}{4\pi}.\frac{i}{r}\left(\frac{3\pi}{2}-1\right)\otimes$ ..... (iii)

From equation (i), (ii) and (iii)

$B_1 : B_2 : B_3 = \pi\odot : \pi\otimes : \left(\frac{3\pi}{2}-1\right)\otimes = -\frac{\pi}{2} : \frac{\pi}{2} : \left(\frac{3\pi}{4}-\frac{1}{2}\right)$

4. (c) At P : $B_{net} = \sqrt{B_1^2 + B_2^2}$

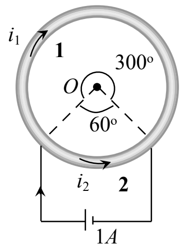


$= \sqrt{\left(\frac{\mu_0}{4\pi}\frac{2i_1}{a}\right)^2 + \left(\frac{\mu_0}{4\pi}\frac{2i_2}{a}\right)^2}$

$= \frac{\mu_0}{2\pi a}(i_1^2 + i_2^2)^{1/2}$

5. (c) $B = \frac{\mu_0}{4\pi}\frac{\theta\, i}{r} \Rightarrow B \propto \theta\, i$ (but $\frac{i_1}{i_2} = \frac{l_2}{l_1} = \frac{\theta_2}{\theta_1}$)

$\Rightarrow \frac{B_1}{B_2} = \frac{\theta_1}{\theta_2}.\frac{i_1}{i_2}$



So, $\frac{B_1}{B_2} = \frac{\theta_1}{\theta_2}\times\frac{\theta_2}{\theta_1}$

$\Rightarrow B_1 = B_2$

6. (c) Magnetic field at any point lying on the current carrying straight conductor is zero.

Here H_1 = Magnetic field at M due to current in PQ.

H_2 = Magnetic field at M due to QR + magnetic field at M due to QS + magnetic field at M due to PQ

$= 0 + \frac{H_1}{2} + H_1 = \frac{3}{2}H_1 \Rightarrow \frac{H_1}{H_2} = \frac{2}{3}$

7. (c, d) $B_{net} = B_1 - B_2 \Rightarrow B_1 - B_2 = 0 \Rightarrow B_1 = B_2$

$\Rightarrow B \propto ni$. So $n_1 i_1 = n_2 i_2$ or $n_1 = n_2$ and $i_1 = i_2$

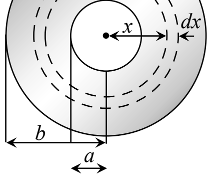
8. (c) Number of turns per unit width $= \frac{N}{b-a}$

Consider an elemental ring of radius x and with thickness dx Number of turns in the ring $= dN = \frac{Ndx}{b-a}$

Magnetic field at the centre due to the ring element

$dB = \frac{\mu_0 (dN) i}{2x} = \frac{\mu_0 i}{2}.\frac{Ndx}{(b-a)}.\frac{1}{x}$

$\therefore$ Field at the centre



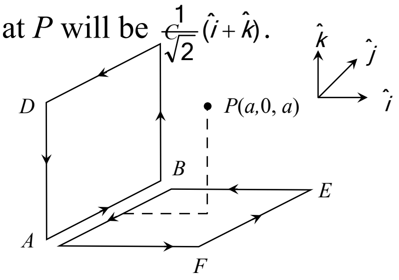
$= \int dB = \frac{\mu_0 Ni}{2(b-a)}\int_a^b \frac{dx}{x}$

$= \frac{\mu_0 Ni}{2(b-a)} \ln \frac{b}{a}.$

9. (d) The magnetic field at $P(a, 0, a)$ due to the loop is equal to the vector sum of the magnetic fields produced by loops *ABCDA* and *AFEBA* as shown in the figure.

Magnetic field due to loop *ABCDA* will be along $\hat{i}$ and due to loop *AFEBA*, along $\hat{k}$. Magnitude of magnetic field due to both the loops will be equal.

Therefore, direction of resultant magnetic field at *P* will be $\frac{1}{\sqrt{2}}(\hat{i}+\hat{k})$.

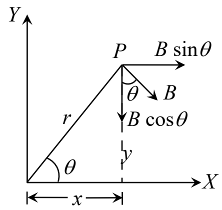


10. (a) Magnetic field at *P* is $\vec{B}$, perpendicular to *OP* in the direction shown in figure.

So, $\vec{B} = B\sin\theta\,\hat{i} - B\cos\theta\,\hat{j}$

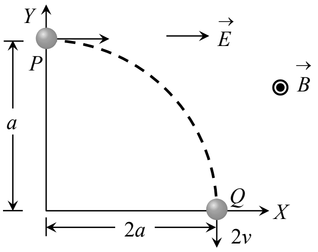
Here $B = \frac{\mu_0}{2\pi}\frac{I}{r}$

$\sin\theta = \frac{y}{r}$ and $\cos\theta = \frac{x}{r}$



$\therefore \quad \vec{B} = \frac{\mu_0 I}{2\pi}\cdot\frac{1}{r^2}(y\hat{i} - x\hat{j}) = \frac{\mu_0 I(y\hat{i} - x\hat{j})}{2\pi(x^2+y^2)}$ (as $r^2 = x^2 + y^2$)

11. (a, b, d) Kinetic energy of the particle at point $P = \frac{1}{2}mv^2$



K.E. of the particle at point $Q = \frac{1}{2}m(2v)^2$

Increase in K.E. $= \frac{3}{2}mv^2$

It comes from the work done by the electric force *qE* on the particle as it covers a distance 2*a* along the *x*-axis. Thus $\frac{3}{2}mv^2 = qE \times 2a \Rightarrow E = \frac{3}{4}\frac{mv^2}{qa}$. The rate of work done by the electric field at *P* $= F \times v = qE \times v = 3\frac{mv^3}{4a}$

At $Q, \vec{F_e} = q\vec{E}$ is along *x*-axis while velocity is along negative *y*-axis. Hence rate of work done by electric field $= \vec{F_e}\cdot\vec{v} = 0$ $(\because \theta = 90^o)$

Similarly, according to equation $\vec{F_m} = q(\vec{v} \times \vec{B})$

Force $\vec{F_m}$ is also perpendicular to velocity vector v.

Hence the rate of work done by the magnetic field = 0

12. (a, c) $r \propto \frac{\sqrt{m}}{q} \Rightarrow r_H : r_{He} : r_o = \frac{\sqrt{1}}{1} : \frac{\sqrt{4}}{1} : \frac{\sqrt{16}}{2} = 1:2:2$

Radius is smallest for H^+, so it is deflected most.

13. (c) As the electric field is switched on, positive ion will start to move along positive *x*-direction and negative ion along negative *x*-direction. Current associated with motion of both types of ions is along positive *x*-direction. According to Fleming's left hand rule force on both types of ions will be along negative *y*-direction.

14. (c) $\vec{v} = 2\times10^5\hat{i}$ and $\vec{B} = (\hat{i} + 4\hat{j} - 3\hat{k})$

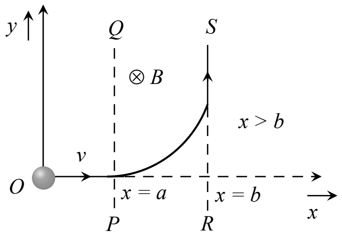
$\vec{F} = q(\vec{v}\times\vec{B}) = -1.6\times10^{-19}[2\times10^5\hat{i}\times(\hat{i}+4\hat{j}-3\hat{k})]$

$= -1.6\times10^{-19}\times2\times10^5[\hat{i}\times\hat{i} + 4(\hat{i}\times\hat{j}) - 3(\hat{i}\times\hat{k})]$

$= -3.2\times10^{-14}[0 + 4\hat{k} + 3\hat{j}] = 3.2\times10^{-14}(-4\hat{k} - 3\hat{k})$

$\Rightarrow |\vec{F}| = 3.2\times10^{-14}\times5 = 1.6\times10^{-13}\,N.$

15. (b) In the figure, the *z*-axis points out of the paper, and the magnetic field is directed into the paper, existing in the region between *PQ* and *RS*. The particle moves in a circular path of radius *r* in the magnetic field. It can just enter the region $x > b$ for $r \geq (b-a)$



Now, $r = \frac{mv}{qB} \geq (b-a)$

or $v \geq \frac{q(b-a)B}{m} \Rightarrow v_{min} = \frac{q(b-a)B}{m}$

16. (b) Electric field can deviate the path of the particle in the shown direction only when it is along negative *y*-direction. In the given options $\vec{E}$ is either zero or along *x*-direction. Hence it is the magnetic field which is really responsible for its curved path. Options (a) and (c) can't be accepted as the path will be helix in that case (when the velocity vector makes an angle other than 0°, 180° or 90° with the magnetic field, path is a helix) option (d) is wrong because in that case component of net force on the particle also comes in *k* direction which is not acceptable as the particle is moving in *x-y* plane. Only in option (b) the particle can move in *x-y* plane.

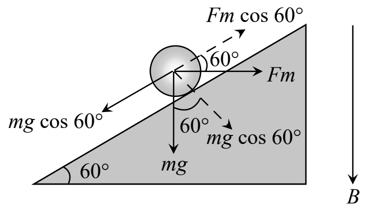
In option (d) : $\vec{F}_{net} = q\vec{E} + q(\vec{v} \times \vec{B})$

Initial velocity is along *x*-direction. So let $\vec{v} = v\hat{i}$

$\therefore \ \vec{F}_{net} = qa\hat{i} + q[(v\hat{i}) \times (c\hat{k} + b\hat{j})] = qa\hat{i} - qvc\hat{j} + qvb\hat{k}$

In option (b) $\vec{F}_{net} = q(a\hat{i}) + q[(v\hat{i}) \times (c\hat{k} + a\hat{i})] = qa\hat{i} - qvc\hat{j}$

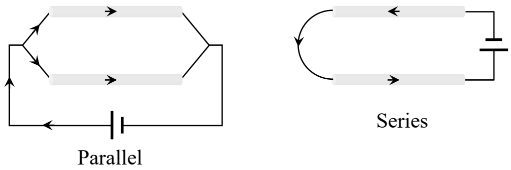
17. (c) The given situation can be drawn as follows



$F = ilB \Rightarrow mg\sin 60^o = ilB\cos 60^o$

$\Rightarrow B = \frac{0.01 \times 10 \times \sqrt{3}}{0.1 \times 1.73} = 1\ T$

18. (a) When connected in parallel the current will be in the same direction and when connected in series the current will be in the opposite direction.



19. (b) If the radius of circle is *r,* then $2\pi r = L \Rightarrow r = \frac{L}{2\pi}$

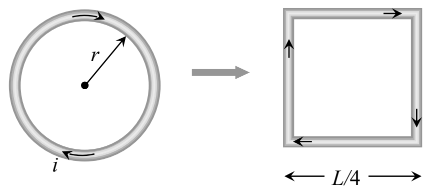
Area $= \pi r^2 = \frac{\pi L^2}{4\pi^2} = \frac{L^2}{4\pi}$

Magnetic moment $= IA = \frac{IL^2}{4\pi}$

20. (d) Initially for circular coil $L = 2\pi r$ and $M = i \times \pi r^2$

$= i \times \pi\left(\frac{L}{2\pi}\right)^2 = \frac{iL^2}{4\pi}$ ..... (i)

Finally for square coil $M' = i \times \left(\frac{L}{4}\right)^2 = \frac{iL^2}{16}$ ..... (ii)



Solving equation (i) and (ii) $M' = \frac{\pi M}{4}$

21. (c) The effective current $i = \frac{q\omega}{2\pi}$ and $A = \pi r^2$.

Magnetic moment $M = iA = \frac{1}{2}q\omega r^2$

Angular moment $L = I\omega = mr^2\omega \Rightarrow \frac{M}{L} = \frac{q}{2m}$

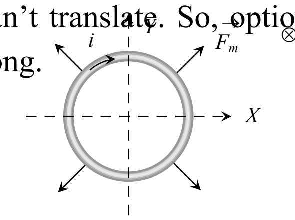
22. (b) On applying Fleming's left hand rule.

23. (b) Current carrying conductors will attract each other, while electron beams will repel each other.

24. (c) Length of the component dl which is parallel to wire (1) is $dl\cos\theta$, so force on it.

$$F = \frac{\mu_0}{4\pi}\cdot\frac{2i_1i_2}{r}(dl\cos\theta) = \frac{\mu_0 i_1 i_2 dl\cos\theta}{2\pi r}$$

25. (b) Net force on a current carrying loop in uniform magnetic field is zero. Hence the loop can't translate. So, options (c) and (d) are wrong.



From Fleming's left hand rule we can see that if magnetic field is perpendicular to paper inwards and current in the loop is clockwise (as shown) the magnetic force $\vec{F_m}$ on each element of the loop is radially outwards, or the loops will have a tendency to expand.

26. (c) $U = -MB\cos\theta$; where θ = Angle between normal to the plane of the coil and direction of magnetic field.

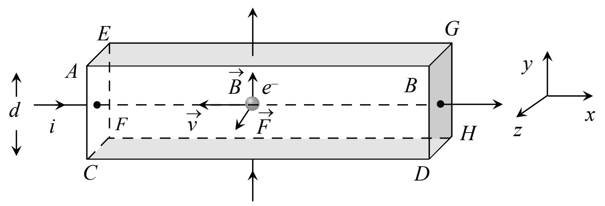
27. (a) As the block is of metal, the charge carriers are electrons, so for current along positive x-axis, the electrons are moving along negative x-axis, *i.e.* $\vec{v} = -v\hat{i}$

and as the magnetic field is along the y-axis, *i.e.* $\vec{B} = B\hat{j}$

so $\vec{F} = q(\vec{v}\times\vec{B})$ for this case yield

$\vec{F} = (-e)[-v\hat{i}\times B\hat{j})]$

i.e., $\vec{F} = evB\hat{k}$ [As $\hat{i}\times\hat{j} = \hat{k}$]



As force on electrons is towards the face *ABCD,* the electrons will accumulate on it an hence it will acquire lower potential.

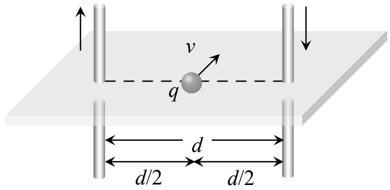
28. (a)

29. (a) $i = \frac{2q\omega}{2\pi} = \frac{q\omega}{\pi}$; $\therefore M = iA = \frac{q\omega}{\pi}\pi R^2 = q\omega R^2$

$L = 2R.mv = 2R.mR\omega = 2mR^2\omega$ $(\because v = R\omega)$

$\Rightarrow \frac{M}{L} = \frac{q}{2m}$

30. (d) According to gives information following figure can be drawn, which shows that direction of magnetic field is along the direction of motion of charge so net force on it is zero.

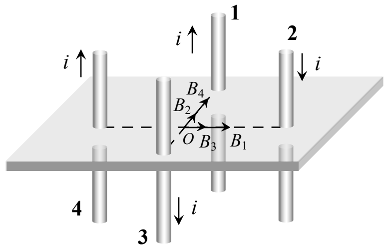


31. (b) $M = iA = i\times\pi R^2$ also $i = \frac{Q\omega}{2\pi} \Rightarrow M = \frac{1}{2}Q\omega R^2$

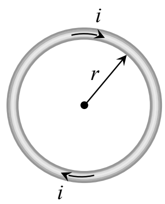
32. (c) Direction of magnetic field (B_1, B_2, B_3 and B_4) at origin due to wires 1, 2, 3 and 4 are shown in the following figure.

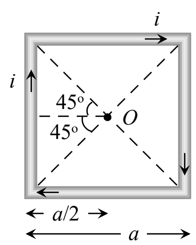
$B_1 = B_2 = B_3 = B_4 = \frac{\mu_0}{4\pi}\cdot\frac{2i}{x} = B$. So net magnetic field at origin O

$B_{net} = \sqrt{(B_1+B_3)^2+(B_2+B_4)^2} = \sqrt{(2B)^2+(2B)^2} = 2\sqrt{2}B$



33. (b) Circular coil Square coil





Length $L = 2\pi r$ Length $L = 4a$

Magnetic field at the centre of circular coil

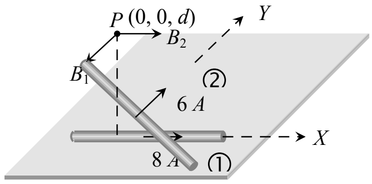
$$B_{circular}=\frac{\mu_0}{4\pi}\cdot\frac{2\pi i}{r}=\frac{\mu_0}{4\pi}\cdot\frac{4\pi^2 i}{L}$$

Magnetic field at the centre of square coil

$$B_{square}=\frac{\mu_0}{4\pi}\cdot\frac{8\sqrt{2}\,i}{a}=\frac{\mu_0}{4\pi}\cdot\frac{32\sqrt{2}\,i}{L}$$

Hence $\frac{B_{circular}}{B_{square}}=\frac{\pi^2}{8\sqrt{2}}$

34. (d) Magnetic field at P due to wire 1, $B_1=\frac{\mu_0}{4\pi}\cdot\frac{2(8)}{d}$



and due to wire 2, $B_2=\frac{\mu_0}{4\pi}\cdot\frac{2(6)}{d}$

$$\Rightarrow B_{net}=\sqrt{B_1^2+B_2^2}=\sqrt{\left(\frac{\mu_0}{4\pi}\cdot\frac{16}{d}\right)^2+\left(\frac{\mu_0}{4\pi}\cdot\frac{12}{d}\right)^2}$$

$$=\frac{\mu_0}{4\pi}\times\frac{2}{d}\times 10=\frac{5\mu_0}{\pi d}$$

35. (b) According to question resistance of wire ADC is twice that of wire ABC. Hence current flows through ADC is half that of ABC *i.e.* $\frac{i_2}{i_1}=\frac{1}{2}$. Also $i_1+i_2=i \Rightarrow i_1=\frac{2i}{3}$ and $i_2=\frac{i}{3}$

Magnetic field at centre O due to wire AB and BC (part 1 and 2)

$$B_1=B_2=\frac{\mu_0}{4\pi}\cdot\frac{2i_1\sin 45^o}{a/2}\otimes=\frac{\mu_0}{4\pi}\cdot\frac{2\sqrt{2}\,i_1}{a}\otimes$$

and magnetic field at centre O due to wires AD and DC (*i.e.* part 3 and 4)

$$B_3=B_4=\frac{\mu_0}{4\pi}\frac{2\sqrt{2}\,i_2}{a}\odot$$

Also $i_1=2i_2$. So $(B_1=B_2)>(B_3=B_4)$

Hence net magnetic field at centre O

$$B_{net}=(B_1+B_2)-(B_3+B_4)$$

$$=2\times\frac{\mu_0}{4\pi}\cdot\frac{2\sqrt{2}\times\left(\frac{2}{3}i\right)}{a}-\frac{\mu_0}{4\pi}\cdot\frac{2\sqrt{2}\left(\frac{i}{3}\right)\times 2}{a}$$

$$=\frac{\mu_0}{4\pi}\cdot\frac{4\sqrt{2}\,i}{3a}(2-1)\otimes=\frac{\sqrt{2}\,\mu_0 i}{3\pi a}\otimes$$

36. (d) By using $B=\frac{\mu_0 i}{2\pi r}\left(\frac{r^2-a^2}{b^2-a^2}\right)$ here $r=\frac{3R}{2}$, $a=R$, $b=2R$

$$\Rightarrow B=\frac{\mu_0 i}{2\pi\left(\frac{3R}{2}\right)}\times\left\{\frac{\left(\frac{3R}{2}\right)^2-R^2}{(2R^2)-R^2}\right\}=\frac{5.\mu_o i}{36\pi R}.$$

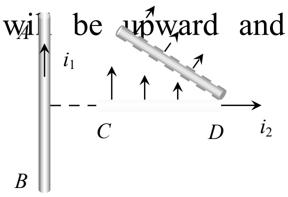
37. (a) Suppose in equilibrium wire PQ lies at a distance r above the wire AB

Hence in equilibrium $mg=Bil$

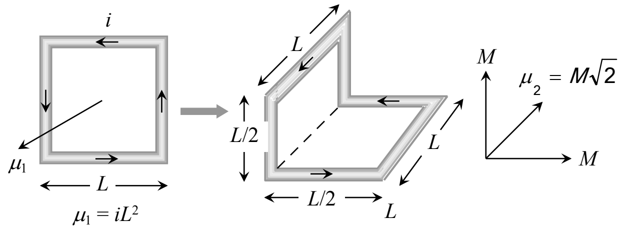
$$\Rightarrow mg=\frac{\mu_0}{4\pi}\left(\frac{2i}{r}\right)\times il$$

$$\Rightarrow 10^{-3}\times 10=10^{-7}\times\frac{2\times(50)^2}{r}\times 0.5 \Rightarrow r=25\,mm$$

38. (c) Since the force on the rod CD is non-uniform it will experience force and torque. From the left hand side it can be seen that the force will be upward and torque is clockwise.



39. (c) Initial magnetic moment = $\mu_1=iL^2$



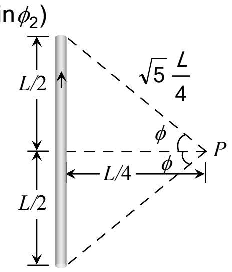
After folding the loop, M = magnetic moment due to each part $=i\left(\frac{L}{2}\right)\times L=\frac{iL^2}{2}=\frac{\mu_1}{2}$

$$\Rightarrow \mu_2=M\sqrt{2}=\frac{\mu_1}{2}\times\sqrt{2}=\frac{\mu_1}{\sqrt{2}}$$

40. (a) By using $B=\frac{\mu_0}{4\pi}\cdot\frac{i}{a}(\sin\phi_1+\sin\phi_2)$

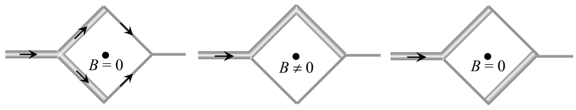
$$\Rightarrow B=\frac{\mu_0}{4\pi}\cdot\frac{i}{(L/4)}(2\sin\phi)$$

Also $\sin\phi=\frac{L/2}{\sqrt{5}L/4}=\frac{2}{\sqrt{5}}$

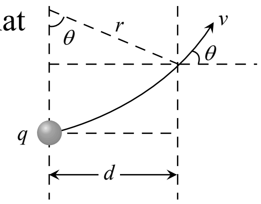


$\Rightarrow B = \frac{4\mu_0 i}{\sqrt{5}\pi L}$

41. (d) In P and R loops, currents are divided in same proportion because the branches have equal resistance. Hence magnetic field produced at centre due to each segment is of equal magnitude but of opposite direction, so net field is zero.



42. (a) From figure it is clear that



$\sin\theta = \frac{d}{r}$ also $r = \frac{p}{qB}$

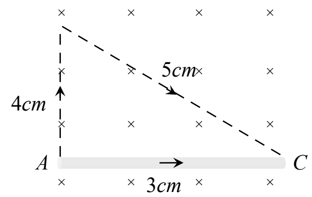
$\therefore \sin\theta = \frac{Bqd}{p}$

43. (a) $\vec{F}_{CAD} = \vec{F}_{CD} = \vec{F}_{CED}$

$\therefore$ Net force on frame $= 3\vec{F}_{CD} = (3)(2)(1)(4)$ $(F = ilB)$

$= 24\ N$

44. (b) The given curved wire can be treated as a straight wire as shown

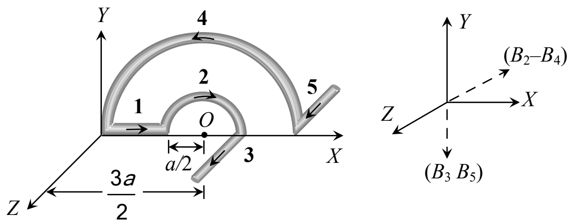


Force acting on the wire AC, $F = Bil = 2\times2\times3\times10^{-2}$

$= 12\times10^{-2}\ N$ along y-axis.

So acceleration of wire $= \frac{F}{m} = \frac{12\times10^{-2}}{10\times10^{-3}} = 12\ m/s^2$

45. (b)



Magnetic field at 0 due to

Part (1) : $B_1 = 0$

Part (2): $B_2 = \frac{\mu_0}{4\pi}.\frac{\pi i}{(a/2)}\otimes$ (along –Z-axis)

Part (3): $B_3 = \frac{\mu_0}{4\pi}.\frac{i}{(a/2)}(\downarrow)$ (along – Y-axis)

Part (4): $B_4 = \frac{\mu_0}{4\pi}.\frac{\pi i}{(3a/2)}\odot$ (along +Z-axis)

Part (5): $B_5 = \frac{\mu_0}{4\pi}.\frac{i}{(3a/2)}(\downarrow)$ (along – Y-axis)

$B_2 - B_4 = \frac{\mu_0}{4\pi}.\frac{\pi i}{a}\left(2 - \frac{2}{3}\right) = \frac{\mu_0 i}{3a}\otimes$ (along – Z-axis)

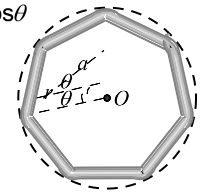
$B_3 + B_5 = \frac{\mu_0}{4\pi}.\frac{1}{a}\left(2 + \frac{2}{3}\right) = \frac{8\mu_0 i}{12\pi a}(\downarrow)$ (along – Y-axis)

Hence net magnetic field

$B_{net} = \sqrt{(B_2 - B_4)^2 + (B_3 + B_5)^2} = \frac{\mu_0 i}{3\pi a}\sqrt{\pi^2 + 4}$

46. (b) Magnetic field at the centre due to one side

$B_1 = \frac{\mu_0}{4\pi}.\frac{2i\sin\theta}{r}$ where $r = a\cos\theta$

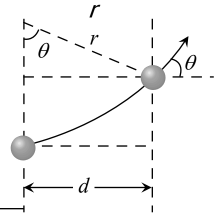


So $B_1 = \frac{\mu_0}{4\pi}.\frac{2i\sin\theta}{a\cos\theta} = \frac{\mu_0 i}{2\pi a}\tan\theta$

Hence net magnetic field

$B_{net} = n\times\frac{\mu_0 i}{2\pi a}\tan\frac{\pi}{n}$.

47. (b) According to following figure $\sin\theta = \frac{d}{r}$



also $r = \frac{\sqrt{2mk}}{qB} = \frac{1}{B}\sqrt{\frac{2mV}{q}}$

$\therefore \sin\theta = Bd\sqrt{\frac{q}{2mV}}$

$= 0.51\times0.1\sqrt{\frac{1.6\times10^{-19}}{2\times1.67\times10^{-27}\times500\times10^3}}$

$= \frac{1}{2} \Rightarrow \theta = 30^o$

48. (b) The field at the midpoint of BC due to AB is $\left(-\frac{\mu_0}{4\pi}.\frac{i}{d/2}\hat{k}\right)$ and the same is due to CD.

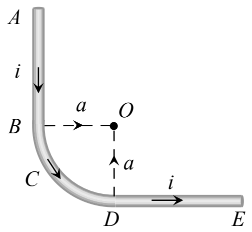
Therefore the total field is $\left[-\left(\frac{\mu_0 i}{\pi d}\right)\hat{k}\right]$

49. (a) The electron reverses it's direction. It can be done by covering semi-circular path in x-z or x-y plane.

50. (d) The field at 0 due to AB is $\frac{\mu_0}{4\pi}.\frac{i}{a}\hat{k}$ and that due to DE is also $\frac{\mu_0}{4\pi}.\frac{i}{a}\hat{k}$.

However the field due to BCD is $\frac{\mu_0}{4\pi}.\frac{i}{a}\left(\frac{\pi}{2}\right)\hat{k}$.

Thus the total field at O is $\frac{\mu_0}{4\pi}.\frac{i}{a}\left(2+\frac{\pi}{2}\right)\hat{k}$



51. (d) The energy of a charged particle moving in magnetic field remains constant because the magnetic field does not do any work. Therefore kinetic energy is constant *i.e.* $u = v$.

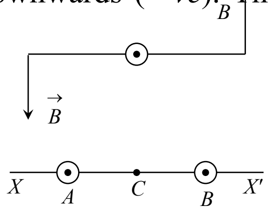
The force on electron will act along negative y-axis initially. The electron will undergo circular motion in clockwise direction and emerge out the field. So $y < 0$.

Graphical Questions

1. (c) $|\vec{B}| = \frac{\mu_0}{4\pi}.\frac{2\pi i}{r} \Rightarrow |\vec{B}| \propto \frac{1}{r}$

2. (a) Every point on line AB will be equidistant from X and Y-axis. So magnetic field at every point on line AB due to wire 1 along X-axis is equal in magnitude but opposite in direction to the magnetic field due to wire along Y-axis. Hence B_{net} on $AB = 0$

3. (b) If the current flows out of the paper, the magnetic field at points to the right of the wire will be upwards and to the left will be downward. Now magnetic field at C, is zero. The field in the region BX' will be upwards (+*ve*) because all points lying in this region are to the right of both the wires. Similarly, magnetic field in the region AX will be downwards (– *ve*). The field in the region AC will be upwards (+*ve*) because points are closer to A compared to B. Similarly magnetic field in region BC will be downward (–*ve*). Graph *(b)* satisfies all these conditions.

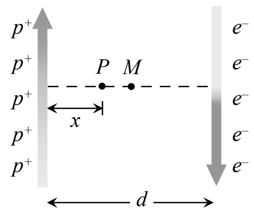


4. (a) Magnetic field inside the conductor $B_{in} \propto r$ and magnetic field outside the conductor $B_{out} \propto \frac{1}{r}$

(where r is the distance of observation point from axis)

5. (c) The magnetic field at points to the right of the proton beam acts perpendicular to the paper inwards (×). The magnetic field at points to the left of the electron beam acts perpendicular to the paper outwards (·).

Magnetic field at mid point M is zero.



Magnetic field at the points closer to proton beam acts perpendicular to the paper inwards (*i.e.* (×)) and at the points closer to electron beam it acts outwards *i.e.* (·). In the given options graph *(c)* satisfies all the conditions.

6. (a) Magnetic field inside the hollow metallic cylinder $B_{in} = 0$, and magnetic field outside it $B_{out} \propto \frac{1}{r}$

7. (a) Magnetic field in the middle of the solenoid's is maximum, magnetic field at the and $B_{end} = \frac{1}{2} B_{\text{centre}}$.

8. (b) The charge will not experience any force if $|\vec{F_e}| = |\vec{F_m}|$. This condition is satisfied in option (*b*) only.

9. (c) The given portion of the curved wire may be treated as a straight wire of length 2*L* which experiences a magnetic force $F_m = Bi(2L)$

10. (a) $\tau = NBiA\sin\theta$ so the graph between τ and θ is a sinusoidal graph.

11. (c) For undeviated motion $|\vec{F_e}| = |\vec{F_m}|$, which happened when $\vec{v}, \vec{E}$ and $\vec{B}$ are mutually perpendicular to each other.

12. (a) If at a place, magnetic induction is *B,* then energy density will be equal to $U = \frac{B^2}{2\mu_0}$. It means, graph between *U* and *B* will be a parabola passing through origin and symmetric about *U*-axis.

13. (b, c) Since length of the wire is equal to *l*, therefore, $2\pi Rn = l$ or $n = \frac{l}{2\pi R}$.

Magnetic induction at centre of a circular coil is given by $B = \frac{\mu_0}{4\pi} \cdot \frac{2\pi ni}{R} = \frac{\mu_0 l i}{4\pi R^2}$ $\Rightarrow$ $B \propto \frac{1}{R^2}$

It means, when $R \to 0, B \to \infty$ and $R \to \infty, B \to 0,$

Hence (b) is correct and (d) is wrong.

Substituting $R = \frac{l}{2\pi n}$ in $B = \frac{\mu_0}{4\pi} \cdot \frac{2\pi ni}{R}$

$B \propto n^2$. It means graph between *B* and *n* will be a parabola having increasing slope and passing through origin. Hence (c) is correct and (a) is wrong.

14. (b) When a current flows through cylindrical shell, then according to Ampere circuital law, magnetic induction inside it will be equal to zero. Hence energy density at $r < R$ is equal to zero.

Therefore, (a), (c) and (d) are wrong.

When *r* > *R,* $B = \frac{\mu_0 i}{2\pi r}$.

Since $U = \frac{B^2}{2\mu_0}$, therefore, outside the shell,

$U = \frac{\mu_0 i^2}{8\pi^2 r^2}$. It means, just outside the shell,

$U = \frac{\mu_0 i^2}{8\pi^2 R^2}$ and when $r \to \infty, U \to 0$.

Hence (b) is correct.

15. (b) Energy density in previous objective, at $r = 2R$, will be equal to $U = \frac{\mu_0 i^2}{32\pi^2 R^2}$ or $U \propto i^2$.

It means, graph-between *U* and *i* will be a parabola, passing through origin, symmetric about *U*-axis and having increasing slope. Hence (b) is correct.

16. (b) Direction of magnetic field at every point on axis of a current carrying coil remains same though magnitude varies. Hence magnetic induction for whole the *x*-axis will remain positive.

Therefore, (c) and (d) are wrong.

Magnitude of magnetic field will very with *x* according to law, $B = \frac{\mu_0 NIR^2}{2(R^2 + x^2)^{3/2}}$.

Hence, at $x = 0, B = \frac{\mu_0 NI}{2R}$ and when $x \to \infty, B \to 0$.

Slope of the graph will be $\frac{dB}{dx} = -\frac{3\mu_0 NIR^2 . x}{2(R^2 + x^2)^{5/2}}$.

It means, at *x* = 0, slope is equal to zero or tangent to the graph at *x* = 0*,* must be parallel to *x*-axis.

Hence (b) is correct and (a) is wrong.

Assertion and Reason

1. (a) Cyclotron is suitable for accelerating heavy particles like protons, α-particles *etc*, and not for electrons because of low mass. Because electrons acquire very high velocities very near to velocity of light and appreciable variation in their mass, occurs.

2. (c) Cyclotron is utilised to accelerate the positive ion. And cyclotron frequency is given by $\nu = \frac{Be}{2\pi m}$. It means cyclotron frequency doesn't depends upon velocity. Therefore, assertion is true and reason false.

3. (a) A moving charge experiences a force in magnetic field. It is because of interaction of two magnetic fields, one which is produced due to the motion of charge and other in which charge is moving.

4. (e) In this case we can not be sure about the absence of the magnetic field because if the electron moving parallel to the direction of magnetic field, the angle between velocity and applied magnetic field is zero ($F = 0$). Then also electron passes without deflection. Also $F = evB\sin\theta \Rightarrow F \propto B$.

5. (a) In the absence of the electric current, the free electrons in a conductor are in a state of random motion, like molecules in a gas. Their average velocity is zero. *i.e.* they do not have any net velocity in a direction. As a result, there is no net magnetic force on the free electrons in the magnetic field. On passing the current, the free electrons acquire drift velocity in a definite direction, hence magnetic force acts on them, unless the field has no perpendicular component.

6. (c) Time taken is independent of velocity and radius of path. However, maximum velocity will be given by $v_{\max} = \frac{qBR}{m}$ where R is radius of Dee's.

7. (a) Due to metallic frame the deflection is only due to current in a coil and magnetic field, not due to vibration in the strings. If string start oscillating, presence of metallic frame in the field make these oscillations damped.

8. (c) The direction of magnetic field due to current carrying conductor can be found by applying right hand thumb rule or right hand palm rule. When electric current is passed through a circular conductor, the magnetic field lines near the center of the conductor are almost straight lines. Magnetic flux direction is determined only by the direction of current.

9. (a) The force on a charged particle moving in a uniform magnetic field always acts in direction perpendicular to the direction of motion of the charge. As work done by magnetic field on the charge is zero, [$W = FS\cos\theta$], so the energy of the charged particle does not change.

10. (b) We know that the direction of the earth's magnetic field is toward north and the velocity of electron is vertically downward. Applying Fleming's left hand rule, the direction of force is towards west. Therefore, an electron coming from outer space will be deflected toward west.

11. (d) In the case of metallic rod, the charge carriers flow through whole of the cross section. Therefore, the magnetic field exists both inside as well as outside. However magnetic field inside the rod will go on decreasing as we go towards the axis.

12. (e) The force experienced by a charge particle in a magnetic field is given by, $\vec{F} = q(\vec{v} \times \vec{B})$ which is independent of mass. As q, v and B are same for both the electron and proton, hence both will experience same force.

13. (b) The torque on the coil in a magnetic field is given by $\tau = nIBA \cos\theta$

For radial field, the coil is set with its plane parallel to the direction of the magnetic field B, then $\theta = 0^o$ and $\cos\theta = 1 \Rightarrow$ Torque = $nIBA$ (1) = $nIBA$ (maximum).

14. (b) The winding of helix carry currents in the same direction therefore they experience an attractive force pulling the lower end out of mercury. As a result of this, the circuit breaks, current becomes zero and hence the force of attraction vanishes. Therefore helix comes back to its final position, completing the circuit again. In this way, the process is repeated and helix executes oscillatory motion.

15. (b) For a solenoid $B_{end} = \frac{1}{2}(B_{in})$. Also for a long solenoid, magnetic field is uniform within it but this reason is not explaining the assertion.

16. (d) When a charged particle is moving on a circular path in a magnetic field, the magnitude of velocity does not change but direction of velocity is changing every moment. Hence velocity is changing, so momentum $(m\vec{v})$ is also changing.

17. (b) Time period, $T = \frac{2\pi m}{Bq}$ as $\left(\frac{m}{q}\right)_\alpha = 2\left(\frac{m}{q}\right)_p \Rightarrow$

$T_\alpha = 2T_p$

Also $T \propto m$, but then $T_\alpha = 4T_p$ which is not the case.

18. (d) When two long parallel wires, are connected to a battery in series. They carry currents in opposite directions, hence they repel each other.

19. (a) Here, both Assertion and Reason are correct and reason is the correct explanation of assertion.