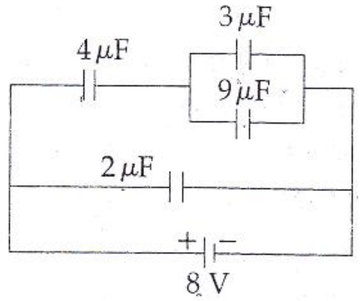
Physics

31. A combination of capacitors is set up as shown in the figure. The magnitude of the electric field, due to a point charge Q (having a charge equal to the sum of the charges on the 4«F and 9«F capcacitors), at a point distant 30 m from it, would equal



(1) 480 N / C **(2)** 240 N / C
(3) 360 N / C **(4)** 420 N / C

Sol. [4] Here $q_{4«F} = 24«C$ and $q_{9«F} = 18«C$

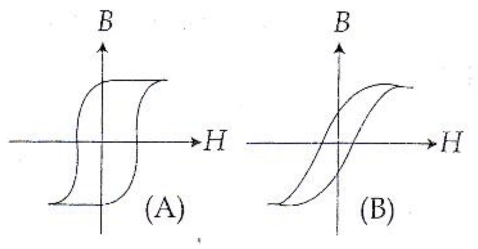
$$\therefore \quad E = k\frac{(q_{4\mu F} + q_{9\mu F})}{r^2} = 420\ N/C$$

32. An observer looks at a distant tree of height 10 m with a telescope of magnifiying power of 20. To the observer the tree appears

(1) 20 times nearer **(2)** 10 times taller
(3) 10 times nearer **(4)** 20 tims taller

Sol. [1] Here visual angle would be enlarged by 20 times & so the tree appears 20 times nearer

33. Hysteresis loop for two magnetic materials A and B are given below



These materials are used to make magnets for electric generators, transformer core and electromagnet core. Then it is proper to use

(1) B for electromagnets and transformers
(2) A for electric generators and transformers
(3) A for electromagnets and B for electric generators.
(4) A for transformers and B for electric generators.

Sol. [1] Both are made from soft magnetic materials.

34. Half lives of two radioactive elements A and B are 20 minutes and 40 minutes, respectively. Initially, the samples have equal number of nuclei, After 80 minutes, the ratio of decayed numbers of A and B nuclei will be

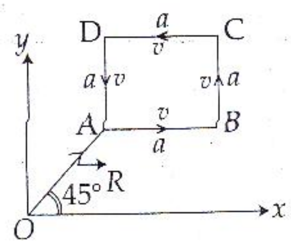
(1) 5 : 4 **(2)** 1 : 16
(3) 4 : 1 **(4)** 1 : 4

Sol. [1] Given duration is equal to 4 half lives of A and 2 of B.

$$\therefore \quad N_{A\,Remaining} = \frac{N_o}{16} \text{ or } N_{A\,decayed} = \frac{15N_o}{16}$$

$$N_{B\,Remaining} = \frac{N_o}{4} \text{ or } N_{B\,decayed} = \frac{3N_o}{4}$$

35. A particle of mass m is moving along the side of a square of side a, with a uniform speed v in the x-y plane as shown in the figure.



Which of the following statements is false for the angular momentum $\vec{L}$ about the origin?

(1) $\vec{L} = \frac{mv}{\sqrt{2}}R\hat{k}$ when the particle is moving from D to A.

(2) $\vec{L} = -\frac{mv}{\sqrt{2}}R\hat{k}$ when the particle is moving from A to B.

(3) $\vec{L} = -mv\left[\frac{R}{\sqrt{2}} - a\right]\hat{k}$ when the particle is moving from C to D.

(4) $\vec{L} = mv\left[\frac{R}{\sqrt{2}} + a\right]\hat{k}$ when the particle is moving from B to C.

Sol. [1, 3] When moving from $A \to B$

$$\vec{L}_o = mv\frac{R}{\sqrt{2}}\left(-\hat{k}\right)$$

When moving from $B \to C$

$$\vec{L}_o = mv\left(\frac{R}{\sqrt{2}} + a\right)\hat{k}$$

When moving from $C \to D$

$$\vec{L}_o = mv\left(\frac{R}{\sqrt{2}} + a\right)\hat{k}$$

When moving from $D \to A$

$$\vec{L}_o = mv\frac{R}{\sqrt{2}}\left(-\hat{k}\right)$$

so options (1) & (3) are incorrect

36. Choose the correct statement

(1) In frequency modulation the amplitude of the high frequency carrier wave is made to very in proportion to the frequency of the audio signal

(2) In amplitude modulation the amplitude of the high frequency carrier wave is made to vary in proportion to the amplitude of the audio signal.

(3) In amplitude modulation the frequency of the high frequency carrier wave is made to vary in proportion to the amplitude of the audio signal.

(4) If frequency modulation the amplitude of the high frequency carrier wave is made to vary in proportion to the amplitude of the audio signal.

Sol. [2]

37. In an experiment for determination of refractive index of glass of a prism by $i - \text{¢}$ plot, it was found that a ray incident at angle 35°, suffers a deviation of 40° and that it emerges at angle 79°. In that case which of the following is closest to the maximum possible value of the refractive index?

(1) 1.8 **(2)** 1.5

(3) 1.6 **(4)** 1.7

Sol. [2] For prism,

$$n = \frac{\sin\left(\frac{A + \text{¢}m}{2}\right)}{\sin(A/2)} \text{ and } \text{¢} = i + e - A$$

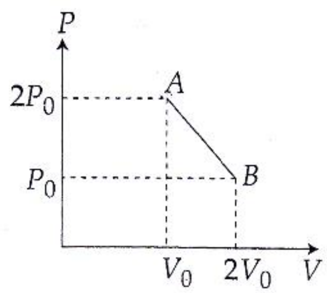
$\Rightarrow$ $A = 74^o$

As per the data , this given case is not of ¢_{min}. Hence n_{max} can be found using this deviation as minimum deviation

$$\therefore\ n_{max} = \frac{\sin\left(\frac{74+40}{2}\right)}{\sin\left(\frac{74}{2}\right)} = 1.4$$

Hence (2) could be the closest one.

38. n moles of an ideal gas undergoes a process $A \to B$ as shown in the figure. The maximum temperature of the gas during the process will be



(1) $\frac{9P_0V_0}{nR}$ **(2)** $\frac{9P_0V_0}{4nR}$

(3) $\frac{3P_0V_0}{2nR}$ **(4)** $\frac{9P_0V_0}{2nR}$

Sol. [2] The temperature of gas will be maximum somewhere between A and B. For the linear process between A and B, the *p–V* equation

$$p - p_0 = \left[\frac{p_0 - 2p_0}{2V_0 - V_0}\right]\left[V - V_0\right]$$

$$p = -\frac{p_0}{V_0}V + 2p_0$$

Using $p = \frac{RT}{V}$ above equation can be rewritten as

$$nRT = -\frac{p_0}{V_0}V^2 + 2p_0V$$

For maximum temperature $\frac{dT}{dV} = 0$. So

$$R\frac{dT}{dV} = -\frac{p_0}{V_0}2V + 3p_0 = 0 \Rightarrow V = \frac{3}{2}V_0$$

Substituting this value of V in (i) we get

$$p=\frac{3p_0}{2}$$

So, maximum temperature

$$T_{max}=\frac{pV}{Rn}=\frac{(3p_0/2)(3/2V_0)}{Rn}=\frac{9}{4}\frac{p_0V_0}{Rn}$$

39. Two identical wires A and B, each of length l, carry the same current I. Wire A is bent into a circle of radius R and wire B is bent to form a square of side a. If B_A and B_B are the values of magnetic field at the centres of the circle and square respectively, then the ratio $\frac{B_A}{B_B}$ is

(1) $\frac{®^2}{8\sqrt{2}}$ **(2)** $\frac{®^2}{8}$

(3) $\frac{®^2}{16\sqrt{2}}$ **(4)** $\frac{®^2}{16}$

Sol. [1] For case of wire A,

$$2®R=l\Rightarrow R=\frac{l}{2®}$$

$$\therefore\ B_A=\frac{«_o I}{2R}=\frac{«_o ® I}{l}$$

For case of wire B, $4a=l$ on $l=\frac{a}{4}$

$$B_B=4\,4\left[\frac{\mu_o i}{4\pi(a/2)}\left(\cos45^o+\cos45^o\right)\right]=\frac{8\sqrt{2}\mu_o I}{l}$$

$$\therefore\ \frac{B_A}{B_B}=\frac{®^2}{8\sqrt{2}}$$

40. A screw gauge with a pitch of 0.5 mm and a circular scale with 50 divisions is used to measure the thickness of a thin sheet of Aluminium. Before starting the measurement, it is found that when the two jaws of the screw gauge are brought in contact, the 45th division coincides with the main scale line and that the zero of the main scale is barely visible. What is the thickness of the sheet if the main scale reading is 0.5 mm and 25th division coincides with the main scale line?

(1) 0.50 mm **(2)** 0.75 mm

(3) 0.80 mm **(4)** 0.70 mm

Sol. [3] Here least count $=\frac{0.5}{50}=0.01$ mm

zero error $=-(50-45)\times\angle C=-0.05$ mm

obtained reading $=0.05$ mm $+\,25\times0.01$ mm
$=0.75$ mm

$\therefore$ true reading $=0.80$ mm

41. For a common emitter configuration, if ~ and have their usual meanings, the incorrect relationship between ~ and is

(1) $\sim=\frac{\ ^2}{1+\ ^2}$ **(2)** $\frac{1}{\sim}=\frac{1}{\ }+1$

(3) $\sim=\frac{\ }{1-\ }$ **(4)** $\sim=\frac{\ }{1+\ }$

Sol. [1, 3] For common emitter configuration,

$$=\frac{\sim}{1-\sim}\Rightarrow\sim=\frac{\ }{1+\ }\ \text{on}\ \frac{1}{\sim}=\frac{1}{\ }+1$$

Hecne (1) and (3) are incorrect

42. The box of a pin hole camera, of length L, has a hole of radius a. It is assumed that when the hole is illuminated by a parallel beam of light of wavelength ª the spread of the spot (obtained on the opposite wall of the camera) is the sum of its geometrical spread and the spread due to diffraction. The spot would then have its minimum size (say b_{min}) when:

(1) $a=\frac{ª^2}{L}$ and $b_{min}=\sqrt{4ªL}$

(2) $a=\frac{ª^2}{L}$ and $b_{min}=\left(\frac{2ª^2}{L}\right)$

(3) $a=\sqrt{ªL}$ and $b_{min}=\left(\frac{2ª^2}{L}\right)$

(4) $a=\sqrt{ªL}$ and $b_{min}=\sqrt{4ªL}$

Sol. [4] Here spread b, $=a+\frac{ªL}{a}$

so for spread to be max, $\frac{db}{da}=0$

$$\Rightarrow\ a=\sqrt{ªL}$$

and $b_{min}=\sqrt{ªL}+\frac{ªL}{\sqrt{ªL}}=\sqrt{4ªL}$

43. A person trying to lose weight by burning fat lifts a mass of 10 kg upto a height of 1 m 1000 times. Assume that the potential energy lost each time he lowers the mass is dissipated. How much fat will he use up considering the work done only when the weight is lifted up? Fat supplies 3.8×10^7 J of energy per kg which is converted to mechanical enegy with a 20% efficiency rate. Take g = 9.8 m s^{-2}.

(1) 12.89×10^{-3} kg **(2)** 2.45×10^{-3} kg

(3) 6.45×10^{-3} kg **(4)** 9.89×10^{-3} kg

Sol. [1] Total work done, $W = N(mgh) = 10^5$ J

Hence fat burned,

$$\Delta m = \frac{10^5}{(0.2)(3.8 \times 10^7)} = 12.89 \times 10^{-3} \text{ kg}$$

44. Arrange the following electromagnetic radiations per quantum in the order of increasing energy

A : Blue light B: Yellow light

C : X-ray D : Radiowaves

(1) B, A, D, C **(2)** D, B, A, C

(3) A, B, D, C **(4)** C, A, B, D

Sol. [2]

45. An ideal gas underoges a quasi static, reversible process in which its molar heat capacity C remains constant. If during this process the relation of pressure P and volume V is given by PV^n = constant , then n is given by (Here C_P and C_V are molar specific heat at constant pressure and constant volume, respectively)

(1) $n = \frac{C - C_V}{C - C_P}$ **(2)** $n = \frac{C_P}{C_V}$

(3) $n = \frac{C - C_P}{C - C_V}$ **(4)** $n = \frac{C_P - C}{C - C_V}$

Sol. [3] For this given polytropic process,

$$C = C_V + \frac{R}{1-n} \text{ or } C - C_V = \frac{R}{1-n}$$

or $1 - n = \frac{R}{C - C_V}$

or $n = 1 - \frac{R}{C - C_V} = \frac{C - (C_V + R)}{C - C_V}$

$$n = 1 - \frac{R}{C - C_V} = \frac{C - (C_V + R)}{C - C_V} = \frac{C - C_P}{C - C_V}$$

46. A satellite is revolving in a circular orbit at a height 'h' from the earth's surface (radius of earth R; h<<R). The minimum increase in its orbital velocity required, so that the satellite could escape from the earth's gravitational field, is close to :(Neglect the effect of atmosphere).

(1) $\sqrt{gR}(\sqrt{2} - 1)$ **(2)** $\sqrt{2gR}$

(3) $\sqrt{gR}$ **(4)** $\sqrt{gR/2}$

Sol. [1] Here $v_{\text{orbital}} = \sqrt{\frac{GM}{R+h}} \approx \sqrt{gR}$ if $h << R$

also $v_{\text{escape}} = \sqrt{2gR}$

Hence increase required, $\Delta V = \sqrt{2gR} - \sqrt{gR}$

$= \sqrt{gR}\,(\sqrt{2} - 1)$

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

(1) $3\,\Omega$ **(2)** $0.01\,\Omega$

(3) $2\,\Omega$ **(4)** $0.1\,\Omega$

Sol. [2] Here range has to be enhanced by $N = \frac{10\text{A}}{1\text{ mA}} = 10^4$

$\therefore$ Shunt required

$$S = \frac{G}{N-1} \approx 0.01\,\Omega$$

48. Radiation of wavelength a , is incident on a photocell. The fastest emitted electron has speed v. If the wavelength is changed to $\frac{3a}{4}$, the speed of the fastest emitted electron will be

(1) $= v\left(\frac{3}{4}\right)^{\frac{1}{2}}$ **(2)** $> v\left(\frac{4}{3}\right)^{\frac{1}{2}}$

(3) $< v\left(\frac{4}{3}\right)^{\frac{1}{2}}$ **(4)** $= v\left(\frac{4}{3}\right)^{\frac{1}{2}}$

Sol. [2] For first case

$$\frac{1}{2}mv^2 = \frac{hc-¤}{a}$$

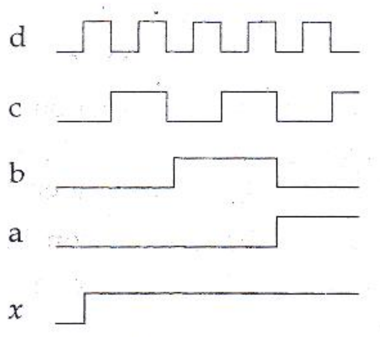
and for second case

$$\frac{1}{2}mv'^2 = \frac{hc}{(3\lambda/4)} - \phi > \frac{4}{3}\left(\frac{hc}{\lambda} - \phi\right)$$

$$\Rightarrow \frac{1}{2}mv'^2 > \frac{4}{3}\left(\frac{1}{2}mv^2\right)$$

$$v' > \sqrt{\frac{4}{3}}\,v$$

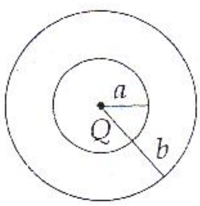
49. If a, b, c, d are inputs to a gate and x is its output, then as per the following time graph, the gate is



(1) NAND **(2)** NOT
(3) AND **(4)** OR

Sol. [4] OR GATE

50. The region between two concentric spheres of radii a and b, respectively (see figure), has volume charge density $° = \frac{A}{r}$, where A is constant and r is the distance from the centre. At the centre of the spehres is a point charge Q. The value of A such that the electric field in the region between the spheres will be constant, is



(1) $\frac{2Q}{®a^2}$ **(2)** $\frac{Q}{2®a^2}$

(3) $\frac{Q}{2®\left(b^2-a^2\right)}$ **(4)** $\frac{2Q}{®\left(a^2-b^2\right)}$

Sol. [2] At any point in the region bwtween them,

$$E = \frac{K\left[Q + \int_a^r \frac{A}{r} \times 4\pi r^2\, dr\right]}{r^2} = \text{constant}$$

or $$E = \frac{K\left[Q + 4\pi A\left(\frac{r^2-a^2}{2}\right)\right]}{r^2} = \text{constant}$$

$$\Rightarrow Q = \frac{4® A a^2}{2} \text{ or } A = \frac{Q}{2na^2}$$

51. A student measures the time period of 100 oscillations of a simple pendulum four times. The data set is 90 s, 91 s, 95 s, and 92 s. If the minimum division in the measuring clock is 1 s, then the reported mean time should be

(1) 92 ± 3s **(2)** 92 ± 2s

(3) 92 ± 5.0s **(4)** 92 ± 1.8s

Sol. [2] Hence $T_{mean} = \frac{90+91+95+92}{4} = 92$

$$\therefore |\Delta T|_{mean} = \frac{|-2|+|-1|+3+0}{4} = 1.5\text{s}$$

so, $T = 92 \pm 1.5$s but since least count of clock is 1s,

$T = 92 \pm 2$s

52. The temepartue dependence resistances of Cu and undoped Si in the temperatrue range 300 –400 K, is best described by

(1) Linear decrease for Cu, linear decrease for Si

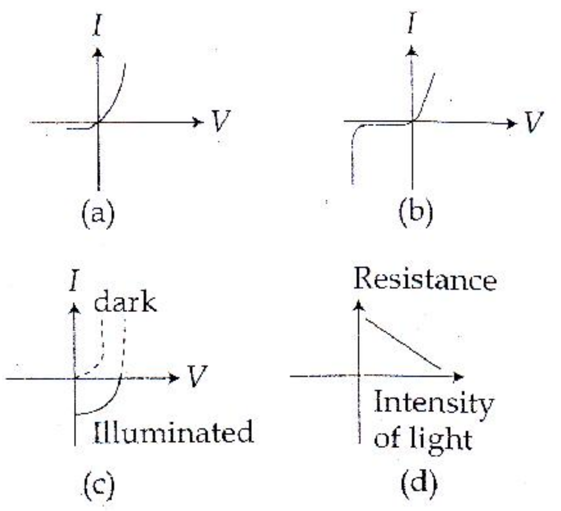
(2) Linear increase for Cu, linear increase for Si

(3) Linear increase for Cu, exponential increase for Si

(4) Linear increase for Cu, exponential decrease for Si.

Sol. [4]

53. Identify the semiconductor devices whose characteristics are given below, in the order (a), (b), (c), (d)



(1) Zener diode, Solar cell, Simple diode, Light dependent resistance

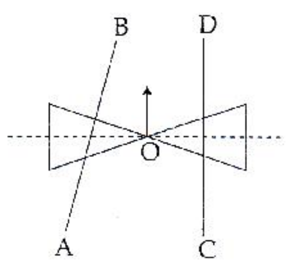
(2) Simple diode, Zener diode, Solar cell, Light dependent resistance

(3) Zener diode, Simple diode, Light dependent resistance, Solar cell

(4) Solar cell, Light dependent resistance, Zener diode, Simple diode.

Sol. [2]

54. A roller is made by joining together two cones at their vertices O. It is kept on two rails AB and CD which are placed asymmetrically (see figure), with its axis perpendicular to CD and its centre O at the centre of line joining AB and CD (see figure). It is given a light push so that it starts rolling with its centre O moving parallel to CD in the direction shown. As it moves, the roller will tend to



(1) turn left and right alternately

(2) turn left

(3) turn right

(4) go straight

Sol. [2] As the roller moves forward, the line of contact in the left half tends to slip forward so friction force acts backward, which produces an anticlockwise torque about O so the roller turns left.

55. A pendulum clock loses 12 s a day if the temperature is 40°C and gains 4 s a day if the temperature is 20°C. The temperature at which the clock will show correct time, and the co-efficient of linear expansion $(\sim)$ of the metal of the pendulum shaft are respectively

(1) 55°C, $\sim = 1.85\times10^{-2}/°C$

(2) 25°C, $\sim = 1.85\times10^{-5}/°C$

(3) 60°C, $\sim = 1.85\times10^{-4}/°C$

(4) 30°C, $\sim = 1.85\times10^{-3}/°C$

Sol. [2] Its clear that temperature at which it show correct time is between 20° & 40°C

using $\frac{\Delta T}{T} = \frac{1}{2} \propto \Delta T$

so, $\frac{12}{24\times60\times60} = \frac{1}{2}\propto(40-T)$ . . . (i)

and $\frac{4}{24\times60\times60} = \frac{1}{2}\propto(T-20)$ . . . (2)

form (i) and (ii) $T = 25°C$ and $\sim = 1.8\times10^{-5}/°C$

56. A uniform string of length 20 m is suspended from a rigid support. A short wave pulse is introduced at its lowest end. It starts moving up the string. The time taken to reach the support is (take $g = 10\,ms^{-2}$)

(1) $\sqrt{2}$ s **(2)** 2®$\sqrt{2}$ s

(3) 2 s **(4)** $2\sqrt{2}$ s

Sol. [4] At any corss section at length x above lowest point,

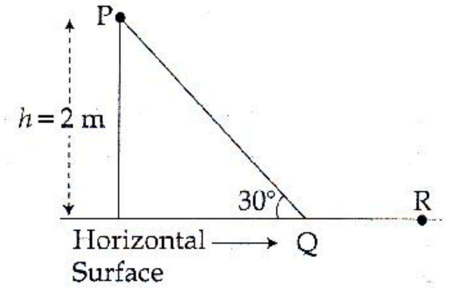
$T = \frac{mgx}{l} = «gx$

Hence speed of wave, $v = \sqrt{\frac{T}{«}} = \sqrt{gx}$

so, $\frac{dx}{dt} = \sqrt{gx} \Rightarrow \int_0^{\ell}\frac{dx}{\sqrt{gx}} = \int_0^{t}dt$

$\Rightarrow t = 2\sqrt{2}s$

57. A point particle of mass *m*, moves along the uniformly rough track PQR as shown in the figure. The coefficient of friction, between the particle and the rough track equals μ. The particle is released, from rest, from the point P and it comes to rest at a point R. The energies, lost by the ball, over the parts, PQ and QR, of the track, are equal to each other, and no energyis lost when particle changes direction from PQ to QR.



The values of the coefficient of friction μ and the distance $x(=QR)$, are, respectively close to

(1) 0.29 and 6.5 m **(2)** 0.2 and 6.5 m
(3) 0.2 and 3.5 m **(4)** 0.29 and 3.5 m

Sol. [4] Here, work done by friction is same in PQ and QR, so

$$f_{PQ}\left(\frac{h}{\sin 30}\right) = f_{QR}(x)$$

or $$(\mu mg\cos 30)\left(\frac{h}{\sin 30}\right) = \mu mgx$$

$\Rightarrow$ $x = h\cot 30^\circ = 3.5$ m

Also from energy considerations,

$mgh = 2\mu mgx$

$\Rightarrow$ $\mu = \frac{2}{7} = 0.29$

58. A pipe open at both ends has a fundamental frequency *f* in air. The pipe is dipped vertically in water so that half of it is in water. The fundamental frequency of the air column is now

(1) f **(2)** $\frac{f}{2}$

(3) $\frac{3f}{4}$ **(4)** $2f$

Sol. [1]

59. A particle performs simple harmonic motion with amplitude *A*. Its speed is trebled at the instant that it is at a distance $\frac{2A}{3}$ from equilibrium position. The new amplitude of the motion is

(1) $\frac{7A}{3}$ **(2)** $\frac{A}{3}\sqrt{41}$

(3) 3 A **(4)** $A\sqrt{3}$

Sol. [1] using $v = \omega\sqrt{A^2 - x^2}$

$$v = \omega\sqrt{A^2 - (2A/3)^2} = \frac{\sqrt{5}}{3}\omega A$$

Now on trepling speed, let new amplitude becomes A' then,

$$3v = \omega\sqrt{(A')^2 - (2A/3)^2}$$

$\Rightarrow$ $A' = \frac{7A}{3}$

60. An arc lamp requires a direct current of 10 A at 80 V to function. If it is connected to a 220 V (rms), 50 Hz AC supply, the series inductor needed for it to work is close to

(1) 0.065 H **(2)** 80 H
(3) 0.08 H **(4)** 0.044 H

Sol. [1] From given information, $R = 8\Omega$,

In second case

$$\frac{V_R}{V} = \frac{R}{Z} = \frac{R}{(\omega L)^2 + R^2}$$

so, $$\frac{80}{220} = \frac{8}{\sqrt{(100\pi L)^2 + 64}}$$

$\Rightarrow L = 0.065$ H