DPP - Daily Practice Problems

Name : | Date :

Start Time : | End Time :

PHYSICS 45

SYLLABUS : ELECTROMAGNETIC INDUCTION - 2 : Self inductance, mutual inductance, Growth and decay of current in L.R. circuit, Transformer, Electric motor, Generator

Max. Marks : 116 | **Time : 60 min.**

GENERAL INSTRUCTIONS

- The Daily Practice Problem Sheet contains 29 MCQ's. For each question only one option is correct. Darken the correct circle/ bubble in the Response Grid provided on each page.
- You have to evaluate your Response Grids yourself with the help of solution booklet.
- Each correct answer will get you 4 marks and 1 mark shall be deduced for each incorrect answer. No mark will be given/ deducted if no bubble is filled. Keep a timer in front of you and stop immediately at the end of 60 min.
- The sheet follows a particular syllabus. Do not attempt the sheet before you have completed your preparation for that syllabus. Refer syllabus sheet in the starting of the book for the syllabus of all the DPP sheets.
- After completing the sheet check your answers with the solution booklet and complete the Result Grid. Finally spend time to analyse your performance and revise the areas which emerge out as weak in your evaluation.

DIRECTIONS (Q.1-Q.20) : There are 20 multiple choice questions. Each question has 4 choices (a), (b), (c) and (d), out of which **ONLY ONE** choice is correct.

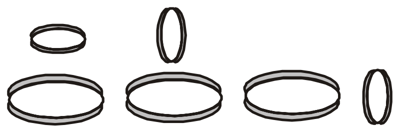
Q.1 A current increases uniformly from zero to one ampere in 0.01 second, in a coil of inductance 10 mH. The induced e.m.f. will be -

(a) 1 V (b) 2 V (c) 3 V (d) 4 V

Q.2 The current in a coil varies with respect to time t as $I = 3t^2 + 2t$. If the inductance of coil be 10 mH, the value of induced e.m.f. at t = 2s will be-

(a) 0.14 V (b) 0.12 V (c) 0.11 V (d) 0.13 V

Q.3 Two circular coils can be arranged in any of the three situations shown in the figure. Their mutual inductance will be



(A) (B) (C)

(a) Maximum in situation (A)
(b) Maximum in situation (B)
(c) Maximum in situation (C)
(d) The same in all situations

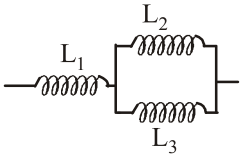
Q.4 A current of 10 A in the primary coil of a circuit is reduced to zero at a uniform rate in 10^{-3} second. If the coefficient of mutual inductance is 3H, the induced e.m.f. in the secondary coil will be-

(a) 3 kV (b) 30 kV (c) 2 kV (d) 20 kV

RESPONSE GRID	1. ⓐⓑⓒⓓ	2. ⓐⓑⓒⓓ	3. ⓐⓑⓒⓓ	4. ⓐⓑⓒⓓ

Space for Rough Work

Q.5 Three inductances are connected as shown below. Assuming no coupling, the resultant inductance will be- ($L_1 = 0.75$ H, $L_2 = L_3 = 0.5$ H)

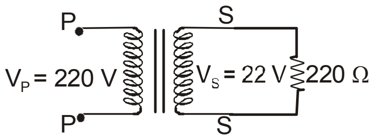


(a) 0.25 H
(b) 0.75 H
(c) 0.01 H
(d) 1 H

Q.6 A solenoid has an inductance of 50 mH and a resistance of 0.025 Ω. If it is connected to a battery, how long will it take for the current to reach one half of its final equilibrium value?

(a) 1.34 s (b) 1.38 s (c) 1.38 ms (d) 0.23 s

Q.7 The current in the primary coil of a transformer (assuming no power loss) as shown in fig. will be –

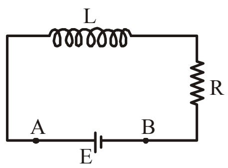


(a) 0.01 A
(b) 1.0 A
(c) 0.1 A
(d) 10^{-6} A.

Q.8 A current of 5A is flowing at 220V in the primary coil of a transformer. If the voltage produced in the secondary coil is 2200V and 50% of power is lost, then the current in the secondary coil will be –

(a) 2.5A (b) 5A (c) 0.25A (d) 0.025A

Q.9 An inductor (L = 100 mH), a resistor (R = 100Ω) and a battery (E = 100 V) are initially connected in series as shown in the figure. After a long time the battery is disconnected after short circuiting the points A and B. The current in the circuit 1 ms after the short circuit is

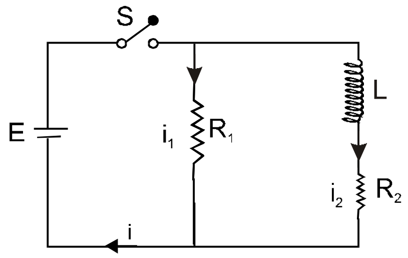


(a) e A
(b) 0.1 A
(c) 1 A
(d) 1/e A

Q.10 Which of the following is constructed on the principle of electromagnetic induction ?

(a) Galvanometer (b) Electric motor
(c) Generator (d) Voltmeter

Q.11 In the circuit, E = 10 volt, $R_1 = 5.0$ ohm, $R_2 = 10$ ohm and L = 5.0 henry. The current just after the switch S is pressed is.



(a) 2.0A (b) 3.0A
(c) 5.0A (d) 6.0A

Q.12 Two inductors L_1 and L_2 are at a sufficient distance apart. Equivalent inductance when they are connected (i) in series (ii) in parallel are

(a) $L_1 + L_2, \dfrac{L_1L_2}{L_1 + L_2}$ (b) $L_1 - L_2, \dfrac{L_1L_2}{L_1 - L_2}$

(c) $L_1 L_2, \dfrac{L_1 + L_2}{L_1L_2}$ (d) None of these

Q.13 A small coil of N_1 turns, l_1 length is tightly wound over the centre of a long solenoid of length l_2, area of cross-section A and number of turns N_2. If a current I flows in the small coil, then the flux through the long solenoid is

(a) zero (b) $\dfrac{\mu_0 N_1^2 AI}{\ell_1}$

(c) inifinite (d) $\dfrac{\mu_0 N_1 N_2 AI}{\ell_2}$

Q.14 If the current in the primary coil is reduced from 3.0 ampere to zero in 0.001 second, the induced e.m.f in the secondary coil is 1500 volt. The mutual inductance of the two coils will be-

(a) 0.5 H (b) 0.05 H (c) 0.005 H (d) 0.0005 H

Q.15 A 50 Hz a.c. current of crest value 1A flows through the primary of a transformer. If the mutual inductance between the primary and secondary be 1.5 H, the crest voltage induced in secondary is-

(a) 75 V (b) 150 V (c) 471 V (d) 300 V

Q.16 In an inductor of inductance L = 100 mH, a current of I = 10A is flowing. The energy stored in the inductor is

(a) 5 J (b) 10 J (c) 100 J (d) 1000 J

RESPONSE GRID					
	5. ⓐⓑⓒⓓ	6. ⓐⓑⓒⓓ	7. ⓐⓑⓒⓓ	8. ⓐⓑⓒⓓ	9. ⓐⓑⓒⓓ
	10. ⓐⓑⓒⓓ	11. ⓐⓑⓒⓓ	12. ⓐⓑⓒⓓ	13. ⓐⓑⓒⓓ	14. ⓐⓑⓒⓓ
	15. ⓐⓑⓒⓓ	16. ⓐⓑⓒⓓ			

Space for Rough Work

Q.17 A step up transformer has transformation ratio 5 : 3. What is voltage in secondary if voltage in primary is 60 V
(a) 20 V (b) 60 V (c) 100 V (d) 180 V

Q.18 A transformer has turn ratio 100 : 1. If secondary coil has 4 amp current then current in primary coil is
(a) 4 A (b) 0.04 A (c) 0.4 A (d) 400 A

Q.19 A step-down transformer is used on a 1000 V line to deliver 20 A at 120 V at the secondary coil. If the efficiency of the transformer is 80%, the current drawn from the line is:
(a) 3 A (b) 30 A (c) 0.3 A (d) 2.4 A

Q.20 Energy stored in an inductor is proportional to (i = current in the inductor)
(a) i (b) $\sqrt{i}$ (c) i^2 (d) i^3

DIRECTIONS (Q.21-Q.23) : In the following questions, more than one of the answers given are correct. Select the correct answers and mark it according to the following codes:

Codes :
(a) 1, 2 and 3 are correct **(b)** 1 and 2 are correct
(c) 2 and 4 are correct **(d)** 1 and 3 are correct

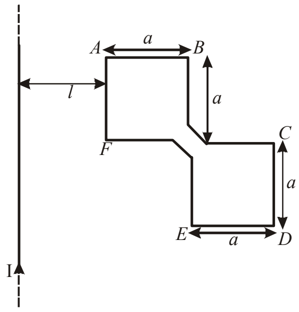
Q.21 Voltage (r. m. s) in the secondary coil of a transformer depends upon
(1) voltage in the primary coil
(2) ratio of number of turns in the two coils
(3) frequency of the source
(4) time-period of the source

Q.22 Core of a transformer can't be made up of
(1) steel (2) alnico (3) iron (4) soft iron

Q.23 Large transformer, when used for some time, become hot and are cooled by circulating oil. The heating of transformer is due to
(1) heating effect of current
(2) hysteresis loss
(3) chemical effect of current
(4) magnetic effect of current

DIRECTIONS (Q.24-Q.26) : Read the passage given below and answer the questions that follows :

In Fig., there is a conducting loop ABCDEFA, of resistance λ per unit length placed near a long straight current-carrying wire. The dimensions are shown in the figure. The long wire lies in the plane of the loop. The current in the long wire varies as $I = I_0 t$.



Q.24 The mutual inductance of the pair is
(a) $\frac{\mu_0 a}{2\pi}\ln\left(\frac{2a+\ell}{\ell}\right)$ (b) $\frac{\mu_0 a}{2\pi}\ln\left(\frac{2a-\ell}{\ell}\right)$
(c) $\frac{2\mu_0 a}{\pi}\ln\left(\frac{a+\ell}{\ell}\right)$ (d) $\frac{\mu_0 a}{\pi}\ln\left(\frac{a+\ell}{\ell}\right)$

Q.25 The e.m.f. induced in the closed loop is
(a) $\frac{\mu_0 I_0 a}{2\pi}\ln\left(\frac{2a+\ell}{\ell}\right)$ (b) $\frac{\mu_0 I_0 a}{2\pi}\ln\left(\frac{2a-\ell}{\ell}\right)$
(c) $\frac{2\mu_0 I_0 a}{\pi}\ln\left(\frac{a+\ell}{\ell}\right)$ (d) $\frac{\mu_0 I_0 a}{\pi}\ln\left(\frac{a+\ell}{\ell}\right)$

Q.26 The heat produced in the loop in time t is
(a) $\frac{\left[\frac{\mu_0}{2\pi}\ln\left(\frac{a+\ell}{\ell}\right)I_0\right]^2 at}{4\lambda}$ (b) $\frac{\left[\frac{\mu_0}{2\pi}\ln\left(\frac{2a+\ell}{\ell}\right)I_0\right]^2 at}{8\lambda}$
(c) $\frac{\left[\frac{2\mu_0}{\pi}\ln\left(\frac{a+\ell}{\ell}\right)I_0\right]^2 at}{3\lambda}$ (d) $\frac{\left[\frac{\mu_0}{2\pi}\ln\left(\frac{3a+\ell}{\ell}\right)I_0\right]^2 at}{6\lambda}$

RESPONSE GRID					
	17. ⓐⓑⓒⓓ	18. ⓐⓑⓒⓓ	19. ⓐⓑⓒⓓ	20. ⓐⓑⓒⓓ	21. ⓐⓑⓒⓓ
	22. ⓐⓑⓒⓓ	23. ⓐⓑⓒⓓ	24. ⓐⓑⓒⓓ	25. ⓐⓑⓒⓓ	26. ⓐⓑⓒⓓ

Space for Rough Work

DIRECTIONS (Qs. 27-Q.29) : Each of these questions contains two statements: Statement-1 (Assertion) and Statement-2 (Reason). Each of these questions has four alternative choices, only one of which is the correct answer. You have to select the correct choice.

(a) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(b) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1.
(c) Statement-1 is False, Statement-2 is True.
(d) Statement-1 is True, Statement-2 is False.

Q.27 Statement-1 : Soft iron is used as a core of transformer.
Statement-2 : Area of hysteresis loop for soft iron is small.

Q.28 Statement-1 : An electric motor will have maximum efficiency when back e.m.f. is equal to half of the applied e.m.f.
Statement-2 : Efficiency of electric motor depends only on magnitude of back e.m.f.

Q.29 Statement-1 : A transformer cannot work on dc supply.
Statement-2 : dc changes neither in magnitude nor in direction.

RESPONSE GRID	27. ⓐⓑⓒⓓ	28. ⓐⓑⓒⓓ	29. ⓐⓑⓒⓓ

DAILY PRACTICE PROBLEM SHEET 45 - PHYSICS			
Total Questions	29	Total Marks	116
Attempted		Correct	
Incorrect		Net Score	
Cut-off Score	28	Qualifying Score	48
Success Gap = Net Score – Qualifying Score			
Net Score = (Correct × 4) – (Incorrect × 1)			

Space for Rough Work

DAILY PRACTICE PROBLEMS

PHYSICS SOLUTIONS 45

1. **(a).** $e = -L\frac{dI}{dt} = -10\times10^{-3}\frac{1.0}{0.01} = -1$ Volt.
   $\therefore |e| = 1$ volt.

2. **(a).** $e = -L\frac{dI}{dt} = -L\frac{d}{dt}[3t^2+2t]$
   $= -L[6t+2] = -10\times10^{-3}[6t+2]$
   $(e)_{at\,t=2} = -10\times10^{-3}(6\times2+2)$
   $= -10\times10^{-3}(14) = -0.14$ Volt
   $|e| = 0.14$ volt.

3. **(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.

4. **(b).** $e_2 = -M\frac{dI_1}{dt} = -\frac{0-10}{3\times10^{-3}} = 3\times10^4$ volt $= 30$ kV.

5. **(d).** L_2 and L_3 are in parallel. Thus their combination gives
   $L' = \frac{L_2L_3}{L_2+L_3} = 0.25$ H
   The L' and L_1 are in series, thus the equivalent inductance is $L = L_1 + L' = 0.75 + 0.25 = 1$H

6. **(a).** We use $e = -L\,\Delta I/\Delta t$ to determine the value of induced emf. (i) $\Delta I = (7-0) = 7$A,
   $\Delta t = (2-0)$ ms $= 2$ms
   Thus $e = -4.6\times\frac{7}{2\times10^{-3}} = -16.1\times10^3$ volt
   (ii) $\Delta I = 5-7 = -2$A,
   $dt = (5-2)$ ms $= 3$ ms
   Thus $e = -4.6\times\frac{(-2)}{3\times10^{-3}} = 3.07\times10^3$ V

7. **(b).** $I = I_0(1-e^{-t/\tau})$
   Where $I = \frac{1}{2}I_0$ and $\tau = L/R$
   Thus $\frac{1}{2}I_0 = I_0(1-e^{-t/\tau})$
   or $\frac{1}{2} = e^{-t/\tau}$ or $2 = e^{+t/\tau}$ or $\log 2 = t/\tau$
   Thus $t = \tau\log_e 2 = \frac{50\times10^{-3}}{0.025}\times0.693 = 1.385$

8. **(a).** $V_S = I_S Z_S \Rightarrow 22 = I_S\times220$
   $\therefore I_S = 0.1$A
   $\frac{V_S}{V_P} = \frac{I_P}{I_S}$
   $\frac{22}{220} = \frac{I_P}{0.1} \Rightarrow I_P = 0.01$ A.

9. **(c).** $V_p = 220$V, $I_p = 5$S, $V_s = 2200$V
   $P_s = \frac{P_p}{2}$, $I_s = ?$
   $\because V_sI_s = \frac{V_pI_p}{2}$
   After putting the given value you will find
   $I_s = 0.25$ A.

10. **(d).** During decary of current
   $$i = i_0e^{-\frac{Rt}{L}} = \frac{E}{R}e^{\frac{Rt}{L}} = \frac{100}{100}e^{\frac{100\times10^{-3}}{100\times10^{-3}}} = \frac{1}{e}\text{A.}$$

11. **(c).** In a generator e.m.f. is induced according as Lenz's rule.
   The minus sign indicates that the direction of the induced e.m.f. is such as to oppose the change in current.

12. **(a).** 'Immediately' after pressing the switch S, the current in the coil L, due to its self-induction will be zero, that is $i_2 = 0$.
   The current will only be found in the resistance R_1 and this will be the total current in the circuit.
   $\therefore i = i_1 = \frac{E}{R_2} = \frac{10\text{ volt}}{5.0\text{ volt}} = 2.0$ ampere.

13. **(a).** (i) In series the same current i will be induced in both the inductors and the total magnetic-flux linked with them will be equal to the sum of the fluxes linked with them individualy, that is,
   $\Phi = L_1i + L_2i$.
   If the equivalent inductance be L, then $\Phi = Li$.
   $\therefore Li = L_1i + L_2i$ or $L = L_1 + L_2$.
   (ii) In parallel, let the induced currents in the two coils be i_1 and i_2. Then the total induced current is
   $i = i_1 + i_2 \quad \therefore \frac{di}{dt} = \frac{di_1}{dt} + \frac{di_2}{dt}$
   In parallel, the induced e.m.f. across each coil will be the same.
   Hence $e = -L_1\frac{di_1}{dt} = -L_2\frac{di_2}{dt}$.
   If the equivalent inductance be L, then $e = -L\frac{di}{dt}$.
   $$\therefore \frac{e}{L} = -\frac{di}{dt} = -\left(\frac{di_1}{dt}+\frac{di_2}{dt}\right) = \frac{e}{L_1}+\frac{e}{L_2}$$

or $\frac{1}{L}=\frac{1}{L_1}+\frac{1}{L_2}$ or $L=\frac{L_1L_2}{L_1+L_2}$.

14. **(d).** If we try to find field of the small coil and then calculate flux through long solenoid, the problem becomes very difficult. So we use the following fact about mutual inductance.

$$M_{21}=M_{12},\ \frac{\phi_2}{I_1}=\frac{\phi_1}{I_2}$$

Thus if I current flows in long solenoid, then flux ϕ through small coil is the same as the flux ϕ_2 that is obtained when I current flows through the small coil. Therefore,

$\phi_2=\phi_1=$ (Field at small coil) × (area) × (turns)

$$=\left(\mu_0\frac{N_2}{\ell_2}I\right)(AN_1)=\frac{\mu_0N_1N_2AI}{\ell_2}$$

15. **(a).** The induced e.m.f. is

$$e=-M\frac{\Delta i}{\Delta t} \quad\text{or}\quad M=-\frac{e}{\Delta i/\Delta t}$$

Here e = 1500 volt.

$$\therefore M=-\frac{1500}{(0-3.0)/0.001}=\frac{1500\times 0.001}{3.0}=0.5\text{ henry.}$$

16. **(c).** $|E_S|=M\left|\frac{dI_p}{dt}\right|=M\left|\frac{d(I_0\sin\omega t)}{dt}\right|$

$=MI_0\omega\,|\cos\omega t|$

$\Rightarrow$ Crest value $=MI_0\omega$

$=1.5\times1\times2\pi\times50$

$=471$ V

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

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

19. **(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

20. **(a)** $\eta=\frac{\text{Output}}{\text{Input}}\Rightarrow\frac{80}{100}=\frac{20\times120}{1000\times i_l}$

$$\Rightarrow i_l=\frac{20\times120\times100}{1000\times80}=3A.$$

21. ()

22. (b)

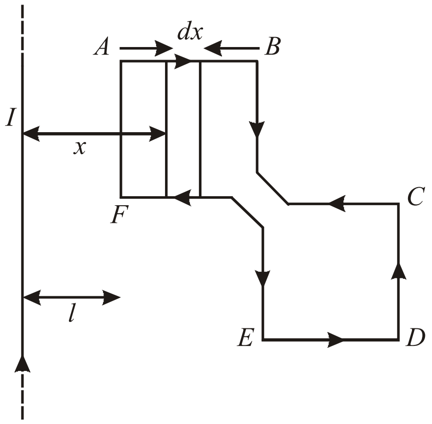
23. (a)

24. (b)

25. (a) **26.** (a) **27.** (b)

Consider a strip at a distance x from the wire of thickness dx. Magnetic flux associated with this strip

$$\Delta\phi=Badx=\frac{\mu_0 Ia}{2\pi x}dx$$



$$\phi=\frac{\mu_0 Ia}{2\pi}\left[\int_l^{a+l}\frac{dx}{x}+\int_{a+l}^{2a+l}\frac{dx}{x}\right]=\frac{\mu_0 Ia}{2\pi}\ln\left(\frac{2a+l}{l}\right)$$

$$M=\frac{\phi}{I_{(primary)}}\Rightarrow M=\frac{\mu_0 a}{2\pi}\ln\left(\frac{2a+l}{l}\right)$$

$$e=-M\frac{dI}{dt}$$

$$e=-MI_0=-\frac{\mu_0I_0a}{2\pi}\ln\left(\frac{2a+l}{l}\right)$$

Heat produced $=\frac{e^2}{R}t=\frac{\left[\frac{\mu_0}{2\pi}\ln\left(\frac{2a+l}{l}\right)I_0\right]^2 at}{8\lambda}$

28. **(a)** Hysteresis loss in the core of transformer is 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.

29. **(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.

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