Answers

Faraday's and Lenz's Law

1	c	2	d	3	b	4	d	5	b
6	c	7	a	8	c	9	a	10	b
11	a	12	b	13	b	14	a	15	d
16	d	17	c	18	b	19	b	20	b
21	b	22	c	23	b	24	b	25	d
26	c	27	d	28	b	29	d	30	d
31	b	32	a	33	b	34	a	35	b
36	b	37	d	38	a	39	a	40	c
41	c	42	b	43	c	44	c	45	d
46	d	47	d	48	d	49	d	50	c
51	b	52	a	53	d	54	b	55	b
56	a	57	c	58	a	59	d	60	b
61	a	62	a	63	d	64	d	65	c
66	c	67	a	68	b				

Motional EMI

1	a	2	b	3	d	4	c	5	b
6	b	7	b	8	c	9	d	10	d
11	b	12	c	13	b	14	c	15	d
16	c	17	c	18	b	19	c	20	b
21	d	22	d	23	d	24	d	25	c
26	a	27	c	28	c	29	c	30	d
31	b	32	b	33	b				

Static EMI

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

Application of EMI (Motor, Dynamo, Transformer ...)

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

Critical Thinking Questions

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

Graphical Questions

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

Assertion and Reason

1	b	2	b	3	c	4	c	5	e
6	e	7	a	8	b	9	c	10	a
11	a	12	b	13	a	14	e	15	a
16	a	17	c	18	b	19	d	20	a

21	a	22	e	23	d	24	d		

Answers and Solutions

Faraday's and Lenz's Law

1. (c) Because induced e.m.f. is given by $E = -N\frac{d\phi}{dt}$.

2. (d) The energy of the field increases with the magnitude of the field. Lenz's law infers that there is an opposite field created due to increase or decrease of magnetic flux around a conductor so as to hold the law of conservation of energy.

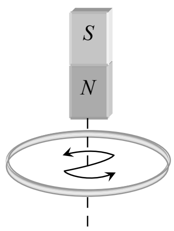
3. (b) We know that $e = \frac{d\phi}{dt}$

   But $e = iR$ and $i = \frac{dq}{dt} \Rightarrow \frac{dq}{dt}R = \frac{d\phi}{dt} \Rightarrow dq = \frac{d\phi}{R}$

4. (d) Similar to Q.3

5. (b) Because there is no change in flux linked with coil

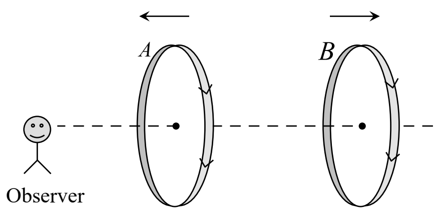
6. (c) As it is seen from the magnet side induced current will be anticlockwise.



7. (a) $e = -\frac{d\phi}{dt} = \frac{-3B_0A_0}{t}$

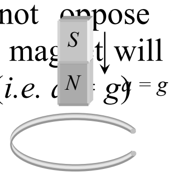
8. (c) $e = -\frac{d\phi}{dt} = -(16t + 3) = -67\,units$

9. (a) Induced current in both the coils assist the main current so current through each coil increases.



10. (b) When the magnet is allowed to fall vertically along the axis of loop with its north pole towards the ring. The upper face of the ring will become north pole in an attempt to oppose the approaching north pole of the magnet. Therefore the acceleration in the magnet is less than g.

    Note : If coil is broken at any point then induced *emf* will be generated in it but no induced current will flow. In this condition the coil will not oppose the motion of magnet and the magnet will fall freely with acceleration g. (*i.e.* $a = g$)



11. (a) $\phi = BA = 10\,weber$

12. (b) The magnitude of induced e.m.f. is directly proportional to the rate of change of magnetic flux. Induced charge doesn't depend upon time.

13. (b)

14. (a) $I = \frac{e}{R} = \frac{-N(d\phi/dt)}{R} = \frac{10 \times 10^8 \times 10^{-4} \times 10^{-4} \times 10}{20} = 5\,A$

15. (d) Induced charge doesn't depend upon the speed of magnet.

16. (d) $|e| = N\left(\frac{\Delta B}{\Delta t}\right).A\cos\theta = 500 \times 1 \times (10 \times 10^{-2})^2 \cos 0 = 5\,V.$

17. (c) When frequency is high, the galvanometer will not show deflection.

18. (b) $e = -\frac{N(B_2 - B_1)A\cos\theta}{\Delta t}$

    $= -\frac{500 \times (0 - 0.1) \times 100 \times 10^{-4}\cos 0}{0.1} = 5\,V$

19. (b) $e = -\frac{N(B_2 - B_1)A\cos\theta}{\Delta t}$

    $= -\frac{50(0.35 - 0.10) \times \pi(3 \times 10^{-2})^2 \times \cos 0^o}{2 \times 10^{-3}} = 17.7\,V.$

20. (b) $|e| = A\frac{\Delta B}{\Delta t} = 2 \times \frac{(4-1)}{2} = 3\,V.$

21. (b) $e = -\dfrac{NBA(\cos\theta_2 - \cos\theta_1)}{\Delta t}$

$= -2000 \times 0.3 \times 70 \times 10^{-4}\,\dfrac{(\cos 180 - \cos 0)}{0.1}$

$\Rightarrow e = 84\ V$

22. (c) The induced current will be in such a direction so that it opposes the change due to which it is produced.

23. (b)

24. (b)

25. (d) According to Lenz's law.

26. (c) $e = -N\left(\dfrac{\Delta B}{\Delta t}\right).A\cos\theta = -100 \times \dfrac{(6-1)}{2} \times (40 \times 10^{-4})\cos 0$

$\Rightarrow |e| = 1\ V$

27. (d)

28. (b)

29. (d)

30. (d) Emf induces in ring and it will opposes the motion. Hence due to the resistance of the ring all energy dissipates.

31. (b) $\Delta Q = \dfrac{NBA}{R}(\cos\theta_1 - \cos\theta_2)$

$= \dfrac{500 \times 0.2 \times 0.1(\cos 0 - \cos 180)}{50} = 0.4\ C$

32. (a) $\phi = NBA\cos\theta = 100 \times 0.2 \times 5 \times 10^{-4}\cos 60^o$

$= 5 \times 10^{-3}\ Wb$

33. (b) $\Delta Q = \dfrac{\Delta\phi}{R} = \dfrac{(10-2)}{2} = 4\,C$

34. (a)

35. (b)

36. (b) $\phi = \mu_0 niA = 4\pi \times 10^{-7} \times \dfrac{3000}{1.5} \times 2 \times \pi(2 \times 10^{-2})^2$

$= 6.31 \times 10^{-6}\ Wb$

37. (d) $q = -\dfrac{N}{R}(B_2 - B_1)A\cos\theta$

$32 \times 10^{-6} = -\dfrac{100}{(160+40)}(0 - B) \times \pi \times (6 \times 10^{-3})^2 \times \cos 0^o$

$\Rightarrow B = 0.565\ T$

38. (a) Faraday's laws involve conversion of mechanical energy into electric energy. This is in accordance with the law of conservation of energy.

39. (a) $e = -\dfrac{N(B_2 - B_1)A\cos\theta}{\Delta t}$

$\Rightarrow 0.1 = \dfrac{-50 \times (0 - 2 \times 10^{-2}) \times 100 \times 10^{-4} \times \cos 0^o}{t}$

$\Rightarrow t = 0.1\,sec.$

40. (c) $q = \dfrac{N}{R}d\phi \quad \therefore q \propto d\phi$

41. (c) $i = \dfrac{|e|}{R} = \dfrac{N}{R}.\dfrac{\Delta B}{\Delta t}A\cos\theta = \dfrac{20}{100} \times 1000 \times (25 \times 10^{-4})\cos 0^o$

$\Rightarrow i = 0.5\ A$

42. (b) According to Lenz's law.

43. (c)

44. (c) E.m.f. or current induces, only when flux linked with the coil changes.

45. (d) $e = -\dfrac{d\phi}{dt} = -\dfrac{d}{dt}(3t^2 + 4t + 9) = -(6t + 4)$

$e = -[6(2) + 4] = -16 \Rightarrow |e| = 16\ volt$

46. (d) $e = -\dfrac{NBA(\cos\theta_2 - \cos\theta_1)}{\Delta t}$

$= -\dfrac{800 \times 4 \times 10^{-5} \times 0.05(\cos 90^o - \cos 0^o)}{0.1} = 0.016\ V$

47. (d)

48. (d)

49. (d) $e = -\dfrac{d\phi}{dt} = -(10t - 4) \Rightarrow$

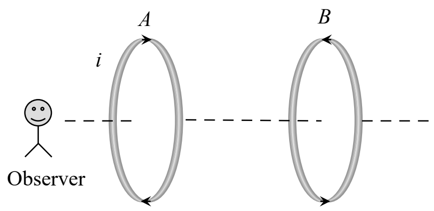
$(e)_{t=2} = -(10 \times 0.2 - 4) = 2\ volt$

50. (c)

51. (b)

52. (a) If bar magnet is falling vertically through the hollow region of long vertical copper tube then the magnetic flux linked with the copper tube (due to 'non-uniform' magnetic field of magnet) changes and eddy currents are generated in the body of the tube by Lenz's law the eddy currents opposes the falling of the magnet which therefore experience a retarding force. The retarding force increases with increasing velocity of the magnet and finally equals the weight of the magnet. The magnet then attains a constant final terminal velocity *i.e.* magnet ultimately falls with zero acceleration in the tube.

53. (d)



If current through A increases, crosses (X) linked with coil B increases, hence anticlockwise current induces in coil *B*. As shown in figure both the current produces repulsive effect.

54. (b) $e = -\frac{d\phi}{dt} = -\frac{d}{dt}\left(5t^3 - 100t + 300\right)$

$= -(15t^2 - 100)$ at $t = 2 sec$; $e = 40\ V$

55. (b) By using $e = -\frac{NBA(\cos\theta_2 - \cos\theta_1)}{\Delta t}$

$e = -\frac{1000 \times 2 \times 10^{-5} \times 500 \times 10^{-4}\left(\cos 180^o - \cos 0^o\right)}{0.2}$

$= 10^{-2}\ volt = 10 mV$

56. (a) Similar to Q. 52

57. (c)

58. (a) Induced charge $Q = -\frac{N}{R}(\phi_2 - \phi_1) = \frac{1}{100}(60 - 10) = 0.5C$

59. (d)

60. (b) $i = \frac{e}{R} = \frac{-N}{R}\frac{(\phi_2 - \phi_1)}{\Delta t} = \frac{-n(W_2 - W_1)}{5Rt}$

61. (a) Magnetic flux linked with the ring changes so current flows through it.

62. (a) $|e| = \frac{d\phi}{dt} = \frac{d}{dt}(5t^2 + 3t + 16) = (10t + 3)$

when $t = 3\,\text{sec}, e_3 = (10 \times 3 + 3) = 33\ V$

when $t = 4\,\text{sec}, e_4 = (10 \times 4 + 3) = 43\ V$

Hence emf induced in fourth second

$= e_4 - e_3 = 43 - 33 = 10\ V$

63. (d) $e = \frac{-NBA(\cos\theta_2 - \cos\theta_1)}{\Delta t}$

$= -\frac{500 \times 4 \times 10^{-4} \times 0.1(\cos 90 - \cos 0)}{0.1} = 0.2\ V$

64. (d) $q = \frac{N}{R}(\Delta\phi) = \frac{1}{2} \times (10 - 2) = 4C$

65. (c) At low frequency of 1 to 2 *Hz*, oscillations may be observed as our eyes will be able to detect it.

66. (c) Since the magnetic field is uniform therefore there will be no change in flux hence no current will be induced.

67. (a) $\phi = BA$

$\Rightarrow$ change in flux $d\phi = B.dA =$ $0.05\,(101 - 100)\,10^{-4}$

$= 5.10^{-6}$ Wb.

Now, charge $dQ = \frac{d\phi}{R} = \frac{5 \times 10^{-6}}{2} = 2.5 \times 10^{-6}\ C.$

68. (b) $\Delta Q = \frac{\Delta\phi}{R} = \frac{n \times BA}{R}$

$\Rightarrow B = \frac{\Delta Q.R}{nA} = \frac{2 \times 10^{-4} \times 80}{40 \times 4 \times 10^{-4}} = 1\ Wb/m^2$

Motional EMI

1. (a) Emf = $e = e_0 \sin\theta$; *e* will be maximum when θ is 90º *i.e.* plane of the coil will be horizontal.

2. (b) Induced e.m.f. $= Blv = 0.3 \times 10^{-4} \times 10 \times 5$

$= 1.5 \times 10^{-3}\ V = 1.5\ mV$

3. (d) Conductor cuts the flux only when, if it moves in the direction of *M*.

4. (c) $e = B_v.vl = 0.2 \times 10^{-4} \times \left(\frac{180 \times 1000}{3600}\right) \times 1 = 10^{-3}\ V$

5. (b) $e = Bvl = 3 \times 10^{-3} \times 10^2 = 0.3\ volt$

6. (b) This is the case of periodic EMI

7. (b) $e = B_v.v.l = 2 \times 10^{-4} \times \left(\frac{360 \times 1000}{3600}\right) \times 50 \Rightarrow e = 1\ V$

8. (c) $e = \frac{1}{2}B\omega r^2 = \frac{1}{2} \times 0.1 \times 2\pi \times 10 \times (0.1)^2 = \pi \times 10^{-2}\ V$

9. (d) $e = \frac{1}{2}B\omega r^2 = \frac{1}{2} \times 0.2 \times 10^{-4} \times 5 \times (1)^2 = 50\mu V$

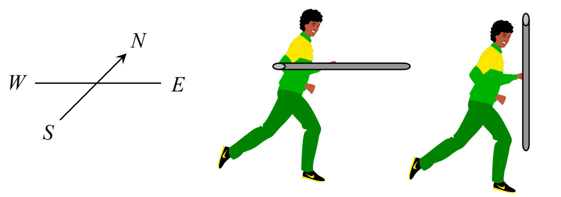
10. (d) No flux change is taking place because magnetic field exists everywhere and is constant in time and space.

11. (b) If player is running with rod in vertical position towards east, then rod cuts the magnetic field of earth perpendicularly (magnetic field of earth is south to north).

Hence Maximum emf induced is

$e = Bvl = 4 \times 10^{-5} \times \frac{30 \times 1000}{3600} \times 3 = 1 \times 10^{-3}\ volt$

When he is running with rod in horizontal position, no field is cut by the rod, so *e* = 0.



12. (c) $e = NBA\omega;\ \omega = 2\pi f = 2\pi \times \frac{2000}{60}$

$\therefore e = 50 \times 0.05 \times 80 \times 10^{-4} \times 2\pi \times \frac{2000}{60} = \frac{4\pi}{3}$

13. (b)

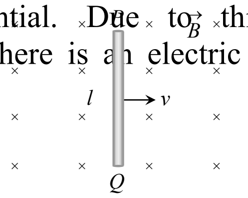
14. (c) According to Fleming right hand rule, the direction of *B* will be perpendicular to the plane of paper and act downward.

15. (d) By Fleming's right hand rule.

16. (c) $e = Bvl \Rightarrow e \propto v \propto gt$

17. (c) $e = Bvl = 0.5 \times 2 \times 1 = 1\ V$

18. (b) A motional emf $e = Bvl$ is induced in the rod, or we can say, a potential difference is induced between the two ends of the rod *AB*, with *P* at higher potential and *Q* at lower potential. Due to this potential difference, there is an electric field in the rod.



19. (c)

20. (b) $e = Bvl \Rightarrow e = 0.7 \times 2 \times (10 \times 10^{-2}) = 0.14\ V$

21. (d) $e = Bvl \Rightarrow e = 0.9 \times 7 \times 0.4 = 2.52\ V$

22. (d)

23. (d)

24. (d) $e = Bl^2 \pi v = 0.4 \times 10^{-4} \times (0.5)^2 \times (3.14) \times \frac{120}{60}$

$= 6.28 \times 10^{-5}\ V$

25. (c) $e = \frac{1}{2} Bl^2 \omega = \frac{1}{2} \times 0.3 \times (2)^2 \times 100 = 60\ V$

26. (a) $e = Bvl = 5 \times 10^{-5} \times \frac{360 \times 1000}{3600} \times 20 = 0.1\ V$

27. (c)

28. (c) Peak value of $emf = e_0 = \omega NBA = 2\pi \nu NBA$

$= 2\pi \times 50 \times 300 \times 4 \times 10^{-2} \times (25 \times 10^{-2} \times 10 \times 10^{-2})$

$= 30\ \pi\ volt$

29. (c) $e = \frac{1}{2} Bl^2 \omega = Bl^2 \pi \nu$

$\Rightarrow e = 0.5 (20 \times 10^{-2})^2 \times 3.14 \times 100 = 6.28\ V$

30. (d)

31. (b) $e_0 = \omega NBA = (2\pi\nu) NB(\pi r^2) = 2 \times \pi^2 \nu\ NBr^2$

$= 2 \times (3.14)^2 \times \frac{1800}{60} \times 4000 \times 0.5 \times 10^{-4} \times (7 \times 10^{-2})^2$

$= 0.58\ V$

32. (b) Two emf's induces in the closed circuit each of value Blv. These two emf's are additive. So $E_{net} = 2Blv$.

33. (b) When a conductor lying along the magnetic north-south, moves eastwards it will cut vertical component of B_0. So induced *emf*

$e = vB_V l = vl(B_0 \sin\delta\ l) = B_0 lv \sin\delta$.

Static EMI

1. (d) $e = -L\frac{di}{dt}$ but $e = 4V$ and $\frac{di}{dt} = \frac{0-1}{10^{-3}} = -1/10^{-3}$

$\therefore \frac{-1}{10^{-3}}(-L) = 4 \Rightarrow L = 4 \times 10^{-3}\ henry$

2. (d) $L = \frac{e}{di/dt} = \frac{5}{(3-2)/10^{-3}} = \frac{5}{1} \times 10^{-3} = 5\ milli\ henry$

3. (b) Energy stored $E = \frac{1}{2} Li^2 = \frac{1}{2} \times 50 \times 10^{-3} \times 4 = 0.1\ J$

4. (a) Given $\frac{di}{dt} = 2\ A/sec,\ L = 5\ H$

$\therefore e = L\frac{di}{dt} = 5 \times 2 = 10\ V$

5. (d) As we know $e = -\frac{d\phi}{dt} = -L\frac{di}{dt}$

Work done against back e.m.f. *e* in time *dt* and current *i* is

$dW = -e i dt = L\frac{di}{dt} i dt = Li\ di \Rightarrow W = L\int_0^i i\ di = \frac{1}{2} Li^2$

6. (d) Induced emf $e = M\frac{di}{dt} = \frac{\mu_0 N_1 N_2 A}{l} \cdot \frac{di}{dt}$

$= \frac{4\pi \times 10^{-7} \times 2000 \times 300 \times 1.2 \times 10^{-3}}{0.30} \times \frac{|2-(-2)|}{0.25}$

$= 48.2 \times 10^{-3}\ V = 48\ mV$

7. (c) Self inductance $L = \mu_0 N^2 A / l = \mu_0 n^2 lA$

Where *n* is the number of turns per unit length and *N* is the total number of turns and $N = nl$

In the given question *n* is same. *A* is increased 4 times and *l* is increased 2 times and hence *L* will be increased 8 times.

8. (c) $M = -\frac{e_2}{di_1/dt} = -\frac{e_1}{di_2/dt}$

Also $e_1 = -L_1 \frac{di_1}{dt} . e_2 = -L_2 \frac{di_2}{dt}$

$$M^2 = \frac{e_1 e_2}{\left(\frac{di_1}{dt}\right)\left(\frac{di_2}{dt}\right)} = L_1 L_2 \Rightarrow M = \sqrt{L_1 L_2}$$

9. (c) Inductance is inherent property of electrical circuits. It will always be found in an electrical circuit whether we want it or not. The circuit in which a large emf is induced when the current in the circuit changes is said to have greater inductance. A straight wire carrying current with no iron part in the circuit will have lesser value of inductance while if the circuit contains a circular coil having many number of turns, the induced emf to oppose the cause will be greater and the circuit is therefore said to have greater value of inductance.

10. (c) Magnetic flux $\phi = LI$

By analogy, since physical quantities mass *(m)* and linear velocity *(v)* are equivalent to electrical quantities inductance *(L)* and current *(I)* respectively. Thus magnetic flux $\phi = LI$ is equivalent to momentum $p = m \times v$.

11. (a) Energy stored $= \frac{1}{2} Li^2$, where Li is a magnetic flux.

12. (b) $L = \mu n i \Rightarrow \frac{L_2}{L_1} = \frac{\mu}{\mu_0}$ (n and i are same)

$\Rightarrow L_2 = \mu_r L_1 = 900 \times 0.18 = 162 \, mH$

13. (b) $e = M \frac{di}{dt} = 0.2 \times 5 = 1 \, V$

14. (d) $e = -L \frac{di}{dt} \Rightarrow 2 = -L\left(\frac{8-2}{3 \times 10^{-2}}\right) \Rightarrow L = 0.01 \, H = 10 \, mH$

15. (d) $e = M \frac{di}{dt} = 1.25 \times 80 = 100 \, V$

16. (b) $\frac{L_B}{L_A} = \left(\frac{n_B}{n_A}\right)^2 \Rightarrow L_B = \left(\frac{500}{600}\right)^2 \times 108 = 75 \, mH$

17. (a) $L \propto N^2$ *i.e.* $\frac{L_1}{L_2} = \left(\frac{N_1}{N_2}\right)^2 \Rightarrow L_2 = L_1\left(\frac{N_2}{N_1}\right)^2 = 4L_1$

18. (b) $e = -L \frac{di}{dt} \Rightarrow 8 = L \frac{(4-2)}{0.05} \Rightarrow L = 0.2 \, H$

19. (b) $e = M \frac{di}{dt} \Rightarrow M = \frac{15000}{3} \times 0.001 = 5 \, H$

20. (b) $L = \frac{e}{di/dt} = \frac{12}{48/60} = 15 \, H$

21. (a) $B = \frac{\mu_0 Ni}{2r} = \frac{4\pi \times 10^{-7} \times 100 \times 2 \times \sqrt{\pi}}{2 \times 10^{-2}} = 0.022 \, wb/m^2$

22. (d) $e = M \frac{di}{dt} = 0.09 \times \frac{20}{0.006} = 300 \, V$

23. (c)

24. (c) Inductors obey the laws of parallel and series combination of resistors.

25. (b) There will be self induction effect when soft iron core is inserted.

26. (c) $L = \mu_0 N^2 A / l$

27. (b)

28. (c) $e = -L \frac{di}{dt} \Rightarrow e = 5 \times \frac{1}{5} = 1 \, volt$

29. (c) $e = L \frac{di}{dt} \Rightarrow L = \frac{Volt - \sec}{Ampere}$

30. (d) $e = -L \frac{di}{dt} = -0.4 \times 10^{-3} \times \frac{250 \times 10^{-3}}{0.1} = -1 \, mV$

31. (b) In steady state current passing through solenoid

$i = \frac{E}{R} = \frac{10}{10} = 1 \, A$

32. (a) $e = L \frac{di}{dt} \Rightarrow 2 = L \times \frac{6}{3 \times 10^{-3}} \Rightarrow L = 1 \, mH$

33. (b) From $i = i_0[1 - e^{-Rt/L}]$, where $i_0 = \frac{5}{5} = 1 \, amp$

$\therefore i = 1\left(1 - e^{\frac{-5 \times 2}{10}}\right) = (1 - e^{-1}) amp$

34. (c) $M = \frac{\mu_0 N_1 N_2 A}{l}$

35. (d) $e = L \frac{di}{dt} = 60 \times 10^{-6} . \frac{(1.5 - 1.0)}{0.1} = 3 \times 10^{-4} \, volt$

36. (a) $\phi = Li \Rightarrow NBA = Li$

Since magnetic field at the centre of circular coil carrying current is given by $B = \frac{\mu_0}{4\pi} . \frac{2\pi Ni}{r}$

$\therefore N . \frac{\mu_0}{4\pi} . \frac{2\pi Ni}{r} . \pi r^2 = Li \Rightarrow L = \frac{\mu_0 N^2 \pi r}{2}$

Hence self inductance of a coil

$= \frac{4\pi \times 10^{-7} \times 500 \times 500 \times \pi \times 0.05}{2} = 25 \, mH$

37. (a) Induced $e.m.f.\ e = M\frac{di}{dt} \Rightarrow 100\times10^{-3} = M\left(\frac{10}{0.1}\right)$

$\therefore M = 10^{-3}\,H = 1\,mH$

38. (c) $\frac{\Delta i}{\Delta t} = \frac{10}{2} = 5\ A/\sec \Rightarrow e = L\frac{\Delta i}{\Delta t} = 0.5\times5 = 2.5\ volts$

39. (c) Time in which the current will decay to $\frac{1}{e}$ of its steady value is $t = \tau = \frac{L}{R} = \frac{50}{10} = 5\,seconds$

40. (a)

41. (d) $L \propto N^2$

42. (a) $e_2 = M\frac{di_1}{dt} \Rightarrow i_2R_2 = M\frac{di_1}{dt} \Rightarrow 0.4\times5 = 0.5\times\frac{di_1}{dt}$

$\Rightarrow \frac{di_1}{dt} = 4\ A/\sec.$

43. (a) $U = \frac{1}{2}Li^2 = \frac{1}{2}\times(50\times10^{-3})\times(4)^2 = 400\times10^{-3} = 0.4\,J$

44. (b) $e = -L\left(\frac{di}{dt}\right) \Rightarrow 8 = -L\times\left(-\frac{2}{0.05}\right) \Rightarrow L = 0.2H$

45. (b) $U = \frac{1}{2}Li^2$ i.e. $\frac{U_2}{U_1} = \left(\frac{i_2}{i_1}\right)^2 = \left(\frac{1}{2}\right)^2 = \frac{1}{4} \Rightarrow U_2 = \frac{1}{4}U_1$

46. (a, b, c, d)

47. (c) $|e| = L\frac{di}{dt} \Rightarrow 220 = L\times\frac{10}{0.5} \Rightarrow L = 11\ H$

48. (b)

49. (d) $t = \tau = \frac{L}{R} = \frac{2.5}{0.5} = 5\ \sec$

50. (c) $L = \mu_0\frac{N^2}{l}A$. When N and l are doubled. L is also doubled.

51. (c) Energy $= \frac{1}{2}Li^2 = \frac{1}{2}\times100\times10^{-3}\times1^2 = 0.05\,J$

52. (b) $e = -M\frac{di}{dt} = -5\times\frac{(-5)}{10^{-3}} = 25000\ V$

53. (a) $L \propto n$(Number of turns), For straight conductor $n = 0$, hence $L = 0$.

54. (a) $\Delta\phi = L\Delta I \Rightarrow L = \frac{\Delta\phi}{\Delta I} = \frac{2\times10^{-2}}{0.01} = 2H$

55. (a) $e = L\frac{di}{dt} \Rightarrow 100 = L\times\frac{4}{0.1} \Rightarrow L = 2.5\ H$

56. (a) The inductances are in parallel $\Rightarrow$ $L_{eq} = \frac{L}{3} = \frac{3}{3} = 1\ H$

57. (a) $|e| = M\frac{di}{dt} \Rightarrow 8\times10^{-3} = M\times3 \Rightarrow A_1 = 2.66mH$

58. (d) $|e| = L\frac{di}{dt} \Rightarrow 10 = L\times\frac{10}{1} \Rightarrow L = 1H$

59. (a) $N\phi = Li \Rightarrow \phi = \frac{Li}{N} = \frac{8\times10^{-3}\times5\times10^{-3}}{400} = 10^{-7} = \frac{\mu_0}{4\pi}wb$

60. (b) According to Lenz's law.

61. (d) $N\phi = Li \Rightarrow \frac{Nd\phi}{dt} = \frac{Ldi}{dt} \Rightarrow NB\frac{dA}{dt} = \frac{Ldi}{dt}$

$\Rightarrow \frac{1\times1\times5}{10^{-3}} = L\times\left(\frac{2-1}{2\times10^{-3}}\right) \Rightarrow L = 10H$

62. (b)

$L = \frac{\mu_0N^2A}{l} = \frac{4\pi\times10^{-7}\times(500)^2\times20\times10^{-4}}{0.5} = 1.25mH$

63. (a) $L_S = L_1 + L_2 = 10H$ ..... (i)

$L_P = \frac{L_1L_2}{L_1+L_2} = 2.4H$ ..... (ii)

On solving (i) and (ii) $L_1L_2 = 24$ ..... (iii)

Also $(L_1 - L_2)^2 = (L_1 + L_2)^2 - 4L_1L_2$

$\Rightarrow (L_1 - L_2)^2 = (10)^2 - 4\times24 = 4 \Rightarrow L_1 - L_2 = 2H$

64. (d) $e = L\frac{di}{dt} \Rightarrow 12 = L\times\frac{45}{60} \Rightarrow L = 16H$

65. (a) $|e| = L\frac{di}{dt} \Rightarrow 1 = \frac{L\times\{10-(-10)\}}{0.5} \Rightarrow L = 25mH$

66. (d) $U = \frac{1}{2}Li^2 \Rightarrow U = \frac{1}{2}\times5\times\left(\frac{100}{10}\right)^2 = 250J$

67. (c) $\phi = Mi \Rightarrow M = \frac{1.2\times10^{-2}}{0.01} = 1.2H$

68. (c) $U = \frac{1}{2}Li^2 \Rightarrow U = \frac{1}{2}\times40\times10^{-3}\times(2)^2 = 0.08\,J$

69. (c) $L \propto N^2$

70. (b) $N_2\phi_2 = Mi_1 \Rightarrow 9\times10^{-5} = M\times3 \Rightarrow M = 3\times10^{-5}\ H$

71. (a) $|e| = L\frac{di}{dt} \Rightarrow 20 = L\times\frac{(18-2)}{0.05} \Rightarrow L = 62.5\ mH$

72. (b) $|e| = L\frac{di}{dt} \Rightarrow |e| = 10\times10^{-6}\times\frac{1}{10} = 1\mu V$

73. (c)

74. (b) $\phi_T = Li \Rightarrow L = \frac{10^{-5}}{5\times10^{-3}} = 2mH$

75. (a) $L \propto N^2$

76. (c) $e = -L\frac{di}{dt}$, since current decreases so $\frac{di}{dt}$ is negative, hence $e = -5\times(-2) = +10V$

77. (c) $e = L\frac{di}{dt} \Rightarrow e = 0.1\times200 = 20V$

78. (c) $e = M\frac{di}{dt} \Rightarrow e = 0.1\times\frac{(20-0)}{0.02} = 100V$

79. (c) $L = \frac{\mu_0 N^2 A}{l} = \frac{4\pi \times 10^{-7} \times (1000)^2 \times 10 \times 10^{-4}}{1}$

=1.256 *mH*

80. (d) In secondary e.m.f. induces only when current through primary changes.

81. (b)

82. (c)

83. (a) $e = L\frac{di}{dt} \Rightarrow 8 = L \times \frac{(2-(-2))}{0.05} \Rightarrow L = 0.1H$

84. (b) $U = \frac{1}{2}Li^2 = \frac{1}{2}L\left(\frac{E}{R}\right)^2 = \frac{1}{2} \times 5 \times \left(\frac{100}{20}\right)^2 = 62.50\,J$

85. (a)

86. (a)

87. (a) $e = -L\frac{di}{dt} \Rightarrow 0.4 = -\frac{L(0.2-1)}{10} \Rightarrow L = 5\ H$

88. (c) $|e| = L\frac{di}{dt} \Rightarrow 30 = L \times \frac{(6-0)}{0.3} \Rightarrow L = 1.5\ H$

89. (b) $i = i_0\left(1 - e^{-\frac{Rt}{L}}\right) \Rightarrow \frac{di}{dt} = -i_0\left(-\frac{R}{L}\right)e^{-\frac{Rt}{L}} = \frac{i_0 R}{L}.e^{-\frac{Rt}{L}}$

At $t = 0$; $\frac{di}{dt} = \frac{i_0 R}{L} = \frac{E}{L} \Rightarrow 4 = \frac{E}{20} \Rightarrow E = 80\ V$

90. (d) $N\phi = Li \Rightarrow 100 \times 10^{-5} = L \times 5 \Rightarrow L = 0.2\ mH.$

91. (d) When the two coils are joined in series such that the winding of one is opposite to the other, then the emf produced in first coil is 180° out of phase of the emf produced in second coil.

Thus, emf produced in first coil is negative and the emf produced in second coil is positive so, net inductance is

$L = L_1 + L_2 = L + L \Rightarrow L = -\frac{\phi}{i} + \frac{\phi}{i} = 0$

92. (a) $e = M\frac{di}{dt} \Rightarrow 1.5 = M \times \frac{30}{0.1} \Rightarrow M = 0.05\ H$

93. (d)

94. (c) Current in B_1 will promptly become zero while current in B_2 will slowly tend to zero.

95. (b)

96. (c) When battery disconnected current through the circuit start decreasing exponentially according to $i = i_0 e^{-Rt/L}$

$\Rightarrow\ 0.37 i_0 = i_0 e^{-Rt/L} \Rightarrow\ 0.37 = \frac{1}{e} = e^{-Rt/L} \Rightarrow$

$t = \frac{L}{R}$

97. (a) Current at any instant of time *t* after closing an *L*-*R* circuit is given by $I = I_0\left[1 - e^{\frac{-R}{L}t}\right]$

Time constant $t = \frac{L}{R}$

$\therefore\ I = I_0\left[1 - e^{\frac{-R}{L} \times \frac{L}{R}}\right] = I_0(1 - e^{-1}) = I_0\left(1 - \frac{1}{e}\right)$

$= I_0\left(1 - \frac{1}{2.718}\right) = 0.63 I_0 = 63\%$ of I_0

98. (c) $i = \frac{V}{R} = \frac{10}{2} = 5A$

$U = \frac{1}{2}Li^2 = \frac{1}{2} \times 2 \times 25 = 25\ J$

99. (d)

100. (d) Time constant $= \frac{L}{R} = \frac{40}{8} = 5$ sec.

101. (b) $t = \tau = \frac{L}{R} = \frac{60}{30} = 2$ sec.

102. (c)

103. (b)

104. (a) $\nu_0 = \frac{1}{2\pi\sqrt{(0.25) \times (0.1 \times 10^{-6})}} = \frac{10^4}{9.93} = 1007\ Hz$

105. (c) $\nu_0 = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2 \times 3.14\sqrt{5 \times 10^{-4} \times 20 \times 10^{-6}}}$

$\nu_0 = \frac{10^4}{6.28} = 1592\ Hz$

106. (d) $i = i_0\left(1 - e^{\frac{-Rt}{L}}\right) \Rightarrow$ For $i = \frac{i_0}{2}$, $t = 0.693\frac{L}{R}$

$\Rightarrow\ t = 0.693 \times \frac{300 \times 10^{-3}}{2} = 0.1\ sec$

107. (c) $|e| = L\left|\frac{di}{dt}\right| = 0.5 \times \frac{10}{2} = 2.5\ V$

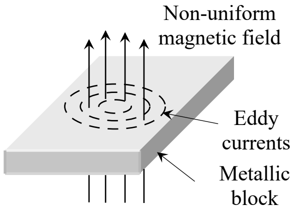
108. (c) Time period of *LC* circuit oscillations $T = 2\pi\sqrt{LC} \Rightarrow$ dimensions of $\sqrt{LC}$ is Time.

Application of EMI (Motor, Dynamo, Transformer...)

1. (b) Hot wire ammeter is not based on the phenomenon of electromagnetic induction.

2. (d)

3. (c) Direction of eddy currents is given by Lenz's rule.



4. (c) In a generator. e.m.f. is induced according as Lenz's rule.

5. (a)

6. (d)

7. (a) Circulation of eddy currents is prevented by use of laminated core.

8. (a)

9. (c)

10. (a)

11. (b) $e \propto \omega$

12. (b)

13. (a) Rotation of magnet in the dynamo creates the variable flux which in turn produces the induced current.

14. (b)

15. (b) With the increasing speed, ω increases. Thus current reduces due to increase in the back e.m.f.

Moreover $i = \frac{V - K\omega}{R}$. More ω will lead to the lesser current.

16. (c) Commutator converts ac into fluctuating dc.

17. (d) Only *ac* dynamo have slip rings.

18. (b) $e \propto \frac{d\phi}{dt}$; if $\phi \to$ maximum then $e \to$ minimum.

19. (d)

20. (c) Motor e.m.f. equation $E_b = V - I_a R_a$

At starting $E_b = 0$, so I_a will be maximum.

21. (d) $i = \frac{E - e}{R} \Rightarrow 1.5 = \frac{220 - e}{20} \Rightarrow e = 190\ V$

22. (d)

23. (d) $e_0 = \omega NBA = (2\pi\nu)\ NBA$

$= 2 \times 3.14 \times 1000 \times 5000 \times 0.2 \times 0.25 = 157\ kV$

24. (a) Back emf $\propto$ speed of motor.

25. (d)

26. (b)

27. (a) Efficiency $\eta = 50\%$ So $e = E/2$

and $i = \frac{E - e}{R} \Rightarrow i = \frac{E - E/2}{R} = \frac{E}{2R}$

$\Rightarrow R = \frac{E}{2i} = \frac{60}{2 \times 10} = 3\Omega$

28. (c)

29. (c) $\eta = \frac{e}{E} \times 100 \Rightarrow e = 0.3\ E$

Now, $i = \frac{E - e}{R} \Rightarrow 12 = \frac{50 - (0.3 \times 50)}{R} \Rightarrow R = 2.9\Omega$

30. (a) $i = \frac{E - e}{R} = \frac{220 - 210}{2} = \frac{10}{2} = 5A$

31. (a)

32. (c) A transformer is a device to convert alternating current at high voltage into low voltage and *vice-versa.*

33. (b) We know that for step down transformer

$V_p > V_s$ but $\frac{V_p}{V_s} = \frac{i_s}{i_p}$; $\therefore i_s > i_p$

Current in the secondary coil is greater than the primary.

34. (c)

35. (a)

36. (b) Transformation ratio $k = \frac{N_s}{N_p} = \frac{V_s}{V_p}$

For step-up transformers, $N_s > N_p$ *i.e.* $V_s > V_p$, hence $k > 1$.

37. (a) $\frac{V_p}{V_s} = \frac{N_p}{N_s} \Rightarrow N_p = \left(\frac{220}{2200}\right) 2000 = 200$

38. (c) Provided no power looses, being assumed.

39. (a) $\frac{N_s}{N_p} = \frac{V_s}{V_p} \Rightarrow \frac{200}{100} = \frac{V_s}{120} \Rightarrow V_s = 240\ V$

also $\frac{V_s}{V_p} = \frac{i_p}{i_s} \Rightarrow \frac{240}{120} = \frac{10}{i_s} \Rightarrow i_s = 5\ A$

40. (c) $\frac{N_s}{N_p} = \frac{V_s}{V_p} \Rightarrow \frac{1}{20} = \frac{V_s}{2400} \Rightarrow V_s = 120\ V$

For 100% efficiency $V_s i_s = V_p i_p$

$\Rightarrow 120 \times 80 = 2400\ i_p \Rightarrow i_p = 4\ A$

41. (b) $\frac{V_p}{V_s}=\frac{N_p}{N_s}=\frac{500}{2500}=\frac{1}{5}\Rightarrow V_p=\frac{200}{5}=40\ V$

Also $i_pV_p=i_sV_s\Rightarrow i_p=i_s\frac{V_s}{V_p}=8\times5=40\ A$

42. (a) $\frac{N_s}{N_p}=\frac{V_s}{V_p}\Rightarrow\frac{250}{100}=\frac{V_s}{28/\sqrt{2}}\Rightarrow V_s=50\ V$

43. (d) $\eta=\frac{V_si_s}{V_pi_p}\times100=\frac{11\times90}{220\times5}\times100=90\,\%$

44. (d) Transformer doesn't work on dc

45. (b)

46. (b)

47. (a) For 100% efficient transformer

$V_si_s=V_pi_p\Rightarrow\frac{V_s}{V_p}=\frac{i_p}{i_s}=\frac{N_s}{N_p}\ \Rightarrow\frac{i_p}{4}=\frac{25}{100}\Rightarrow i_p=1\ A$

48. (a)

49. (d) $\frac{N_s}{N_p}=\frac{i_p}{i_s}\ \Rightarrow\ i_s=i_p\times\frac{N_p}{N_s}=2\times\frac{100}{20}=10\ A$

50. (a) $\frac{V_s}{V_p}=\frac{i_p}{i_s}\Rightarrow i_p=\frac{11000\times2}{220}=100\ A$

51. (c) $\frac{N_p}{N_s}=\frac{V_p}{V_s}=\frac{i_s}{i_p}$. The transformer is step-down type, so primary coil will have more turns. Hence

$\frac{5000}{500}=\frac{2200}{V_s}=\frac{i_s}{4}\Rightarrow V_s=220\ V,\ i_s=40\ amp$

52. (b) $i_s=\frac{P_s}{V_s}=\frac{4.4\times10^3}{11\times10^3}=0.4\ A$

53. (b) $\frac{N_s}{N_p}=\frac{V_s}{V_p}=\frac{22000}{220}=100$

54. (b)

55. (a)

56. (b) $\frac{N_s}{N_p}=\frac{i_p}{i_s}$ or $\frac{25}{1}=\frac{i_p}{2}\Rightarrow i_p=50A$

57. (c) $\frac{V_s}{V_p}=\frac{N_s}{N_p}\Rightarrow V_s=\frac{N_s}{N_p}\times V_p=\frac{10}{200}\times240=12\ volts$

58. (a) $\frac{V_s}{V_p}=\frac{N_s}{N_p}\Rightarrow\frac{V_s}{20}=\frac{5000}{500}\ \Rightarrow V_s=200\ V$

Frequency remains unchanged.

59. (a) $\frac{V_s}{V_p}=\frac{N_s}{N_p}=k\Rightarrow\frac{V_s}{30}=\frac{3}{2}\Rightarrow V_s=45\ V$

60. (a) $\frac{N_s}{N_p}=\frac{i_p}{i_s}\Rightarrow\frac{i_p}{i_s}=\frac{4}{5}$

61. (d) $V_p=200\ V,\ \ V_s=6\,V$

$P_{out}=V_si_s\Rightarrow30=6\times i_s\Rightarrow i_s=5\ A$

From $\frac{V_s}{V_p}=\frac{i_p}{i_s}\Rightarrow\frac{6}{200}=\frac{i_p}{5}\Rightarrow i_p=0.15\ A$

62. (b) $\frac{E_p}{E_s}=\frac{N_p}{N_s}\Rightarrow\frac{200}{E_s}=\frac{100}{20}\Rightarrow E_s=40\ V$

63. (d) Since all the losses are neglected.

So $P_{out}=P_{in}$

64. (c)

65. (b) $\frac{i_p}{i_s}=\frac{N_s}{N_p}\Rightarrow\frac{i_p}{4}=\frac{1}{100}\Rightarrow i_p=0.04\ A$

66. (b) $N_p:N_s=1:10$ and $V_s=0.5\times200=100\ V$

$\frac{V_s}{V_p}=\frac{N_s}{N_p}\Rightarrow\frac{100}{V_p}=\frac{10}{1}\Rightarrow V_p=10\ V$

$\frac{i_p}{i_s}=\frac{N_s}{N_p}\Rightarrow\frac{i_p}{0.5}=\frac{10}{1},\ i_p=5\ amp$

67. (c)

68. (d) $\frac{V_p}{V_s}=\frac{i_s}{i_p}\Rightarrow\frac{220}{22000}=\frac{i_s}{5}\Rightarrow i_s=0.05\ amp$

69. (b) $\frac{V_p}{V_s}=\frac{i_s}{i_p}\Rightarrow i_s=4\times\frac{140}{280}=2A$

70. (c) $P_s=V_si_s\Rightarrow1000=V_s\times8\Rightarrow V_s=\frac{1000}{8}$

$\frac{V_p}{V_s}=\frac{N_p}{N_s}\Rightarrow\frac{(1000/8)}{500}=\frac{100}{N_s}\Rightarrow N_s=400$

71. (a) Transformer works on ac only.

72. (b) $\frac{N_s}{N_p}=\frac{V_s}{V_p}=\frac{2200}{220}=\frac{10}{1}$

73. (c) Transformation ratio $k=\frac{V_s}{V_p}\Rightarrow\frac{5}{3}=\frac{V_s}{60}\Rightarrow V_s=100\ V$

74. (c) $\frac{N_s}{N_p}=\frac{V_s}{V_p}\Rightarrow\frac{N_s}{600}=\frac{2200}{220}\Rightarrow N_s=6000$

75. (b) For 100% efficiency $V_si_s=V_pi_p$

$\Rightarrow1100\times2=220\times i_p\Rightarrow i_p=10A$

76. (c)

77. (c) Amplitude of the current $i_0=\frac{e_0}{R}=\frac{\omega NBA}{R}=\frac{2\pi\nu NB(\pi r^2)}{R}$

$i_0=\frac{2\pi\times1\times10^{-2}\times\pi(0.3)^2}{\pi^2}=6\times10^{-3}\ A=6mA$

78. (a) $\frac{N_s}{N_p}=\frac{i_p}{i_s}\Rightarrow\frac{2000}{500}=\frac{48}{i_s}\Rightarrow i_s=12A$

79. (a) $U=\frac{1}{2}Li^2=\frac{1}{2}\times100\times10^{-3}\times(10)^2=5J$

80. (c) As $\frac{I_p}{I_s} = \frac{n_p}{n_s}$; *i.e.* $\frac{3}{I_s} = \frac{3}{2} \Rightarrow I_s = 2A$.

81. (a)

82. (b)

83. (a) $\eta = \frac{\text{output power}}{\text{input power}} = \frac{E_s I_s}{E_p I_p} \Rightarrow \frac{80}{100} = \frac{200 \times I_s}{4 \times 10^3}$

$\Rightarrow I_S = \frac{80}{100} \times \frac{4 \times 1000}{200} = 16A$

Also, $E_p I_p = 4KW \Rightarrow I_p = \frac{4 \times 10^3}{100} = 40A$

84. (a) $\frac{N_P}{N_S} = \frac{I_S}{I_P} \Rightarrow I_P = \frac{N_S}{N_P} I_S = \frac{10}{1} \times 2 = 20\ A$.

85. (b)

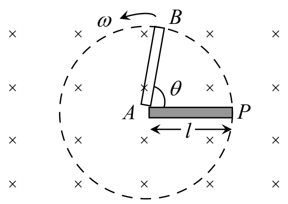
86. (a) $\eta = \frac{\text{Output}}{\text{Input}} \Rightarrow \frac{80}{100} = \frac{20 \times 20}{1000 \times i_l}$

$\Rightarrow i_l = \frac{20 \times 120 \times 100}{1000 \times 80} = 3A$.

Critical Thinking Questions

1. (d) If electron is moving from left to right, the flux linked with the loop (which is into the page) will first increase and then decrease as the electron passes by. So the induced current in the loop will be first anticlockwise and will change direction as the electron passes by.

2. (a) If in time *t*. the rod turns by an angle *θ*, the area generated by the rotation of rod will be $= \frac{1}{2} l \times l\theta$ $= \frac{1}{2} l^2\theta$



So the flux linked with the area generated by the rotation of rod

$\phi = B\left(\frac{1}{2} l^2\theta\right)\cos 0 = \frac{1}{2} Bl^2\theta = \frac{1}{2} Bl^2\omega\, t$

And so $e = \frac{d\phi}{dt} = \frac{d}{dt}\left(\frac{1}{2} Bl^2\omega t\right) = \frac{1}{2} Bl^2\omega$

3. (a, c, d) From Faraday's Law, the induced voltage $V \propto L$

rate of change of current is constant $\left(V = -L\frac{di}{dt}\right)$

$\therefore \frac{V_2}{V_1} = \frac{L_2}{L_1} = \frac{2}{8} = \frac{1}{4} \Rightarrow \frac{V_1}{V_2} = 4$

Power given to the two coils is same, *i.e.,*

$V_1 i_1 = V_2 i_2 \Rightarrow \frac{i_1}{i_2} = \frac{V_2}{V_1} = \frac{1}{4}$

Energy stored $W = \frac{1}{2} Li^2$

$\Rightarrow \frac{W_2}{W_1} = \left(\frac{L_2}{L_1}\right)\left(\frac{i_2}{i_1}\right)^2 = \left(\frac{1}{4}\right)(4)^2 = 4 \Rightarrow \frac{W_1}{W_2} = \frac{1}{4}$

4. (b) $i = i_0(1 - e^{-Rt/L})$

$i_0 = \frac{E}{R}$(Steady current) when $t = \infty$

$i_\infty = \frac{E}{R}(1 - e^{-\infty}) = \frac{5}{10} = 1.5$

$i_1 = 1.5(1 - e^{-R/L}) = 1.5(1 - e^{-2}) \Rightarrow$

$\frac{i_\infty}{i_1} = \frac{1}{1 - e^{-2}} = \frac{e^2}{e^2 - 1}$

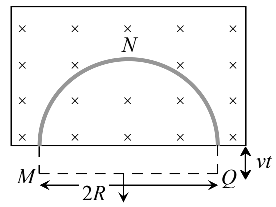
5. (d) Mutual inductance between two coil in the same plane with their centers coinciding is given by

$M = \frac{\mu_0}{4\pi}\left(\frac{2\pi^2 R_2^2 N_1 N_2}{R_1}\right)$ *henry*.

6. (d) Rate of decrease of area of the semicircular ring $-\frac{dA}{dt} = (2R)V$

According to Faraday's law of induction induced emf

$e = -\frac{d\phi}{dt} = -B\frac{dA}{dt} = -B(2RV)$



The induced current in the ring must generate magnetic field in the upward direction. Thus *Q* is at higher potential.

7. (b) Induced potential difference between two ends $= Blv = B_H lv$

$= 3 \times 10^{-5} \times 2 \times 50 = 30 \times 10^{-3}\,volt = 3\,millivolt$

By Fleming's right hand rule, end *A* becomes positively charged.

8. (b) Effective length between *A* and *B* remains same.

9. (d) Circular loop behaves as a magnetic dipole whose one surface will be *N*-pole and another will be *S*-pole. Therefore magnetic lines a force emerges from *N* will meet at *S*.

Hence total magnetic flux through x-y plane is zero.

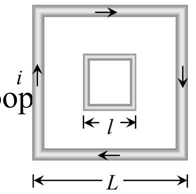
10. (c) If the current increases with time in loop A, then magnetic flux in B will increase. According to Lenz's law, loop $-B$ is repelled by loop $-A$.

11. (b) $e = M\frac{di}{dt} = 0.005 \times \frac{d}{dt}(i_0 \sin\omega t) = 0.005 \times i_0\omega \cos\omega t$

$\therefore e_{max} = 0.005 \times 10 \times 100\pi = 5\pi$

12. (b) Magnetic field produced due to large loop

$B = \frac{\mu_0}{4\pi}\frac{8\sqrt{2}i}{L}$



Flux linked with smaller loop

$\phi = B(l^2) = \frac{\mu_0}{4\pi}\frac{8\pi i l^2}{L}$

$\therefore \phi = Mi \Rightarrow M = \frac{\phi}{i} = \frac{\mu_0}{4\pi}.\frac{8\sqrt{2}l^2}{L} \Rightarrow M \propto \frac{l^2}{L}$

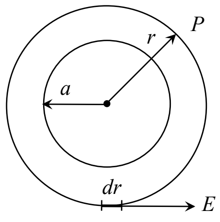
13. (b) Rate of work $= \frac{W}{t} = P = Fv$, also

$F = Bil = B\left(\frac{Bvl}{R}\right)l$

$\Rightarrow P = \frac{B^2v^2l^2}{R} = \frac{(0.5)^2 \times (2)^2 \times (1)^2}{6} = \frac{1}{6} W$

14. (b) Construct a concentric circle of radius r. The induced electric field (E) at any point on the circle is equal to that at P. For this circle

$\oint \vec{E}.\vec{dl} = \left|\frac{d\phi}{dt}\right| = A\left|\frac{dB}{dt}\right|$



or $E \times (2\pi r) = \pi a^2.\left|\frac{dB}{dt}\right|$

$\Rightarrow E = \frac{a^2}{2r}\left|\frac{dB}{dt}\right| \Rightarrow E \propto \frac{1}{r}$

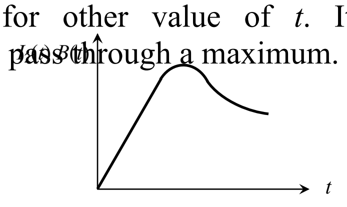
15. (d) Using k_1, k_2 etc, as different constants.

$I_1(t) = k_1[1 - e^{-t/\tau}]$, $B(t) = k_2 I_1(t)$

$I_2(t) = k_3\frac{dB(t)}{dt} = k_4 e^{-t/\tau}$

$\therefore I_2(t)\, B(t) = k_5[1 - e^{-t/\tau}][e^{-t/\tau}]$

This quantity is zero for $t = 0$ and $t = \infty$ and positive for other value of t. It must, therefore, pass through a maximum.

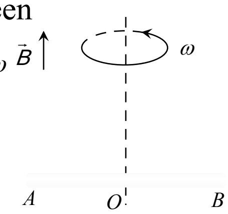


16. (a) The mutual inductance between two coils depends on their degree of flux linkage, *i.e.*, the fraction of flux linked with one coil which is also linked to the other coil. Here, the two coils in arrangement (a) are placed with their planes parallel. This will allow maximum flux linkage.

17. (d) Both AD and BC are straight conductors moving in a uniform magnetic field and emf will be induced in both. This will cause electric fields in both, but no net current flows in the circuit.

18. (d) Potential difference between

O and A is $V_0 - V_A = \frac{1}{2}Bl^2\omega$



O and B is $V_0 - V_B = \frac{1}{2}Bl^2\omega$

so $V_A - V_B = 0$

19. (c) $i = i_0\left(1 - e^{\frac{-Rt}{L}}\right) \Rightarrow \frac{di}{dt} = \frac{d}{dt}i_0 - \frac{d}{dt}i_0 e^{\frac{-Rt}{L}}$

$\Rightarrow \frac{di}{dt} = 0 - i_0\left(-\frac{R}{L}\right)e^{\frac{-Rt}{L}} = \frac{i_0 R}{L}e^{-\frac{Rt}{L}}$

Initially,

$t = 0 \Rightarrow \frac{di}{dt} = \frac{i_0 \times R}{L} = \frac{E}{L} = \frac{5}{2} = 2.5\ amp/sec$

20. (d) When switch S is closed magnetic field lines passing through Q increases in the direction from right to left. So, according to Lenz's law induced current in Q *i.e.* I_{Q_1} will flow in such a direction so that the magnetic field lines due to I_{Q_2} passes from left to right through Q. This is possible when I_{Q_1} flows in anticlockwise direction as seen by E. Opposite is the case when switch S is opened *i.e.* I_{Q_2} will be clockwise as seen by E.

21. (b) Power $P = \frac{e^2}{R}$; hence $e = -\left(\frac{d\phi}{dt}\right)$ where

$\phi = NBA$

$\therefore e = -NA\left(\frac{dB}{dt}\right)$ Also $R \propto \frac{l}{r^2}$

Where R = resistance, r = radius, l = Length

$\therefore P \propto \frac{N^2r^2}{l} \Rightarrow \frac{P_1}{P_2} = 1$

22. (a) $H = \frac{V^2t}{R}$ and $V = \frac{N(B_2 - B_1)A\cos\theta}{t}$

$V = \frac{1 \times (1-2) \times 0.01 \times \cos 0^o}{10^{-3}} = 10\ V$

So, $H = \frac{(10)^2 \times 10^{-3}}{0.01} = 10\ J$

23. (d) Peak current in the circuits $i_0 = \frac{12}{6} = 2A$

Current decreases from $2A$ to $1A$ *i.e.,* becomes half in time $t = 0.693\frac{L}{R} = 0.693 \times \frac{8.4 \times 10^{-3}}{6} = 1\,milli\,sec$

24. (a) Induced current in the circuit $i = \frac{Bvl}{R}$

Magnetic force acting on the wire $F_m = Bil = B\left(\frac{Bvl}{R}\right)l$

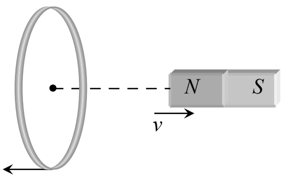
$\Rightarrow F_m = \frac{B^2vl^2}{R}$ External force needed to move the rod with constant velocity

$(F_m) = \frac{B^2vl^2}{R} = \frac{(0.15)^2 \times (2) \times (0.5)^2}{3} = 3.75 \times 10^{-3}\ N$

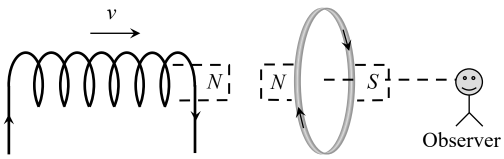
25. (c) According to Lenz's Law

26. (b) $\left(\frac{d\phi}{dt}\right)_{\text{In first case}} = e$

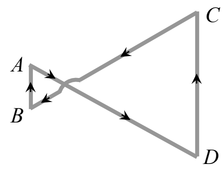
$\left(\frac{d\phi}{dt}\right)_{\text{relative velocity } 2v} = 2\left(\frac{d\phi}{dt}\right)_{\text{I case}} = 2e$



27. (b) The direction of current in the solenoid is anti-clockwise as seen by observer. On displacing it towards the loop a current in the loop will be induced in a direction so as to oppose the approach of solenoid. Therefore the direction of induced current as observed by the observer will be clockwise.



28. (a) Inward magnetic field (×) increasing. Therefore, induced current in both the loops should be anticlockwise. But as the area of loop on right side is more, induced *emf* in this will be more compared to the left side loop $\left(e = -\frac{d\phi}{dt} = -A.\frac{dB}{dt}\right)$. Therefore net current in the complete loop will be in a direction shown below. Hence only option (a) is correct.

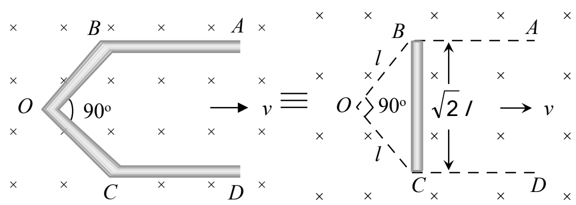


29. (b) Equivalent resistance of the given Wheatstone bridge circuit (balanced) is 3Ω so total resistance in circuit is $R = 3 + 1 = 4\Omega$. The emf induced in the loop $e = Bvl$.

So induced current $i = \frac{e}{R} = \frac{Bvl}{R}$

$\Rightarrow 10^{-3} = \frac{2 \times v \times (10 \times 10^{-2})}{4} \Rightarrow v = 2cm/sec$

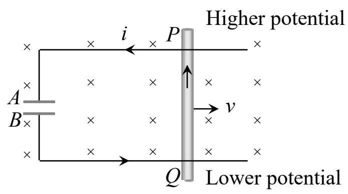
30. (b) There is no induced emf in the part *AB* and *CD* because they are moving along their length while emf induced between *B* and *C* *i.e.* between *A* and *D* can be calculated as follows



Induced emf between *B* and *C* = Induced emf between *A* and *B* = $Bv(\sqrt{2}\,l) = 1 \times 1 \times 1 \times \sqrt{2} = 1.41\,volt.$

31. (a) $Q = CV = C\,(Bvl) = 10 \times 10^{-6} \times 4 \times 2 \times 1 = 80\ \mu C$

According to Fleming's right hand rule induced current flows from *Q* to *P*. Hence *P* is at higher potential and *Q* is at lower potential. Therefore *A* is positively charged and *B* is negatively charged.



32. (b) If resistance is constant (10Ω) then steady current in the circuit $i=\frac{5}{10}=0.5\,A$. But resistance is increasing it means current through the circuit start decreasing. Hence inductance comes in picture which induces a current in the circuit in the same direction of main current. So $i > 0.5\,A$.

33. (d) $P=\frac{e^2}{R}$; $e=-\frac{d}{dt}(BA)=A\frac{d}{dt}(B_o e^{-t})=AB_o e^{-t}$

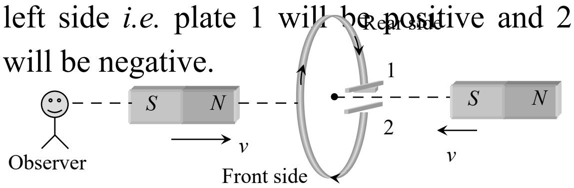
$\Rightarrow P=\frac{1}{R}(AB_o e^{-t})^2=\frac{A^2B_o^2e^{-2t}}{R}$

At the time of starting $t = 0$ so $P=\frac{A^2B_o^2}{R}$

$\Rightarrow P=\frac{(\pi r^2)^2B_o^2}{R}=\frac{B_o^2\pi^2r^4}{R}$

34. (c) When key k is pressed, current through the electromagnet start increasing *i.e.* flux linked with ring increases which produces repulsion effect.

35. (b) By the movement of both the magnets, current will be anticlockwise, as seen from left side *i.e.* plate 1 will be positive and 2 will be negative.



36. (a) Since the current is increasing, so inward magnetic flux linked with the ring also increasing (as viewed from left side). Hence induced current in the ring is anticlockwise, so end x will be positive.

Induced emf $|e|=A\frac{dB}{dt}=A\frac{d}{dt}(B_o+\alpha t)\Rightarrow|e|=A\alpha$

37. (a) Current in the inner coil $i=\frac{e}{R}=\frac{A_1}{R_1}\frac{dB}{dt}$

length of the inner coil $=2\pi a$

so it's resistance $R_1=50\times10^{-3}\times2\pi\,(a)$

$\therefore i_1=\frac{\pi a^2}{50\times10^{-3}\times2\pi\,(a)}\times0.1\times10^{-3}=10^{-4}\,A$

According to lenz's law direction of i_1 is clockwise.

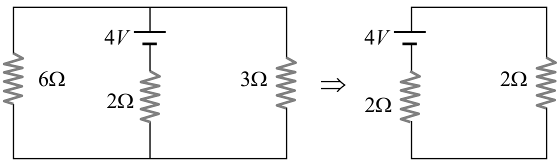
Induced current in outer coil $i_2=\frac{e_2}{R_2}=\frac{A_2}{R_2}\frac{dB}{dt}$

$\Rightarrow i_2=\frac{\pi b^2}{50\times10^{-3}\times(2\pi b)}\times0.1\times10^{-3}=2\times10^{-4}\,A\,(CW)$

38. (c) Motional emf $e=Bvl\Rightarrow e=2\times2\times1=4\,V$

This acts as a cell of emf $E=4\,V$ and internal resistance $r=2\Omega$.

This simple circuit can be drawn as follows



Current through the connector $i=\frac{4}{2+2}=1\,A$

$\therefore$ magnetic force on connector $F_m=Bil=2\times1\times1=2\,N$

(Towards left)

39. (b) Due to magnetic field, wire will experience an upward force $F=Bil=B\left(\frac{Bvl}{R}\right)l\Rightarrow F=\frac{B^2vl^2}{R}$

If wire slides down with constant velocity then

$F=mg\Rightarrow\frac{B^2vl^2}{R}=mg\Rightarrow v=\frac{mgR}{B^2l^2}$

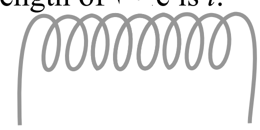
40. (c) By using $e=\frac{1}{2}Bl^2\omega$

For part AO ; $e_{OA}=e_O-e_A=\frac{1}{2}Bl^2\omega$

For part OC; $e_{OC}=e_O-e_C=\frac{1}{2}B(3l)^2\omega$

$\therefore e_A-e_C=4\,Bl^2\omega$

41. (c) Suppose solenoid has N turns, each of radius r and length of the wire is l.



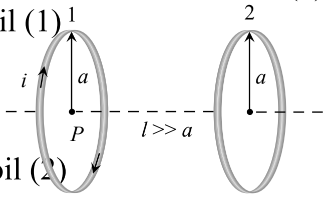
It's self inductance $L=\frac{\mu_0N^2A}{l_0}=\frac{\mu_0N^2\pi r^2}{l_0}$ .... (i)

Also length of the wire $l=N\times2\pi r$

$\Rightarrow N^2r^2=\frac{l^2}{4\pi^2}$ .... (ii)

From equation (i) and (ii) $I=\sqrt{\dfrac{4\pi L I_o}{\mu_o}}$

42. (d) Magnetic field at the location of coil (2) produced due to coil (1)



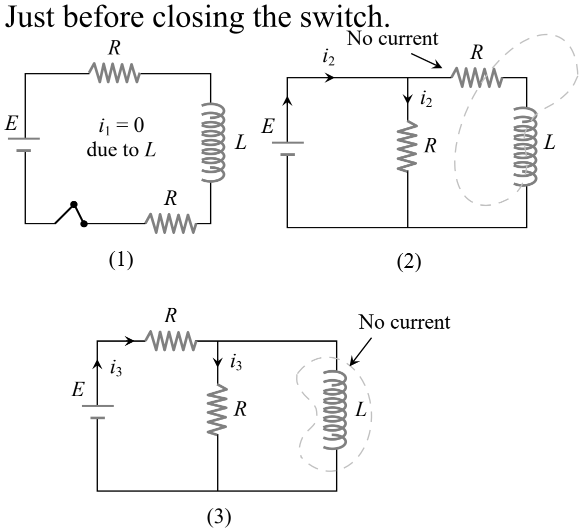
$$B_1=\frac{\mu_o}{4\pi}\cdot\frac{2M}{l^3}$$

Flux linked with coil (2)

$$\phi_2=B_1A_2=\frac{\mu_o}{4\pi}\frac{2i(\pi a^2)}{l^3}\times(\pi a^2)$$

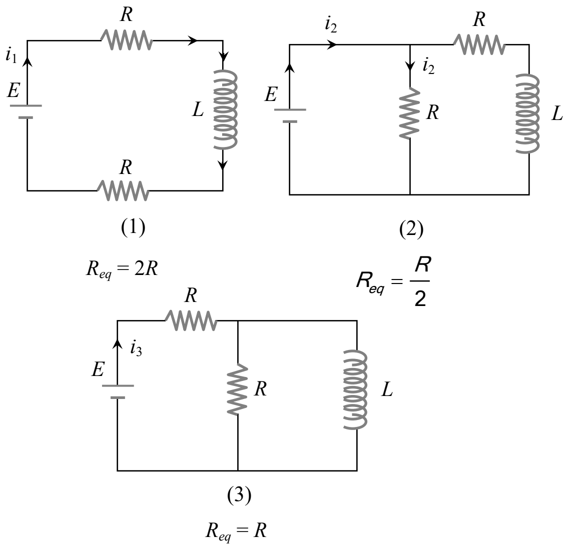
Also $\phi_2=Mi\ \Rightarrow M=\dfrac{\mu_o\pi a^4}{2l^3}$

43. (a) Just before closing the switch.



$i_1=0,\ i_2=\dfrac{E}{R},\ i_3=\dfrac{E}{2R}$ so $i_2>i_3>i_1\quad(i_1=0)$

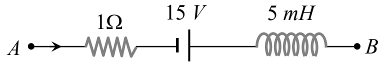
After a long time closing the switch



Hence $i_2>i_3>i_1$

44. (c) By using Kirchoff's voltage law

$$V_A-iR+E-L\frac{di}{dt}=V_B\Rightarrow V_B-V_A=15\ volt.$$



45. (d) The rate of increase of current

$$=\frac{di}{dt}=\frac{d}{dt}i_0\left(1-e^{-Rt/L}\right)=\frac{d}{dt}i_0-\frac{d}{dt}i_0e^{-Rt/L}$$

$$=0-i_0e^{-Rt/L}.\frac{d}{dt}\left(-\frac{Rt}{L}\right)=i_0\frac{R}{L}e^{-Rt/L}$$

$$=\frac{50}{180}\times\frac{180}{5\times10^{-3}}\times e^{-(180\times0.001)/(5\times10^{-3})}=10^4\times e^{-36}\ A/\sec$$

46. (b) We know that $i=i_o\left[1-e^{\frac{-Rt}{L}}\right]$ or

$$\frac{3}{4}i_o=i_o\left[1-e^{-t/\tau}\right]$$

(where $\tau=\dfrac{L}{R}=$ time constant)

$$\frac{3}{4}=1-e^{-t/\tau}\ \text{ or }\ e^{-t/\tau}=1-\frac{3}{4}=\frac{1}{4}$$

$$e^{t/\tau}=4\ \text{ or }\ \frac{t}{\tau}=\ln 4$$

$$\Rightarrow\tau=\frac{t}{\ln 4}=\frac{4}{2\ln 2}\Rightarrow\tau=\frac{2}{\ln 2}\ sec$$

47. (b) In a constant magnetic field conducting ring oscillates with a frequency of 100 *Hz*.

i.e. $T=\dfrac{1}{100}s$ in time $\dfrac{T}{2}$ flux links with coil changes from BA to zero. $\Rightarrow$ Induced emf

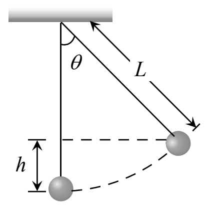
$$=\frac{\text{change in flux}}{\text{time}}$$

$$=\frac{BA}{T/2}=\frac{2BA}{T}=\frac{2B\times\pi r^2}{T}=\frac{2\times0.01\times\pi\times1^2}{1/100}=4\pi V$$

Induced electric field along the circle, using Maxwell equation $\oint E.dl=-\dfrac{d\phi}{dt}=A\dfrac{dB}{dt}=e$

$$\Rightarrow E=\frac{1}{2\pi r}\times\left(\pi r^2\times\frac{dB}{dt}\right)=\frac{e}{2\pi r}=\frac{4\pi}{2\pi r}=2\ V/m$$

48. (a)



$\Rightarrow h=L(1-\cos\theta)$ ....(i)

Maximum velocity at equilibrium is given by

$\therefore\ v^2 = 2gh = 2gL(1-\cos\theta) = 2gL\left(2\sin^2\frac{\theta}{2}\right)$

$\Rightarrow v = 2\sqrt{gL}\sin\frac{\theta}{2}$

Thus, max. potential difference

$V_{max} = BvL = B\times 2\sqrt{gL}\sin\frac{\theta}{2}L = 2BL\sin\frac{\theta}{2}(gL)^{1/2}.$

Graphical Questions

1. (d) At B, flux is maximum, so from $|e| = \frac{d\phi}{dt}$ at B $|e| = 0$

2. (b) As the magnet moves towards the coil, the magnetic flux increases (nonlinearly). Also there is a change in polarity of induced emf when the magnet passes on to the other side of the coil.

3. (c) Rate of decay of current between $t = 5\ ms$ to $6\ ms$ $= \frac{di}{dt} = -(\text{Slope of the line } BC)$

$= -\left(\frac{5}{1\times 10^{-3}}\right) = -5\times 10^3\ A/s$. Hence induced emf $e = -L\frac{di}{dt} = -4.6\times(-5\times 10^3) = 23\times 10^3\ V$.

4. (b) $e = -M\frac{di}{dt} = -1.5\frac{(1-0)}{(T/4)} = -\frac{6}{T}$, $T = \frac{2\pi}{\omega} = \frac{2\pi}{200} = \frac{\pi}{100}$

$\Rightarrow |e| = \frac{600}{\pi} = 190.9\ V \simeq 191\ V$

5. (d) When loop enters in field between the pole pieces, flux linked with the coil first increases (constantly) so a constant emf induces, when coil entered completely within the field, no flux change so $e = 0$.

When coil exit out, flux linked with the coil decreases, hence again emf induces, but in opposite direction.

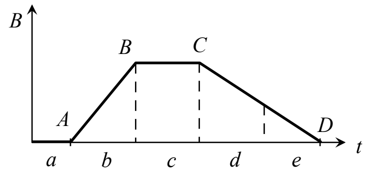
6. (a) $|dq| = \frac{d\phi}{R} = i\,dt =$ Area under $i-t$ graph

$\therefore d\phi =$ (Area under $i-t$ graph) R

$= \frac{1}{2}\times 4\times 0.1\times(10) = 2\ wb.$

7. (b) Induced emf $e = A\frac{dB}{dt}$

i.e. $e \propto \frac{dB}{dt}$ (= slope of $B-t$ graph)



In the given graph slope of AB > slope of CD, slope in the 'a' region = slope in the 'c' region = 0, slope in the 'd' region = slope in the 'e' region $\neq 0$. That's why $b > (d = e) > (a = c)$

8. (b) $P = Fv = Bil\times v = B\left(\frac{Bvl}{R}\right)l\times v = \frac{B^2v^2l^2}{R} \Rightarrow P \propto v^2$

9. (b) As x increases so $\frac{dB}{dt}$ increases *i.e.* induced emf (e) is negative. When loop completely entered in the magnetic field, emf = 0

When it exit out x increases but $\frac{dB}{dt}$ decreases *i.e.* e is positive.

10. (c) According to $i-t$ graph, in the first half current is in-creasing uniformly so a constant negative emf induces in the circuit.

In the second half current is decreasing uniformly so a constant positive emf induces

Hence graph (c) is correct

11. (b) $i = i_0\left(1 - e^{-\frac{R}{L}t}\right)$

12. (a) $\frac{di}{dt}$ = slope of $i-t$ graph slope of graph (2) < slope of graph (1) so $\left(\frac{di}{dt}\right)_2 < \left(\frac{di}{dt}\right)_1$

Also $L \propto \frac{1}{(di/dt)} \Rightarrow L_2 > L_1$

13. (b) $\phi = BA = B \times \pi r^2$

$\therefore \phi \propto r^2 \Rightarrow \phi = kr^2$ (k = constant)

$\therefore e = \frac{d\phi}{dt} = k.2r\frac{dr}{dt}$

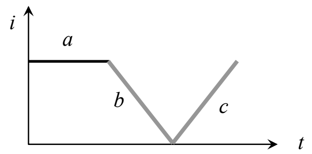
From 0 – 1, r is constant, $\therefore \frac{dr}{dt} = 0$ hence, $e = 0$

From 1 – 2, $r = \alpha t, \therefore \frac{dr}{dt} = \alpha$ hence $e \propto r \Rightarrow e \propto t$

From 2 – 3, again r is constant, $\therefore \frac{dr}{dt} = 0$ hence $e = 0$

14. (c) Emf induces during 'a' = 0

emf induced during 'b' is constant throughout emf induced during 'c' is constant throughout magnitude of emf induced during 'b' is equal to the magnitude of emf induced during 'c'. But the direction opposite.



15. (a) $U = \frac{1}{2}Li^2$

$\therefore$ Rate $= \frac{dU}{dt} = Li\left(\frac{di}{dt}\right)$

At $t = 0, i = 0 \therefore \text{rate} = 0$

At $t = \infty, i = i_0$ but $\frac{di}{dt} = 0,$ therefore rate = 0

16. (c) At the time $t = 0$, e is max and is equal to E, but current i is zero.

As the time passes, current through the circuit increases but induced emf decreases.

17. (d) If at any instant, current through the circuit is i then applying Kirchoffs voltage law, $iR + e = E \Rightarrow e = E - iR$. Therefore, graph between e and i will be a straight line having negative slope and having a positive intercept.

18. (c) When loop is entering in the field, magnetic flux (*i.e.* ×) linked with the loop increases so induced emf in it $e = Bvl = 0.6 \times 10^{-2} \times 5 \times 10^{-2} = 3 \times 10^{-4}\ V$ (Negative) .

When loop completely entered in the field (after 5 *sec*) flux linked with the loop remains constant so $e = 0$.

After 15 *sec*, loop begins to exit out, linked magnetic flux decreases so induced emf $e = 3 \times 10^{-4}\ V$ (Positive).

19. (a)

Assertion and Reason

1. (b) When a metallic conductor is moved in a magnetic field; magnetic flux is varied. It disturbs the free electrons of the metal and set up an induced emf in it. As there are no free ends of the metal *i.e.* it will be closed in itself so there will be induced current.

2. (b) The relation of induced emf is $e = \frac{Ldi}{dt}$ and current i is given by $i = \frac{e}{R} = \frac{1}{R}.\frac{L.di}{dt} \Rightarrow \frac{di}{dt} = i\frac{R}{L} = \frac{i}{L/R}$.

In order to decreases the rate of increase of current through solenoid. We have to increase the time constant $\frac{L}{R}$.

3. (c) According to Faraday's laws, the conversion of mechanical energy into electrical energy. This is in accordance with the law of conservation of energy. It is also clearly known that in pure resistance, the emf is in phase with the current.

4. (c) Presence of magnetic flux cannot produce current.

5. (e) E.M.F. induces, when there is change in magnetic flux. Faraday did experiment in which, there is relative motion between the coil and magnet, the flux linked with the coil changes and e.m.f. induces.

6. (e) Since both the loops are identical (same area and number of turns) and moving with a same speed in same magnetic field. Therefore same emf is induced in both the coils. But the induced current will be more in the copper loop as its resistance will be lesser as compared to that of the aluminium loop.

7. (a) The inductance coils made of copper will have very small ohmic resistance. Due to change in magnetic flux a large induced current will be produced in such an inductance, which will offer appreciable opposition to the flow of current.

8. (b) Self-inductance of a coil is its property virtue of which the coil opposes any change in the current flowing through it.

9. (c) The manner in which the two coils are oriented, determines the coefficient of coupling between them.

$M = K^2 . L_1 L_2$

When the two coils are wound on each other, the coefficient of coupling is maximum and hence mutual inductance between the coil is maximum.

10. (a) The induced current in the ring opposes the motion of falling magnet. Therefore, the acceleration of the falling magnet will be less than that due to gravity.

11. (e) As the aircraft flies, magnetic flux changes through its wings due to the vertical component of the earth's magnetic field. Due to this, induced emf is produced across the wings of the aircraft. Therefore, the wings of the aircraft will not be at the same potential.

12. (b) According to Lenz's law, induced emf are in a direction such as to attempt to maintain the original magnetic flux when a change occurs. When the switch is opened, the sudden drop in the magnetic field in the circuit induces an emf in a direction that attempts to keep the original current flowing. This can cause a spark as the current bridges the air gap between the poles of the switch. (The spark is more likely in circuits with large inductance).

13. (b) Mutual inductance is the phenomenon according to which an opposing e.m.f. produce flux in a coil as a result of change in current or magnetic flux linked with a neighboring coil. But when two coils are inductively coupled, in addition to induced e.m.f. produced due to mutual induction, also induced e.m.f. is produced in each of the two coils due to self-induction.

14. (e) Lenz's Law is based on conservation of energy and induced emf always opposes the cause of it *i.e.*, change in magnetic flux.

15. (a) As the coil rotates, the magnetic flux linked with the coil (being $\vec{B} . \vec{A}$) will change and emf will be induced in the loop.

16. (a)

17. (c) When the satellite moves in inclined plane with equatorial plane (including orbit around the poles), the value of magnetic field will change both in magnitude and direction. Due to this, the magnetic flux through the satellite will change and hence induced currents will be produced in the metal of the satellite. But no current will induced if satellite orbits in the equatorial plane because the magnetic flux does not change through the metal of the satellite in this plane.

18. (b) When the tube is heated its resistance gets increased due to which eddy currents produced in copper tube becomes weak. Hence opposing force also gets reduced and

the terminal velocity of magnet gets increased.

19. (d) When a metal piece falls from a certain height then eddy currents are produced in it due to earth's magnetic field. Eddy current oppose the motion of piece. Hence metal piece falls with a smaller acceleration (as compared to g). But no eddy current are produced in non-metal piece, hence it drops with acceleration due to gravity. Therefore non-metal piece will reach the earth's surface earlier.

20. (a) Transformer works on *ac* only, *ac* changes in magnitude as well as in direction.

21. (a) Hysteresis loss in the core of transformer directly proportional to the hysteresis loop area of the core material. Since soft iron has narrow hysteresis loop area, that is why soft iron core is used in the transformer.

22. (e) *ac* generator is based on the principle of the electromagnetic induction. When a coil is rotated about an axis perpendicular to the direction of uniform magnetic field, an induced emf is produced across it.

23. (d) Efficiency of electric motor is maximum when the back emf set up in the armature is half the value of the applied battery *emf.*

24. (d) Backs *emf.* $e \propto \omega$. At start $\omega = 0$ so $e = 0$