72. For production of beats the two sources must have
(a) different frequencies and same amplitude
(b) different frequencies
(c) different frequencies, same amplitude and same phase
(d) different frequencies and same phase *(1992)*

73. The frequency of sinusodial wave
$y = 0.40\cos[2000\,t + 0.80]$ would be
(a) 1000π Hz (b) 2000 Hz
(c) 20 Hz (d) $\frac{1000}{\pi}$ Hz *(1992)*

74. With the propogation of a longitudinal wave through a material medium, the quantities transmitted in the propogation direction are
(a) energy, momentum and mass
(b) energy
(c) energy and mass
(d) energy and linear momentum *(1992)*

75. Two trains move towards each other with the same speed. The speed of sound is 340 m/s. If the height of the tone of the whistle of one of them heard on the other changes to 9/8 times, then the speed of each train should be
(a) 20 m/s (b) 2 m/s
(c) 200 m/s (d) 2000 m/s *(1991)*

76. A closed organ pipe (closed at one end) is excited to support the third overtone. It is found that air in the pipe has
(a) three nodes and three antinodes
(b) three nodes and four antinodes
(c) four nodes and three antinodes
(d) four nodes and four antinodes *(1991)*

77. Velocity of sound waves in air is 330 m/s. For a particular sound wave in air, a path difference of 40 cm is equivalent to phase difference of $1.6\,\pi$. The frequency of this wave is
(a) 165 Hz (b) 150 Hz
(c) 660 Hz (d) 330 Hz *(1990)*

78. A 5.5 metre length of string has a mass of 0.035 kg. If the tension in the string in 77 N, the speed of a wave on the string is
(a) 110 m s^{-1} (b) 165 m s^{-1}
(c) 77 m s^{-1} (d) 102 m s^{-1} *(1989)*

79. If the amplitude of sound is doubled and the frequency reduced to one fourth, the intensity of sound at the same point will be
(a) increasing by a factor of 2
(b) decreasing by a factor of 2
(c) decreasing by a factor of 4
(d) unchanged *(1989)*

80. The velocity of sound in any gas depends upon
(a) wavelength of sound only
(b) density and elasticity of gas
(c) intensity of sound waves only
(d) amplitude and frequency of sound *(1988)*

81. Equation of progressive wave is given by
$y = 4\sin\left[\pi\left(\frac{t}{5} - \frac{x}{9}\right) + \frac{\pi}{6}\right]$ where y, x are in cm and t is in seconds. Then which of the following is correct ?
(a) $v = 5$ cm (b) $\lambda = 18$ cm
(c) $a = 0.04$ cm (d) $f = 50$ Hz *(1988)*

Answer Key

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

EXPLANATIONS

1. **(a) :** Nearest harmonics of an organ pipe closed at one end is differ by twice of its fundamental frequency.

$\therefore$ $260 - 220 = 2\upsilon$, $\upsilon = 20$ Hz

2. **(c) :** The required frequency of sound heard by the driver of second car is given as

$$\upsilon' = \upsilon\left(\frac{v + v_o}{v - v_s}\right),$$

where v = velocity of sound

v_o = velocity of observer, *i.e.*, second car

v_s = velocity of source *i.e.*, first car

$$\upsilon' = 400\left(\frac{340 + 16.5}{340 - 22}\right) = 400\left(\frac{356.5}{318}\right)$$

$\upsilon' \approx 448$ Hz

3. **(b) :** Second overtone of an open organ pipe

$$\text{(Third harmonic)} = 3 \times \upsilon'_0 = 3 \times \frac{v}{2L'}$$

First overtone of a closed organ pipe

$$\text{(Third harmonic)} = 3 \times \upsilon_0 = 3 \times \frac{v}{4L}$$

According to question,

$$3\upsilon'_0 = 3\upsilon_0 \Rightarrow 3 \times \frac{v}{2L'} = 3 \times \frac{v}{4L}$$

$\therefore$ $L' = 2L$

4. **(d)**

5. **(a) :** Here, frequency of sound emitted by siren, $\upsilon_0 = 800$ Hz

Speed of source, $v_s = 15$ m s^{-1}

Speed of sound in air, $v = 330$ m s^{-1}

Apparent frequency of sound at the cliff

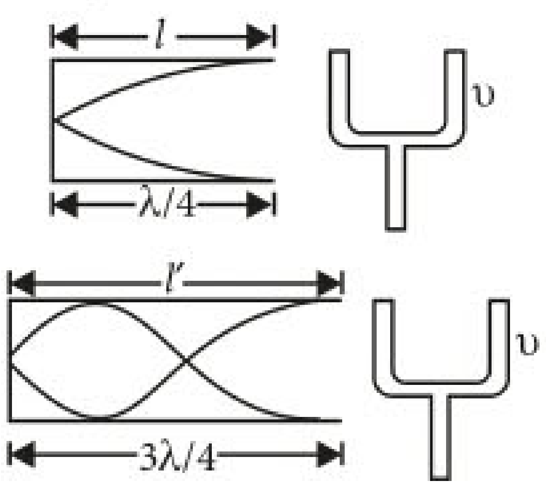
= frequency heard by observer = υ

Using Doppler's effect of sound

$$\upsilon = \left(\frac{v}{v - v_s}\right)\upsilon_0 = \frac{330}{330 - 15} \times 800$$

$$= \frac{330}{315} \times 800 = 838.09 \text{ Hz} \approx 838 \text{ Hz}$$

6. **(a) :** From figure,



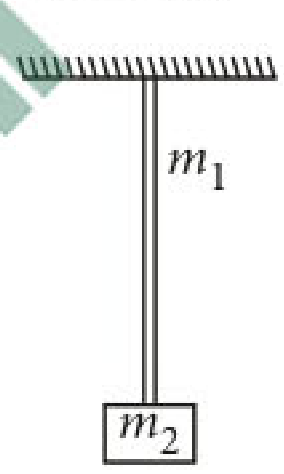
First harmonic is obtained at

$$l = \frac{\lambda}{4} = 50 \text{ cm}$$

Third harmonic is obtained for resonance,

$$l' = \frac{3\lambda}{4} = 3 \times 50 = 150 \text{ cm}.$$

7. **(d) :** Wavelength of pulse at the lower end,



$$\lambda_1 \propto \text{velocity } (v_1) = \sqrt{\frac{T_1}{\mu}}$$

$$\text{Similarly, } \lambda_2 \propto v_2 = \sqrt{\frac{T_2}{\mu}}$$

$$\therefore \quad \frac{\lambda_2}{\lambda_1} = \sqrt{\frac{T_2}{T_1}} = \sqrt{\frac{(m_1 + m_2)g}{m_2 g}}$$

$$= \sqrt{\frac{m_1 + m_2}{m_2}}$$

8. **(b) :** For a string fixed at both ends, the resonant frequencies are

$$\upsilon_n = \frac{nv}{2L} \quad \text{where } n = 1, 2, 3, \ldots..$$

The difference between two consecutive resonant frequencies is

$$\Delta\upsilon_n = \upsilon_{n+1} - \upsilon_n = \frac{(n+1)v}{2L} - \frac{nv}{2L} = \frac{v}{2L}$$

which is also the lowest resonant frequency ($n = 1$).

Thus the lowest resonant frequency for the given string = 420 Hz – 315 Hz = 105 Hz

9. **(c) :** Since 4.0 g of a gas occupies 22.4 litres at NTP, so the molecular mass of the gas is

$$M = 4.0 \text{ g mol}^{-1}$$

As the speed of the sound in the gas is

$$v = \sqrt{\frac{\gamma RT}{M}}$$

where γ is the ratio of two specific heats, R is the universal gas constant and T is the temperature of the gas.

$$\therefore \quad \gamma = \frac{Mv^2}{RT}$$

Here, $M = 4.0$ g mol^{-1} = 4.0×10^{-3} kg mol^{-1},

$v = 952$ m s^{-1}, $R = 8.3$ J K^{-1} mol^{-1} and $T = 273$ K (at NTP)

$$\therefore \quad \gamma = \frac{(4.0 \times 10^{-3} \text{ kg mol}^{-1})(952 \text{ ms}^{-1})^2}{(8.3 \text{ J K}^{-1} \text{mol}^{-1})(273 \text{ K})} = 1.6$$

By definition, $\gamma = \frac{C_p}{C_v}$ or $C_p = \gamma C_v$

But $\gamma = 1.6$ and $C_v = 5.0 \text{ JK}^{-1}\text{ mol}^{-1}$

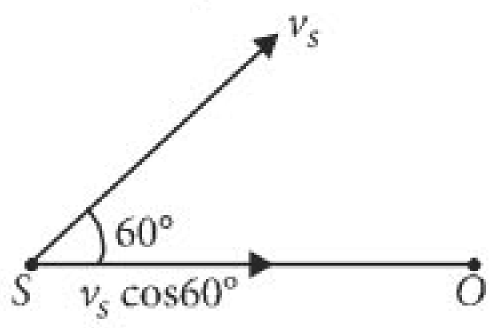
$\therefore \quad C_p = (1.6)(5.0 \text{ JK}^{-1}\text{ mol}^{-1}) = 8.0 \text{ JK}^{-1}\text{ mol}^{-1}$

10. (d) : Here,

Frequency of source, $\upsilon_0 = 100$ Hz

Velocity of source, $v_s = 19.4 \text{ ms}^{-1}$

Velocity of sound in air, $v = 330 \text{ ms}^{-1}$



As the velocity of source along the source observer line is $v_s\cos60°$ and the observer is at rest, so the apparent frequency observed by the observer is

$$\upsilon = \upsilon_0\left(\frac{v}{v - v_s\cos 60°}\right)$$

$$= (100 \text{ Hz})\left(\frac{330 \text{ ms}^{-1}}{330 \text{ ms}^{-1} - (19.4 \text{ ms}^{-1})\left(\frac{1}{2}\right)}\right)$$

$$= (100 \text{ Hz})\left(\frac{330 \text{ ms}^{-1}}{330 \text{ ms}^{-1} - 9.7 \text{ ms}^{-1}}\right)$$

$$= (100 \text{ Hz})\left(\frac{330 \text{ ms}^{-1}}{320.3 \text{ ms}^{-1}}\right) = 103 \text{ Hz}$$

11. (a) : For closed organ pipe, fundamental frequency is given by $\upsilon_c = \frac{v}{4l}$

For open organ pipe, fundamental frequency is given by $\upsilon_o = \frac{v}{2l'}$

2nd overtone of open organ pipe

$\upsilon' = 3\upsilon_o$; $\upsilon' = \frac{3v}{2l'}$

According to question, $\upsilon_c = \upsilon'$

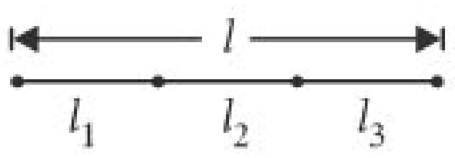
$$\frac{v}{4l} = \frac{3v}{2l'}$$

$l' = 6l$

Here, $l = 20$ cm, $l' = ?$

$\therefore \quad l' = 6 \times 20 = 120$ cm

12. (a) :



$$n_1 = \frac{1}{2l_1}\sqrt{\frac{T}{\mu}} \quad \text{...(i)}$$

$$n_2 = \frac{1}{2l_2}\sqrt{\frac{T}{\mu}} \quad \text{...(ii)}$$

$$n_3 = \frac{1}{2l_3}\sqrt{\frac{T}{\mu}} \quad \text{...(iii)}$$

$$n = \frac{1}{2l}\sqrt{\frac{T}{\mu}} \quad \text{...(iv)}$$

From eqn. (iv), we get

$$\frac{1}{n} = \frac{2l}{\sqrt{\frac{T}{\mu}}}$$

As $l = l_1 + l_2 + l_3$

$$\therefore \quad \frac{1}{n} = \frac{2(l_1 + l_2 + l_3)}{\sqrt{\frac{T}{\mu}}} = \frac{2l_1}{\sqrt{\frac{T}{\mu}}} + \frac{2l_2}{\sqrt{\frac{T}{\mu}}} + \frac{2l_3}{\sqrt{\frac{T}{\mu}}}$$

$$= \frac{1}{n_1} + \frac{1}{n_2} + \frac{1}{n_3} \quad \text{[Using (i), (ii) and (iii)]}$$

13. (d) : Fundamental frequency of the closed organ pipe is

$$\upsilon = \frac{v}{4L}$$

Here, $v = 340 \text{ m s}^{-1}$, $L = 85 \text{ cm} = 0.85$ m

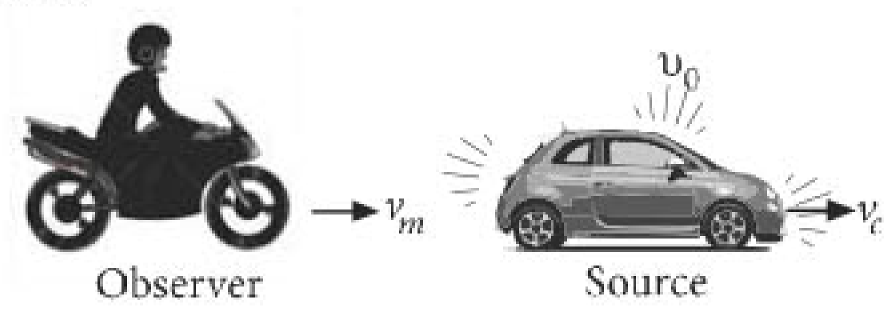
$$\therefore \quad \upsilon = \frac{340 \text{ m s}^{-1}}{4 \times 0.85 \text{ m}} = 100 \text{ Hz}$$

The natural frequencies of the closed organ pipe will be

$\upsilon_n = (2n - 1)\upsilon = \upsilon, 3\upsilon, 5\upsilon, 7\upsilon, 9\upsilon, 11\upsilon, 13\upsilon, ...$
$= 100$ Hz, 300 Hz, 500 Hz, 700 Hz, 900 Hz, 1100 Hz, 1300 Hz,... and so on

Thus, the natural frequencies lies below the 1250 Hz is 6.

14. (c) :



Here, speed of motorcyclist, $v_m = 36 \text{ km hour}^{-1}$

$$= 36 \times \frac{5}{18} = 10 \text{ m s}^{-1}$$

Speed of car,

$$v_c = 18 \text{ km hour}^{-1} = 18 \times \frac{5}{18} \text{ m s}^{-1} = 5 \text{ m s}^{-1}$$

Frequency of source, $\upsilon_0 = 1392$ Hz

Speed of sound, $v = 343 \text{ m s}^{-1}$

The frequency of the honk heard by the motorcyclist is

$$\upsilon' = \upsilon_0\left(\frac{v + v_m}{v + v_c}\right) = 1392\left(\frac{343 + 10}{343 + 5}\right)$$

$$= \frac{1392 \times 353}{348} = 1412 \text{ Hz}$$

15. (b) : Pressure change will be minimum at both ends.

16. (c) : The standard equation of a wave travelling along +ve x-direction is given by

$y = A\sin(kx - \omega t)$

where

A = Amplitude of the wave

k = angular wave number

ω = angular frequency of the wave

Given: $A = 1$ m, $\lambda = 2\pi$ m, $\upsilon = \frac{1}{\pi}$Hz

As $k = \frac{2\pi}{\lambda} = \frac{2\pi}{2\pi} = 1$

$\omega = 2\pi\upsilon = 2\pi \times \frac{1}{\pi} = 2$

$\therefore$ The equation of the given wave is

$y = 1\sin(1x - 2t) = \sin(x - 2t)$

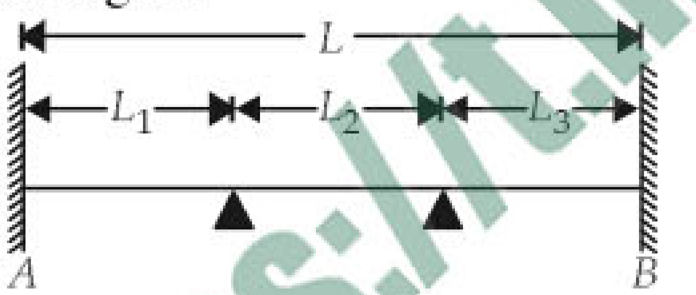
17. (c) : Let υ be frequency of the unknown source. As it gives 4 beats per second when sounded with a source of frequency 250 Hz,

$\therefore$ $\upsilon = 250 \pm 4 = 246$ Hz or 254 Hz

Second harmonic of this unknown source = 492 Hz or 508 Hz which gives 5 beats per second, when sounded with a source of frequency 513 Hz.

Therefore unknown frequency, $\upsilon = 254$ Hz.

18. (d) : Let L(= 100 cm) be the length of the wire and L_1, L_2 and L_3 are the lengths of the segments as shown in the figure.



Fundamental frequency, $\upsilon \propto \frac{1}{L}$

As the fundamental frequencies are in the ratio of 1 : 3 : 5,

$\therefore$ $L_1 : L_2 : L_3 = \frac{1}{1} : \frac{1}{3} : \frac{1}{5} = 15 : 5 : 3$

Let x be the common factor. Then

$15x + 5x + 3x = L = 100$

$23x = 100$ or $x = \frac{100}{23}$

$\therefore$ $L_1 = 15 \times \frac{100}{23} = \frac{1500}{23}$ cm

$L_2 = 5 \times \frac{100}{23} = \frac{500}{23}$ cm

$L_3 = 3 \times \frac{100}{23} = \frac{300}{23}$ cm

$\therefore$ The bridges should be placed from A at $\frac{1500}{23}$ cm and $\frac{2000}{23}$ cm respectively.

19. (a) : The situation as shown in the figure.

Here,

Speed of listener, $v_L = 1$ ms^{-1}

Speed of sound, $v = 330$ ms^{-1}

Frequency of each source, $\upsilon = 660$ Hz

Apparent frequency due to P,

$$\upsilon' = \frac{\upsilon(v - v_L)}{v}$$

Apparent frequency due to Q,

$$\upsilon'' = \frac{\upsilon(v + v_L)}{v}$$

Number of beats heard by the listener per second is

$$\upsilon'' - \upsilon' = \frac{\upsilon(v + v_L)}{v} - \upsilon\frac{(v - v_L)}{v}$$

$$= \frac{2\upsilon v_L}{v} = \frac{2 \times 660 \times 1}{330} = 4$$

20. (c) : Let l be the length of the string. Fundamental frequency is given by

$$\upsilon = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$$

or $\upsilon \propto \frac{1}{l}$ ($\because$ T and μ are constants)

Here, $l_1 = \frac{k}{\upsilon_1}, l_2 = \frac{k}{\upsilon_2}, l_3 = \frac{k}{\upsilon_3}$ and $l = \frac{k}{\upsilon}$

But $l = l_1 + l_2 + l_3$

$$\therefore \quad \frac{1}{\upsilon} = \frac{1}{\upsilon_1} + \frac{1}{\upsilon_2} + \frac{1}{\upsilon_3}$$

21. (d) : Given : $y_1 = 4\sin 600\pi t$, $y_2 = 5\sin 608\pi t$

$\therefore$ $\omega_1 = 600\pi$ or $2\pi\upsilon_1 = 600\pi$ or $\upsilon_1 = 300$

$A_1 = 4$

and $\omega_2 = 608\pi$ or $2\pi\upsilon_2 = 608\pi$ or $\upsilon_2 = 304$

$A_2 = 5$

Number of beats heard per second

$= \upsilon_2 - \upsilon_1 = 304 - 300 = 4$

$$\frac{I_{max}}{I_{min}} = \frac{(A_1 + A_2)^2}{(A_1 - A_2)^2} = \frac{(4+5)^2}{(4-5)^2} = \frac{81}{1}$$

22. (b) : The given wave equation is

$$y = 3\sin\frac{\pi}{2}(50t - x)$$

$$y = 3\sin\left(25\pi t - \frac{\pi}{2}x\right) \quad \text{...(i)}$$

The standard wave equation is

$y = A\sin(\omega t - kx)$ ...(ii)

Comparing (i) and (ii), we get

$\omega = 25\pi,\ k = \frac{\pi}{2}$

Wave velocity,

$$v = \frac{\omega}{k} = \frac{25\pi}{(\pi/2)} = 50\ \text{ms}^{-1}$$

Particle velocity, $v_p = \frac{dy}{dt} = \frac{d}{dt}\left(3\sin\left(\left(25\pi t - \frac{\pi}{2}\right)\right)\right)$

$$= 75\pi\cos\left(25\pi t - \frac{\pi}{2}\right)$$

Maximum particle velocity, $(v_p)_{max} = 75\pi\ \text{ms}^{-1}$

$$\therefore\ \frac{(v_p)_{max}}{v} = \frac{75\pi}{50} = \frac{3}{2}\pi$$

23. (c) : Here,

Speed of the train, $v_T = 220\ \text{ms}^{-1}$

Speed of sound in air, $v = 330\ \text{ms}^{-1}$

The frequency of the echo detected by the driver of the train is

$$\upsilon' = \upsilon\left(\frac{v + v_T}{v - v_T}\right) = 1000\left(\frac{330+220}{330-220}\right)$$

$$= 1000 \times \frac{550}{110} = 5000\ \text{Hz}$$

24. (a) : $y_1 = a\sin(\omega t + kx + 0.57)$

$\therefore$ Phase, $\phi_1 = \omega t + kx + 0.57$

$$y_2 = a\cos(\omega t + kx) = a\sin\left(\omega t + kx + \frac{\pi}{2}\right)$$

$\therefore$ Phase, $\phi_2 = \omega t + kx + \frac{\pi}{2}$

Phase difference, $\Delta\phi = \phi_2 - \phi_1$

$$= \left(\omega t + kx + \frac{\pi}{2}\right) - (\omega t + kx + 0.57) = \frac{\pi}{2} - 0.57$$

$= (1.57 - 0.57)$ radian $= 1$ radian

25. (c) : Here, $v_{air} = 350$ m/s, $v_{brass} = 3500$ m/s

When a sound wave travels from one medium to another medium its frequency remains the same

$\because$ Frequency, $\upsilon = \frac{v}{\lambda}$

Since υ remains the same in both the medium

$$\Rightarrow\ \frac{v_{air}}{\lambda_{air}} = \frac{v_{brass}}{\lambda_{brass}}$$

$$\lambda_{brass} = \lambda_{air} \times \frac{v_{brass}}{v_{air}} = \lambda_{air} \times \frac{3500}{350} = 10\lambda_{air}$$

26. (b) : As $\upsilon = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$. $\therefore\ \frac{\Delta\upsilon}{\upsilon} = \frac{1}{2}\frac{\Delta T}{T}$

$$\frac{\Delta T}{T} = 2\frac{\Delta\upsilon}{\upsilon} = 2 \times \frac{6}{600} = 0.02$$

27. (c) : The given wave equation is

$y = A\sin(\omega t - kx)$

Wave velocity, $v = \frac{\omega}{k}$ ...(i)

Particle velocity, $v_p = \frac{dy}{dt} = A\omega\cos(\omega t - kx)$

Maximum particle velocity, $(v_p)_{max} = A\omega$ ...(ii)

According to the given question

$v = (v_p)_{max}$

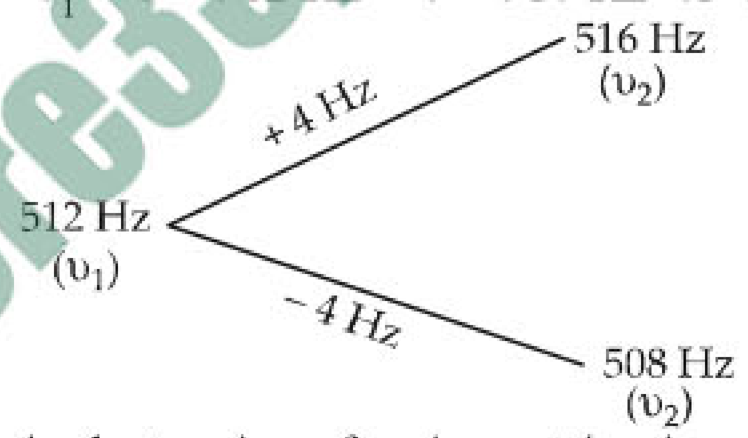
$\frac{\omega}{k} = A\omega$ (Using (i) and (ii))

$\frac{1}{k} = A$ or $\frac{\lambda}{2\pi} = A$ $\left(\because\ k = \frac{2\pi}{\lambda}\right)$

$\lambda = 2\pi A$

28. (d) : Let the frequencies of tuning fork and piano string be υ_1 and υ_2 respectively.

$\therefore\ \upsilon_2 = \upsilon_1 \pm 4 = 512\ \text{Hz} \pm 4 = 516$ Hz or 508 Hz



Increase in the tension of a piano string increases its frequency.

If $\upsilon_2 = 516$ Hz, further increase in υ_2, resulted in an increase in the beat frequency. But this is not given in the question.

If $\upsilon_2 = 508$ Hz, further increase in υ_2 resulted in decrease in the beat frequency. This is given in the question. When the beat frequency decreases to 2 beats per second. Therefore, the frequency of the piano string before increasing the tension was 508 Hz.

29. (a) : $l_1 = 0.516$ m, $l_2 = 0.491$ m, $T = 20$ N.

Mass per unit length, $\mu = 0.001$ kg/m.

Frequency, $\upsilon = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$

$$\upsilon_1 = \frac{1}{2\times 0.516}\sqrt{\frac{20}{0.001}}$$

$$\upsilon_2 = \frac{1}{2\times 0.491}\sqrt{\frac{20}{0.001}}$$

$\therefore$ Number of beats $= \upsilon_1 - \upsilon_2 = 7$.

30. (b) : Car is the source and the hill is observer.

Frequency heard at the hill, υ_1

$$\therefore\ \upsilon_1 = \frac{\upsilon \times v}{(v - V)} = \frac{600 \times 330}{330 - 30}$$

Now for reflection, the hill is the source and the driver the observer.

$\therefore\ \upsilon_2 = \upsilon_1 \times \dfrac{(330+30)}{330}$

$\Rightarrow\ \upsilon_2 = \dfrac{600\times 330}{300}\times\dfrac{360}{330} \Rightarrow \upsilon_2 = 720$ Hz.

31. **(c) :** Amplitude = 2 cm = 0.02 m, v = 128 m/s

$\lambda = \dfrac{4}{5} = 0.8$ m; $\upsilon = \dfrac{128}{0.8} = 160$ Hz

$\omega = 2\pi\upsilon = 2\pi\times 160 = 1005$; $k = \dfrac{2\pi}{\lambda} = \dfrac{2\pi}{0.8} = 7.85$

$\therefore\ y = 0.02\sin(7.85x - 1005t)$.

32. **(b) :** $x = a\sin(\omega t + \pi/6)$

$\dfrac{dx}{dt} = a\omega\cos(\omega t + \pi/6)$

Max. velocity = $a\omega$

$\therefore\ \dfrac{a\omega}{2} = a\omega\cos(\omega t + \pi/6)$;

$\therefore\ \cos(\omega t + \pi/6) = \dfrac{1}{2}$

60° or $\dfrac{2\pi}{6}$ radian $= \dfrac{2\pi}{T}\cdot t + \pi/6$;

$\dfrac{2\pi}{T}\cdot t = \dfrac{2\pi}{6} - \dfrac{\pi}{6} = +\dfrac{\pi}{6}$

$\therefore\ t = +\dfrac{\pi}{6}\times\dfrac{T}{2\pi} = \left|+\dfrac{T}{12}\right|$

33. **(b) :** Other factors such as ω and v remaining the same, $I = A^2 \times$ constant K, or $A = \sqrt{\dfrac{I}{K}}$

On superposition

$A_{max} = A_1 + A_2$ and $A_{min} = A_1 - A_2$

$\therefore\ A^2_{max} = A_1^2 + A_2^2 + 2A_1A_2$

$\Rightarrow\ \dfrac{I_{max}}{K} = \dfrac{I_1}{K} + \dfrac{I_2}{K} + \dfrac{2\sqrt{I_1I_2}}{K}$

$A^2_{min} = A_1^2 + A_2^2 - 2A_1A_2$

$\Rightarrow\ \dfrac{I_{min}}{K} = \dfrac{I_1}{K} + \dfrac{I_2}{K} - \dfrac{2\sqrt{I_1I_2}}{K}$

$\therefore\ I_{max} + I_{min} = 2I_1 + 2I_2$

34. **(a) :** $y = 0.25\sin(10\pi x - 2\pi t)$

$y_{max} = 0.25$

$k = \dfrac{2\pi}{\lambda} = 10\pi \Rightarrow \lambda = 0.2$ m

$\omega = 2\pi f = 2\pi \Rightarrow f = 1$ Hz

The sign is negative inside the bracket. Therefore this wave travels in the positive x-direction.

35. **(b) :** $Y_1 = 4\sin 500\pi t$, $Y_2 = 2\sin 506\pi t$

$\omega_1 = 500\pi$, $\omega_1 = 2\pi\upsilon$, $\upsilon_1 = 250$, $\upsilon_2 = 253$

$\upsilon = \upsilon_2 - \upsilon_1 = 253 - 250 = 3$ beats/s.

Number of beats per minute = 3 × 60 = 180.

36. **(a) :** Frequency = $\dfrac{\text{velocity}}{\text{wavelength}}$

$\therefore\ \upsilon_1 = \dfrac{v}{\lambda_1} = \dfrac{330}{5} = 66$ Hz

and $\upsilon_2 = \dfrac{v}{\lambda_2} = \dfrac{330}{5.5} = 60$ Hz

Number of beats per second = $\upsilon_1 - \upsilon_2$
= 66 – 60 = 6.

37. **(b) :** Reverberation time, $T = \dfrac{0.61V}{aS}$

where V is the volume of room in cubic metres, a is the average absorption coefficient of the room, S is the total surface area of room in square metres.

or, $T \propto \dfrac{V}{S}$

or, $\dfrac{T_1}{T_2} = \left(\dfrac{V_1}{V_2}\right)\left(\dfrac{S_2}{S_1}\right) = \left(\dfrac{V}{8V}\right)\left(\dfrac{4S}{S}\right) = \dfrac{1}{2}$

or, $T_2 = 2T_1 = 2\times 1 = 2$ sec. ($\because T_1 = 1$ sec)

38. **(a) :** $y(x, t) = 8.0\sin(0.5\pi x - 4\pi t - \dfrac{\pi}{4})$

Compare with a standard wave equation,

$y = a\sin\left(\dfrac{2\pi x}{\lambda} - \dfrac{2\pi t}{T} + \phi\right)$

we get $\dfrac{2\pi}{\lambda} = 0.5\pi$ or, $\lambda = \dfrac{2\pi}{0.5\pi} = 4$ m.

$\dfrac{2\pi}{T} = 4\pi$ or, $T = \dfrac{2\pi}{4\pi} = \dfrac{1}{2}$ sec.

$\upsilon = 1/T = 2$ Hz.

Wave velocity, $v = \lambda\upsilon = 4\times 2 = 8$ m/sec.

39. **(c) :** Light waves are electromagnetic waves. Light waves are transverse in nature and do not require a medium to travel, hence they can travel in vacuum. Sound waves are longitudinal waves and require a medium to travel. They do not travel in vacuum.

40. **(c) :** $d_1 = 2$ m, $d_2 = 3$ m

Intensity $\propto \dfrac{1}{(\text{distance})^2}$

$I_1 \propto \dfrac{1}{2^2}$ and $I_2 \propto \dfrac{1}{3^2}$

$\therefore\ \dfrac{I_1}{I_2} = \dfrac{9}{4}$.

41. **(a) :** $y_1 = 10^{-6}\sin[100t + (x/50) + 0.5]$

$y_2 = 10^{-6}\cos[100t + (x/50)]$

[using $\cos x = \sin(x + \pi/2)$]

$= 10^{-6}\sin[100t + (x/50) + \pi/2]$

$= 10^{-6}\sin[100t + (x/50) + 1.57]$

The phase difference = 1.57 – 0.5 = 1.07

[or using $\sin x = \cos(\pi/2 - x)$. We get the same result.]

42. (b) : 1st the car is the source and at the cliff, one observes f'.

$$\therefore \quad f' = \frac{v}{v - v_s} f$$

2nd cliff is now source. It emits frequency f' and the observer is now the driver who observes f''.

$$\therefore \quad f'' = \left[\frac{v + v_o}{v}\right] f' \quad \text{or} \quad 2f = \left[\frac{v + v_o}{v - v_s}\right] f$$

$\Rightarrow \; 2v - 2v_o = v + v_o$ [as $v_s = v_o$]

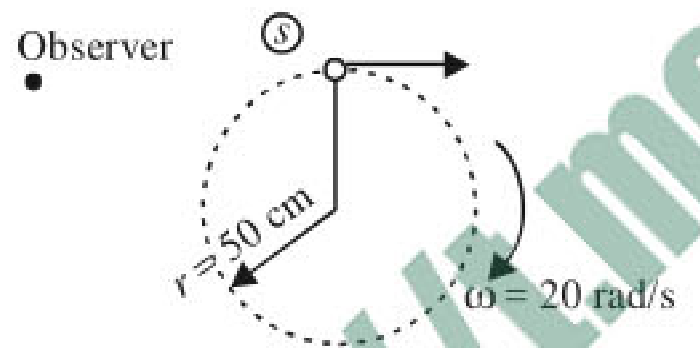
$\Rightarrow v_o = \frac{v}{3}$

43. (b) : Apparent frequency, $f' = \frac{v + v_O}{v} f$

$$= \frac{v + (1/5)\,v}{v} f = 1.2 f$$

Wavelength does not change by motion of observer.

44. (b) : The whistle is revolving in a circle of radius 50 cm. So the source (whistle) is moving and the observer is fixed.



The minimum frequency will be heard by the observer when the linear velocity of the whistle (source) will be in a direction as shown in the figure, *i.e.* when the source is receding.

The apparent frequency heard by the observer is then given by $\upsilon' = \upsilon\left(\frac{V}{V + v}\right)$

where V and v are the velocities of sound and source respectively and υ is the actual frequency.

Now, $v = r\,\omega = 0.5 \times 20 = 10$ m/s

$V = 340$ m/s, $\upsilon = 385$ Hz.

$$\therefore \quad \upsilon' = 385 \times \frac{340}{340 + 10} = 374 \text{ Hz.}$$

45. (c) : The equation of progressive wave travelling in positive x-direction is given by

$$y = a\sin\frac{2\pi}{\lambda}(vt - x)$$

Here $a = 0.2$ m, $v = 360$ m/sec, $\lambda = 60$ m

$$\therefore y = 0.2\sin\frac{2\pi}{60}(360t - x) = 0.2\sin\left[2\pi\left(6t - \frac{x}{60}\right)\right].$$

46. (c) : Comparing the given equation with general equation, $y = a\sin 2\pi\left(\frac{t}{T} - \frac{x}{\lambda}\right)$, we get

$$T = \frac{2\pi}{100} \text{ and } \lambda = 20\pi$$

$$\therefore \quad v = \upsilon\lambda = \frac{100}{2\pi} \times 20\pi = 1000 \text{ m/s.}$$

47. (b) : Resultant amplitude = $2a\,(1 + \cos\phi) = a$

$\therefore \;(1 + \cos\phi) = 1/2; \quad \cos\phi = -\frac{1}{2}; \quad \phi = \frac{2\pi}{3}.$

48. (c) : $n = \frac{1}{2l}\sqrt{\frac{T}{\pi r^2 \rho}}$

$\rho_1' = \frac{\rho}{2}$; $T' = 2T$ and $D' = 2D$ or $r' = 2r$

$$n' = \frac{1}{2l}\sqrt{\frac{2T}{\pi(2r)^2 \frac{\rho}{2}}}$$

After solving, $n' = \frac{1}{2l}\sqrt{\frac{T}{\pi r^2 l}} = n.$

49. (b) : Given : $x = a\cos(\omega t + \delta)$

and $y = a\cos(\omega t + \alpha)$ ...(i)

where, $\delta = \alpha + \pi/2$

$\therefore \quad x = a\cos(\omega t + \alpha + \pi/2)$

$= -a\sin(\omega t + \alpha)$ ...(ii)

Given the two waves are acting in perpendicular direction with the same frequency and phase difference $\pi/2$.

From equations (i) and (ii),

$x^2 + y^2 = a^2$

which represents the equation of a circle.

50. (a) : As $n \propto (1/l)$ and $l = l_1 + l_2 + l_3$

$$\therefore \quad \frac{1}{n} = \frac{1}{n_1} + \frac{1}{n_2} + \frac{1}{n_3}.$$

51. (a) : $f' = \frac{v - u}{v} f$; $f'' = \frac{v + u}{v} f$

Number of beats = $f'' - f' = \frac{2u}{\lambda}$

52. (c) : Number of beats produced per second,

$$= \upsilon_1 - \upsilon_2 = \frac{v}{\lambda_1} - \frac{v}{\lambda_2}$$

$$12 = v\left[\frac{1}{50} - \frac{1}{51}\right] \quad \text{or} \quad 12 = \frac{v \times 1}{50 \times 51}$$

or, $v = 12 \times 50 \times 51$ cm/s = 306 m/s.

53. (d) : The given equation of wave is

$$y = y_0\sin\frac{2\pi}{\lambda}(vt - x)$$

Particle velocity = $\frac{dy}{dt} = y_0\cos\frac{2\pi}{\lambda}(vt - x)\frac{2\pi v}{\lambda}$

$$\left(\frac{dy}{dt}\right)_{max} = y_0 \frac{2\pi}{\lambda} v.$$

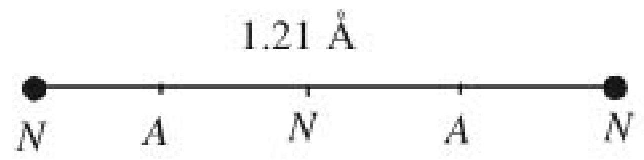
$\therefore \quad y_0 \frac{2\pi}{\lambda} v = 2v \quad$ or $\quad \lambda = \pi y_0.$

54. (b) : $n' = n + n_1 = \frac{nv}{v - v_s \cos\theta}$

$$= \frac{nv}{v} \quad [\because \cos 90° = 0]$$

$n' = n \quad \therefore n_1 = 0$

55. (c) : Distance between a node and adjoining antinode = $\lambda/4$



From figure, distance between two atoms

$$= 4 \times \frac{\lambda}{4} = 1.21\ \text{Å} \quad \text{or,} \quad \lambda = 1.21\ \text{Å}.$$

56. (c) : Displacement, $Y_{max} = a$, $Y_{min} = 0$
Time taken = $T/4$
$\therefore T/4 = 0.170 \quad \therefore T = 0.68$
The frequency of wave = $1/T$ = 1.47 Hz

57. (a) : The frequency of standing wave,

$$\upsilon = \frac{n}{2l} v$$

$$= \frac{5 \times 20}{2 \times 10} = 5 \text{ Hz}.$$

58. (d) : For the cylindrical tube open at both ends, $f = v/2l$.

When half of the tube is in water, it behaves as a closed pipe of length $l/2$.

$\therefore \quad f' = \frac{v}{4(l/2)} = \frac{v}{2l}. \quad \therefore f' = f.$

59. (c) : Sound wave equation is
$y = 0.0015 \sin (62.4\, x + 316\, t)$.

Comparing it with the general equation of motion

$y = A \sin 2\pi \left[\frac{x}{\lambda} + \frac{t}{T}\right]$, we get $\frac{2\pi}{\lambda} = 62.4$

or $\quad \lambda = \frac{2\pi}{62.4} = 0.1$ unit.

60. (a) : Phase difference $\theta = 60° = \frac{\pi}{3}$ rad.

Phase difference $(\theta) = \frac{\pi}{3} = \frac{2\pi}{\lambda} \times$ Path difference.

Therefore path difference $= \frac{\pi}{3} \times \frac{\lambda}{2\pi} = \frac{\lambda}{6}$.

61. (a) : Length of sonometer wire (l) = 110 cm and ratio of frequencies = 1 : 2 : 3.

Frequency $(\upsilon) \propto \frac{1}{l}$ or $l \propto \frac{1}{\upsilon}$.

Therefore $AC : CD : DB = \frac{1}{1} : \frac{1}{2} : \frac{1}{3} = 6 : 3 : 2.$

Therefore $AC = 6 \times \frac{110}{11} = 60$ cm and

$CD = 3 \times \frac{110}{11} = 30$ cm.

Thus $AD = 60 + 30 = 90$ cm.

62. (c) : Frequency (υ) = 4.2 MHz = 4.2×10^6 Hz and speed of sound (v) = 1.7 km/s = 1.7×10^3 m/s.

Wave length of sound in tissue $(\lambda) = \frac{v}{\upsilon} = \frac{1.7 \times 10^3}{4.2 \times 10^6}$

$= 4 \times 10^{-4}$ m.

63. (a) : Frequency of first source with 5 beats/sec = 100 and frequency of second source with 5 beats/sec = 205. The frequency of the first source = 100 ± 5 = 105 or 95 Hz.

Therefore frequency of second harmonic source = 210 Hz or 190 Hz.

As the second harmonic gives 5 beats/second with the sound of frequency 205 Hz, therefore frequency of second harmonic source should be 210 Hz. The frequency of source = 105 Hz.

64. (a) : Wavelength (λ) = 5000 Å and velocity (v) = 1.5×10^4 m/s.

Wavelength of the approaching star, $(\lambda') = \lambda \frac{c - v}{c}$ or

$$\frac{\lambda'}{\lambda} = 1 - \frac{v}{c}$$

or, $\quad \frac{v}{c} = 1 - \frac{\lambda'}{\lambda} = \frac{\lambda - \lambda'}{\lambda} = \frac{\Delta\lambda}{\lambda}$

Therefore $\Delta\lambda = \lambda \times \frac{v}{c} = 5000\ \text{Å} \times \frac{1.5 \times 10^6}{3 \times 10^8} = 25\ \text{Å}$.

(where $\Delta\lambda$ is the change in the wavelength)

65. (a, b) : (a) represents a harmonic progressive wave in the standard form where as (b) also represents a harmonic progressive wave, both travelling in the positive x- direction. In (b), a is the angular velocity, ω and b is k; c is the initial phase.
(d) represents only S.H.M.

66. (a) : Frequency (υ) = 100 Hz and distance from fixed end = 10 cm = 0.1 m. When a stationary wave is produced, the fixed end behaves as a node. Thus wavelength (λ) = 2 × 0.1 = 0.2 m.
Therefore velocity $v = \upsilon\lambda = 100 \times 0.2 = 20$ m/s.

67. (a) : $y = A \sin(100\,t)\cos(0.01\,x)$. Comparing it with standard equation

$$y = A\sin\left(\frac{2\pi}{T}t\right)\cos\left(\frac{2\pi}{\lambda}x\right),$$

we get $T = \frac{\pi}{50}$ and $\lambda = 200\,\pi$.

Therefore velocity, $(v) = \frac{\lambda}{T} = \frac{200\,\pi}{\pi/50} = 200 \times 50$
$= 10000 = 10^4$ m/s.

68. (a) : First case: Frequency = υ;
No. of beats/sec. = 5 and
frequency (sounded with) = 200 Hz.
Second case: Frequency = $2\,\upsilon$; No. of beats/sec = 10 and frequency (sounded with) = 420 Hz.
In the first case, frequency $(\upsilon) = 200 \pm 5 = 205$ or 195 Hz. And in the second case, frequency $(2\upsilon) = 420 \pm 10$
or $\upsilon = 210 \pm 5 = 205$ or 215. So common value of υ in both the cases is 205 Hz.

69. (c) : Beats are produced. Frequency of beats will be $\frac{1}{3} - \frac{1}{4} = \frac{1}{12}$. Hence time period = 12 s.

70. (c) : $f = \frac{1}{2l}\left[\frac{T}{\mu}\right]^{\frac{1}{2}}$ when f is halved, the length is doubled
$\therefore$ Length is 1 m.

71. (c) : Velocity of sound $v \propto \sqrt{T}$

$$\therefore \quad \frac{v}{2v} = \frac{\sqrt{273+27}}{\sqrt{T}} \quad \text{or} \quad T = 1200\text{ K} = 927°\text{C}$$

72. (b) : For production of beats different frequencies are essential. The different amplitudes effect the minimum and maximum amplitude of the beats. If frequencies are different, phases will be different.

73. (d) : Compare with the equation
$y = a\cos(2\pi\upsilon t + \phi)$
This give $2\pi\upsilon = 2000$
$$\upsilon = \frac{1000}{\pi}\text{Hz}$$

74. (b) : With the propogation of a longitudinal wave, energy alone is propagated.

75. (a) : Here $\upsilon' = \frac{9}{8}\upsilon$

Source and observer are moving in opposite direction, apparent frequency

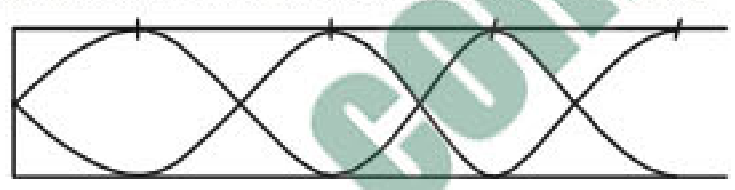
$$\upsilon' = \upsilon \times \frac{(v+u)}{(v-u)}$$

$$\frac{9}{8}\upsilon = \upsilon \times \frac{340+u}{340-u}$$

$\Rightarrow \quad 9 \times 340 - 9u = 8 \times 340 + 8u$

$\Rightarrow \quad 17u = 340 \times 1 \;\Rightarrow\; u = \frac{340}{17} = 20$ m/s

76. (d) : Third overtone has a frequency $4n$, 4th harmonic = three full loops + one half loop, which would make four nodes and four antinodes.



77. (c) : From $\Delta x = \frac{\lambda}{2\pi}\Delta\phi$,

$$\lambda = 2\pi\frac{\Delta x}{\Delta\phi} = \frac{2\pi(0.4)}{1.6\pi} = 0.5\text{ m}$$

$$\upsilon = \frac{v}{\lambda} = \frac{330}{0.5} = 660\text{ Hz}$$

78. (a) : $\mu = \frac{0.035}{5.5}$ kg/m, $T = 77$ N
where μ is mass per unit length.

$$v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{77 \times 5.5}{0.035}} = 110\text{ m/s}$$

79. (c) : Intensity $\propto$ (amplitude)^2 and also intensity $\propto$ (frequency)^2. Therefore original $I \propto A^2\omega^2$

$$I' \propto 4A^2\frac{\omega^2}{16} \quad i.e., \ \frac{1}{4}I$$

80. (b) : Velocity of sound in any gas depends upon density and elasticity of gas.

$$v = \sqrt{\frac{\gamma P}{\rho}} \text{ or } \sqrt{\frac{B}{\rho}}$$

81. (b) : The standard equation of a progressive wave is

$$y = a\sin\left[2\pi\left(\frac{t}{T} - \frac{x}{\lambda}\right) + \phi\right]$$

The given equation can be written as

$$y = 4\sin\left[2\pi\left(\frac{t}{10} - \frac{x}{18}\right) + \frac{\pi}{6}\right]$$

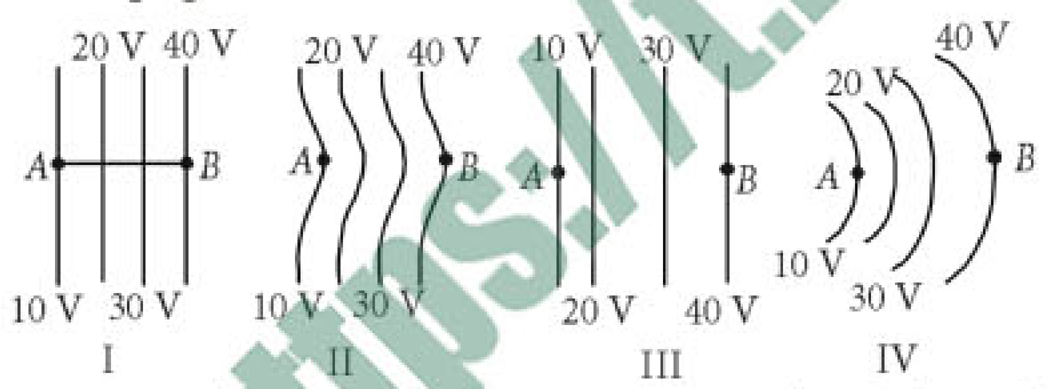
$\therefore \quad a = 4$ cm, $T = 10$ s,
$\lambda = 18$ cm and $\phi = \pi/6$.

Chapter 12 Electrostatics

1. A capacitor is charged by a battery. The battery is removed and another identical uncharged capacitor is connected in parallel. The total electrostatic energy of resulting system
(a) decreases by a factor of 2
(b) remains the same
(c) increases by a factor of 2
(d) increases by a factor of 4 *(NEET 2017)*

2. Suppose the charge of a proton and an electron differ slightly. One of them is $-e$, the other is $(e + \Delta e)$. If the net of electrostatic force and gravitational force between two hydrogen atoms placed at a distance d (much greater than atomic size) apart is zero, then Δe is of the order of [Given: mass of hydrogen $m_h = 1.67 \times 10^{-27}$ kg]
(a) 10^{-23} C (b) 10^{-37} C
(c) 10^{-47} C (d) 10^{-20} C
(NEET 2017)

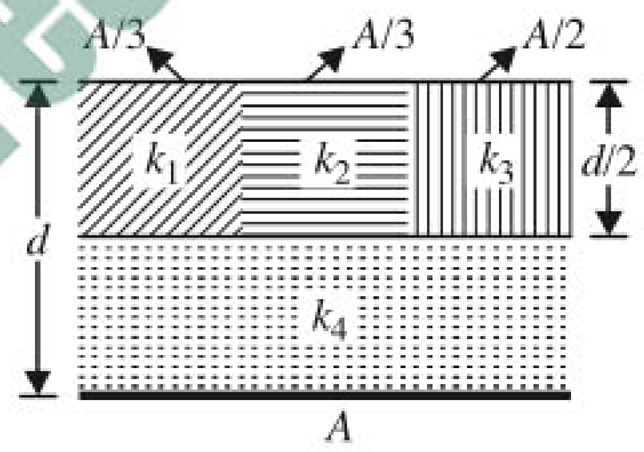
3. The diagrams below show regions of equipotentials.



A positive charge is moved from A to B in each diagram.
(a) In all the four cases the work done is the same.
(b) Minimum work is required to move q in figure (I).
(c) Maximum work is required to move q in figure (II).
(d) Maximum work is required to move q in figure (III). *(NEET 2017)*

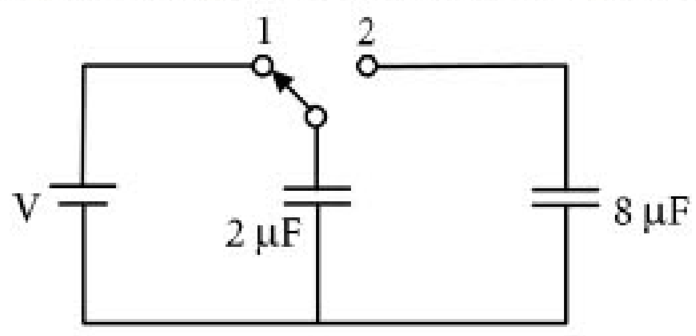
4. An electric dipole is placed at an angle of 30° with an electric field intensity 2×10^5 N C^{-1}. It experiences a torque equal to 4 N m. The charge on the dipole, if the dipole length is 2 cm, is
(a) 8 mC (b) 2 mC (c) 5 mC (d) 7 μC
(NEET -II 2016)

5. A parallel-plate capacitor of area A, plate separation d and capacitance C is filled with four dielectric materials having dielectric constants k_1, k_2, k_3 and k_4 as shown in the figure. If a single dielectric material is to be used to have the same capacitance C in this capacitor, then its dielectric constant k is given by



(a) $k = k_1 + k_2 + k_3 + 3k_4$
(b) $k = \frac{2}{3}(k_1 + k_2 + k_3) + 2k_4$
(c) $\frac{2}{k} = \frac{3}{k_1 + k_2 + k_3} + \frac{1}{k_4}$
(d) $\frac{1}{k} = \frac{1}{k_1} + \frac{1}{k_2} + \frac{1}{k_3} + \frac{3}{2k_4}$ *(NEET -II 2016)*

6. A capacitor of 2 μF is charged as shown in the diagram. When the switch S is turned to position 2, the percentage of its stored energy dissipated is



(a) 75% (b) 80%
(c) 0% (d) 20%
(NEET-I 2016)

7. Two identical charged spheres suspended from a common point by two massless strings of lengths l, are initially at a distance d $(d << l)$ apart because of their mutual repulsion. The

charges begin to leak from both the spheres at a constant rate. As a result, the spheres approach each other with a velocity v. Then v varies as a function of the distance x between the spheres, as

(a) $v \propto x^{-1/2}$ (b) $v \propto x^{-1}$
(c) $v \propto x^{1/2}$ (d) $v \propto x$

(NEET-I 2016)

8. A parallel plate air capacitor has capacity C, distance of separation between plates is d and potential difference V is applied between the plates. Force of attraction between the plates of the parallel plate air capacitor is

(a) $\frac{CV^2}{d}$ (b) $\frac{C^2V^2}{2d^2}$ (c) $\frac{C^2V^2}{2d}$ (d) $\frac{CV^2}{2d}$

(2015)

9. If potential (in volts) in a region is expressed as $V(x, y, z) = 6xy - y + 2yz$, the electric field (in N/C) at point (1, 1, 0) is

(a) $-(2\hat{i}+3\hat{j}+\hat{k})$ (b) $-(6\hat{i}+9\hat{j}+\hat{k})$
(c) $-(3\hat{i}+5\hat{j}+3\hat{k})$ (d) $-(6\hat{i}+5\hat{j}+2\hat{k})$

(2015)

10. The electric field in a certain region is acting radially outward and is given by $E = Ar$. A charge contained in a sphere of radius 'a' centred at the origin of the field, will be given by

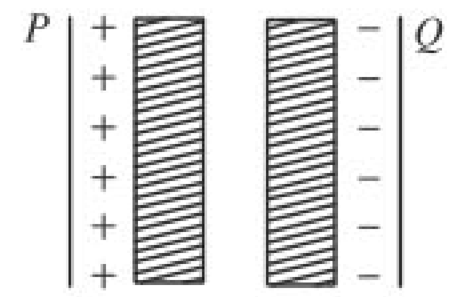
(a) $4\pi\varepsilon_0 Aa^3$ (b) $\varepsilon_0 Aa^3$
(c) $4\pi\varepsilon_0 Aa^2$ (d) $A\varepsilon_0 a^2$

(2015 Cancelled)

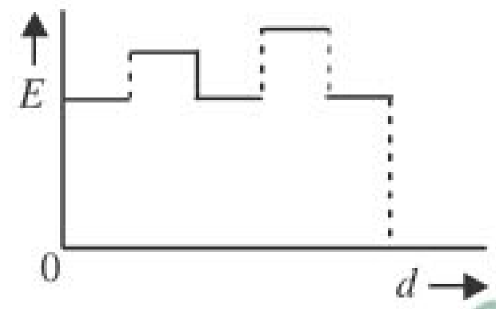
11. A parallel plate air capacitor of capacitance C is connected to a cell of emf V and then disconnected from it. A dielectric slab of dielectric constant K, which can just fill the air gap of the capacitor, is now inserted in it. Which of the following is incorrect?

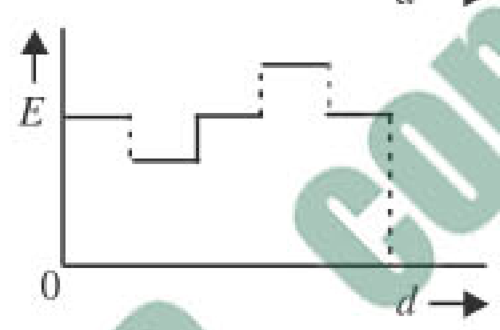
(a) The change in energy stored is $\frac{1}{2}CV^2\left(\frac{1}{K}-1\right)$.
(b) The charge on the capacitor is not conserved.
(c) The potential difference between the plates decreases K times.
(d) The energy stored in the capacitor decreases K times. *(2015 Cancelled)*

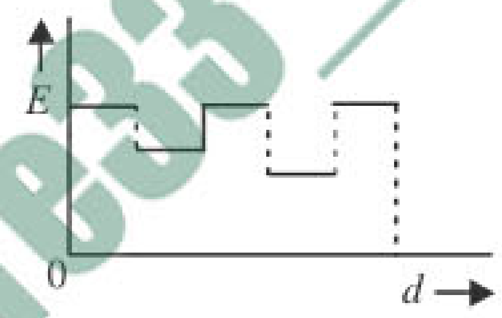
12. Two thin dielectric slabs of dielectric constants K_1 and K_2 ($K_1 < K_2$) are inserted between plates of a parallel plate capacitor, as shown in the figure. The variation of electric field E between the plates with distance d as measured from plate P is correctly shown by

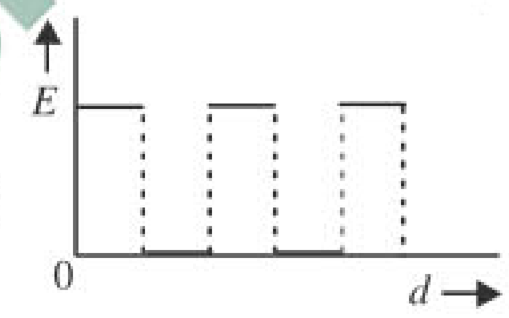


$K_1 < K_2$

(a)


(b)


(c)


(d)


(2014)

13. A conducting sphere of radius R is given a charge Q. The electric potential and the electric field at the centre of the sphere respectively are

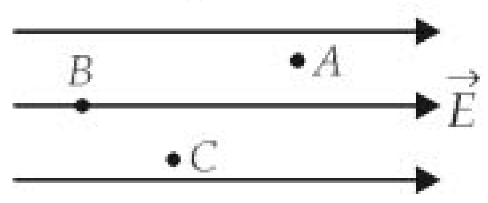
(a) zero and $\frac{Q}{4\pi\varepsilon_0 R^2}$ (b) $\frac{Q}{4\pi\varepsilon_0 R}$ and zero
(c) $\frac{Q}{4\pi\varepsilon_0 R}$ and $\frac{Q}{4\pi\varepsilon_0 R^2}$ (d) both are zero

(2014)

14. In a region, the potential is represented by $V(x, y, z) = 6x - 8xy - 8y + 6yz$, where V is in volts and x, y, z are in metres. The electric force experienced by a charge of 2 coulomb situated at point (1, 1, 1) is

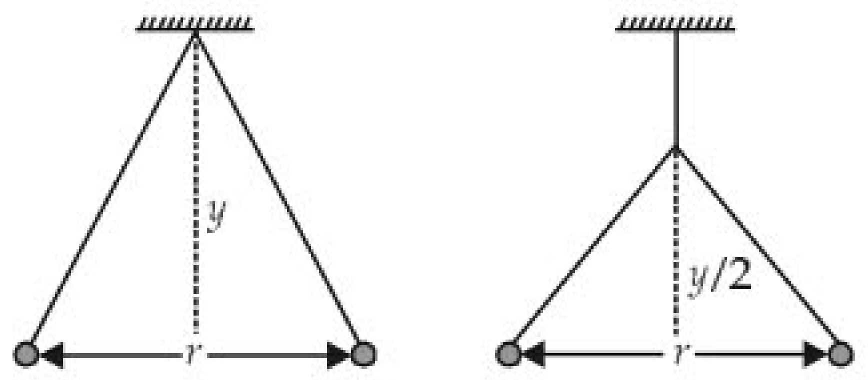
(a) $6\sqrt{5}$ N (b) 30 N
(c) 24 N (d) $4\sqrt{35}$ N *(2014)*

15. A, B and C are three points in a uniform electric field. The electric potential is



(a) maximum at C
(b) same at all the three points A, B and C
(c) maximum at A
(d) maximum at B *(NEET 2013)*

16. Two pith balls carrying equal charges are suspended from a common point by strings of equal length, the equilibrium separation between them is r. Now the strings are rigidly clamped at half the height. The equilibrium separation between the balls now become



(a) $\left(\frac{2r}{\sqrt{3}}\right)$ (b) $\left(\frac{2r}{3}\right)$ (c) $\left(\frac{1}{\sqrt{2}}\right)^2$ (d) $\left(\frac{r}{\sqrt[3]{2}}\right)$

(NEET 2013)

17. An electric dipole of dipole moment p is aligned parallel to a uniform electric field E. The energy required to rotate the dipole by 90° is
(a) p^2E (b) pE
(c) infinity (d) pE^2
(Karnataka NEET 2013)

18. A charge q is placed at the centre of the line joining two equal charges Q. The system of the three charges will be in equilibrium if q is equal to
(a) $-Q/4$ (b) $Q/4$ (c) $-Q/2$ (d) $Q/2$
(Karnataka NEET 2013)

19. An electric dipole of moment p is placed in an electric field of intensity E. The dipole acquires a position such that the axis of the dipole makes an angle θ with the direction of the field. Assuming that the potential energy of the dipole to be zero when $\theta = 90°$, the torque and the potential energy of the dipole will respectively be
(a) $pE\sin\theta, -pE\cos\theta$ (b) $pE\sin\theta, -2pE\cos\theta$
(c) $pE\sin\theta, 2pE\cos\theta$ (d) $pE\cos\theta, -pE\sin\theta$
(2012)

20. Four point charges $-Q$, $-q$, $2q$ and $2Q$ are placed, one at each corner of the square. The relation between Q and q for which the potential at the centre of the square is zero is

(a) $Q = -q$ (b) $Q = -\frac{1}{q}$

(c) $Q = q$ (d) $Q = \frac{1}{q}$ *(2012)*

21. What is the flux through a cube of side a if a point charge of q is at one of its corner?

(a) $\frac{2q}{\varepsilon_0}$ (b) $\frac{q}{8\varepsilon_0}$ (c) $\frac{q}{\varepsilon_0}$ (d) $\frac{q}{2\varepsilon_0}6a^2$

(2012)

22. A parallel plate capacitor has a uniform electric field E in the space between the plates. If the distance between the plates is d and area of each plate is A, the energy stored in the capacitor is

(a) $\frac{1}{2}\varepsilon_0 E^2$ (b) $\frac{E^2Ad}{\varepsilon_0}$

(c) $\frac{1}{2}\varepsilon_0 E^2 Ad$ (d) $\varepsilon_0 EAd$

(Mains 2012, 2011, 2008)

23. Two metallic spheres of radii 1 cm and 3 cm are are given charges of -1×10^{-2} C and 5×10^{-2} C, respectively. If these are connected by a conducting wire, the final charge on the bigger sphere is
(a) 2×10^{-2} C (b) 3×10^{-2} C
(c) 4×10^{-2} C (d) 1×10^{-2} C
(Mains 2012)

24. A charge Q is enclosed by a Gaussian spherical surface of radius R. If the radius is doubled, then the outward electric flux will
(a) increase four times
(b) be reduced to half
(c) remain the same
(d) be doubled *(2011)*

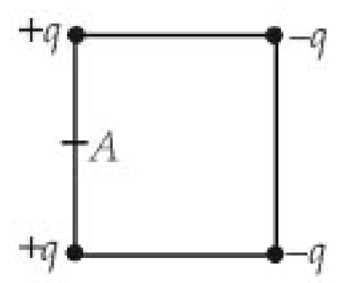
25. Four electric charges $+q$, $+q$, $-q$ and $-q$ are placed at the corners of a square of side $2L$ (see figure). The electric potential at point A, midway between the two charges $+q$ and $+q$, is

(a) $\frac{1}{4\pi\varepsilon_0}\frac{2q}{L}\left(1+\sqrt{5}\right)$

(b) $\frac{1}{4\pi\varepsilon_0}\frac{2q}{L}\left(1+\frac{1}{\sqrt{5}}\right)$

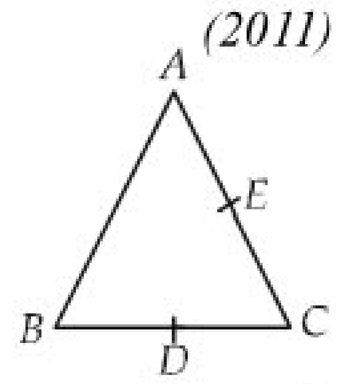
(c) $\frac{1}{4\pi\varepsilon_0}\frac{2q}{L}\left(1-\frac{1}{\sqrt{5}}\right)$

(d) zero



(2011)

26. Three charges, each $+q$, are placed at the corners of an isosceles triangle ABC of sides BC and AC, $2a$. D and E are the mid points of BC and CA. The work done in taking a charge Q from D to E is



(a) $\frac{3qQ}{4\pi\varepsilon_0 a}$ (b) $\frac{3qQ}{8\pi\varepsilon_0 a}$ (c) $\frac{qQ}{4\pi\varepsilon_0 a}$ (d) zero

(Mains 2011)

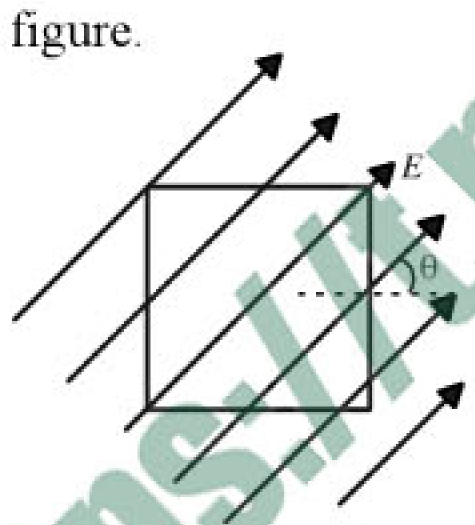
27. The electric potential V at any point (x, y, z), all in metres in space is given by $V = 4x^2$ volt. The electric field at the point $(1, 0, 2)$ in volt/meter, is
(a) 8 along negative X-axis
(b) 8 along positive X-axis
(c) 16 along negative X-axis
(d) 16 along positive X-axis *(Mains 2011)*

28. Two positive ions, each carrying a charge q, are separated by a distance d. If F is the force of repulsion between the ions, the number of electrons missing from each ion will be
(e being the charge on an electron)

(a) $\frac{4\pi\varepsilon_0 Fd^2}{e^2}$ (b) $\sqrt{\frac{4\pi\varepsilon_0 Fe^2}{d^2}}$

(c) $\sqrt{\frac{4\pi\varepsilon_0 Fd^2}{e^2}}$ (d) $\frac{4\pi\varepsilon_0 Fd^2}{q^2}$ *(2010)*

29. A square surface of side L meter in the plane of the paper is placed in a uniform electric field E(volt/m) acting along the same plane at an angle θ with the horizontal side of the square as shown in figure.



The electric flux linked to the surface, in units of volt m is
(a) EL^2 (b) $EL^2\cos\theta$
(c) $EL^2\sin\theta$ (d) zero *(2010)*

30. A series combination of n_1 capacitors, each of value C_1, is charged by a source of potential difference $4V$. When another parallel combination of n_2 capacitors, each of value C_2, is charged by a source of potential difference V, it has the same (total) energy stored in it, as the first combination has. The value of C_2, in terms of C_1, is then

(a) $\frac{2C_1}{n_1 n_2}$ (b) $16\frac{n_2}{n_1}C_1$

(c) $2\frac{n_2}{n_1}C_1$ (d) $\frac{16C_1}{n_1 n_2}$ *(2010)*

31. Two parallel metal plates having charges $+Q$ and $-Q$ face each other at a certain distance between them. If the plates are now dipped in kerosene oil tank, the electric field between the plates will
(a) become zero (b) increase
(c) decrease (d) remain same
(Mains 2010)

32. The electric field at a distance $\frac{3R}{2}$ from the centre of a charged conducting spherical shell of radius R is E. The electric field at a distance $\frac{R}{2}$ from the centre of the sphere is

(a) zero (b) E (c) $\frac{E}{2}$ (d) $\frac{E}{3}$

(Mains 2010)

33. Three concentric spherical shells have radii a, b and c $(a < b < c)$ and have surface charge densities σ, $-\sigma$ and σ respectively. If V_A, V_B and V_C denote the potentials of the three shells, then, for $c = a + b$, we have
(a) $V_C = V_B \neq V_A$ (b) $V_C \neq V_B \neq V_A$
(c) $V_C = V_B = V_A$ (d) $V_C = V_A \neq V_B$
(2009)

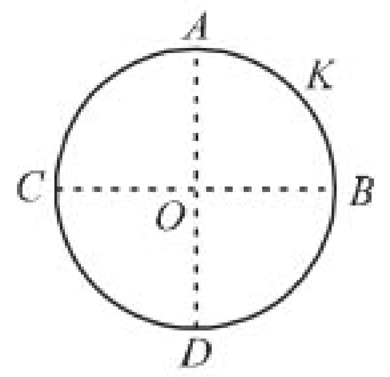
34. Three capacitors each of capacitance C and of breakdown voltage V are joined in series. The capacitance and breakdown voltage of the combination will be

(a) $3C, \frac{V}{3}$ (b) $\frac{C}{3}, 3V$

(c) $3C, 3V$ (d) $\frac{C}{3}, \frac{V}{3}$ *(2009)*

35. The electric potential at a point (x, y, z) is given by $V = -x^2y - xz^3 + 4$.
The electric field at that point is
(a) $\vec{E} = \hat{i}\,2xy + \hat{j}\,(x^2 + y^2) + \hat{k}\,(3xz - y^2)$
(b) $\vec{E} = \hat{i}\,z^3 + \hat{j}\,xyz + \hat{k}\,z^2$
(c) $\vec{E} = \hat{i}\,(2xy - z^3) + \hat{j}\,xy^2 + \hat{k}\,3z^2x$
(d) $\vec{E} = \hat{i}\,(2xy + z^3) + \hat{j}\,x^2 + \hat{k}\,3xz^2$ *(2009)*

36. A thin conducting ring of radius R is given a charge $+Q$. The electric field at the centre O of the ring due to the charge on the part AKB of the ring is E. The electric field at the centre due to the charge on the part $ACDB$ of the ring is

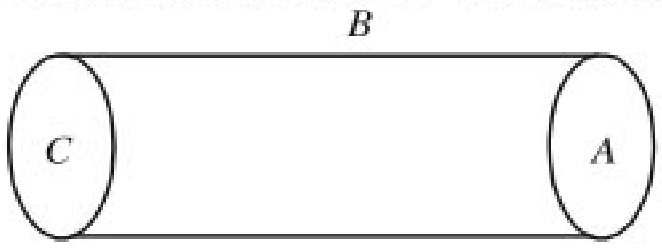


(a) E along KO (b) $3E$ along OK
(c) $3E$ along KO (d) E along OK
(2008)

37. The electric potential at a point in free space due to charge Q coulomb is $Q \times 10^{11}$ volts. The electric field at that point is

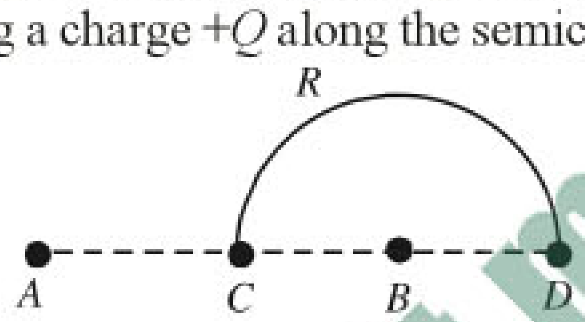
(a) $4\pi\varepsilon_0 Q \times 10^{20}$ volt/m
(b) $12\pi\varepsilon_0 Q \times 10^{22}$ volt/m
(c) $4\pi\varepsilon_0 Q \times 10^{22}$ volt/m
(d) $12\pi\varepsilon_0 Q \times 10^{20}$ volt/m *(2008)*

38. A hollow cylinder has a charge q coulomb within it. If f is the electric flux in units of voltmeter associated with the curved surface B, the flux linked with the plane surface A in units of V-m will be



(a) $\dfrac{q}{2\varepsilon_0}$
(b) $\dfrac{\phi}{3}$
(c) $\dfrac{q}{\varepsilon_0} - \phi$ (d) $\dfrac{1}{2}\left(\dfrac{q}{\varepsilon_0} - \phi\right)$ *(2007)*

39. Charges $+q$ and $-q$ are placed at points A and B respectively which are a distance $2L$ apart, C is the midpoint between A and B. The work done in moving a charge $+Q$ along the semicircle CRD is

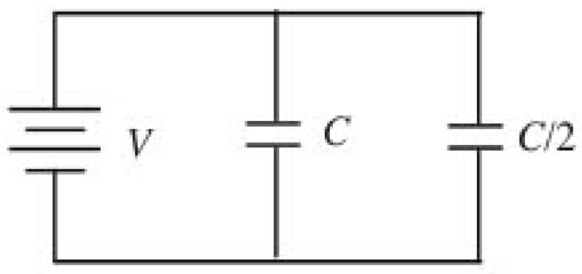


(a) $\dfrac{qQ}{2\pi\varepsilon_0 L}$ (b) $\dfrac{qQ}{6\pi\varepsilon_0 L}$
(c) $-\dfrac{qQ}{6\pi\varepsilon_0 L}$ (d) $\dfrac{qQ}{4\pi\varepsilon_0 L}$ *(2007)*

40. Three point charges $+q$, $-2q$ and $+q$ are placed at points $(x = 0, y = a, z = 0)$, $(x = 0, y = 0, z = 0)$ and $(x = a, y = 0, z = 0)$ respectively. The magnitude and direction of the electric dipole moment vector of this charge assembly are

(a) $\sqrt{2}qa$ along the line joining points $(x = 0, y = 0, z = 0)$ and $(x = a, y = a, z = 0)$
(b) qa along the line joining points $(x = 0, y = 0, z = 0)$ and $(x = a, y = a, z = 0)$
(c) $\sqrt{2}qa$ along $+x$ direction
(d) $\sqrt{2}qa$ along $+y$ direction. *(2007)*

41. Two condensers, one of capacity C and other other of capacity $C/2$ are connected to a V-volt battery, as shown in the figure. The work done in charging fully both the condensers is



(a) $\dfrac{1}{4}CV^2$ (b) $\dfrac{3}{4}CV^2$
(c) $\dfrac{1}{2}CV^2$ (d) $2CV^2$. *(2007)*

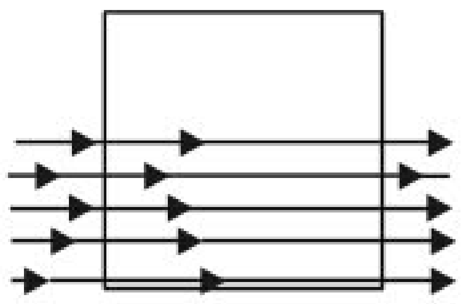
42. A parallel plate air capacitor is charged to a potential difference of V volts. After disconnecting the charging battery the distance between the plates of the capacitor is increased using an insulating handle. As a result the potential difference between the plates

(a) increases (b) decreases
(c) does not change (d) becomes zero *(2006)*

43. An electric dipole of moment $\vec{p}$ is lying along a uniform electric field $\vec{E}$. The work done in rotating the dipole by 90° is

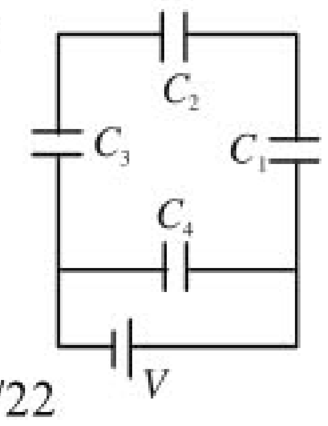
(a) pE (b) $\sqrt{2}pE$
(c) $pE/2$ (d) $2pE$. *(2006)*

44. A square surface of side L metres is in the plane of the paper. A uniform electric field $\vec{E}$ (volt/m), also in the plane of the paper is limited only to the lower half of the square surface (see figure). The electric flux in SI units associated with the surface is



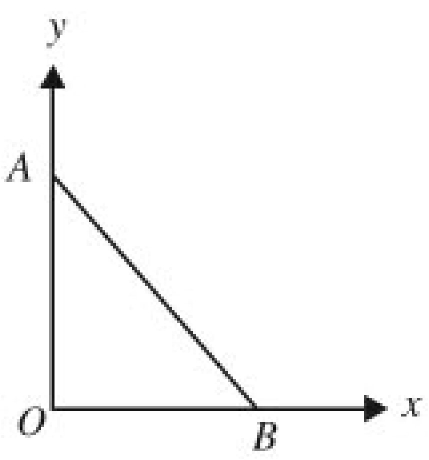
(a) EL^2 (b) $EL^2/2\varepsilon_0$ (c) $EL^2/2$ (d) zero *(2006)*

45. A network of four capacitors of capacity equal to $C_1 = C$, $C_2 = 2C$, $C_3 = 3C$ and $C_4 = 4C$ are connected to a battery as shown in the figure. The ratio of the charges on C_2 and C_4 is



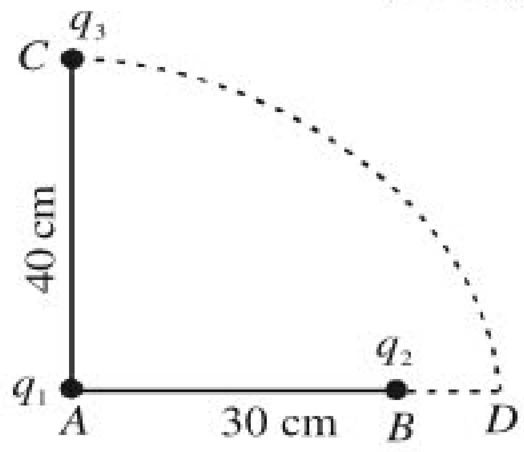
(a) 4/7 (b) 3/22
(c) 7/4 (d) 22/3 *(2005)*

46. As per the diagram a point charge $+q$ is placed at the origin O. Work done in taking another point charge $-Q$ from the point A [coordinates $(0, a)$] to another point B



[coordinates $(a, 0)$] along the straight path AB is
(a) zero
(b) $\left(\frac{qQ}{4\pi\varepsilon_0}\frac{1}{a^2}\right)\cdot\sqrt{2}\,a$
(c) $\left(\frac{-qQ}{4\pi\varepsilon_0}\frac{1}{a^2}\right)\cdot\sqrt{2}\,a$
(d) $\left(\frac{qQ}{4\pi\varepsilon_0}\frac{1}{a^2}\right)\cdot\frac{a}{\sqrt{2}}$
(2005)

47. Two charges q_1 and q_2 are placed 30 cm apart, as shown in the figure. A third charge q_3 is moved along the arc of a circle of radius 40 cm from C to D.



The change in the potential energy of the system is $\frac{q_3}{4\pi\varepsilon_0}k$, where k is
(a) $8q_1$ (b) $6q_1$
(c) $8q_2$ (d) $6q_2$. *(2005)*

48. A bullet of mass 2 g is having a charge of 2 μC. Through what potential difference must it be accelerated, starting from rest, to acquire a speed of 10 m/s ?
(a) 5 kV (b) 50 kV
(c) 5 V (d) 50 V *(2004)*

49. An electric dipole has the magnitude of its charge as q and its dipole moment is p. It is placed in a uniform electric field E. If its dipole moment is along the direction of the field, the force on it and its potential energy are respectively
(a) $2q\cdot E$ and minimum
(b) $q\cdot E$ and $p\cdot E$
(c) zero and minimum
(d) $q\cdot E$ and maximum *(2004)*

50. Three capacitors each of capacity 4 μF are to be connected in such a way that the effective capacitance is 6 μF. This can be done by
(a) connecting all of them in series
(b) connecting them in parallel
(c) connecting two in series and one in parallel
(d) connecting two in parallel and one in series
(2003)

51. A charge q is located at the centre of a cube. The electric flux through any face is
(a) $\frac{2\pi q}{6(4\pi\varepsilon_0)}$ (b) $\frac{4\pi q}{6(4\pi\varepsilon_0)}$
(c) $\frac{\pi q}{6(4\pi\varepsilon_0)}$ (d) $\frac{q}{6(4\pi\varepsilon_0)}$ *(2003)*

52. Identical charges $(-q)$ are placed at each corners of cube of side b then electrostatic potential energy of charge $(+q)$ which is placed at centre of cube will be
(a) $\frac{-4\sqrt{2}\,q^2}{\pi\varepsilon_0 b}$ (b) $\frac{-8\sqrt{2}\,q^2}{\pi\varepsilon_0 b}$
(c) $\frac{-4\,q^2}{\sqrt{3}\,\pi\varepsilon_0 b}$ (d) $\frac{8\sqrt{2}\,q^2}{4\,\pi\varepsilon_0 b}$ *(2002)*

53. A capacitor of capacity C_1 charged upto V volt and then connected to an uncharged capacitor of capacity C_2. The final potential difference across each will be
(a) $\frac{C_2V}{C_1+C_2}$ (b) $\frac{C_1V}{C_1+C_2}$
(c) $\left(1+\frac{C_2}{C_1}\right)$ (d) $\left(1-\frac{C_2}{C_1}\right)V$.
(2002)

54. Some charge is being given to a conductor. Then its potential is
(a) maximum at surface
(b) maximum at centre
(c) remain same throughout the conductor
(d) maximum somewhere between surface and centre. *(2002)*

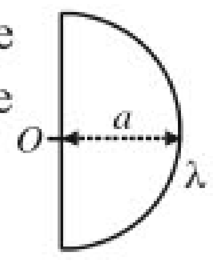
55. A dipole of dipole moment $\vec{p}$ is placed in uniform electric field $\vec{E}$ then torque acting on it is given by
(a) $\vec{\tau}=\vec{p}\cdot\vec{E}$ (b) $\vec{\tau}=\vec{p}\times\vec{E}$
(c) $\vec{\tau}=\vec{p}+\vec{E}$ (d) $\vec{\tau}=\vec{p}-\vec{E}$. *(2001)*

56. Energy per unit volume for a capacitor having area A and separation d kept at potential difference V is given by
(a) $\frac{1}{2}\varepsilon_0\frac{V^2}{d^2}$ (b) $\frac{1}{2\varepsilon_0}\frac{V^2}{d^2}$
(c) $\frac{1}{2}CV^2$ (d) $\frac{Q^2}{2C}$. *(2001)*

57. A charge Q μC is placed at the centre of a cube, the flux coming out from each face will be
(a) $\frac{Q}{6\varepsilon_0}\times10^{-6}$ (b) $\frac{Q}{6\varepsilon_0}\times10^{-3}$
(c) $\frac{Q}{24\varepsilon_0}$ (d) $\frac{Q}{8\varepsilon_0}$ *(2001)*

58. A charge Q is situated at the corner of a cube, the electric flux passed through all the six faces of the cube is
(a) $\frac{Q}{6\varepsilon_0}$ (b) $\frac{Q}{8\varepsilon_0}$ (c) $\frac{Q}{\varepsilon_0}$ (d) $\frac{Q}{2\varepsilon_0}$
(2000)

59. Electric field at centre O of semicircle of radius a having linear charge density λ given as



(a) $\dfrac{2\lambda}{\varepsilon_0 a}$ (b) $\dfrac{\lambda\pi}{\varepsilon_0 a}$

(c) $\dfrac{\lambda}{2\pi\varepsilon_0 a}$ (d) $\dfrac{\lambda}{\pi\varepsilon_0 a}$ *(2000)*

60. A capacitor is charged with a battery and energy stored is U. After disconnecting battery another capacitor of same capacity is connected in parallel to the first capacitor. Then energy stored in each capacitor is

(a) $U/2$ (b) $U/4$

(c) $4U$ (d) $2U$. *(2000)*

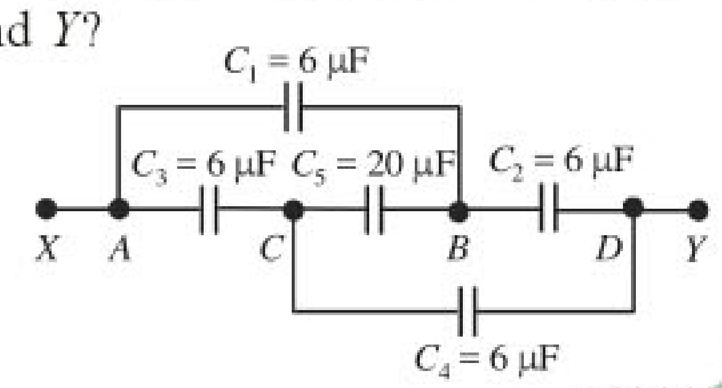
61. What is the effective capacitance between points X and Y?

(a) 12 μF

(b) 18 μF

(c) 24 μF

(d) 6 μF



(1999)

62. When air is replaced by a dielectric medium of constant K, the maximum force of attraction between two charges separated by a distance

(a) increases K times

(b) remains unchanged

(c) decreases K times

(d) increases K^{-1} times. *(1999)*

63. In bringing an electron towards another electron, the electrostatic potential energy of the system

(a) becomes zero (b) increases

(c) decreases (d) remains same *(1999)*

64. A parallel plate condenser with oil between the plates (dielectric constant of oil $K = 2$) has a capacitance C. If the oil is removed, then capacitance of the capacitor becomes

(a) $\dfrac{C}{\sqrt{2}}$ (b) $2C$ (c) $\sqrt{2}C$ (d) $\dfrac{C}{2}$ *(1999)*

65. A hollow insulated conduction sphere is given a positive charge of 10 μC. What will be the electric field at the centre of the sphere if its radius is 2 metres?

(a) 20 μC m^{-2} (b) 5 μC m^{-2}

(c) zero (d) 8 μC m^{-2} *(1998)*

66. A particle of mass m and charge q is placed at rest in a uniform electric field E and then released. The kinetic energy attained by the particle after moving a distance y is

(a) qEy (b) qE^2y (c) qEy^2 (d) q^2Ey *(1998)*

67. A point Q lies on the perpendicular bisector of an electrical dipole of dipole moment p. If the distance of Q from the dipole is r (much larger than the size of the dipole), then the electric field at Q is proportional to

(a) p^2 and r^{-3} (b) p and r^{-2}

(c) p^{-1} and r^{-2} (d) p and r^{-3} *(1998)*

68. A point charge $+q$ is placed at the centre of a cube of side l. The electric flux emerging from the cube is

(a) $\dfrac{6ql^2}{\varepsilon_0}$ (b) $\dfrac{q}{6l^2\varepsilon_0}$ (c) zero (d) $\dfrac{q}{\varepsilon_0}$. *(1996)*

69. The energy stored in a capacitor of capacity C and potential V is given by

(a) $\dfrac{CV}{2}$ (b) $\dfrac{C^2V^2}{2}$ (c) $\dfrac{C^2V}{2}$ (d) $\dfrac{CV^2}{2}$ *(1996)*

70. Two metallic spheres of radii 1 cm and 2 cm are given charges 10^{-2} C and 5×10^{-2} C respectively. If they are connected by a conducting wire, the final charge on the smaller sphere is

(a) 3×10^{-2} C (b) 4×10^{-2} C

(c) 1×10^{-2} C (d) 2×10^{-2} C *(1995)*

71. There is an electric field E in x-direction. If the work done on moving a charge of 0.2 C through a distance of 2 m along a line making an angle 60° with x-axis is 4 J, then what is the value of E?

(a) 5 N/C (b) 20 N/C

(c) $\sqrt{3}$ N/C (d) 4 N/C. *(1995)*

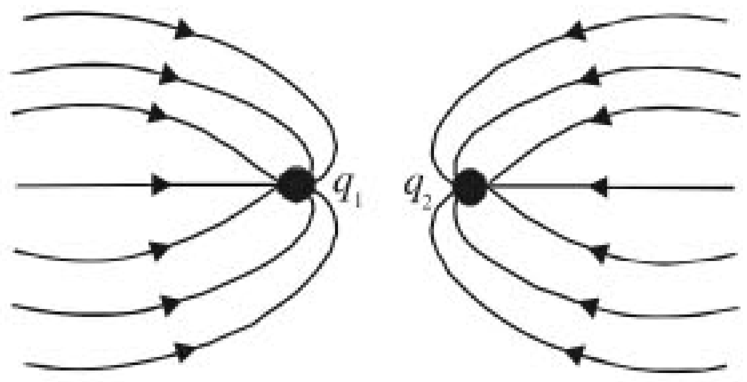
72. A charge q is placed at the centre of the line joining two exactly equal positive charges Q. The system of three charges will be in equilibrium, if q is equal to

(a) $-Q$ (b) $Q/2$ (c) $-Q/4$ (d) $+Q$ *(1995)*

73. An electric dipole of moment p is placed in the position of stable equilibrium in uniform electric field of intensity E. This is rotated through an angle θ from the initial position. The potential energy of the electric dipole in the final position is

(a) $-pE\cos\theta$ (b) $pE(1-\cos\theta)$
(c) $pE\cos\theta$ (d) $pE\sin\theta$. *(1994)*

74. The given figure gives electric lines of force due to two charges q_1 and q_2. What are the signs of the two charges?



(a) q_1 is positive but q_2 is negative
(b) q_1 is negative but q_2 is positive
(c) both are negative
(d) both are positive. *(1994)*

75. Charge q_2 is at the centre of a circular path with radius r. Work done in carrying charge q_1, once around this equipotential path, would be

(a) $\frac{1}{4\pi\varepsilon_0}\times\frac{q_1q_2}{r^2}$ (b) $\frac{1}{4\pi\varepsilon_0}\times\frac{q_1q_2}{r}$
(c) zero (d) infinite. *(1994)*

76. A hollow metallic sphere of radius 10 cm is charged such that potential of its surface is 80 V. The potential at the centre of the sphere would be

(a) 80 V (b) 800 V
(c) zero (d) 8 V. *(1994)*

77. Point charges $+4q$, $-q$ and $+4q$ are kept on the X-axis at point $x = 0$, $x = a$ and $x = 2a$ respectively.

(a) only $-q$ is in stable equilibrium
(b) all the charges are in stable equilbrium
(c) all of the charges are in unstable equilibrium
(d) none of the charges is in equilibrium *(1988)*

Answer Key

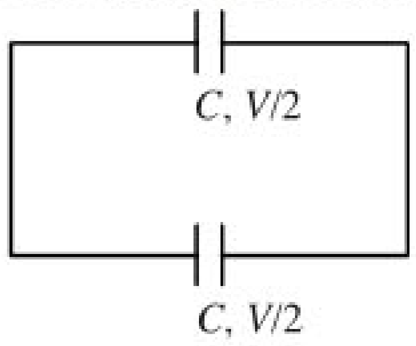
1. (a)	2. (b)	3. (a)	4. (b)	5. (c)	6. (b)	7. (a)	8. (d)	9. (d)	10. (a)
11. (b)	12. (c)	13. (b)	14. (d)	15. (d)	16. (d)	17. (b)	18. (a)	19. (a)	20. (a)
21. (b)	22. (c)	23. (b)	24. (c)	25. (c)	26. (d)	27. (a)	28. (c)	29. (d)	30. (d)
31. (c)	32. (a)	33. (d)	34. (b)	35. (d)	36. (d)	37. (c)	38. (d)	39. (c)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

EXPLANATIONS

1. **(a) :** When the capacitor is charged by a battery of potential V, then energy stored in the capacitor,

$$U_i = \frac{1}{2}CV^2 \qquad \text{...(i)}$$

When the battery is removed and another identical uncharged capacitor is connected in parallel



Common potential, $V' = \dfrac{CV}{C+C} = \dfrac{V}{2}$

$\therefore$ Then the energy stored in the capacitor,

$$U_f = \frac{1}{2}(2C)\left(\frac{V}{2}\right)^2 = \frac{1}{4}CV^2 \qquad \text{...(ii)}$$

$\therefore$ From eqns. (i) and (ii)

$$U_f = \frac{U_i}{2}$$

that means the total electrostatic energy of resulting system will decreases by a factor of 2.

2. **(b) :** A hydrogen atom consists of an electron and a proton.

$\therefore$ Charge on one hydrogen atom

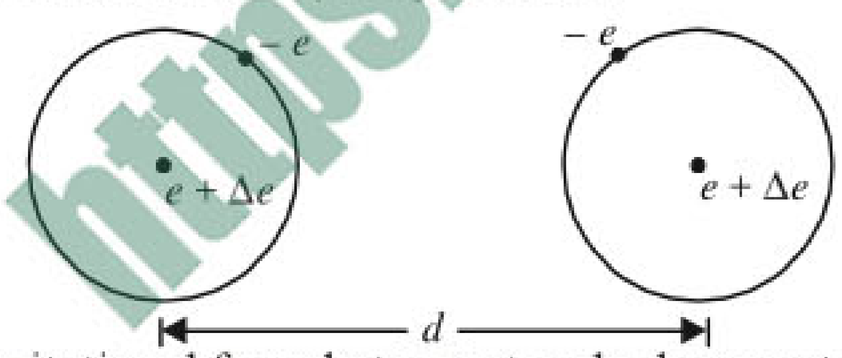
$= q_e + q_p = -e + (e + \Delta e) = \Delta e$

Since a hydrogen atom carry a net charge Δe,

$\therefore$ Electrostatic force,

$$F_e = \frac{1}{4\pi\varepsilon_o}\frac{(\Delta e)^2}{d^2} \qquad \text{...(i)}$$

will act between two hydrogen atoms.



The gravitational force between two hydrogen atoms is given as

$$F_g = \frac{Gm_h m_h}{d^2} \qquad \text{...(ii)}$$

Since, the net force on the system is zero, $F_e = F_g$

Using eqns. (i) and (ii), we get

$$\frac{(\Delta e)^2}{4\pi\varepsilon_o d^2} = \frac{Gm_h^2}{d^2}$$

$(\Delta e)^2 = 4\pi\varepsilon_o G m_h^2$

$= 6.67 \times 10^{-11} \times (1.67 \times 10^{-27})^2/(9 \times 10^9)$

$\Delta e \approx 10^{-37}$ C

3. **(a) :** Work done is given as $W = q\Delta V$

In all the four cases the potential difference from A to B is same.

$\therefore$ In all the four cases the work done is same.

4. **(b) :** Here, $\theta = 30°$, $E = 2 \times 10^5$ N C^{-1}

$\tau = 4$ N m, $l = 2$ cm $= 0.02$ m, $q = ?$

$\tau = pE\sin\theta = (ql)E\sin\theta$

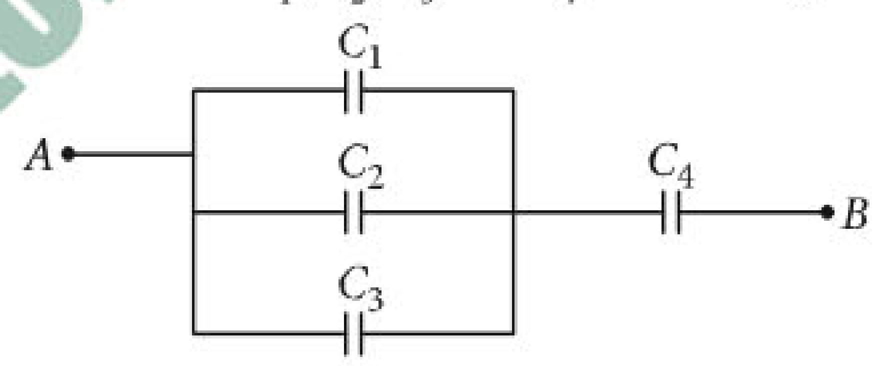
$$\therefore \quad q = \frac{\tau}{El\sin\theta} = \frac{4}{2\times10^5 \times 0.02 \times \frac{1}{2}}$$

$$= \frac{4}{2\times10^3} = 2\times10^{-3}\,\text{C} = 2\,\text{mC}$$

5. **(c) :** Here, $C_1 = \dfrac{2\varepsilon_0 k_1 A}{3d}$, $C_2 = \dfrac{2\varepsilon_0 k_2 A}{3d}$

$C_3 = \dfrac{2\varepsilon_0 k_3 A}{3d}$, $C_4 = \dfrac{2\varepsilon_0 k_4 A}{d}$

Given system of C_1, C_2, C_3 and C_4 can be simplified as



$$\therefore \quad \frac{1}{C_{AB}} = \frac{1}{C_1 + C_2 + C_3} + \frac{1}{C_4}$$

Suppose, $C_{AB} = \dfrac{k\varepsilon_0 A}{d}$

$$\frac{1}{k\left(\frac{\varepsilon_0 A}{d}\right)} = \frac{1}{\frac{2}{3}\frac{\varepsilon_0 A}{d}(k_1 + k_2 + k_3)} + \frac{1}{\frac{2\varepsilon_0 A}{d}k_4}$$

$$\Rightarrow \quad \frac{1}{k} = \frac{3}{2(k_1 + k_2 + k_3)} + \frac{1}{2k_4}$$

$$\therefore \quad \frac{2}{k} = \frac{3}{k_1 + k_2 + k_3} + \frac{1}{k_4}$$

6. **(b) :** Initially, the energy stored in 2 μF capacitor is

$$U_i = \frac{1}{2}CV^2 = \frac{1}{2}(2 \times 10^{-6})V^2 = V^2 \times 10^{-6}\ \text{J}$$

Initially, the charge stored in 2 μF capacitor is $Q_i = CV = (2 \times 10^{-6})V = 2V \times 10^{-6}$ coulomb. When switch S is turned to position 2, the charge flows and both the capacitors share charges till a common potential V_C is reached.

$$V_C = \frac{\text{total charge}}{\text{total capacitance}} = \frac{2V \times 10^{-6}}{(2+8)\times10^{-6}} = \frac{V}{5}\ \text{volt}$$

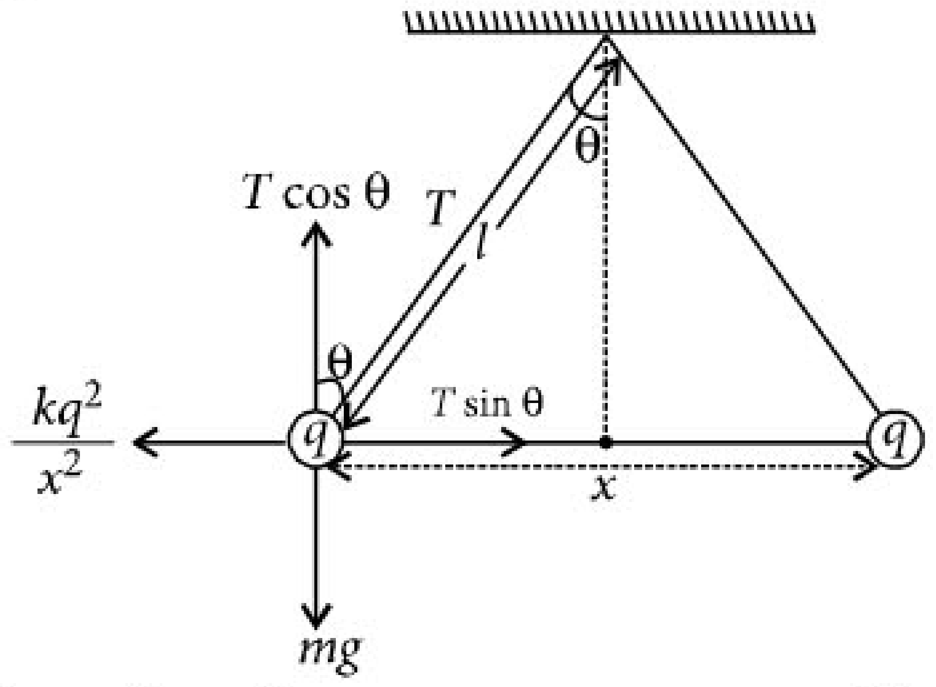
Finally, the energy stored in both the capacitors

$$U_f = \frac{1}{2}[(2+8)\times 10^{-6}]\left(\frac{V}{5}\right)^2 = \frac{V^2}{5}\times 10^{-6}\text{ J}$$

% loss of energy, $\Delta U = \frac{U_i - U_f}{U_i}\times 100\%$

$$= \frac{(V^2 - V^2/5)\times 10^{-6}}{V^2\times 10^{-6}}\times 100\% = 80\%$$

7. (a) :



From figure, $T\cos\theta = mg$ ...(i)

$$T\sin\theta = \frac{kq^2}{x^2} \quad \text{...(ii)}$$

From eqns. (i) and (ii), $\tan\theta = \frac{kq^2}{x^2 mg}$

Since θ is small, ∴ $\tan\theta \approx \sin\theta = \frac{x}{2l}$

$$\therefore \frac{x}{2l} = \frac{kq^2}{x^2 mg} \Rightarrow q^2 = x^3\frac{mg}{2lk} \text{ or } q \propto x^{3/2}$$

$$\Rightarrow \frac{dq}{dt} \propto \frac{3}{2}\sqrt{x}\frac{dx}{dt} = \frac{3}{2}\sqrt{x}v$$

Since, $\frac{dq}{dt}$ = constant

$$\therefore v \propto \frac{1}{\sqrt{x}}$$

8. (d) : Force of attraction between the plates of the parallel plate air capacitor is

$$F = \frac{Q^2}{2\varepsilon_0 A}$$

where Q is the charge on the capacitor, ε_0 is the permittivity of free space and A is the area of each plate.

But $Q = CV$

and $C = \frac{\varepsilon_0 A}{d}$ or $\varepsilon_0 A = Cd$

$$\therefore F = \frac{C^2V^2}{2Cd} = \frac{CV^2}{2d}$$

9. (d) : The electric field $\vec{E}$ and potential V in a region are related as

$$\vec{E} = -\left[\frac{\partial V}{\partial x}\hat{i} + \frac{\partial V}{\partial y}\hat{j} + \frac{\partial V}{\partial z}\hat{k}\right]$$

Here, $V(x, y, z) = 6xy - y + 2yz$

$$\therefore \vec{E} = -\left[\frac{\partial}{\partial x}(6xy - y + 2yz)\hat{i} + \frac{\partial}{\partial y}(6xy - y + 2yz)\hat{j} + \frac{\partial}{\partial z}(6xy - y + 2yz)\hat{k}\right]$$

$$= -[(6y)\hat{i} + (6x - 1 + 2z)\hat{k} + (2y)\hat{k}]$$

At point (1, 1, 0),

$$\vec{E} = -[(6(1))\hat{i} + (6(1) - 1 + 2(0))\hat{j} + (2(1))\hat{k}]$$

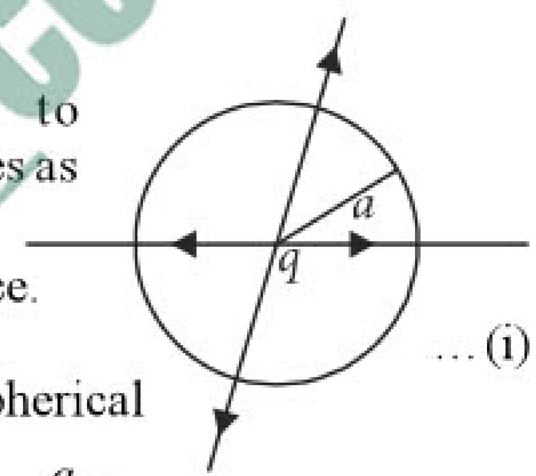
$$= -(6\hat{i} + 5\hat{j} + 2\hat{k})$$

10. (a) : According to question, electric field varies as

$E = Ar$

Here r is the radial distance.

At $r = a$, $E = Aa$ ...(i)

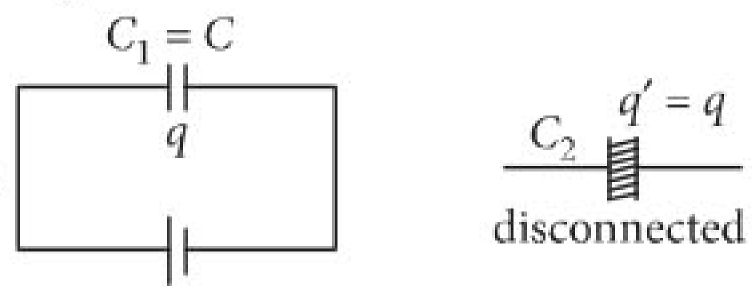


Net flux emitted from a spherical surface of radius a is $\phi_{\text{net}} = \frac{q_{en}}{\varepsilon_0}$

$$\Rightarrow (Aa)\times(4\pi a^2) = \frac{q}{\varepsilon_0} \quad \text{[Using equation (i)]}$$

$$\therefore q = 4\pi\varepsilon_0 A a^3$$

11. (b) :



$q = CV \Rightarrow V = q/C$

Due to dielectric insertion, new capacitance

$C_2 = CK$

Initial energy stored in capacitor, $U_1 = \frac{q^2}{2C}$

Final energy stored in capacitor, $U_2 = \frac{q^2}{2KC}$

Change in energy stored, $\Delta U = U_2 - U_1$

$$\Delta U = \frac{q^2}{2C}\left(\frac{1}{K} - 1\right) = \frac{1}{2}CV^2\left(\frac{1}{K} - 1\right)$$

New potential difference between plates

$$V' = \frac{q}{CK} = \frac{V}{K}$$

12. (c)

13. (b) : For the conducting sphere,

Potential at the centre = Potential on the sphere

$$= \frac{1}{4\pi\varepsilon_0}\frac{Q}{R}$$

Electric field at the centre = 0

14. (d) : Here, $V(x, y, z) = 6x - 8xy - 8y + 6yz$

The x, y and z components of electric field are

$$E_x = -\frac{\partial V}{\partial x} = -\frac{\partial}{\partial x}(6x - 8xy - 8y + 6yz)$$
$$= -(6 - 8y) = -6 + 8y$$
$$E_y = -\frac{\partial V}{\partial y} = -\frac{\partial}{\partial y}(6x - 8xy - 8y + 6yz)$$
$$= -(-8x - 8 + 6z) = 8x + 8 - 6z$$
$$E_z = -\frac{\partial V}{\partial z} = -\frac{\partial}{\partial z}(6x - 8xy - 8y + 6yz) = -6y$$
$$\vec{E} = E_x\hat{i} + E_y\hat{j} + E_z\hat{k}$$
$$= (-6 + 8y)\hat{i} + (8x + 8 - 6z)\hat{j} - 6y\hat{k}$$

At point (1, 1, 1)

$$\vec{E} = (-6 + 8)\hat{i} + (8 + 8 - 6)\hat{j} - 6\hat{k} = 2\hat{i} + 10\hat{j} - 6\hat{k}$$

The magnitude of electric field $\vec{E}$ is

$$\vec{E} = \sqrt{E_x^2 + E_y^2 + E_z^2} = \sqrt{(2)^2 + (10)^2 + (-6)^2}$$
$$= \sqrt{140} = 2\sqrt{35}\text{ N C}^{-1}$$

Electric force experienced by the charge

$$F = qE = 2\text{ C} \times 2\sqrt{35}\text{ N C}^{-1} = 4\sqrt{35}\text{ N}$$

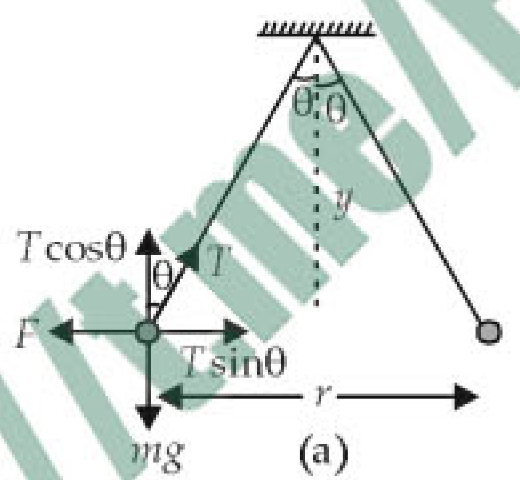
15. (d) : In the direction of electric field, electric potential decreases.

$\therefore\quad V_B > V_C > V_A$

16. (d) : Let m be mass of each ball and q be charge on each ball.

Force of repulsion,

$$F = \frac{1}{4\pi\varepsilon_0}\frac{q^2}{r^2}$$



(a)

In equilibrium

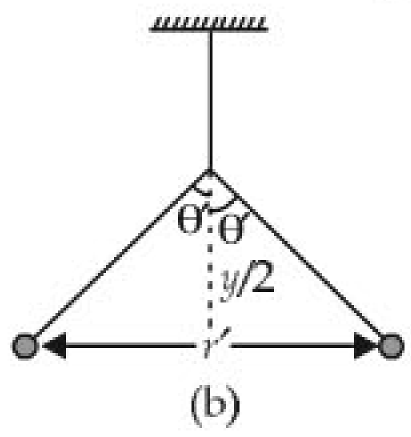
$$T\cos\theta = mg \qquad \text{...(i)}$$
$$T\sin\theta = F \qquad \text{...(ii)}$$

Divide (ii) by (i), we get, $\tan\theta = \frac{F}{mg} = \frac{\frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}}{mg}$

From figure (a),

$$\frac{r/2}{y} = \frac{\frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}}{mg} \qquad \text{...(iii)}$$

$$\tan\theta' = \frac{\frac{1}{4\pi\varepsilon_0}\frac{q^2}{r'^2}}{mg}$$



(b)

From figure (b)

$$\frac{r'/2}{y/2} = \frac{\frac{1}{4\pi\varepsilon_0}\frac{q^2}{r'^2}}{mg} \qquad \text{...(iv)}$$

Divide (iv) by (iii), we get

$$\frac{2r'}{r} = \frac{r^2}{r'^2}$$
$$r'^3 = \frac{r^3}{2} \Rightarrow r' = \frac{r}{\sqrt[3]{2}}$$

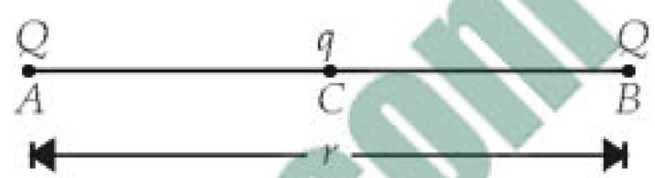
17. (b) : Potential energy of dipole,

$U = -pE(\cos\theta_2 - \cos\theta_1)$

Here, $\theta_1 = 0°$, $\theta_2 = 90°$

$\therefore\quad U = -pE(\cos 90° - \cos 0°) = -pE(0 - 1) = pE$

18. (a) : The situation is as shown in the figure.



Let two equal charges Q each placed at points A and B at a distance r apart. C is the centre of AB where charge q is placed.

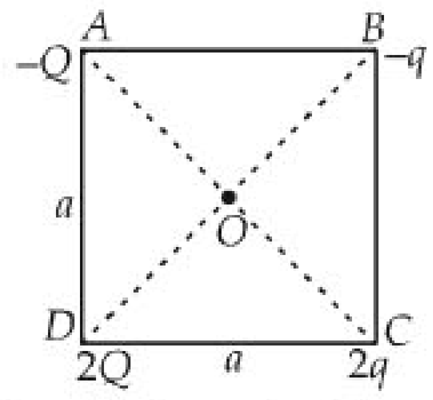
For equilibrium, net force on charge $Q = 0$

$$\therefore\quad \frac{1}{4\pi\varepsilon_0}\frac{QQ}{r^2} + \frac{1}{4\pi\varepsilon_0}\frac{Qq}{(r/2)^2} = 0$$
$$\frac{1}{4\pi\varepsilon_0}\frac{Q^2}{r^2} = -\frac{1}{4\pi\varepsilon_0}\frac{4Qq}{r^2} \text{ or } Q = -4q \text{ or } q = -\frac{Q}{4}$$

19. (a) : Torque, $\tau = pE\sin\theta$

Potential energy, $U = -pE\cos\theta$

20. (a) :



Let a be the side length of the square $ABCD$.

$$\therefore\quad AC = BD = \sqrt{a^2 + a^2} = a\sqrt{2}$$
$$OA = OB = OC = OD = \frac{a\sqrt{2}}{2} = \frac{a}{\sqrt{2}}$$

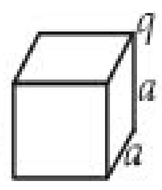
Potential is a scalar quantity.

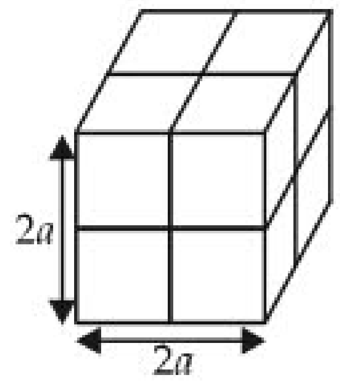
Potential at the centre O due to given charge configuration is

$$V = \frac{1}{4\pi\varepsilon_0}\left[\frac{(-Q)}{\left(\frac{a}{\sqrt{2}}\right)} + \frac{(-q)}{\left(\frac{a}{\sqrt{2}}\right)} + \frac{(2q)}{\left(\frac{a}{\sqrt{2}}\right)} + \frac{2Q}{\left(\frac{a}{\sqrt{2}}\right)}\right] = 0$$

$\Rightarrow\quad -Q - q + 2q + 2Q = 0$ or $Q + q = 0$ or $Q = -q$

21. (b) :





Eight identical cubes are required so that the given charge q appears at the centre of the bigger cube.
Thus, the electric flux passing through the given cube is

$$\phi = \frac{1}{8}\left(\frac{q}{\varepsilon_0}\right) = \frac{q}{8\varepsilon_0}$$

22. (c) : Capacitance of a parallel plate capacitor is

$$C = \frac{\varepsilon_0 A}{d} \quad \text{...(i)}$$

Potential difference between the plates is

$$V = Ed \quad \text{...(ii)}$$

The energy stored in the capacitor is

$$U = \frac{1}{2}CV^2 = \frac{1}{2}\left(\frac{\varepsilon_0 A}{d}\right)(Ed)^2 \quad \text{(Using (i) and (ii))}$$

$$= \frac{1}{2}\varepsilon_0 E^2 Ad$$

23. (b) : When the given metallic spheres are connected by a conducting wire, charge will flow till both the spheres acquire a common potential which is given by
Common potential,

$$V = \frac{q_1+q_2}{C_1+C_2} = \frac{-1\times10^{-2}+5\times10^{-2}}{4\pi\varepsilon_0 R_1 + 4\pi\varepsilon_0 R_2}$$

$$= \frac{4\times10^{-2}}{4\pi\varepsilon_0(1\times10^{-2}+3\times10^{-2})}$$

$$= \frac{4\times10^{-2}}{4\pi\varepsilon_0\times4\times10^{-2}} \quad \text{...(i)}$$

$\therefore$ Final charge on the bigger sphere is

$$= 4\pi\varepsilon_0\times3\times10^{-2}\times\frac{4\times10^{-2}}{4\pi\varepsilon_0\times4\times10^{-2}} \quad \text{(Using (i))}$$

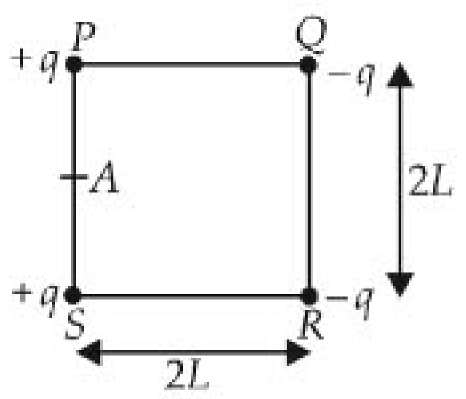
$= 3 \times 10^{-2}$ C

24. (c) : According to Gauss's law

$$\phi_E = \frac{Q_{\text{enclosed}}}{\varepsilon_0}$$

If the radius of the Gaussian surface is doubled, the outward electric flux will remain the same. This is because electric flux depends only on the charge enclosed by the surface.

25. (c) : A is the midpoint of PS



$\therefore$ $PA = AS = L$

$$AR = AQ = \sqrt{(SR)^2 + (AS)^2}$$

$$= \sqrt{(2L)^2 + (L)^2} = L\sqrt{5}$$

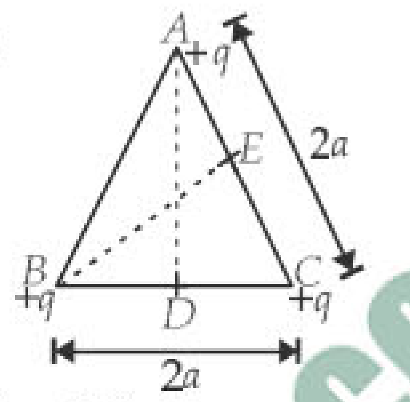
Electric potential at point A due to the given charge configuration is

$$V_A = \frac{1}{4\pi\varepsilon_0}\left[\frac{q}{PA}+\frac{q}{AS}+\frac{(-q)}{AQ}+\frac{(-q)}{AR}\right]$$

$$= \frac{1}{4\pi\varepsilon_0}\left[\frac{q}{L}+\frac{q}{L}-\frac{q}{L\sqrt{5}}-\frac{q}{L\sqrt{5}}\right]$$

$$= \frac{1}{4\pi\varepsilon_0}\left[\frac{2q}{L}-\frac{2q}{L\sqrt{5}}\right] = \frac{1}{4\pi\varepsilon_0}\frac{2q}{L}\left[1-\frac{1}{\sqrt{5}}\right]$$

26. (d) :



Here, $AC = BC = 2a$
D and E are the midpoints of BC and AC.
$\therefore$ $AE = EC = a$ and $BD = DC = a$
In ΔADC, $(AD)^2 = (AC)^2 - (DC)^2$
$= (2a)^2 - (a)^2 = 4a^2 - a^2 = 3a^2$
$AD = a\sqrt{3}$

Similarly, potential at point D due to the given charge configuration is

$$V_D = \frac{1}{4\pi\varepsilon_0}\left[\frac{q}{BD}+\frac{q}{DC}+\frac{q}{AD}\right]$$

$$= \frac{q}{4\pi\varepsilon_0}\left[\frac{1}{a}+\frac{1}{a}+\frac{1}{\sqrt{3}a}\right] = \frac{q}{4\pi\varepsilon_0 a}\left[2+\frac{1}{\sqrt{3}}\right] \quad \text{...(i)}$$

Potential at point E due to the given charge configuration is

$$V_E = \frac{1}{4\pi\varepsilon_0}\left[\frac{q}{AE}+\frac{q}{EC}+\frac{q}{BE}\right]$$

$$= \frac{q}{4\pi\varepsilon_0}\left[\frac{1}{a}+\frac{1}{a}+\frac{1}{a\sqrt{3}}\right] = \frac{q}{4\pi\varepsilon_0 a}\left[2+\frac{1}{\sqrt{3}}\right] \quad \text{...(ii)}$$

From the (i) and (ii), it is clear that

$V_D = V_E$

The work done in taking a charge Q from D to E is

$W = Q(V_E - V_D) = 0 \qquad (\because V_D = V_E)$

27. (a) : $\vec{E} = -\vec{\nabla}V$

where $\vec{\nabla} = \hat{i}\frac{\partial}{\partial x}+\hat{j}\frac{\partial}{\partial y}+\hat{k}\frac{\partial}{\partial z}$

$$\therefore \quad \vec{E} = -\left[\hat{i}\frac{\partial V}{\partial x}+\hat{j}\frac{\partial V}{\partial y}+\hat{k}\frac{\partial V}{\partial z}\right]$$

Here, $V = 4x^2$ $\therefore$ $\vec{E} = -8x\hat{i}$

The electric field at point (1, 0, 2) is

$\vec{E}_{(1,0,2)} = -8\hat{i}$ V m^{-1}

So electric field is along the negative X-axis.

28. (c) : According to Coulomb's law, the force of repulsion between the two positive ions each of charge q, separated by a distance d is given by

$$F = \frac{1}{4\pi\varepsilon_0}\frac{(q)(q)}{d^2}$$

$$F = \frac{q^2}{4\pi\varepsilon_0 d^2}$$

$$q^2 = 4\pi\varepsilon_0 F d^2$$

$$q = \sqrt{4\pi\varepsilon_0 F d^2} \qquad \text{...(i)}$$

Since, $q = ne$

where,

n = number of electrons missing from each ion

e = magnitude of charge on electron

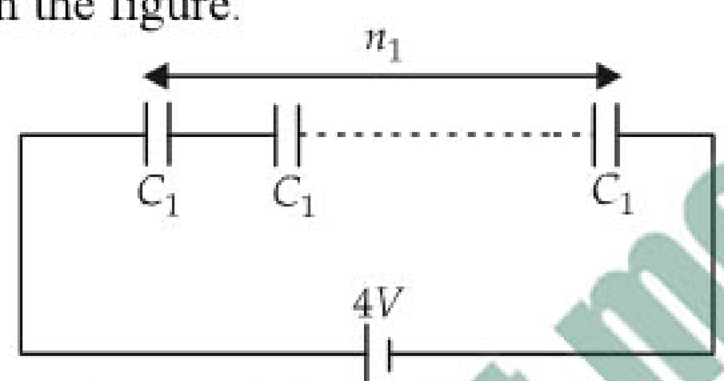
$$\therefore \quad n = \frac{q}{e}$$

$$n = \frac{\sqrt{4\pi\varepsilon_0 F d^2}}{e} \qquad \text{(Using (i))}$$

$$= \sqrt{\frac{4\pi\varepsilon_0 F d^2}{e^2}}$$

29. (d)

30. (d) : A series combination of n_1 capacitors each of capacitance C_1 are connected to $4V$ source as shown in the figure.



Total capacitance of the series combination of the capacitors is

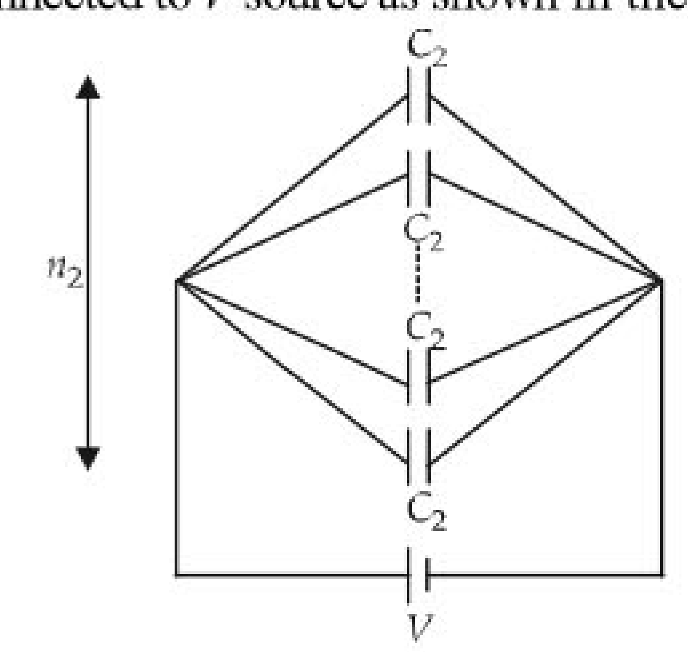
$$\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_1} + \frac{1}{C_1} + \text{.........upto } n_1 \text{terms} = \frac{n_1}{C_1}$$

$$\text{or} \quad C_s = \frac{C_1}{n_1} \qquad \text{...(i)}$$

Total energy stored in a series combination of the capacitors is

$$U_s = \frac{1}{2}C_s(4V)^2 = \frac{1}{2}\left(\frac{C_1}{n_1}\right)(4V)^2 \quad \text{(Using (i))} \qquad \text{...(ii)}$$

A parallel combination of n_2 capacitors each of capacitance C_2 are connected to V source as shown in the figure.



Total capacitance of the parallel combination of capacitors is

$$C_p = C_2 + C_2 + \text{..........+ upto } n_2 \text{ terms} = n_2 C_2$$

$$\text{or} \quad C_p = n_2 C_2 \qquad \text{...(iii)}$$

Total energy stored in a parallel combination of capacitors is

$$U_p = \frac{1}{2}C_p V^2$$

$$= \frac{1}{2}(n_2 C_2)(V)^2 \qquad \text{(Using (iii)) (iv)}$$

According to the given problem,

$$U_s = U_p$$

Substituting the values of U_s and U_p from equations (ii) and (iv), we get

$$\frac{1}{2}\frac{C_1}{n_1}(4V)^2 = \frac{1}{2}(n_2 C_2)(V)^2$$

$$\text{or} \quad \frac{C_1 16}{n_1} = n_2 C_2 \text{ or } C_2 = \frac{16 C_1}{n_1 n_2}$$

31. (c) : Electric field between two parallel plates placed in vacuum is given by

$$E = \frac{\sigma}{\varepsilon_0}$$

In a medium of dielectric constant K, $E' = \dfrac{\sigma}{\varepsilon_0 K}$

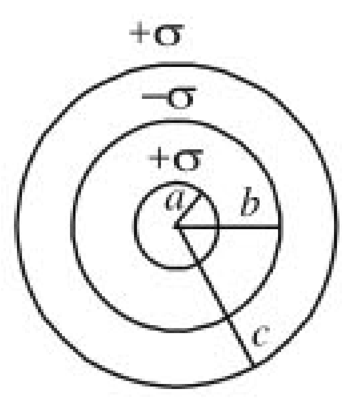
For kerosene oil $K > 1 \;\Rightarrow\; E' < E$

32. (a) : Electric field inside a charged conductor is always zero.

33. (d) : $V_A = \dfrac{1}{4\pi\varepsilon_0}\left\{\dfrac{q_A}{a} + \dfrac{q_B}{b} + \dfrac{q_C}{c}\right\}$

$$= \frac{4\pi}{4\pi\varepsilon_0}\left\{\frac{a^2\sigma}{a} - \frac{b^2\sigma}{b} + \frac{c^2\sigma}{c}\right\}$$

$$V_A = \frac{1}{\varepsilon_0}\left\{\frac{a^2\sigma}{a} - \frac{b^2\sigma}{b} + \frac{c^2\sigma}{c}\right\}$$



$$V_B = \frac{1}{\varepsilon_0}\left\{\frac{a^2\sigma}{b} - \frac{b^2\sigma}{b} + \frac{c^2\sigma}{c}\right\}$$

$$V_C = \frac{1}{\varepsilon_0}\left\{\frac{a^2\sigma}{c} - \frac{b^2\sigma}{c} + \frac{c^2\sigma}{c}\right\}$$

Given $c = a + b$.

If $a = a$, $b = 2a$ and $c = 3a$ for example, as $c > b > a$,

$$V_A = \frac{1}{\varepsilon_0}\left\{\frac{a^2\sigma}{a} - \frac{4a^2\sigma}{2a} + \frac{c^2\sigma}{c}\right\}$$

$$V_B = \frac{1}{\varepsilon_0}\left\{\frac{a^2\sigma}{2a} - \frac{4a^2\sigma}{2a} + \frac{c^2\sigma}{c}\right\}$$

$$V_C = \frac{1}{\varepsilon_0}\left\{\frac{a^2\sigma}{3a} - \frac{4a^2\sigma}{3a} + \frac{c^2\sigma}{c}\right\}$$

It can seen by taking out common factors that

$V_A = V_C > V_B$ i.e., $V_A = V_C \neq V_B$

34. (b) : Three capacitors of capacitance C each are in series.

$\therefore$ Total capacitance, $C_{\text{total}} = \frac{C}{3}$

The charge is the same, Q, when capacitors are in series.

$$V_{\text{total}} = \frac{Q}{C} = \frac{Q}{C/3} = 3V.$$

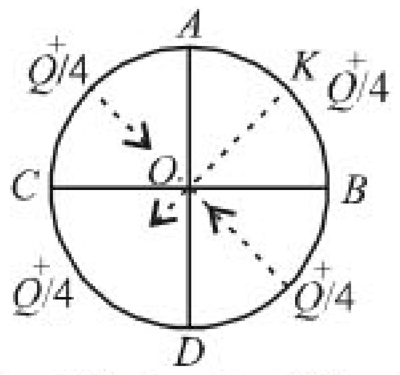
35. (d) : The electric potential at a point,

$V = -x^2y - xz^3 + 4.$

The field $\vec{E} = -\vec{\nabla}V = -\left(\frac{\partial V}{\partial x}\hat{i} + \frac{\partial V}{\partial y}\hat{j} + \frac{\partial V}{\partial z}\hat{k}\right)$

$\therefore$ $\vec{E} = \hat{i}(2xy + z^3) + \hat{j}x^2 + \hat{k}(3xz^2)$

36. (d) :



The fields at O due to AC and BD cancel each other. The field due to CD is acting in the direction OK and equal in magnitude to E due to AKB.

37. (c) : $V = \frac{1}{4\pi\varepsilon_0}\cdot\frac{Q}{r} = Q.10^{11}$ volts

$\therefore$ $\frac{1}{r} = 4\pi\varepsilon_0\cdot 10^{11}$

$$E = \frac{\text{potential}}{r} = Q\cdot 10^{11}\times 4\pi\varepsilon_0\cdot 10^{11}$$

$\Rightarrow$ $E = 4\pi\varepsilon_0\cdot Q\cdot 10^{22}$ volt/m

38. (d) : Let ϕ_A, ϕ_B and ϕ_C are the electric flux linked with A, B and C.

According to Gauss theorem,

$$\phi_A + \phi_B + \phi_C = \frac{q}{\varepsilon_0}$$

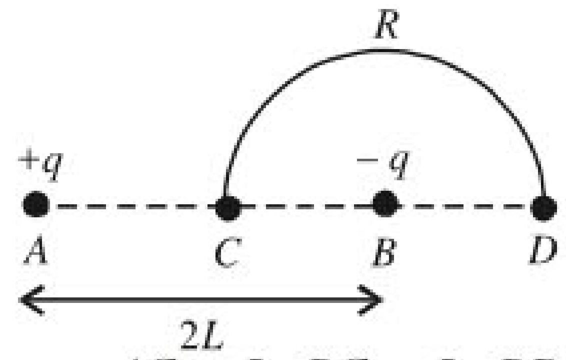
Since $\phi_A = \phi_C$,

$\therefore$ $2\phi_A + \phi_B = \frac{q}{\varepsilon_0}$ or $2\phi_A = \frac{q}{\varepsilon_0} - \phi_B$

or, $2\phi_A = \frac{q}{\varepsilon_0} - \phi$ (Given $\phi_B = \phi$).

$\therefore$ $\phi_A = \frac{1}{2}\left(\frac{q}{\varepsilon_0} - \phi\right).$

39. (c) :



From figure, $AC = L$, $BC = L$, $BD = BC = L$

$AD = AB + BD = 2L + L = 3L$

Potential at C is given by

$$V_C = \frac{1}{4\pi\varepsilon_0}\left[\frac{q}{AC} + \frac{(-q)}{BC}\right] = \frac{1}{4\pi\varepsilon_0}\left[\frac{q}{L} - \frac{q}{L}\right] = 0$$

Potential at D is given by

$$V_D = \frac{1}{4\pi\varepsilon_0}\left[\frac{q}{AD} + \frac{(-q)}{BD}\right] = \frac{1}{4\pi\varepsilon_0}\left[\frac{q}{3L} - \frac{q}{L}\right]$$

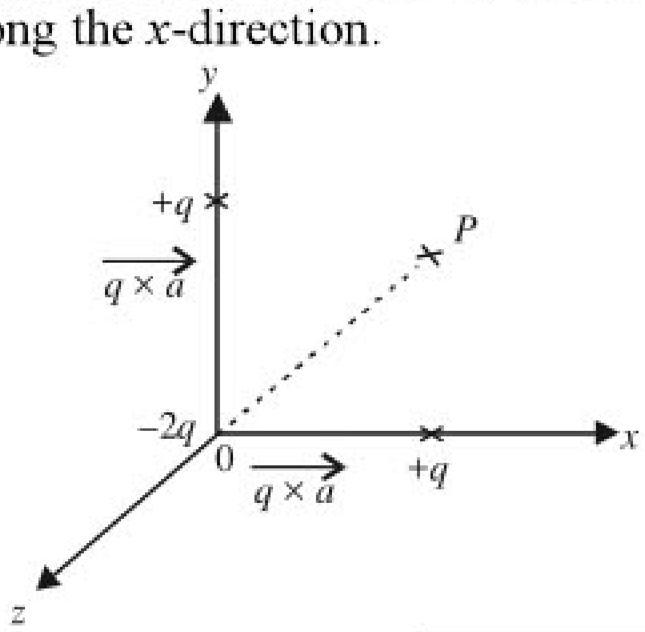
$$= \frac{1}{4\pi\varepsilon_0}\frac{q}{L}\left[\frac{1}{3} - 1\right] = \frac{-q}{6\pi\varepsilon_0}.$$

Work done in moving charge $+Q$ along the semicircle CRD is given by

$$W = [V_D - V_C](+Q) = \left[\frac{-q}{6\pi\varepsilon_0} - 0\right](Q) = \frac{-qQ}{6\pi\varepsilon_0 L}$$

Comments : Potential at C is zero because the charges are equal and opposite and the distances are the same. Potential at D due to $-q$ is greater than that at A $(+q)$, because D is closer to B. Therefore it is negative.

40. (a) : This consists of two dipoles, $-q$ and $+q$ with dipole moment along with the $+y$-direction and $-q$ and $+q$ along the x-direction.



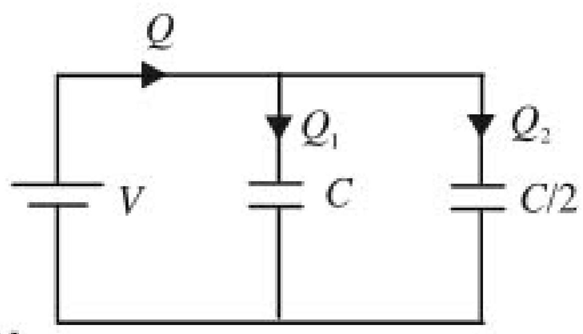
$\therefore$ The resultant moment $= \sqrt{q^2a^2 + q^2a^2} = \sqrt{2}qa.$

Along the direction 45° that is along OP where P is $(+a, +a, 0)$.

41. (b) : As the capacitors are connected in parallel, therefore potential difference across both the condensors remains the same.

$\therefore$ $Q_1 = CV$;

$Q_2 = \frac{C}{2}V$



Also, $Q = Q_1 + Q_2$

$= CV + \frac{C}{2}V = \frac{3}{2}CV.$

Work done in charging fully both the condensors is given by

$$W = \frac{1}{2}QV = \frac{1}{2}\times\left(\frac{3}{2}CV\right)V = \frac{3}{4}CV^2.$$

42. (a) : Capacitance of a parallel plate capacitor

$$C = \frac{\varepsilon_0 A}{d} \qquad \text{... (i)}$$

Also capacitance = $\dfrac{\text{potential difference}}{\text{charge}}$ ... (ii)

When battery is disconnected and the distance between the plates of the capacitor is increased then capacitance increases and charge remains constant.

Since capacitance = $\dfrac{\text{potential difference}}{\text{charge}}$

$\therefore$ Potential difference increases.

43. (a) : Work done in deflecting a dipole through an angle θ is given by

$$W = \int_0^\theta pE\sin\theta\, d\theta = pE(1-\cos\theta)$$

Since $\theta = 90°$

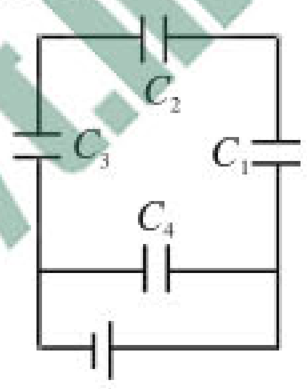
$\therefore$ $W = pE(1 - \cos 90°)$ or, $W = pE$.

44. (d) : Electric flux, $\phi_E = \int \vec{E}\cdot d\vec{S}$

$= \int EdS\cos\theta = \int EdS\cos 90° = 0.$

The lines are parallel to the surface.

45. (b) : C_1, C_2 and C_3 are in series



$$\frac{1}{C'} = \frac{1}{C} + \frac{1}{2C} + \frac{1}{3C}$$

or, $\dfrac{1}{C'} = \dfrac{6+3+2}{6C} = \dfrac{11}{6C}$

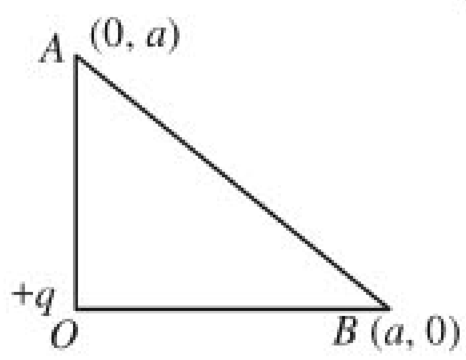
or, $C' = \dfrac{6C}{11}$

All the capacitors in branch 1 is in series so the charge on each capacitor is $Q' = \dfrac{6}{11}CV$

Also charge on capacitor C_4 is $Q = 4CV$

$\therefore$ Ratio = $\dfrac{Q'}{Q} = \dfrac{6CV}{11\times 4CV} = \dfrac{3}{22}$.

46. (a) : Work done is equal to zero because the potential of A and B are the same = $\dfrac{1}{4\pi\varepsilon_0}\dfrac{q}{a}$



No work is done if a particle does not change its potential energy.

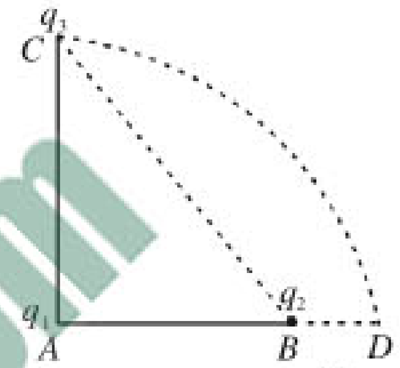
i.e. initial potential energy = final potential energy.

47. (c) : The potential energy when q_3 is at point C

$$U_1 = \frac{1}{4\pi\varepsilon_0}\left[\frac{q_1q_3}{0.40} + \frac{q_2q_3}{\sqrt{(0.40)^2+(0.30)^2}}\right]$$

The potential energy when q_3 is at point D

$$U_2 = \frac{1}{4\pi\varepsilon_0}\left[\frac{q_1q_3}{0.40} + \frac{q_2q_3}{0.10}\right]$$



Thus change in potential energy is

$\Delta U = U_2 - U_1$

$$\Rightarrow \frac{q_3}{4\pi\varepsilon_0}k = \frac{1}{4\pi\varepsilon_0}\left[\frac{q_1q_3}{0.40} + \frac{q_2q_3}{0.10} - \frac{q_1q_3}{0.40} - \frac{q_2q_3}{0.50}\right]$$

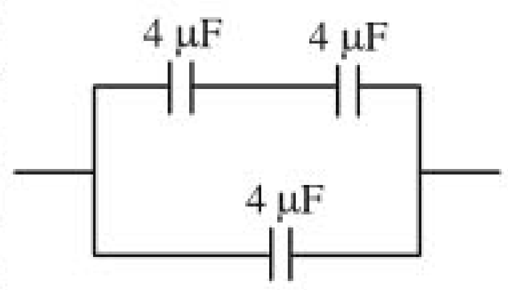
$$\Rightarrow k = \frac{5q_2 - q_2}{0.50} = \frac{4q_2}{0.50} = 8q_2.$$

48. (b) : Using $\dfrac{1}{2}mv^2 = qV$

$$V = \frac{1}{2}\times\frac{2\times10^{-3}\times10\times10}{2\times10^{-6}} = 50\text{ kV}$$

49. (c) : The total force on dipole is zero because $F = qE$ is applied on each charge but in opposite direction. The potential energy is $U = -\vec{p}\cdot\vec{E}$, which is minimum when $\vec{p}$ and $\vec{E}$ are parallel.

50. (c) : To get equivalent capacitance 6 μF. Out of the 4 μF capacitance, two are connected in series and third one is connected in parallel.



$$C_{eq} = \frac{4\times4}{4+4} + 4 = 2 + 4 = 6\text{ μF}.$$

51. (b) : The total flux through the cube $\phi_{total} = \dfrac{q}{\varepsilon_0}$

$\therefore$ the electric flux through any face

$$\phi_{face} = \frac{q}{6\,\varepsilon_0} = \frac{4\pi q}{6(4\pi\varepsilon_0)}.$$

52. (c) : There are eight corners of a cube and in each corner there is a charge of $(-q)$. At the centre of the corner there is a charge of $(+q)$. Each corner is equidistant from the centres of the cube and the distance (d) is half of the diagonals of the cube.

Diagonal of the cube = $\sqrt{b^2+b^2+b^2} = \sqrt{3}\,b$

$\therefore$ $d = \sqrt{3}\,b/2$

Now, electric potential energy of the charge $(+q)$ due to a charge $(-q)$ at one corner = U

$$= \frac{q_1 q_2}{4\pi\varepsilon_0 r} = \frac{(+q)\times(-q)}{4\pi\varepsilon_0(\sqrt{3}b/2)} = -\frac{q^2}{2\pi\varepsilon_0(\sqrt{3}b)}.$$

$\therefore$ Total electric potential energy due to all the eight identical charges $= 8U = -\frac{8q^2}{2\pi\varepsilon_0\sqrt{3}b} = \frac{-4q^2}{\sqrt{3}\,\pi\varepsilon_0 b}.$

53. (b) : Charge on first capacitor $= q_1 = C_1 V$

Charge on second capacitor $= q_2 = 0$

When they are connected, in parallel the total charge

$q = q_1 + q_2$. $\therefore$ $q = C_1 V$.

and capacitance, $C = C_1 + C_2$

Let V' be the common potential difference across each capacitor, then $q = CV'$.

$$\therefore \quad V' = \frac{q}{C} = \frac{C_1}{C_1 + C_2} V.$$

54. (c) : Electric field intensity E is zero within a conductor due to charge given to it.

Also, $E = -\frac{dV}{dx}$ or $\frac{dV}{dx} = 0$. (inside the conductor)

$\therefore$ V = constant. [V is potential]

So potential remains same throughout the conductor.

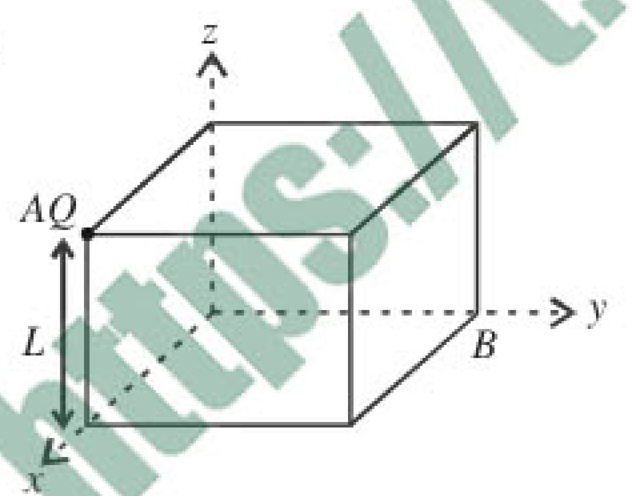
55. (b) : When an electric dipole is placed in a uniform electrical field $\vec{E}$, the torque on the dipole is given by $\vec{\tau} = \vec{p} \times \vec{E}$

56. (a) : Energy density $= \frac{1}{2}\varepsilon_0 \frac{V^2}{d^2}$

57. (a) : For complete cube $\phi = \frac{Q}{\varepsilon_0} \times 10^{-6}$

For each face $\phi = \frac{1}{6}\frac{Q}{\varepsilon_0} \times 10^{-6}$

58. (b) :



As at a corner, 8 cubes can be placed symmetrically, flux linked with each cube (due to a charge Q at the corner) will be $\frac{Q}{8\varepsilon_0}$.

Now for the faces passing through the edge A, electric field E at a face will be parallel to area of face and so flux for these three faces will be zero. Now as the cube has six faces and flux linked with three faces (through A) is zero, so flux linked with remaining three faces will be $\frac{Q}{8\varepsilon_0}$

Hence, electric flux passed through all the six faces of the cube is $\frac{Q}{8\varepsilon_0}$

59. (c)

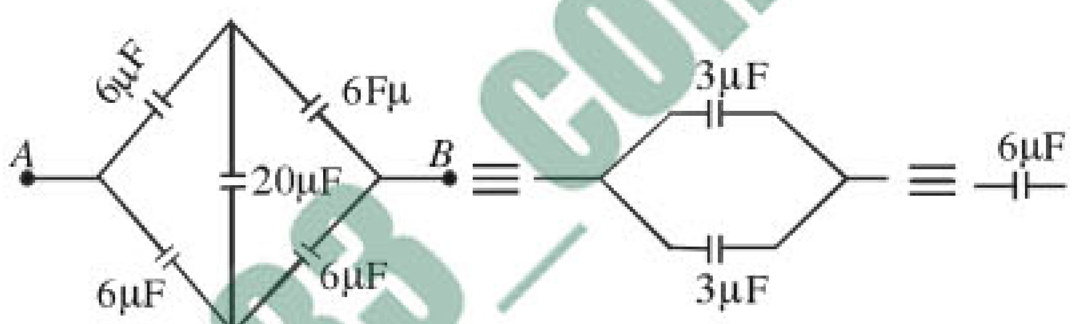
60. (b) : Let q be the charge on each capacitor.

$\therefore$ Energy stored, $U = \frac{1}{2}CV^2 = \frac{1}{2}\frac{q^2}{C}$

Now, when battery is disconnected and another capacitor of same capacity is connected in parallel to the first capacitor, then voltage across each capacitor, $V = \frac{q}{2C}$

$\therefore$ Energy stored $= \frac{1}{2}C\left(\frac{q}{2C}\right)^2 = \frac{1}{4}\cdot\frac{1}{2}\frac{q^2}{C} = \frac{1}{4}U.$

61. (d) : Reconstruction of circuits gives



62. (c) : $F_m = \frac{F_0}{K}$ *i.e.*, decreases K times

63. (b) : In bringing an electron towards another electron, work has to be done (since same charges repel each other). The work done stored as electrostatic potential energy, and hence, electrostatic potential energy of the system increases.

64. (d) : Capacitance of capacitor with oil between the plate, $C = \frac{K\varepsilon_0 A}{d}$

If oil is removed capacitance, $C' = \frac{\varepsilon_0 A}{d} = \frac{C}{K} = \frac{C}{2}$

65. (c) : Field inside a conducting sphere = 0.

66. (a) : As $v^2 = 0^2 + 2ay = 2\,(F/m)\,y = 2\left(\frac{qE}{m}\right)y$

K.E. $= \frac{1}{2}mv^2$

$\therefore$ K.E. $= \frac{1}{2}m\left[2\frac{(qE)}{m}y\right]$ $\Rightarrow$ K.E. $= qEy$

67. (d) : The electric field at a point on equatorial line (perpendicular bisector) of dipole at a distance r is given by, $E = \frac{p}{4\pi\varepsilon_0}\cdot\frac{1}{(r^2 + a^2)^{3/2}}$

where $2a$ = length of dipole

For, $r >> a$;

$\therefore$ $E = \frac{p}{4\pi\varepsilon_0}\cdot\frac{1}{r^3}$. *i.e.*, $E \propto p$ and $E \propto r^{-3}$.

68. (d) : Electric flux emerging from the cube does not depend on size of cube.

Total flux $= \frac{q}{\varepsilon_0}$

69. (d)

70. (d) : Radii of sphere $(R_1) = 1$ cm $= 1 \times 10^{-2}$ m; $(R_2) = 2$ cm $= 2 \times 10^{-2}$ m and charges on sphere; $(Q_1) = 10^{-2}$C and $(Q_2) = 5 \times 10^{-2}$ C.

Common potential $(V) = \dfrac{\text{Total charge}}{\text{Total capacity}} = \dfrac{Q_1 + Q_2}{C_1 + C_2}$

$$= \frac{(1\times10^{-2}) + (5\times10^{-2})}{4\pi\varepsilon_0 10^{-2} + 4\pi\varepsilon_0(2\times10^{-2})} = \frac{6\times10^{-2}}{4\pi\varepsilon_0(3\times10^{-2})}$$

Therefore final charge on smaller sphere (C_1V)

$$= 4\pi\varepsilon_0 \times 10^{-2} \times \frac{6\times10^{-2}}{4\pi\varepsilon_0 \times 3\times10^{-2}} = 2 \times 10^{-2}\text{ C.}$$

71. (b) : Charge $(q) = 0.2$ C; Distance $(d) = 2$ m; Angle $\theta = 60^\circ$ and work done $(W) = 4$ J.

Work done in moving the charge (W)

$= Fd\cos\theta = qEd\cos\theta$

or, $E = \dfrac{W}{qd\cos\theta} = \dfrac{4}{0.2\times2\times\cos 60^\circ} = \dfrac{4}{0.4\times0.5}$

$= 20$ N/C.

72. (c) : For equilibrium of charge Q, the force of repulsion due to similar charges Q should be balanced by the force of attraction due to charge q and

$$\frac{1}{4\pi\varepsilon_0}\times\frac{Qq}{(r/2)^2} + \frac{1}{4\pi\varepsilon_0}\times\frac{Q^2}{r^2} = 0$$

or $\quad 4\times\dfrac{Q}{r^2}q = -\dfrac{Q^2}{r^2}$ or $4q = -Q$ or $q = -\dfrac{Q}{4}$.

73. (b) : To orient the dipole at any angle θ from its initial position, work has to be done on the dipole from $\theta = 0^\circ$ to θ

$\therefore$ Potential energy $= pE(1 - \cos\theta)$

74. (c) : Electric lines of force start from the positive charge and end at the negative charge. Since the electric lines for both the charges are ending, therefore both q_1 and q_2 are negative charges.

75. (c) : Work done on carrying a charge from one place to another on an equipotential surface is zero.

76. (a) : Potential inside the sphere is the same as that on the surface *i.e.*, 80 V.

77. (c) : Net force on each of the charge due to the other charges is zero. However, disturbance in any direction other than along the line on which the charges lie, will not make the charges return.

Chapter 13 Current Electricity

1. The resistance of a wire is 'R' ohm. If it is melted and stretched to 'n' times its original length, its new resistance will be

(a) $\frac{R}{n}$ (b) n^2R (c) $\frac{R}{n^2}$ (d) nR

(NEET 2017)

2. A potentiometer is an accurate and versatile device to make electrical measurements of EMF because the method involves

(a) potential gradients

(b) a condition of no current flow through the galvanometer

(c) a combination of cells, galvanometer and resistances

(d) cells *(NEET 2017)*

3. The potential difference $(V_A - V_B)$ between the points A and B in the given figure is

(a) –3 V (b) +3 V (c) +6 V (d) +9 V

(NEET-II 2016)

4. A filament bulb (500 W, 100 V) is to be used in a 230 V main supply. When a resistance R is connected in series, it works perfectly and the bulb consumes 500 W. The value of R is

(a) 230 Ω (b) 46 Ω (c) 26 Ω (d) 13 Ω

(NEET-II 2016)

5. A potentiometer wire is 100 cm long and a constant potential difference is maintained across it. Two cells are connected in series first to support one another and then in opposite direction. The balance points are obtained at 50 cm and 10 cm from the positive end of the wire in the two cases. The ratio of emf's is

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

(NEET-I 2016)

6. The charge flowing through a resistance R varies with time t as $Q = at - bt^2$, where a and b are positive constants. The total heat produced in R is

(a) $\frac{a^3R}{2b}$ (b) $\frac{a^3R}{b}$ (c) $\frac{a^3R}{6b}$ (d) $\frac{a^3R}{3b}$

(NEET-I 2016)

7. Two metal wires of identical dimensions are connected in series. If σ_1 and σ_2 are the conductivities of the metal wires respectively, the effective conductivity of the combination is

(a) $\frac{\sigma_1+\sigma_2}{\sigma_1\sigma_2}$ (b) $\frac{\sigma_1\sigma_2}{\sigma_1+\sigma_2}$

(c) $\frac{2\sigma_1\sigma_2}{\sigma_1+\sigma_2}$ (d) $\frac{\sigma_1+\sigma_2}{2\sigma_1\sigma_2}$ *(2015)*

8. A circuit contains an ammeter, a battery of 30 V and a resistance 40.8 ohm all connected in series. If the ammeter has a coil of resistance 480 ohm and a shunt of 20 ohm, the reading in the ammeter will be

(a) 2 A (b) 1 A (c) 0.5 A (d) 0.25 A

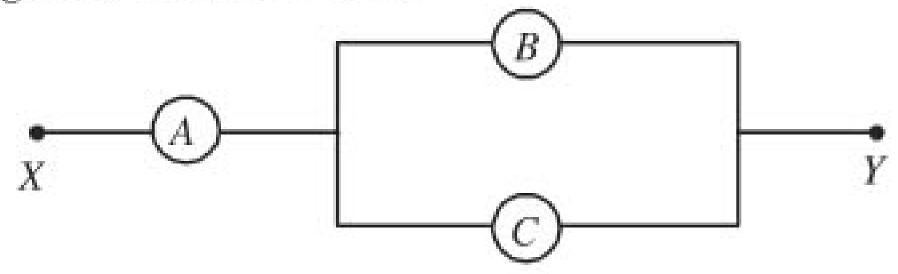
(2015)

9. A potentiometer wire of length L and a resistance r are connected in series with a battery of e.m.f. E_0 and a resistance r_1. An unknown e.m.f. E is balanced at a length l of the potentiometer wire. The e.m.f. E will be given by

(a) $\frac{E_0 l}{L}$ (b) $\frac{LE_0 r}{(r+r_1)l}$

(c) $\frac{LE_0 r}{l r_1}$ (d) $\frac{E_0 r}{(r+r_1)}\cdot\frac{l}{L}$ *(2015)*

10. A, B and C are voltmeters of resistance R, $1.5R$ and $3R$ respectively as shown in the figure. When some potential difference is applied between X and Y, the voltmeter readings are V_A, V_B and V_C respectively. Then



(a) $V_A = V_B \neq V_C$ (b) $V_A \neq V_B \neq V_C$
(c) $V_A = V_B = V_C$ (d) $V_A \neq V_B = V_C$

(2015 Cancelled)

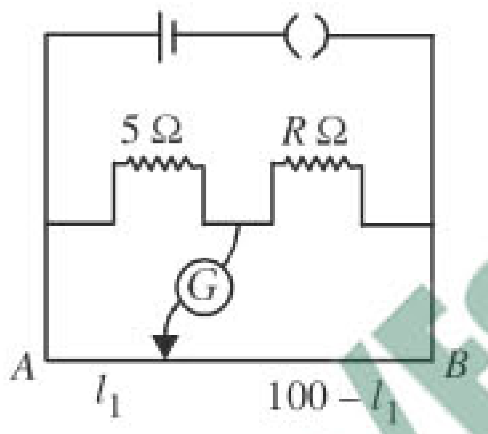
11. Across a metallic conductor of non-uniform cross section a constant potential difference is applied. The quantity which remains constant along the conductor is
(a) drift velocity (b) electric field
(c) current density (d) current

(2015 Cancelled)

12. A potentiometer wire has length 4 m and resistance 8 Ω. The resistance that must be connected in series with the wire and an accumulator of e.m.f. 2 V, so as to get a potential gradient 1 mV per cm on the wire is
(a) 44 Ω (b) 48 Ω (c) 32 Ω (d) 40 Ω

(2015 Cancelled)

13. The resistances in the two arms of the meter bridge are 5 Ω and R Ω respectively. When the resistance R is shunted with an equal resistance, the new balance point is at $1.6l_1$. The resistance R is



(a) 10 Ω (b) 15 Ω (c) 20 Ω (d) 25 Ω

(2014)

14. Two cities are 150 km apart. Electric power is sent from one city to another city through copper wires. The fall of potential per km is 8 volt and the average resistance per km is 0.5 Ω. The power loss in the wire is
(a) 19.2 W (b) 19.2 kW
(c) 19.2 J (d) 12.2 kW *(2014)*

15. A potentiometer circuit has been set up for finding the internal resistance of a given cell. The main battery, used across the potentiometer wire, has an emf of 2.0 V and a negligible internal resistance. The potentiometer wire itself is 4 m long. When the resistance R, connected across the given cell, has values of
(i) infinity (ii) 9.5 Ω
the balancing lengths on the potentiometer wire are found to be 3 m and 2.85 m, respectively. The value of internal resistance of the cell is
(a) 0.25 Ω (b) 0.95 Ω
(c) 0.5 Ω (d) 0.75 Ω *(2014)*

16. The resistances of the four arms P, Q, R and S in a Wheatstone's bridge are 10 ohm, 30 ohm, 30 ohm and 90 ohm, respectively. The e.m.f. and internal resistance of the cell are 7 volt and 5 ohm respectively. If the galvanometer resistance is 50 ohm, the current drawn from the cell will be
(a) 0.1 A (b) 2.0 A (c) 1.0 A (d) 0.2 A

(NEET 2013)

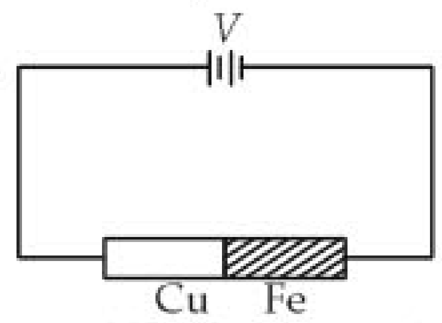
17. The internal resistance of a 2.1 V cell which gives a current of 0.2 A through a resistance of 10 Ω is
(a) 0.8 Ω (b) 1.0 Ω (c) 0.2 Ω (d) 0.5 Ω

(NEET 2013)

18. A wire of resistance 4 Ω is stretched to twice its original length. The resistance of stretched wire would be
(a) 8 Ω (b) 16 Ω (c) 2 Ω (d) 4 Ω

(NEET 2013)

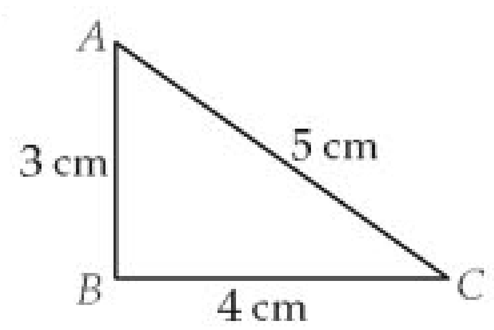
19. Two rods are joined end to end, as shown. Both have a cross-sectional area of 0.01 cm^2.



Each *is* 1 meter long. One rod is of copper with a resistivity of 1.7×10^{-6} ohm-centimeter, the other is of iron with a resistivity of 10^{-5} ohm-centimeter.
How much voltage is required to produce a current of 1 ampere in the rods?
(a) 0.00145 V (b) 0.0145 V
(c) 1.7×10^{-6} V (d) 0.117 V

(Karnataka NEET 2013)

20. A 12 cm wire is given a shape of a right angled triangle ABC having sides 3 cm, 4 cm and 5 cm as shown in the figure. The resistance between two ends (AB, BC, CA) of the respective sides are measured one by one by a multi-meter. The resistances will be in the ratio



(a) 9 : 16 : 25 (b) 27 : 32 : 35
(c) 21 : 24 : 25 (d) 3 : 4 : 5

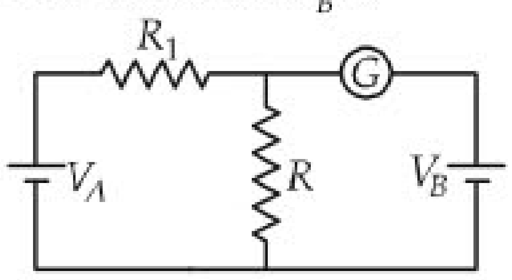
(Karnataka NEET 2013)

21. Ten identical cells connected in series are needed to heat a wire of length one meter and radius 'r' by 10°C in time 't'. How many cells will be required to heat the wire of length two meter of the same radius by the same temperature in time 't'?

(a) 20 (b) 30 (c) 40 (d) 10

(Karnataka NEET 2013)

22. In the circuit shown the cells A and B have negligible resistances. For $V_A = 12$ V, $R_1 = 500\ \Omega$ and $R = 100\ \Omega$ the galvanometer (G) shows no deflection. The value of V_B is

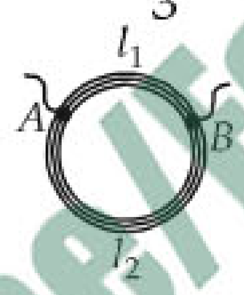


(a) 4 V (b) 2 V (c) 12 V (d) 6 V

(2012)

23. A ring is made of a wire having a resistance $R_0 = 12\ \Omega$. Find the points A and B, as shown in the figure, at which a current carrying conductor should be connected so that the resistance R of the sub circuit between these points is equal to $\frac{8}{3}\ \Omega$.

(a) $\frac{l_1}{l_2} = \frac{5}{8}$ (b) $\frac{l_1}{l_2} = \frac{1}{3}$



(c) $\frac{l_1}{l_2} = \frac{3}{8}$ (d) $\frac{l_1}{l_2} = \frac{1}{2}$

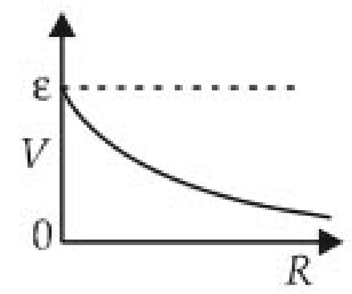
(2012)

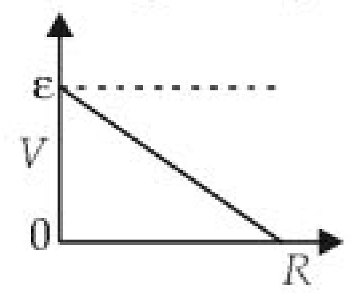
24. If voltage across a bulb rated 220 volt-100 watt drops by 2.5% of its rated value, the percentage of the rated value by which the power would decrease is

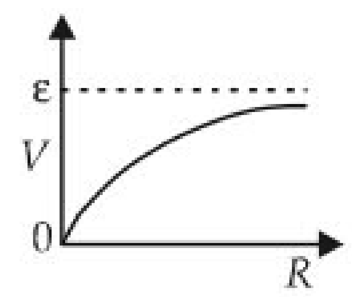
(a) 20% (b) 2.5% (c) 5% (d) 10%

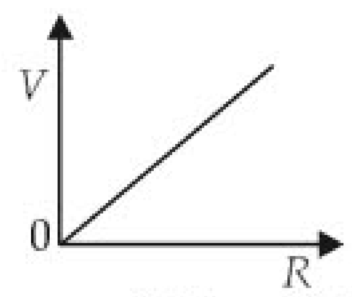
(2012)

25. A cell having an emf ε and internal resistance r is connected across a variable external resistance R. As the resistance R is increased, the plot of potential difference V across R is given by

(a)


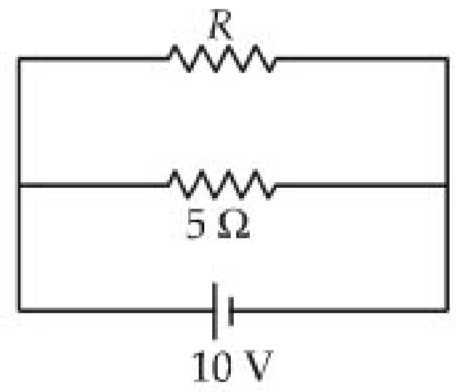
(b)


(c)


(d)


(Mains 2012)

26. The power dissipated in the circuit shown in the figure is 30 watts. The value of R is



(a) 20 Ω (b) 15 Ω (c) 10 Ω (d) 30 Ω

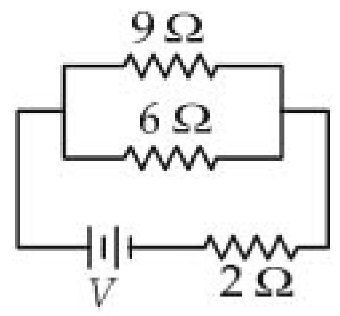
(Mains 2012)

27. A current of 2 A flows through a 2 Ω resistor when connected across a battery. The same battery supplies a current of 0.5 A when connected across a 9 Ω resistor. The internal resistance of the battery is

(a) 0.5 Ω (b) 1/3 Ω (c) 1/4 Ω (d) 1 Ω

(2011)

28. If power dissipated in the 9 Ω resistor in the circuit shown is 36 watt, the potential difference across the 2 Ω resistor is



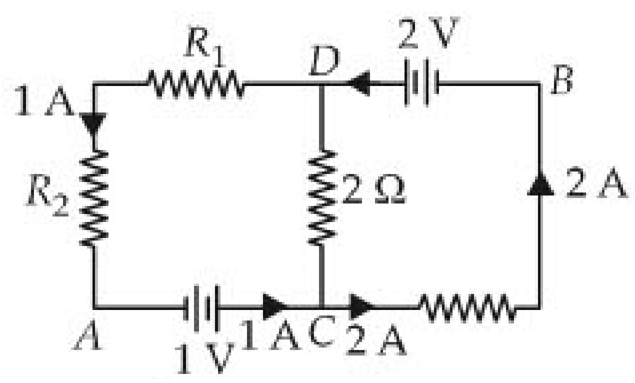
(a) 4 volt

(b) 8 volt

(c) 10 volt

(d) 2 volt *(2011)*

29. In the circuit shown in the figure, if the potential at point A is taken to be zero, the potential at point B is



(a) +1 V (b) −1 V (c) +2 V (d) −2 V

(Mains 2011)

30. Consider the following two statements.

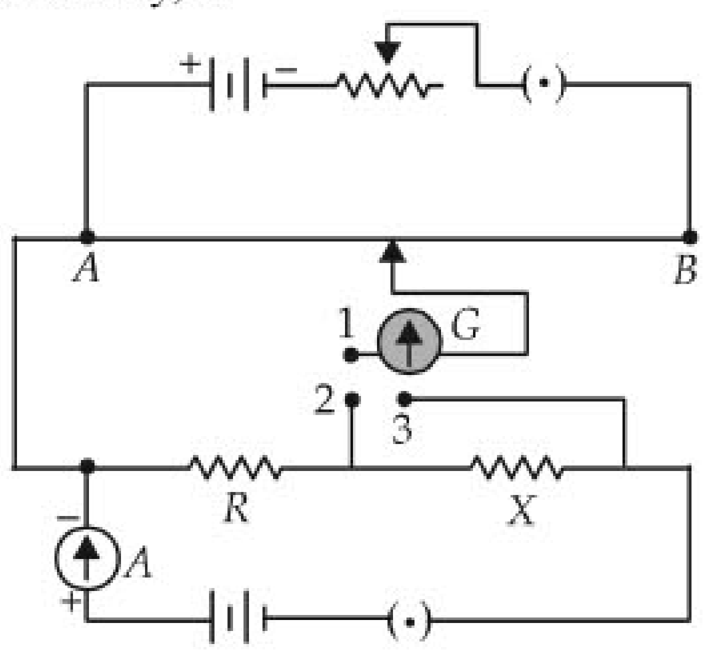
(A) Kirchhoff's junction law follows from the conservation of charge.

(B) Kirchhoff's loop law follows from the conservation of energy.

Which of the following is correct?

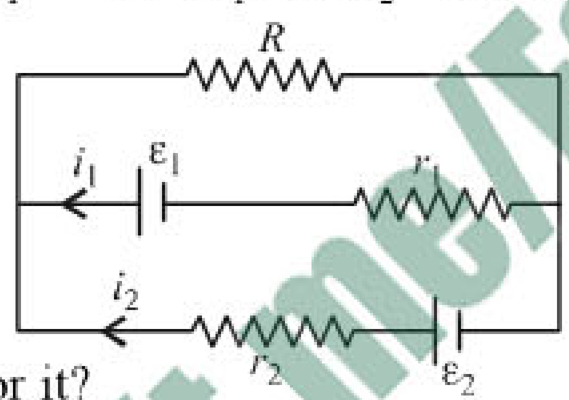
(a) Both (A) and (B) are wrong
(b) (A) is correct and (B) is wrong
(c) (A) is wrong and (B) is correct
(d) Both (A) and (B) are correct *(2010)*

31. A potentiometer circuit is set up as shown. The potential gradient, across the potentiometer wire, is k volt/cm and the ammeter, present in the circuit, reads 1.0 A when two way key is switched off. The balance points, when the key between the terminals (i) 1 and 2 (ii) 1 and 3, is plugged in, are found to be at lengths l_1 cm and l_2 cm respectively. The magnitudes, of the resistors R and X, in ohms, are then, equal, respectively, to



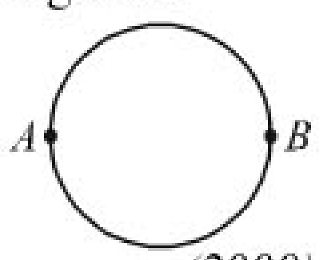
(a) $k(l_2 - l_1)$ and kl_2 (b) kl_1 and $k(l_2 - l_1)$
(c) $k(l_2 - l_1)$ and kl_1 (d) kl_1 and kl_2 *(2010)*

32. See the electrical circuit shown in this figure. Which of the following equations is a correct equation for it?



(a) $\varepsilon_2 - i_2r_2 - \varepsilon_1 - i_1r_1 = 0$
(b) $-\varepsilon_2 - (i_1 + i_2)R + i_2r_2 = 0$
(c) $\varepsilon_1 - (i_1 + i_2)R + i_1r_1 = 0$
(d) $\varepsilon_1 - (i_1 + i_2)R - i_1r_1 = 0$ *(2009)*

33. A wire of resistance 12 ohms per meter is bent to form a complete circle of radius 10 cm. The resistance between its two diametrically opposite points, A and B as shown in the figure is



(a) 3 Ω
(b) 6π Ω
(c) 6 Ω
(d) 0.6π Ω *(2009)*

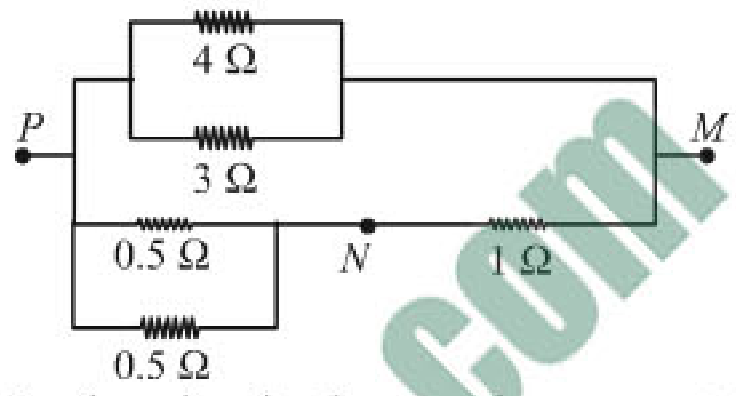
34. A student measures the terminal potential difference (V) of a cell (of emf ε and internal resistance r) as a function of the current (I) flowing through it. The slope, and intercept, of the graph between V and I, then, respectively, equal

(a) $-r$ and ε (b) r and $-$ε
(c) $-$ε and r (d) ε and $-r$ *(2009)*

35. The mean free path of electrons in a metal is 4×10^{-8} m. The electric field which can give on an average 2 eV energy to an electron in the metal will be in units V/m

(a) 5×10^{-11} (b) 8×10^{-11}
(c) 5×10^{7} (d) 8×10^{7} *(2009)*

36.



In the circuit shown, the current through the 4 Ω resistor is 1 amp when the points P and M are connected to a d.c. voltage source. The potential difference between the points M and N is

(a) 0.5 volt (b) 3.2 volt
(c) 1.5 volt (d) 1.0 volt *(2008)*

37. A wire of a certain material is stretched slowly by ten percent. Its new resistance and specific resistance become respectively

(a) both remain the same
(b) 1.1 times, 1.1 times
(c) 1.2 times, 1.1 times
(d) 1.21 times, same *(2008)*

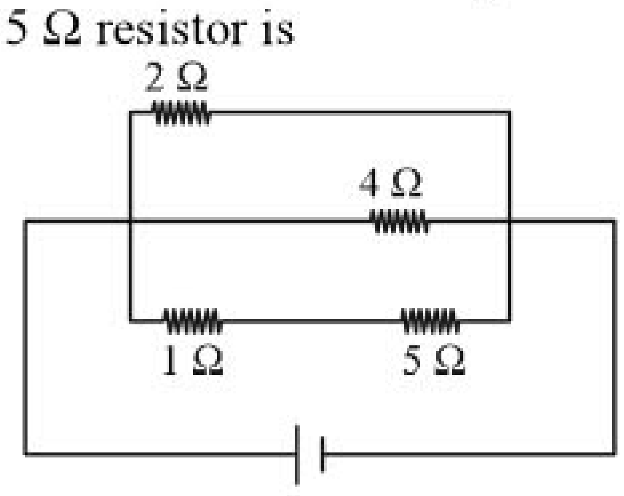
38. A cell can be balanced against 110 cm and 100 cm of potentiometer wire, respectively with and without being short circuited through a resistance of 10 Ω. Its internal resistance is

(a) 2.0 ohm (b) zero
(c) 1.0 ohm (d) 0.5 ohm *(2008)*

39. An electric kettle takes 4 A current at 220 V. How much time will it take to boil 1 kg of water from temperature 20°C ? The temperature of boiling water is 100°C

(a) 12.6 min (b) 4.2 min
(c) 6.3 min (d) 8.4 min *(2008)*

40. A current of 3 amp. flows through the 2 Ω resistor shown in the circuit. The power dissipated in the 5 Ω resistor is

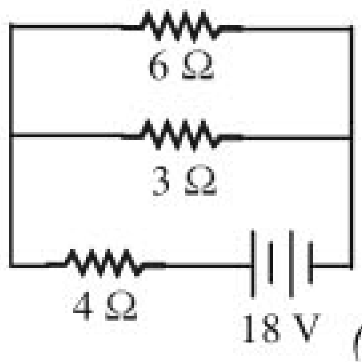


(a) 1 watt
(b) 5 watt
(c) 4 watt
(d) 2 watt

(2008)

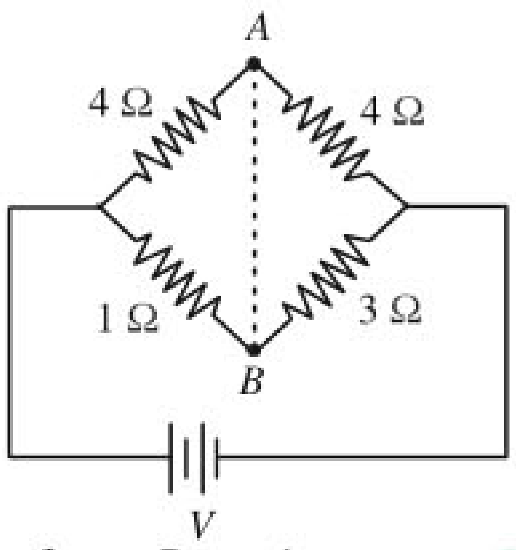
41. Three resistances P, Q, R each of 2 Ω and an unknown resistance S form the four arms of a Wheatstone bridge circuit. When a resistance of 6 Ω is connected in parallel to S the bridge gets balanced. What is the value of S?
(a) 3 Ω (b) 6 Ω (c) 1 Ω (d) 2 Ω. *(2007)*

42. The total power dissipated in watt in the circuit shown here is



(a) 40
(b) 54
(c) 4
(d) 16. *(2007)*

43. In the circuit shown, if a conducting wire is connected between points A and B, the current in this wire will



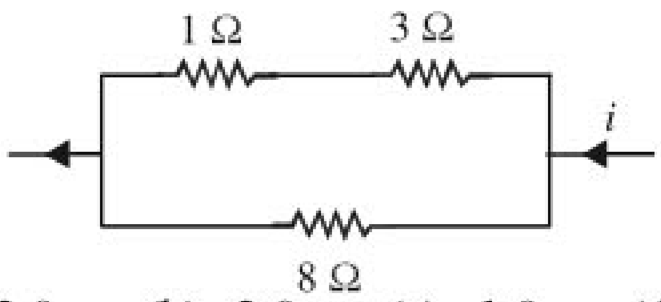
(a) flow from B to A
(b) flow from A to B
(c) flow in the direction which will be decided by the value of V
(d) be zero. *(2006)*

44. Kirchhoff's first and second laws of electrical circuits are consequences of
(a) conservation of energy and electric charge respectively
(b) conservation of energy
(c) conservation of electric charge and energy respectively
(d) conservation of electric charge. *(2006)*

45. Two cells, having the same e.m.f. are connected in series through an external resistance R. Cells have internal resistances r_1 and r_2 $(r_1 > r_2)$ respectively. When the circuit is closed, the potential difference across the first cell is zero. The value of R is

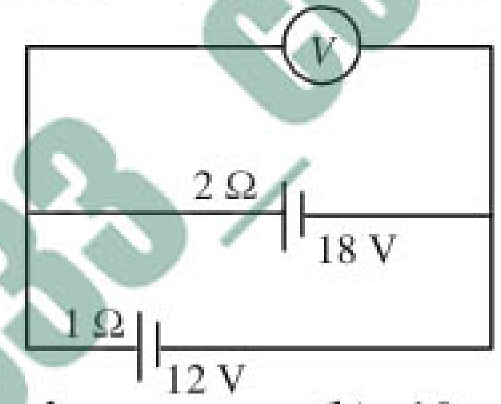
(a) $r_1 + r_2$ (b) $r_1 - r_2$ (c) $\frac{r_1 + r_2}{2}$ (d) $\frac{r_1 - r_2}{2}$ *(2006)*

46. Power dissipated across the 8 Ω resistor in the circuit shown here is 2 watt. The power dissipated in watt units across the 3 Ω resistor is



(a) 3.0 (b) 2.0 (c) 1.0 (d) 0.5 *(2006)*

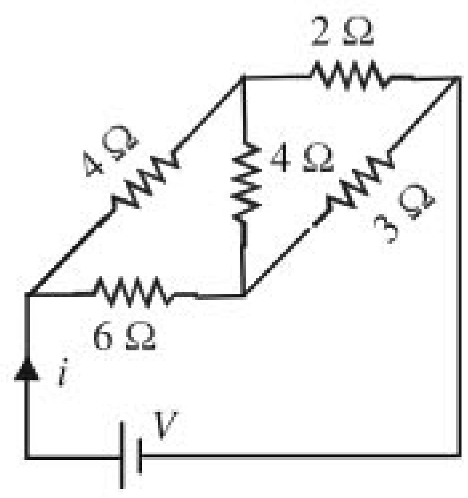
47. Two batteries, one of emf 18 volts and internal resistance 2 Ω and the other of emf 12 volts and internal resistance 1 Ω, are connected as shown. The voltmeter V will record a reading of



(a) 30 volt (b) 18 volt
(c) 15 volt (d) 14 volt. *(2005)*

48. When a wire of uniform cross-section a, length l and resistance R is bent into a complete circle, resistance between any two of diametrically opposite points will be
(a) $R/4$ (b) $4R$ (c) $R/8$ (d) $R/2$. *(2005)*

49. For the network shown in the figure the value of the current i is



(a) $\frac{9V}{35}$
(b) $\frac{18V}{5}$
(c) $\frac{5V}{9}$
(d) $\frac{5V}{18}$ *(2005)*

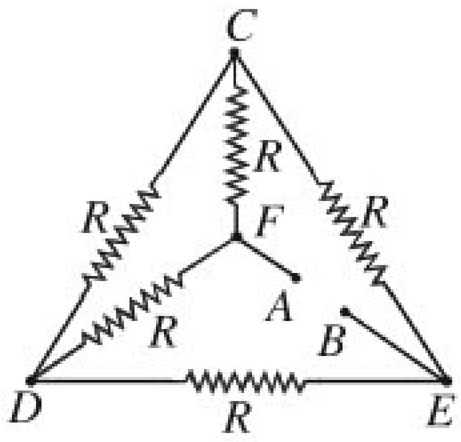
50. A 5-ampere fuse wire can withstand a maximum power of 1 watt in the circuit. The resistance of the fuse wire is
(a) 0.04 ohm (b) 0.2 ohm
(c) 5 ohm (d) 0.4 ohm. *(2005)*

51. The electric resistance of a certain wire of iron is R. If its length and radius are both doubled, then
(a) The resistance will be doubled and the specific resistance will be halved.
(b) The resistance will be halved and the specific resistance will remain unchanged.

(c) The resistance will be halved and the specific resistance will be doubled.
(d) The resistance and the specific resistance, will both remain unchanged. *(2004)*

52. Resistance n, each of r ohm, when connected in parallel give an equivalent resistance of R ohm. If these resistances were connected in series, the combination would have a resistance in ohms, equal to
(a) n^2R (b) R/n^2 (c) R/n (d) nR *(2004)*

53. Five equal resistances each of resistance R are connected as shown in the figure. A battery of V volts is connected between A and B. The current flowing in $AFCEB$ will be



(a) $\frac{3V}{R}$ (b) $\frac{V}{R}$ (c) $\frac{V}{2R}$ (d) $\frac{2V}{R}$ *(2004)*

54. A 6 volt battery is connected to the terminals of a three metre long wire of uniform thickness and resistance of 100 ohm. The difference of potential between two points on the wire separated by a distance of 50 cm will be
(a) 2 volt (b) 3 volt (c) 1 volt (d) 1.5 volt *(2004)*

55. When three identical bulbs of 60 watt, 200 volt rating are connected in series to a 200 volt supply, the power drawn by them will be
(a) 60 watt (b) 180 watt
(c) 10 watt (d) 20 watt *(2004)*

56. In India electricity is supplied for domestic use at 220 V. It is supplied at 110 V in USA. If the resistance of a 60 W bulb for use in India is R, the resistance of a 60 W bulb for use in USA will be
(a) R (b) $2R$ (c) $R/4$ (d) $R/2$ *(2004)*

57. In a Wheatstone's bridge all the four arms have equal resistance R. If the resistance of the galvanometer arm is also R, the equivalent resistance of the combination as seen by the battery is
(a) $R/4$ (b) $R/2$ (c) R (d) $2R$ *(2003)*

58. Two 220 volt, 100 watt bulbs are connected first in series and then in parallel. Each time the combination is connected to a 220 volt a.c. supply line. The power drawn by the combination in each case respectively will be
(a) 50 watt, 100 watt (b) 100 watt, 50 watt
(c) 200 watt, 150 watt (d) 50 watt, 200 watt *(2003)*

59. An electric kettle has two heating coils. When one of the coils is connected to an a.c. source, the water in the kettle boils in 10 minutes. When the other coil is used the water boils in 40 minutes. If both the coils are connected in parallel, the time taken by the same quantity of water to boil will be
(a) 8 minutes (b) 4 minutes
(c) 25 minutes (d) 15 minutes *(2003)*

60. Fuse wire is a wire of
(a) high resistance and high melting point
(b) high resistance and low melting point
(c) low resistance and low melting point
(d) low resistance and high melting point *(2003)*

61. For a cell terminal potential difference is 2.2V when circuit is open and reduces to 1.8 V when cell is connected to a resistance of $R = 5\ \Omega$. Determine internal resistance of cell (r)
(a) $\frac{10}{9}\ \Omega$ (b) $\frac{9}{10}\ \Omega$ (c) $\frac{11}{9}\ \Omega$ (d) $\frac{5}{9}\ \Omega$ *(2002)*

62. Specific resistance of a conductor increases with
(a) increase in temperature
(b) increase in cross-section area
(c) increase in cross-section and decrease in length
(d) decrease in cross-section area. *(2002)*

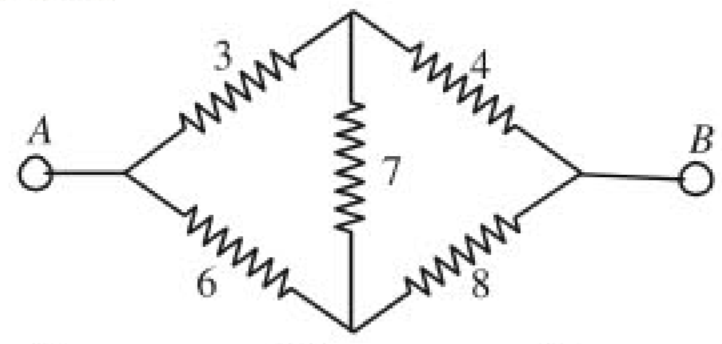
63. Copper and silicon is cooled from 300 K to 60 K, the specific resistance
(a) decrease in copper but increase in silicon
(b) increase in copper but decrease in silicon
(c) increase in both
(d) decrease in both. *(2001)*

64. The resistance of each arm of the Wheatstone's bridge is 10 ohm. A resistance of 10 ohm is

connected in series with a galvanometer then the equivalent resistance across the battery will be
(a) 10 ohm (b) 15 ohm
(c) 20 ohm (d) 40 ohm. *(2001)*

65. If specific resistance of a potentiometer wire is 10^{-7} Ω m and current flow through it is 0.1 amp., cross-sectional area of wire is 10^{-6} m^2 then potential gradient will be
(a) 10^{-2} volt/m (b) 10^{-4} volt/m
(c) 10^{-6} volt/m (d) 10^{-8} volt/m. *(2001)*

66. The net resistance of the circuit between A and B is



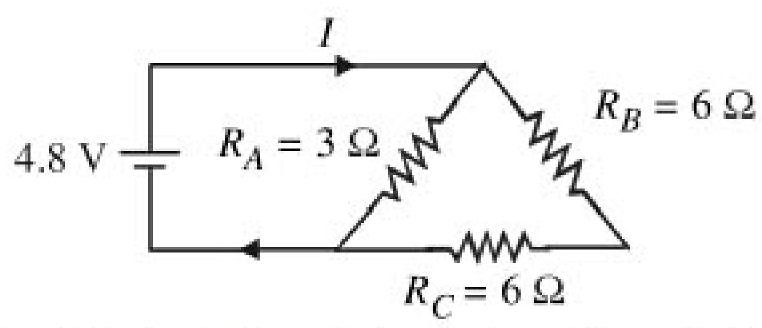
(a) $\frac{8}{3}\Omega$ (b) $\frac{14}{3}\Omega$ (c) $\frac{16}{3}\Omega$ (d) $\frac{22}{3}\Omega$ *(2000)*

67. A car battery of emf 12 V and internal resistance 5×10^{-2} Ω, receives a current of 60 amp, from external source, then terminal potential difference of battery is
(a) 12 V (b) 9 V (c) 15 V (d) 20 V. *(2000)*

68. Two bulbs of (40 W, 200 V), and (100 W, 200 V). Then correct relation for their resistances
(a) $R_{40} < R_{100}$ (b) $R_{40} > R_{100}$
(c) $R_{40} = R_{100}$
(d) no relation can be predicted. *(2000)*

69. The potentiometer is best for measuring voltage, as
(a) it has a sensitive galvanometer and gives null deflection
(b) it has wire of high resistance
(c) it measures p.d. in closed circuit
(d) it measures p.d in open circuit. *(2000)*

70. The current in the given circuit is



(a) 4.9 A (b) 6.8 A (c) 8.3 A (d) 2.0 A *(1999)*

71. The internal resistance of a cell of e.m.f. 2 V is 0.1 Ω. It is connected to a resistance of 3.9 Ω. The voltage across the cell will be
(a) 1.95 V (b) 1.9 V (c) 0.5 V (d) 2 V *(1999)*

72. In a meter bridge, the balancing length from the left end (standard resistance of one ohm is in the right gap) is found to be 20 cm. The value of the unknown resistance is
(a) 0.8 Ω (b) 0.5 Ω (c) 0.4 Ω (d) 0.25 Ω *(1999)*

73. A potentiometer consists of a wire of length 4 m and resistance 10 Ω. It is connected to a cell of e.m.f. 2 V. The potential difference per unit length of the wire will be
(a) 5 V/m (b) 2 V/m
(c) 0.5 V/m (d) 10 V/m *(1999)*

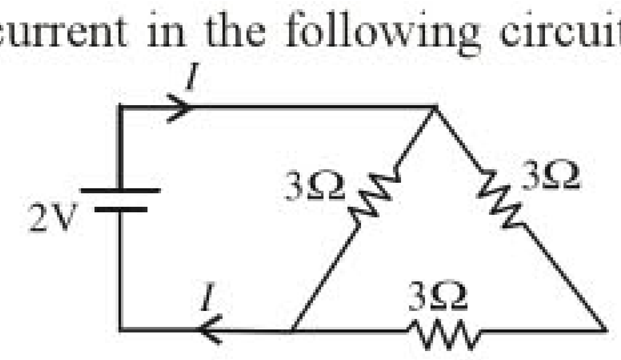
74. The resistance of a discharge tube is
(a) non-ohmic (b) ohmic
(c) zero (d) both (b) and (c) *(1999)*

75. Three equal resistors connected in series across a source of e.m.f. together dissipate 10 watt of power. What will be the power dissipated in watt if the same resistors are connected in parallel across the same source of e.m.f.?
(a) 30 (b) $\frac{10}{3}$ (c) 10 (d) 90 *(1998)*

76. A 5°C rise in temperature is observed in a conductor by passing a current. When the current is doubled the rise in temperature will be approximately
(a) 20°C (b) 16°C (c) 10°C (d) 12°C *(1998)*

77. Three copper wires of lengths and cross-sectional areas are (l, A), $(2l, A/2)$ and $(l/2, 2A)$. Resistance is minimum in
(a) wire of cross-sectional area $2A$
(b) wire of cross-sectional area $\frac{A}{2}$
(c) wire of cross-sectional area A
(d) same in all three cases. *(1997)*

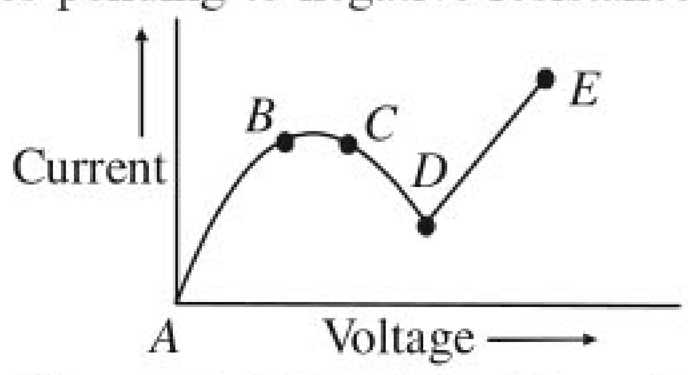
78. The current in the following circuit is



(a) 2/3 A (b) 1 A (c) 1/8 A (d) 2/9 A. *(1997)*

79. Kirchhoff's first law, *i.e.* $\Sigma i = 0$ at a junction, deals with the conservation of
(a) momentum (b) angular momentum
(c) charge (d) energy
(1997, 1992)

80. From the graph between current (I) and voltage (V) is shown below. Identify the portion corres-ponding to negative resistance



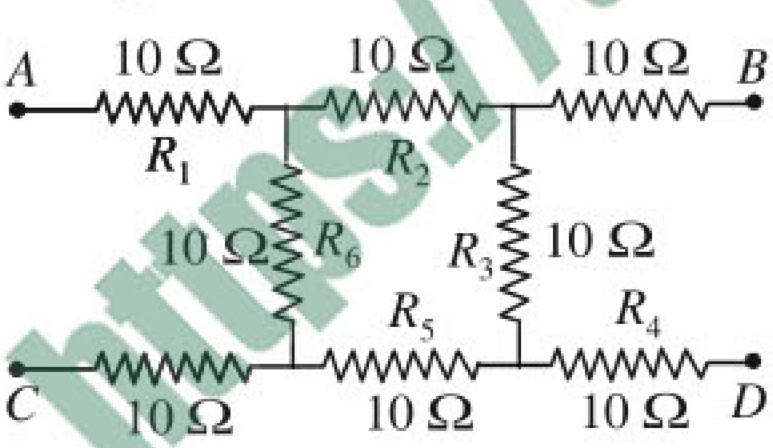
(a) CD (b) DE (c) AB (d) BC
(1997)

81. A (100 W, 200 V) bulb is connected to a 160 volts supply. The power consumption would be
(a) 100 W (b) 125 W (c) 64 W (d) 80 W.
(1997)

82. One kilowatt hour is equal to
(a) 36×10^{-5} J (b) 36×10^{-4} J
(c) 36×10^{5} J (d) 36×10^{3} J *(1997)*

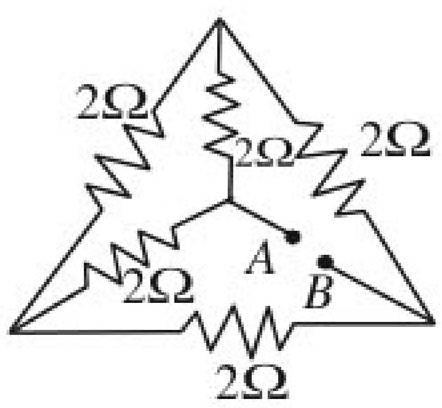
83. If two bulbs, whose resistances are in the ratio of 1 : 2 are connected in series, the power dissipated in them has the ratio of
(a) 2 : 1 (b) 1 : 4 (c) 1 : 1 (d) 1 : 2.
(1997)

84. What will be the equivalent resistance between the two points A and D?



(a) 30 Ω (b) 40 Ω (c) 10 Ω (d) 10 Ω.
(1996)

85. In the network shown in the figure, each of the resistance is equal to 2 Ω. The resistance between the points A and B is



(a) 3 Ω (b) 4 Ω (c) 1 Ω (d) 2 Ω.
(1995)

86. Two wires of the same metal have same length, but their cross-sections are in the ratio 3 : 1. They are joined in series. The resistance of thicker wire is 10 Ω. The total resistance of the combination will be
(a) 40 Ω (b) 100 Ω
(c) (5/2) Ω (d) (40/3) Ω. *(1995)*

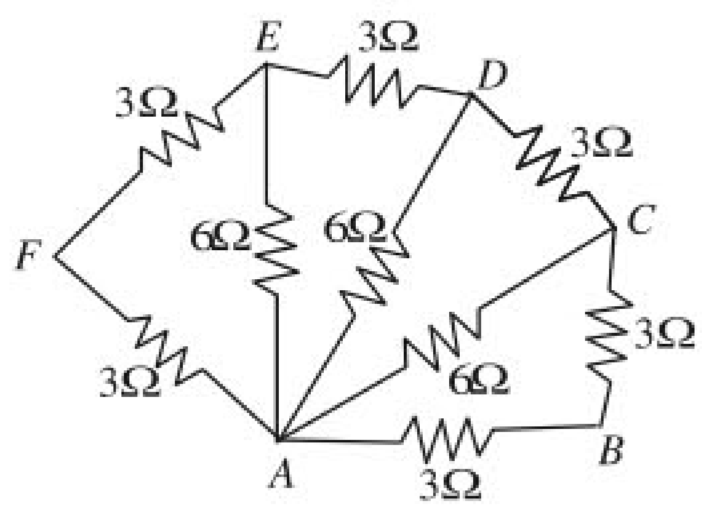
87. In good conductors of electricity, the type of bonding that exists is
(a) metallic (b) vander Waals
(c) ionic (d) covalent. *(1995)*

88. A heating coil is labelled 100 W, 220 V. The coil is cut in half and the two pieces are joined in parallel to the same source. The energy now liberated per second is
(a) 200 W (b) 400 W (c) 25 W (d) 50 W
(1995)

89. A 4 μF capacitor is charged to 400 V. If its plates are joined through a resistance of 2 kΩ, then heat produced in the resistance is
(a) 0.64 J (b) 1.28 J (c) 0.16 J (d) 0.32 J
(1995)

90. A wire 50 cm long and 1 mm^2 in cross-section carries a current of 4 A when connected to a 2 V battery. The resistivity of the wire is
(a) 4×10^{-6} Ωm (b) 1×10^{-6} Ωm
(c) 2×10^{-7} Ωm (d) 5×10^{-7} Ωm.
(1994)

91. Six resistors of 3 Ω each are connected along the sides of a hexagon and three resistors of 6 Ω each are connected along AC, AD and AE as shown in the figure. The equivalent resistance between A and B is equal to



(a) 2 Ω (b) 6 Ω (c) 3 Ω (d) 9 Ω
(1994)

92. A flow of 10^7 electrons per second in a conducting wire constitutes a current of

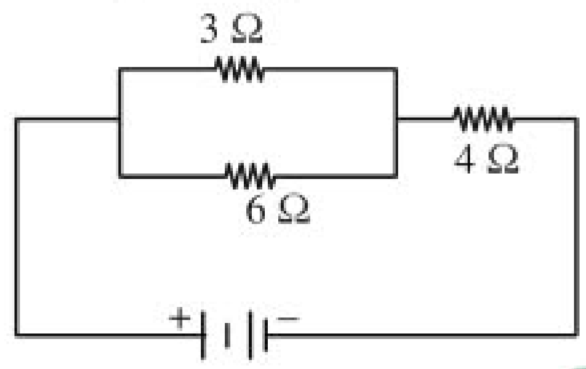
(a) 1.6×10^{-12} A (b) 1.6×10^{26} A
(c) 1.6×10^{-26} A (d) 1.6×10^{12} A. *(1994)*

93. Identify the set in which all the three materials are good conductors of electricity
(a) Cu, Hg and NaCl
(b) Cu, Ge and Hg
(c) Cu, Ag and Au
(d) Cu, Si and diamond. *(1994)*

94. An electric bulb is rated 60 W, 220 V. The resistance of its filament is
(a) 870 Ω (b) 780 Ω
(c) 708 Ω (d) 807 Ω. *(1994)*

95. Three resistances each of 4 Ω are connected to form a triangle. The resistance between any two terminals is
(a) 12 Ω (b) 2 Ω (c) 6 Ω (d) 8/3 Ω *(1993)*

96. Current through 3 Ω resistor is 0.8 ampere, then potential drop through 4 Ω resistor is

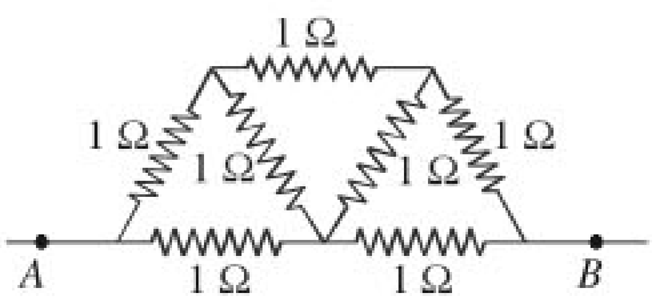


(a) 9.6 V (b) 2.6 V (c) 4.8 V (d) 1.2 V *(1993)*

97. A battery of e.m.f 10 V and internal resistance 0.5 Ω is connected across a variable resistance R. The value of R for which the power delivered in it is maximum is given by
(a) 0.5 Ω (b) 1.0 Ω (c) 2.0 Ω (d) 0.25 Ω *(1992)*

98. The velocity of charge carriers of current (about 1 ampere) in a metal under normal conditions is of the order of
(a) a fraction of mm/sec
(b) velocity of light
(c) several thousand metres/second
(d) a few hundred metres per second *(1991)*

99. In the network shown in figure each resistance is 1 Ω. The effective resistance between A and B is



(a) $\frac{4}{3}$ Ω (b) $\frac{3}{2}$ Ω (c) 7 Ω (d) $\frac{8}{7}$ Ω *(1990)*

100. Two identical batteries each of e.m.f 2 V and internal resistance 1 Ω are available to produce heat in an external resitance by passing a current through it. The maximum power that can be developed across R using these batteries is
(a) 3.2 W (b) 2.0 W
(c) 1.28 W (d) $\frac{8}{9}$ W *(1990)*

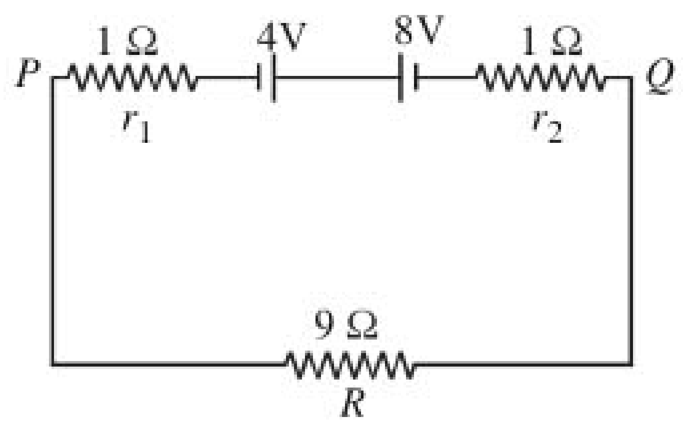
101. You are given several identical resistances each of value R = 10 Ω and each capable of carrying a maximum current of one ampere. It is required to make a suitable combination of these resistances of 5 Ω which can carry a current of 4 ampere. The minimum number of resistances of the type R that will be required for this job is
(a) 4 (b) 10 (c) 8 (d) 20 *(1990)*

102. A current of 2 A, passing through a conductor produces 80 J of heat in 10 seconds. The resistance of the conductor in ohm is
(a) 0.5 (b) 2 (c) 4 (d) 20 *(1989)*

103. 40 electric bulbs are connected in series across a 220 V supply. After one bulb is fused the remaining 39 are connected again in series across the same supply. The illumination will be
(a) more with 40 bulbs than with 39
(b) more with 39 bulbs than with 40
(c) equal in both the cases
(d) in the ratio $40^2 : 39^2$ *(1989)*

104. n equal resistors are first connected in series and then connected in parallel. What is the ratio of the maximum to the minimum resistance ?
(a) n (b) $1/n^2$ (c) n^2 (d) $1/n$ *(1989)*

105. Two batteries of emf 4 V and 8 V with internal resistance 1 Ω and 2 Ω are connected in a circuit with resistance of 9 Ω as shown in figure. The current and potential difference between the points P and Q are



(a) $\frac{1}{3}$ A and 3 V

(b) $\frac{1}{6}$ A and 4 V

(c) $\frac{1}{9}$ A and 9 V

(d) $\frac{1}{12}$ A and 12 V *(1988)*

106. The masses of the wires of copper is in the ratio of 1 : 3 : 5 and their lengths are in the ratio of 5 : 3 : 1. The ratio of their electrical resistance is

(a) 1 : 3 : 5

(b) 5 : 3 : 1

(c) 1 : 25 : 125

(d) 125 : 15 : 1 *(1988)*

Answer Key

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

EXPLANATIONS

1. (b) : The resistance of a wire of length l and area A and resistivity ρ is given as

$$R = \frac{\rho l}{A}$$

Given, $l' = nl$

As the volume of the wire remains constant

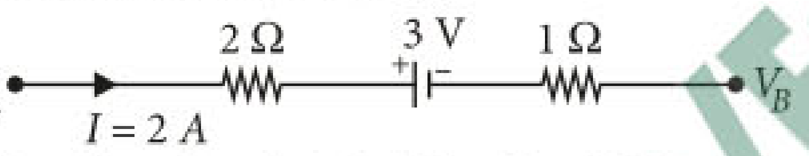
$\therefore \quad A'l' = Al$

$$A' = \frac{Al}{l'} = \frac{Al}{nl} \text{ or } A' = \frac{A}{n}$$

$$\therefore \quad R' = \frac{\rho l'}{A'}$$

$$R' = \frac{\rho nl}{\frac{A}{n}} = \frac{n^2 \rho l}{A} = n^2 R$$

2. (b) : A potentiometer is an accurate and versatile device to make electrical measurements of emf because the method involves a condition of no current flow through the galvanometer, the device can be used to measure potential difference, internal resistance of a cell and compare emf's of two sources.

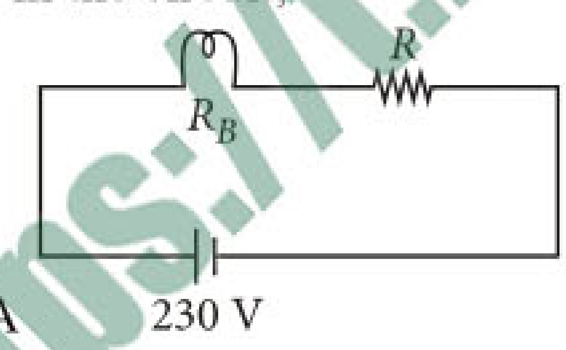
3. (d) : 

$V_{AB} = V_A - V_B = 2 \times 2 + 3 + 1 \times 2 = 9$ V

4. (c) : Resistance of bulb, $R_B = \frac{V^2}{P} = \frac{(100)^2}{500} = 20\ \Omega$

Power of the bulb in the circuit,

$P = VI$



$$I = \frac{P}{V_B}$$

$$= \frac{500}{100} = 5 \text{ A}$$

$V_R = IR \Rightarrow (230 - 100) = 5 \times R$

$\therefore \quad R = 26\ \Omega$

5. (b) : Suppose two cells have emfs ε_1 and ε_2 (also $\varepsilon_1 > \varepsilon_2$).

Potential difference per unit length of the potentiometer wire = k (say)

When ε_1 and ε_2 are in series and support each other then

$\varepsilon_1 + \varepsilon_2 = 50 \times k$ ...(i)

When ε_1 and ε_2 are in opposite direction

$\varepsilon_1 - \varepsilon_2 = 10 \times k$ ...(ii)

On adding eqn. (i) and eqn. (ii)

$2\varepsilon_1 = 60k \Rightarrow \varepsilon_1 = 30k$ and $\varepsilon_2 = 50k - 30k = 20k$

$$\therefore \quad \frac{\varepsilon_1}{\varepsilon_2} = \frac{30k}{20k} = \frac{3}{2}$$

6. (c) : Given, $Q = at - bt^2$

$$\therefore \quad I = \frac{dQ}{dt} = a - 2bt$$

At $t = 0, Q = 0 \Rightarrow I = 0$

Also, $I = 0$ at $t = a/2b$

$\therefore$ Total heat produced in resistance R,

$$H = \int_0^{a/2b} I^2 R dt = R \int_0^{a/2b} (a - 2bt)^2 dt$$

$$= R \int_0^{a/2b} (a^2 + 4b^2 t^2 - 4abt) dt$$

$$= R\left[a^2 t + 4b^2 \frac{t^3}{3} - 4ab\frac{t^2}{2}\right]_0^{a/2b}$$

$$= R\left[a^2 \times \frac{a}{2b} + \frac{4b^2}{3} \times \frac{a^3}{8b^3} - \frac{4ab}{2} \times \frac{a^2}{4b^2}\right]$$

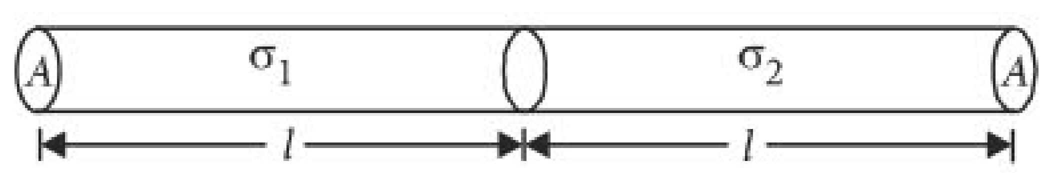
$$= \frac{a^3 R}{b}\left[\frac{1}{2} + \frac{1}{6} - \frac{1}{2}\right] = \frac{a^3 R}{6b}$$

7. (c) : As both metal wires are of identical dimensions, so their length and area of cross-section will be same. Let them be l and A respectively. Then The resistance of the first wire is

$$R_1 = \frac{l}{\sigma_1 A} \quad \text{... (i)}$$

and that of the second wire is

$$R_2 = \frac{l}{\sigma_2 A} \quad \text{... (ii)}$$



As they are connected in series, so their effective resistance is

$$R_s = R_1 + R_2$$

$$= \frac{l}{\sigma_1 A} + \frac{l}{\sigma_2 A} \quad \text{(using (i) and (ii))}$$

$$= \frac{l}{A}\left(\frac{1}{\sigma_1} + \frac{1}{\sigma_2}\right) \quad \text{... (iii)}$$

If σ_{eff} is the effective conductivity of the combination, then

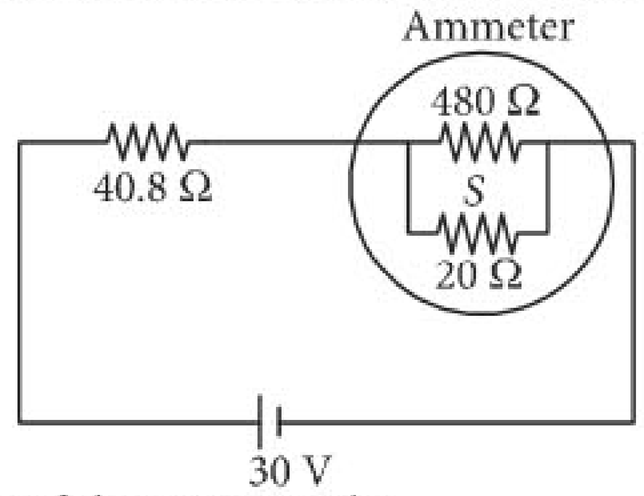
$$R_s = \frac{2l}{\sigma_{eff} A} \quad \text{... (iv)}$$

Equating eqns. (iii) and (iv), we get

$$\frac{2l}{\sigma_{\text{eff}} A} = \frac{l}{A}\left(\frac{1}{\sigma_1} + \frac{1}{\sigma_2}\right)$$

$$\frac{2}{\sigma_{\text{eff}}} = \frac{\sigma_2 + \sigma_1}{\sigma_1 \sigma_2} \quad \text{or} \quad \sigma_{\text{eff}} = \frac{2\sigma_1\sigma_2}{\sigma_1 + \sigma_2}$$

8. **(c) :** The circuit is shown in the figure.



Resistance of the ammeter is

$$R_A = \frac{(480\ \Omega)(20\ \Omega)}{(480\ \Omega + 20\ \Omega)} = 19.2\ \Omega$$

(As 480 Ω and 20 Ω are in parallel)

As ammeter is in series with 40.8 Ω,

∴ Total resistance of the circuit is

$R = 40.8\ \Omega + R_A = 40.8\ \Omega + 19.2\ \Omega = 60\ \Omega$

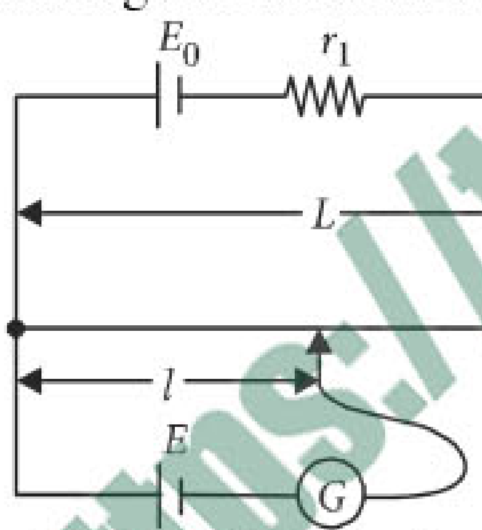
By Ohm's law,

Current in the circuit is

$$I = \frac{V}{R} = \frac{30\ \text{V}}{60\ \Omega} = \frac{1}{2}\ \text{A} = 0.5\ \text{A}$$

Thus the reading in the ammeter will be 0.5 A.

9. **(d) :**



The current through the potentiometer wire is

$$I = \frac{E_0}{(r + r_1)}$$

and the potential difference across the wire is

$$V = Ir = \frac{E_0 r}{(r + r_1)}$$

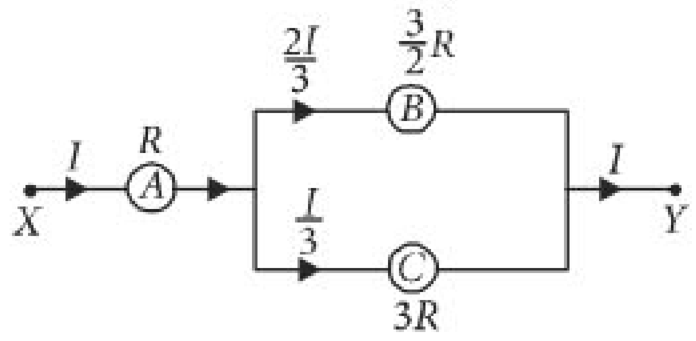
The potential gradient along the potentiometer wire is

$$k = \frac{V}{L} = \frac{E_0 r}{(r + r_1)L}$$

As the unknown e.m.f. E is balanced against length l of the potentiometer wire,

$$\therefore \quad E = kl = \frac{E_0 r}{(r + r_1)} \frac{l}{L}$$

10. **(c) :** The current flowing in the different branches of circuit is indicated in the figure.



$$V_A = IR$$

$$V_B = \frac{2I}{3} \times \frac{3}{2} R = IR$$

$$V_C = \frac{I}{3} \times 3R = IR$$

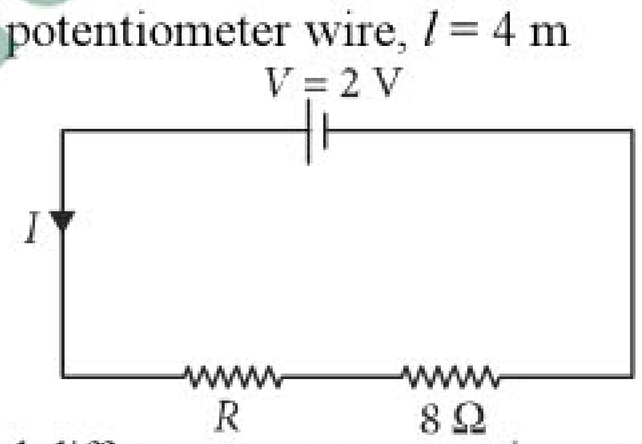
Thus, $V_A = V_B = V_C$

11. **(d) :** The area of cross section of conductor is non uniform so current density will be different but the flow of electrons will be uniform so current will be constant.

12. **(c) :** Required potential gradient = 1 mV cm^{-1}

$$= \frac{1}{10}\ \text{V m}^{-1}$$

Length of potentiometer wire, l = 4 m



So potential difference across potentiometer wire

$$= \frac{1}{10} \times 4 = 0.4\ \text{V} \qquad \ldots\text{(i)}$$

In the circuit, potential difference across 8 Ω

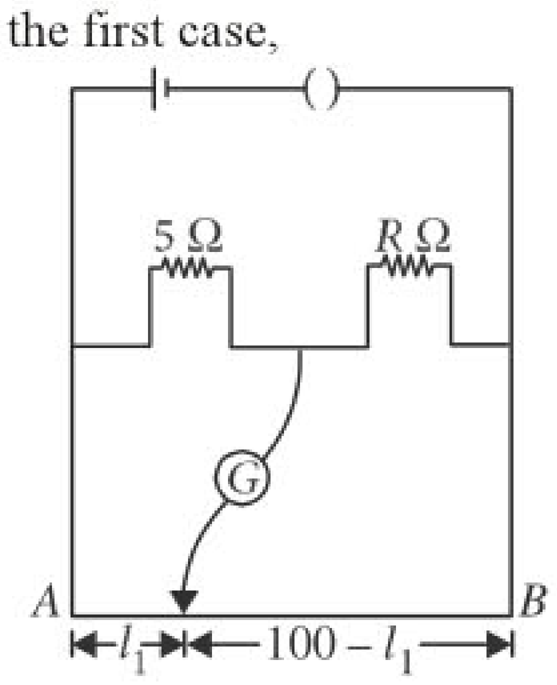
$$= I \times 8 = \frac{2}{8 + R} \times 8 \qquad \ldots\text{(ii)}$$

Using equation (i) and (ii), we get, $0.4 = \dfrac{2}{8 + R} \times 8$

$$\frac{4}{10} = \frac{16}{8 + R},\ 8 + R = 40$$

∴ $R = 32\ \Omega$

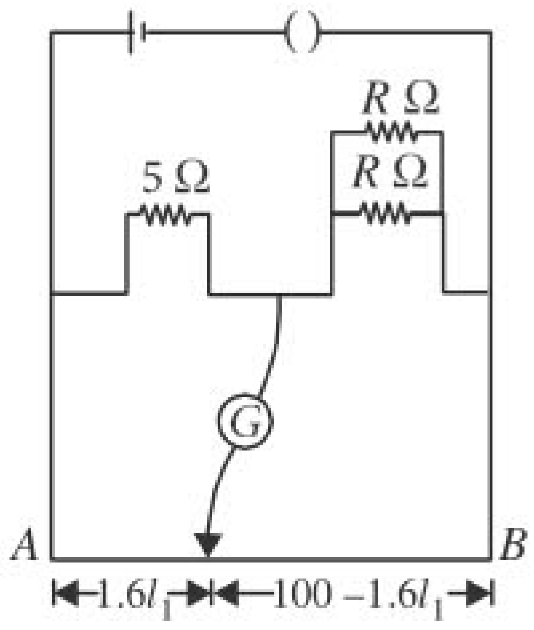
13. **(b) :** In the first case,



At balance point

$$\frac{5}{R}=\frac{l_1}{100-l_1} \qquad \text{...(i)}$$

In the second case,



At balance point

$$\frac{5}{(R/2)}=\frac{1.6l_1}{100-1.6l_1} \qquad \text{...(ii)}$$

Divide eqn. (i) by eqn. (ii), we get

$$\frac{1}{2}=\frac{100-1.6l_1}{1.6(100-l_1)}$$

$$160-1.6l_1=200-3.2l_1$$

$$1.6l_1=40 \quad \text{or} \quad l_1=\frac{40}{1.6}=25\text{ cm}$$

Substituting this value in eqn. (i), we get

$$\frac{5}{R}=\frac{25}{75}$$

$$R=\frac{375}{25}\ \Omega=15\ \Omega$$

14. (b) : Here,

Distance between two cities = 150 km

Resistance of the wire, $R=(0.5\ \Omega\text{ km}^{-1})(150\text{ km})=75\ \Omega$

Voltage drop across the wire,

$$V=(8\text{ V km}^{-1})(150\text{ km})=1200\text{ V}$$

Power loss in the wire is

$$P=\frac{V^2}{R}=\frac{(1200\text{ V})^2}{75\ \Omega}=19200\text{ W}=19.2\text{ kW}$$

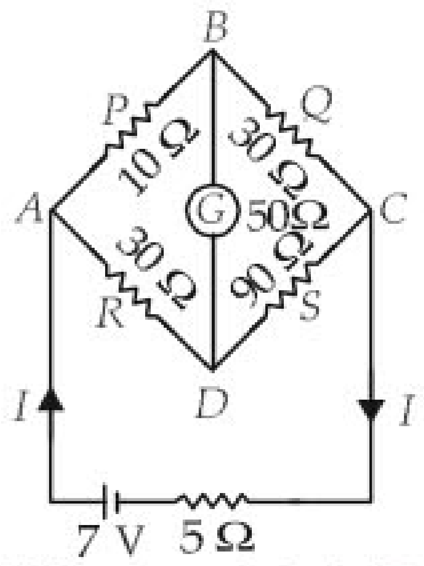
15. (c) : The internal resistance of the cell is

$$r=\left(\frac{l_1}{l_2}-1\right)R$$

Here, $l_1=3$ m, $l_2=2.85$ m, $R=9.5\ \Omega$

$$\therefore \quad r=\left(\frac{3}{2.85}-1\right)(9.5\ \Omega)=\frac{0.15}{2.85}\times 9.5\ \Omega=0.5\ \Omega$$

16. (d) : The situation is as shown in the figure.



For a balanced Wheatstone's bridge

$$\frac{P}{Q}=\frac{R}{S}$$

$$\therefore \quad \frac{10\ \Omega}{30\ \Omega}=\frac{30\ \Omega}{90\ \Omega} \quad \text{or} \quad \frac{1}{3}=\frac{1}{3}$$

It is a balanced Wheatstone's bridge. Hence no current flows in the galvanometer arm. Hence, resistance 50 Ω becomes ineffective.

$\therefore$ The equivalent resistance of the circuit is

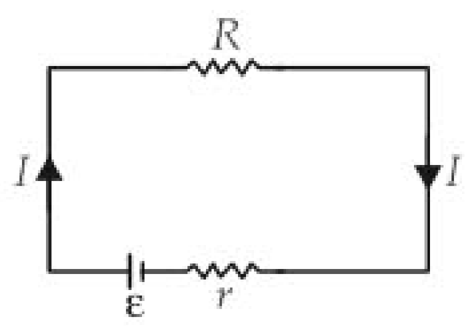
$$R_{eq}=5\ \Omega+\frac{(10\ \Omega+30\ \Omega)(30\ \Omega+90\ \Omega)}{(10\ \Omega+30\ \Omega)+(30\ \Omega+90\ \Omega)}$$

$$=5\ \Omega+\frac{(40\ \Omega)(120\ \Omega)}{40\ \Omega+120\ \Omega}=5\ \Omega+30\ \Omega=35\ \Omega$$

Current drawn from the cell is

$$I=\frac{7\text{ V}}{35\ \Omega}=\frac{1}{5}\text{ A}=0.2\text{ A}$$

17. (d) : $I=\dfrac{\varepsilon}{R+r}$



or $IR+Ir=\varepsilon$

Here, $R=10\ \Omega$, $r=?$,

$\varepsilon=2.1$ V, $I=0.2$ A

$\therefore \quad 0.2\times 10+0.2\times r=2.1$

$2+0.2r=2.1$

$0.2r=0.1$ or $r=\dfrac{1}{2}=0.5\ \Omega$

18. (b) : Resistance of a wire, $R=\rho\dfrac{l}{A}=4\ \Omega$ ...(i)

When wire is stretched twice, its new length be l'. Then

$l'=2l$

On stretching volume of the wire remains constant.

$\therefore lA=l'A'$ where A' is the new cross-sectional area

or $\quad A'=\dfrac{l}{l'}A=\dfrac{l}{2l}A=\dfrac{A}{2}$

$\therefore$ Resistance of the stretched wire is

$$R'=\rho\frac{l'}{A'}=\rho\frac{2l}{(A/2)}=4\rho\frac{l}{A}$$

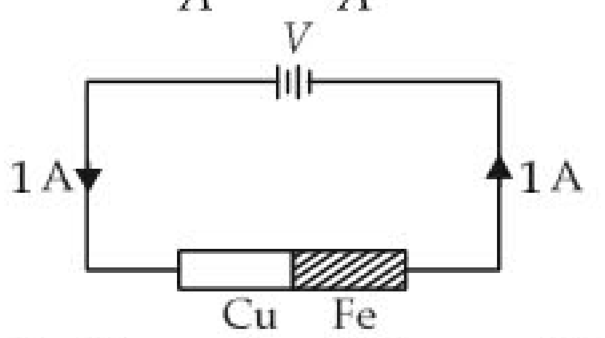
$$=4(4\ \Omega)=16\ \Omega \qquad \text{(Using (i))}$$

19. (d) : Here,
Length of each rod, $l = 1$ m
Area of cross-section of each rod,
$A = 0.01\text{ cm}^2 = 0.01 \times 10^{-4}\text{ m}^2$
Resistivity of copper rod,
$\rho_{cu} = 1.7 \times 10^{-6}\ \Omega\text{ cm}$
$= 1.7 \times 10^{-6} \times 10^{-2}\ \Omega\text{ m} = 1.7 \times 10^{-8}\ \Omega\text{ m}$
Resistivity of iron rod,
$\rho_{Fe} = 10^{-5}\ \Omega\text{ cm}$
$= 10^{-5} \times 10^{-2}\ \Omega\text{ m} = 10^{-7}\ \Omega\text{ m}$
$\therefore$ Resistance of copper rod,

$$R_{Cu} = \rho_{Cu}\frac{l}{A}$$

and resistance of iron rod, $R_{Fe} = \rho_{Fe}\dfrac{l}{A}$
As copper and iron rods are connected in series, therefore equivalent resistance is

$$R = R_{Cu} + R_{Fe} = \rho_{Cu}\frac{l}{A} + \rho_{Fe}\frac{l}{A} = (\rho_{Cu} + \rho_{Fe})\frac{l}{A}$$



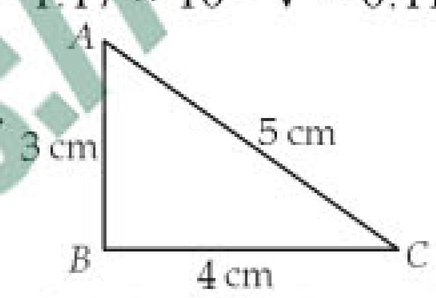
Voltage required to produce 1 A current in the rods is
$V = IR = (1)(R_{Cu} + R_{Fe})$

$$= (\rho_{Cu} + \rho_{Fe})\left(\frac{l}{A}\right)$$

$$= (1.7\times10^{-8} + 10^{-7})\left(\frac{1}{0.01\times10^{-4}}\right)\text{V}$$

$$= 10^{-7}\,(0.17 + 1)(10^{6})\text{ V} = 1.17 \times 10^{-1}\text{ V} = 0.117\text{ V}$$

20. (b) : Let ρ and A be resistivity and area of cross-section of the wire respectively.



The wire is bent in the form of right triangle as shown in adjacent figure.

Resistance of side AB is $R_1 = \dfrac{3\rho}{A}$

Resistance of side BC is $R_2 = \dfrac{4\rho}{A}$

Resistance of side AC is $R_3 = \dfrac{5\rho}{A}$

$\therefore$ The resistance between the ends A and B is

$$R_{AB} = \frac{R_1(R_2+R_3)}{R_1+R_2+R_3} = \frac{\frac{3\rho}{A}\left(\frac{4\rho}{A}+\frac{5\rho}{A}\right)}{\frac{3\rho}{A}+\left(\frac{4\rho}{A}+\frac{5\rho}{A}\right)} = \frac{27}{12}\frac{\rho}{A}$$

The resistance between the ends B and C is

$$R_{BC} = \frac{R_2(R_1+R_3)}{R_2+R_1+R_3} = \frac{\frac{4\rho}{A}\left(\frac{3\rho}{A}+\frac{5\rho}{A}\right)}{\frac{4\rho}{A}+\frac{3\rho}{A}+\frac{5\rho}{A}} = \frac{32}{12}\frac{\rho}{A}$$

The resistance between the ends A and C is

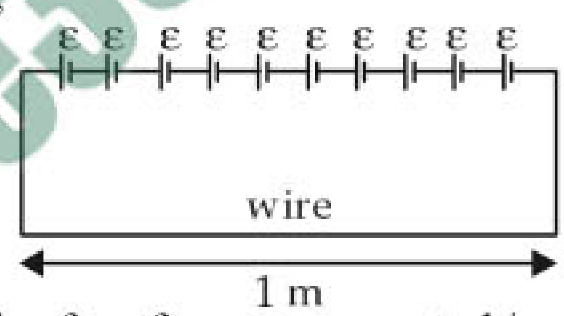
$$R_{AC} = \frac{R_3(R_1+R_2)}{R_3+R_1+R_2} = \frac{\frac{5\rho}{A}\left(\frac{3\rho}{A}+\frac{4\rho}{A}\right)}{\frac{5\rho}{A}+\frac{3\rho}{A}+\frac{4\rho}{A}} = \frac{35}{12}\frac{\rho}{A}$$

$$\therefore\ R_{AB} : R_{BC} : R_{AC} = \frac{27}{12} : \frac{32}{12} : \frac{35}{12} = 27 : 32 : 35$$

21. (a) : Let ρ be resistivity of the material of the wire and r be radius of the wire.
Therefore, resistance of 1 m wire is

$$R = \frac{\rho(1)}{\pi r^2} = \frac{\rho}{\pi r^2} \qquad \left(\because R = \frac{\rho l}{A}\right)$$

Let ε be emf of each cell.
In first case,

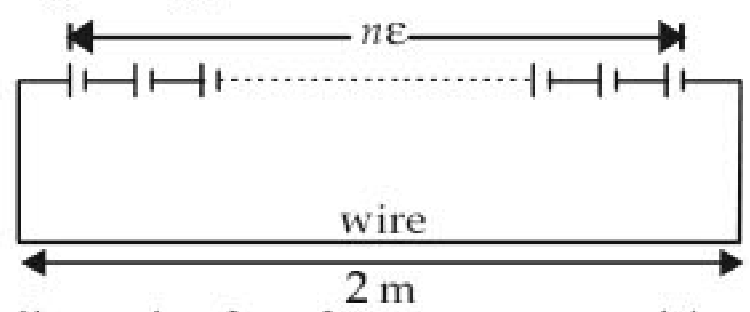


10 cells each of emf ε are connected in series to heat the wire of length 1 m by $\Delta T(= 10°\text{C})$ in time t.

$$\therefore\ \frac{(10\varepsilon)^2}{R}t = ms\Delta T \qquad \ldots\text{(i)}$$

In second case,
Resistance of same wire of length 2 m is

$$R' = \frac{\rho(2)}{\pi r^2} = \frac{2\rho}{\pi r^2} = 2R$$



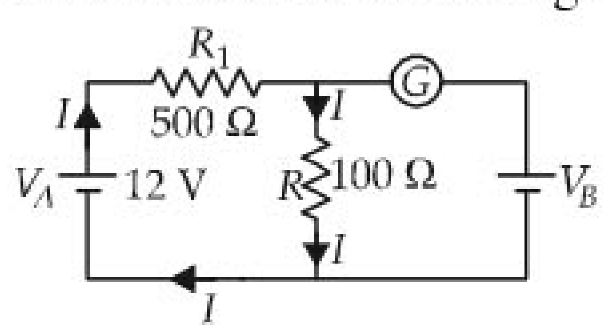
Let n cells each of emf ε are connected in series to heat the same wire of length 2 m, by the same temperature ΔT (= 10°C) in the same time t.

$$\therefore\ \frac{(n\varepsilon)^2 t}{2R} = (2m)s\Delta T \qquad \ldots\text{(ii)}$$

Divide (ii) by (i), we get

$$\frac{n^2}{200} = 2 \ \Rightarrow\ n^2 = 400 \quad \therefore\ n = 20$$

22. (b) : Since the galvanometer shows no deflection so current will flow as shown in the figure.



Current, $I = \frac{V_A}{R_1 + R} = \frac{12\text{ V}}{(500+100)\ \Omega} = \frac{12}{600}\text{ A}$

$V_B = IR = \left(\frac{12}{600}\text{ A}\right)(100\ \Omega) = 2\text{ V}$

23. (d) : Let x be resistance per unit length of the wire. Then,

The resistance of the upper portion is

$R_1 = xl_1$

The resistance of the lower portion is

$R_2 = xl_2$

Equivalent resistance between A and B is

$$R = \frac{R_1R_2}{R_1+R_2} = \frac{(xl_1)(xl_2)}{xl_1 + xl_2}$$

$$\frac{8}{3} = \frac{xl_1l_2}{l_1+l_2} \text{ or } \frac{8}{3} = \frac{xl_1l_2}{l_2\left(\frac{l_1}{l_2}+1\right)} \text{ or } \frac{8}{3} = \frac{xl_1}{\left(\frac{l_1}{l_2}+1\right)} \quad \text{...(i)}$$

Also $R_0 = xl_1 + xl_2$

$12 = x(l_1 + l_2)$

$$12 = xl_2\left(\frac{l_1}{l_2}+1\right) \quad \text{...(ii)}$$

Divide (i) by (ii), we get

$$\frac{\frac{8}{3}}{12} = \frac{\frac{xl_1}{\left(\frac{l_1}{l_2}+1\right)}}{xl_2\left(\frac{l_1}{l_2}+1\right)} \text{ or } \frac{8}{36} = \frac{l_1}{l_2\left(\frac{l_1}{l_2}+1\right)^2}$$

$$\left(\frac{l_1}{l_2}+1\right)^2\frac{8}{36} = \frac{l_1}{l_2} \text{ or } \left(\frac{l_1}{l_2}+1\right)^2\frac{2}{9} = \frac{l_1}{l_2}$$

Let $y = \frac{l_1}{l_2}$

$\therefore\ 2(y+1)^2 = 9y$ or $2y^2 + 2 + 4y = 9y$

or $2y^2 - 5y + 2 = 0$

Solving this quadratic equation, we get

$$y = \frac{1}{2} \text{ or } 2 \ \therefore\ \frac{l_1}{l_2} = \frac{1}{2}$$

24. (c) : Power, $P = \frac{V^2}{R}$

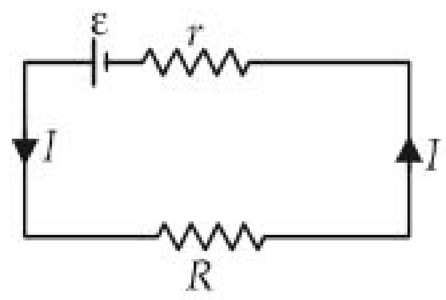
As the resistance of the bulb is constant

$\therefore\ \frac{\Delta P}{P} = \frac{2\Delta V}{V}$

% decrease in power $= \frac{\Delta P}{P}\times 100 = \frac{2\Delta V}{V}\times 100$

$= 2 \times 2.5\% = 5\%$

25. (c) :



Current in the circuit, $I = \frac{\varepsilon}{R+r}$

Potential difference across R,

$$V = IR = \left(\frac{\varepsilon}{R+r}\right)R$$

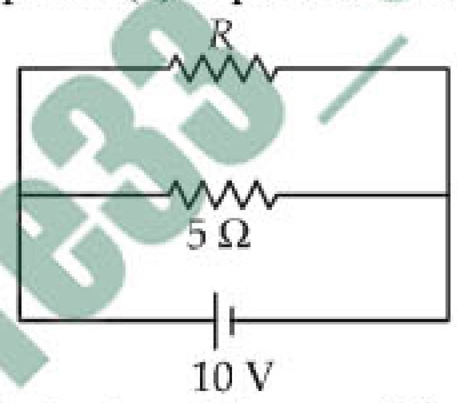
$$V = \frac{\varepsilon}{1+\frac{r}{R}}$$

When $R = 0$, $V = 0$

$R = \infty$, $V = \varepsilon$

Hence, option (c) represents the correct graph.

26. (c) :



The equivalent resistance of the given circuit is

$$R_{eq} = \frac{5R}{5+R}$$

Power dissipated in the given circuit is

$$P = \frac{V^2}{R_{eq}} \text{ or } 30 = \frac{(10)^2}{\left(\frac{5R}{5+R}\right)}$$

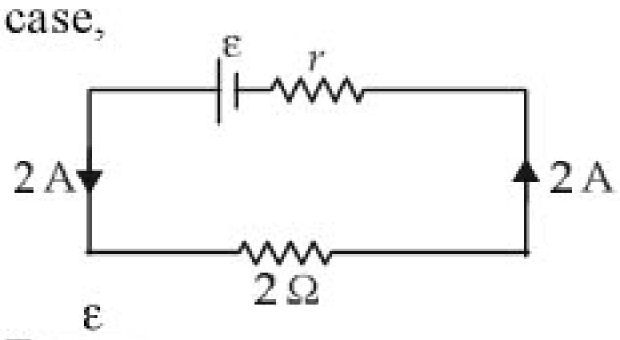
$150R = 100(5 + R)$

$150R = 500 + 100R$ or $50R = 500$

$$R = \frac{500}{50} = 10\ \Omega$$

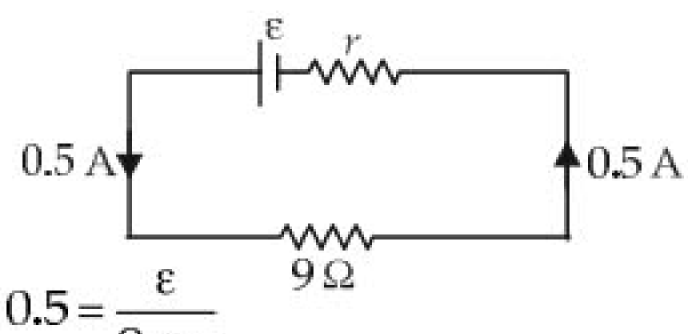
27. (b) : Let ε be the emf and r be internal resistance of the battery.

In the first case,



$$2 = \frac{\varepsilon}{2+r} \quad \text{...(i)}$$

In the second case,



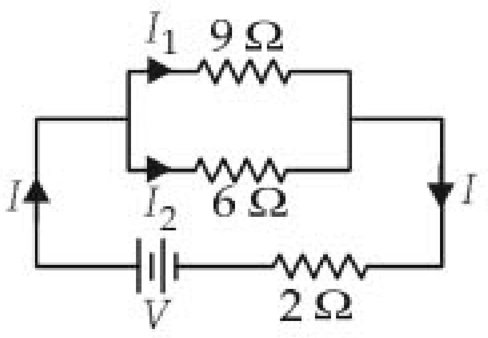
$$0.5 = \frac{\varepsilon}{9+r} \quad \text{...(ii)}$$

Divide (i) by (ii), we get

$$\frac{2}{0.5}=\frac{9+r}{2+r} \Rightarrow 4+2r=4.5+0.5r$$

$$1.5r=0.5 \Rightarrow r=\frac{0.5}{1.5}=\frac{1}{3}\,\Omega$$

28. (c) :



Current flows through the 9 Ω resistor is

$$I_1^2=\frac{36}{9}=4 \qquad (\text{As } P=I^2R)$$

$I_1=2$ A

As the resistors 9 Ω and 6 Ω are connected in parallel, therefore potential difference across them is same.

$\therefore \quad 9I_1=6I_2$

$$I_2=\frac{9\times 2}{6}=3\text{ A}$$

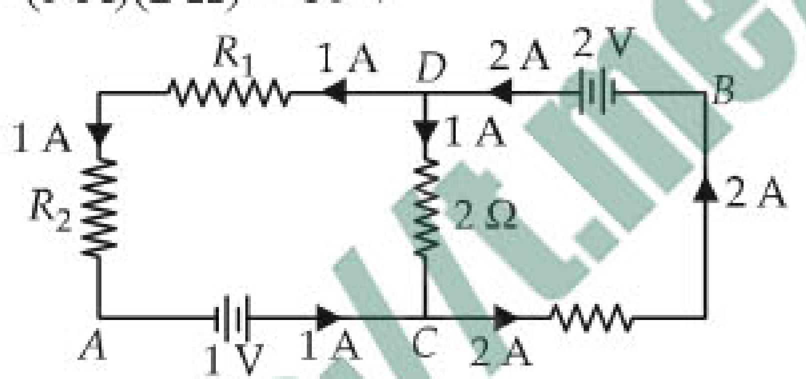
Current drawn from the battery is

$I=I_1+I_2=(2+3)\text{ A}=5\text{ A}$

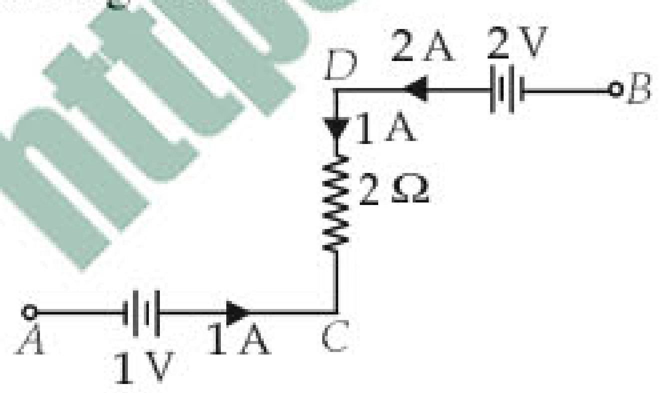
The potential difference across the 2 Ω resistor is

$=(5\text{ A})(2\ \Omega)=10$ V

29. (a) :



Applying Kirchhoff voltage law in the circuit as shown in the figure below.



$\therefore \quad V_A+1+2(1)-2=V_B$

$0+1=V_B \qquad (\because V_A=0\text{ V (Given)})$

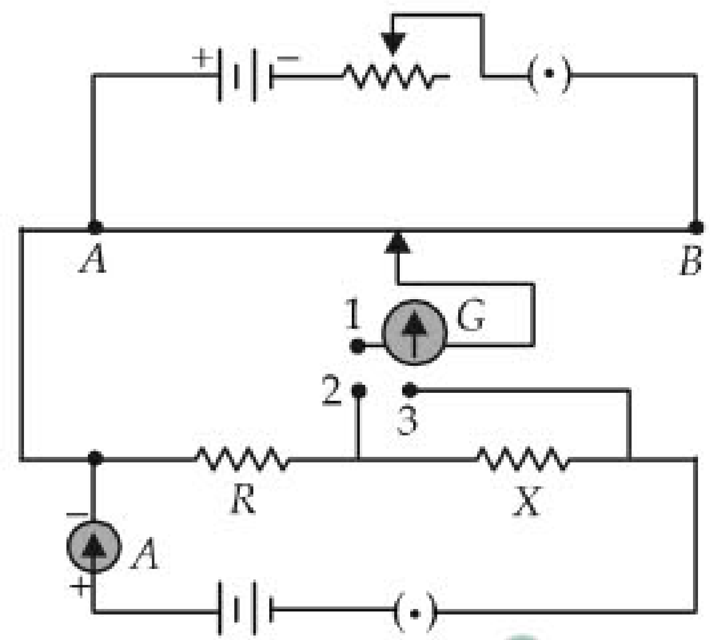
$V_B=+1$ V

30. (d) : Kirchhoff's junction law or Kirchhoff's first law is based on the conservation of charge.

Kirchhoff's loop law or Kirchhoff's second law is based on the conservation of energy.

Hence both statements (A) and (B) are correct.

31. (b) :



When the two way key is switched off, then

The current flowing in the resistors R and X is

$I=1$ A ...(i)

When the key between the terminals 1 and 2 is plugged in, then

Potential difference across $R=IR=kl_1$ ...(ii)

where k is the potential gradient across the potentiometer wire

When the key between the terminals 1 and 3 is plugged in, then

Potential difference across $(R+X)=I(R+X)=kl_2$ ...(iii)

From equation (ii), we get

$$R=\frac{kl_1}{I}=\frac{kl_1}{1}=kl_1\ \Omega \qquad ...(iv)$$

From equation (iii), we get

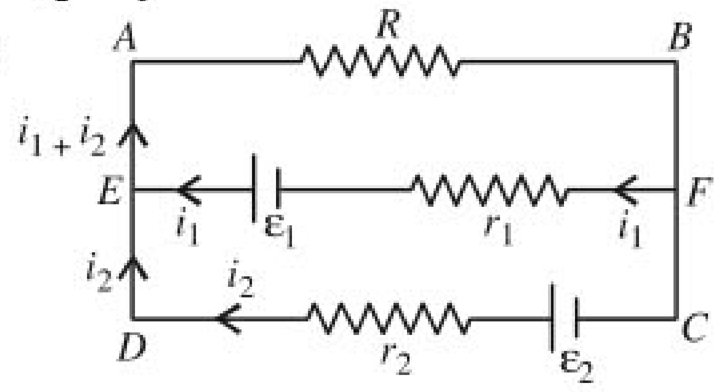
$$R+X=\frac{kl_2}{I}=\frac{kl_2}{1}=kl_2\ \Omega \qquad (\text{Using (i)})$$

$X=kl_2-R$

$=kl_2-kl_1 \qquad$ (Using (iv))

$=k(l_2-l_1)\ \Omega$

32. (d) :

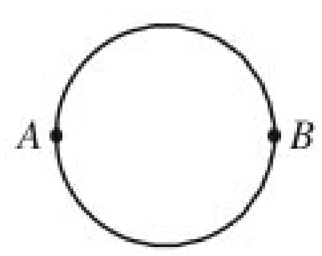


Applying Kirchhoff's equation to the loop $ABFE$,

$-(i_1+i_2)R-i_1r_1+\varepsilon_1=0$

or $\varepsilon_1-(i_1+i_2)R-i_1r_1=0.$

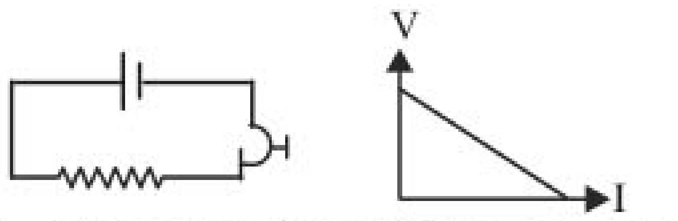
33. (d) : Wire of length $2\pi\times 0.1$ m of 12 Ω/m is bent to a circle.



Resistance of each part

$=12\times\pi\times 0.1=1.2\pi\ \Omega$

$\therefore$ Resistance between A and $B=0.6\pi\ \Omega$.

34. (a) : 

$V = \varepsilon - Ir$, comparing with $y = c - mx$

$\therefore$ Slope $= -r$, internal resistance.

V_{max} = emf ε. This is intercept on the y-axis.

$\therefore$ Slope is negative.

$\because$ I decreases as R increases.

35. (c) : Energy = 2 eV = $eE\lambda$

$\therefore\ E = \dfrac{2eV}{e\lambda} = \dfrac{2}{4\times10^{-8}} = 5\times10^{7}$ V/m.

36. (b) : As the P.D. between 4 Ω and 3 Ω (in parallel), are the same,

4×1 amp $= 3 \times i_1 \Rightarrow\ i_1 = \dfrac{4}{3}$ A

Total resistance of 4 Ω and 3 Ω = 12/7 Ω.

Current in MQP (upper one) $= 1 + \dfrac{4}{3} = \dfrac{7}{3}$ A

$\therefore$ P.D. $= \dfrac{12}{7}\times\dfrac{7}{3} = 4$ V

Current in $MNP = \dfrac{4}{1.25} = \dfrac{4\times4}{5} = \dfrac{16}{5}$ A

$\therefore$ P.D. across 1 Ω $= \dfrac{16}{5}$ A $\times 1\,\Omega = \dfrac{16}{5}$ volt

$\Rightarrow$ P.D. across 1 Ω = 3.2 volt.

37. (d) : $\dfrac{\Delta l}{l} = 0.1 \quad \therefore\ l = 1.1$

but the area also decreases by 0.1.

mass $= \rho l A = V\rho$. $\ln l + \ln A = \ln$ mass.

$\therefore\ \dfrac{\Delta l}{l} + \dfrac{\Delta A}{A} = 0 \ \Rightarrow\ \dfrac{\Delta l}{l} = \dfrac{-\Delta A}{A}$

Length increases by 0.1, resistance increases, area decreases by 0.1, then also resistance will increase. Total increase in resistance is approximately 1.2 times, due to increase in length and decrease in area. But specific resistance does not change.

38. (c) : [In the question, the length 110 cm & 100 cm are interchanged] as $\varepsilon > \dfrac{\varepsilon R}{R+r}$

Without being short circuited through R, only the battery ε is balanced.

$$\varepsilon = \frac{V}{L}\times l_1 = \frac{V}{L}\times 110\text{ cm} \qquad \ldots\text{(i)}$$

When R is connected across ε,

$$Ri = R\cdot\left(\frac{\varepsilon}{R+r}\right) = \frac{V}{L}\times l_2 \ \Rightarrow\ \frac{R\varepsilon}{R+r} = \frac{V}{L}\times 100 \qquad \ldots\text{(ii)}$$

Dividing eqn. (i) and (ii), $\dfrac{(R+r)}{R} = \dfrac{110}{100}$

$\Rightarrow\ 1 + \dfrac{r}{R} = \dfrac{110}{100} \Rightarrow \dfrac{r}{R} = \dfrac{110}{100} - \dfrac{100}{100}$

$\Rightarrow\ r = R\cdot\dfrac{10}{100} = \dfrac{R}{10}$. As $R = 10\,\Omega$; $r = 1\,\Omega$.

39. (c) : Power = 220 V × 4 A = 880 watts. = 880 J/s.

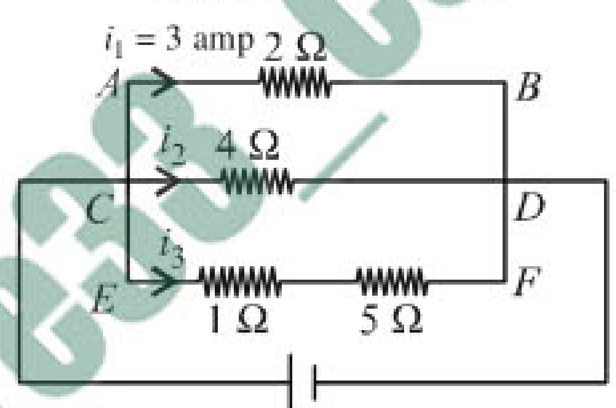
Heat needed to raise the temperature of 1 kg water through 80°C

$= ms.\Delta T \times 4.2$ J/cal

$= 1000$ g × 1 cal/g × 80 × 4.2 J/cal.

$\therefore$ time taken $= \dfrac{1000\times1\times80\times4.2}{880} = \dfrac{336\times10^{3}}{880}$

= 382 s = 6.3 min.

40. (b) : 

2 Ω, 4 Ω and (1 Ω + 5 Ω) are in parallel.

So potential difference is the same.

$V = 2\,\Omega\cdot i_1 = 4\,\Omega\cdot i_2 = 6\,\Omega\cdot i_3$

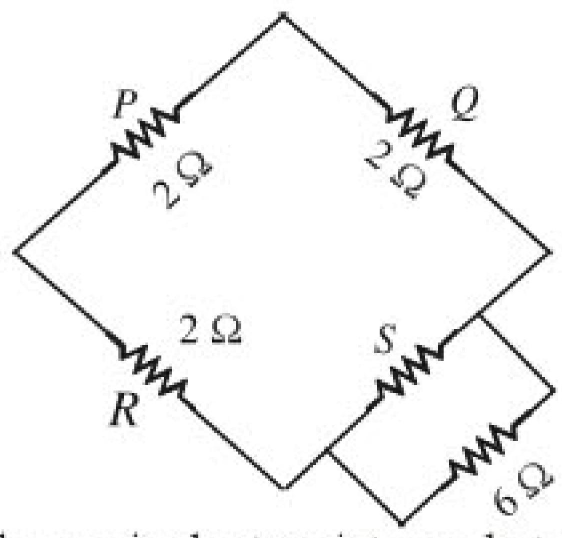
$2\cdot3 = 6\,\Omega\,.\,i_3 \Rightarrow i_3 = 1$ amp.

Total P.D. = 5 × 1 + 1 × 1 = 6 V.

$\therefore$ Power dissipated in 5 Ω resistance $= \dfrac{V'^2}{R}$

where V' is the P.D. across 5 Ω = 5 V.

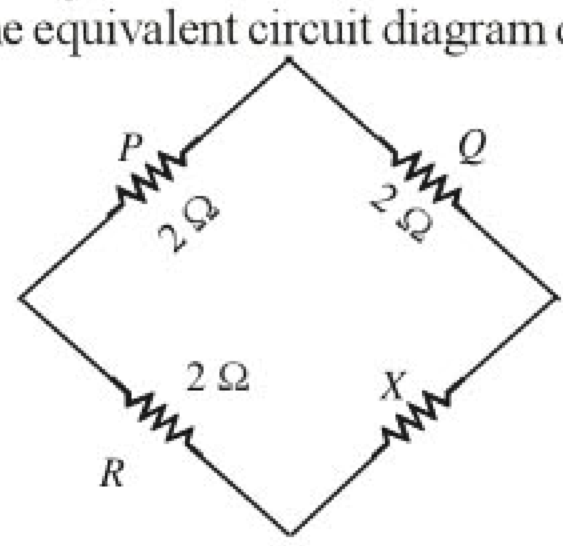
$\therefore$ Power $= \dfrac{25}{5\,\Omega} = 5$ watt

41. (a) : 

Let X be the equivalent resistance between S and 6 Ω.

$\therefore\ \dfrac{1}{X} = \dfrac{1}{S} + \dfrac{1}{6}$ ... (i)

Therefore, the equivalent circuit diagram drawn below.



For a balanced Wheatstone bridge, we get

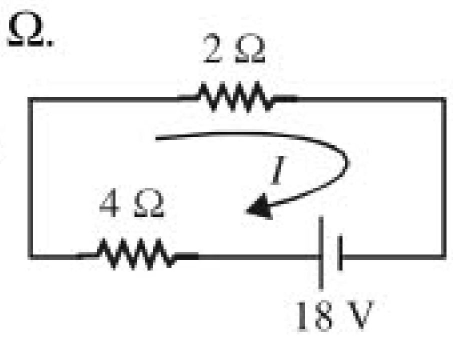
$$\frac{P}{Q}=\frac{R}{X} \quad \text{or} \quad \frac{2}{2}=\frac{2}{X} \quad \Rightarrow \quad X = 2\ \Omega.$$

From eqn. (i), we get

$$\frac{1}{2}=\frac{1}{S}+\frac{1}{6} \quad \text{or,} \quad \frac{1}{S}=\frac{2}{6} \quad \text{or,} \quad S=3\ \Omega.$$

42. (b) : In the given circuit 6 Ω and 3 Ω are in parallel, and hence its equivalent resistance is given by

$$\frac{1}{R_p}=\frac{1}{6}+\frac{1}{3} \quad \text{or} \quad R_p=2\ \Omega.$$



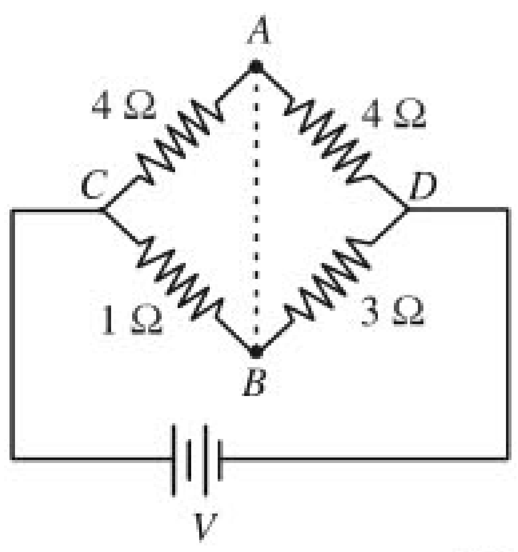
The equivalent circuit diagram is given in figure.

Total current in the circuit,

$$I=\frac{18}{2+4}=3\text{ A}.$$

Power in the circuit = VI = 18 × 3 = 54 watt.

43. (a) :



Current through arm CAD, $I=\frac{V}{8}$ amp

Potential difference between C and $A = V_C - V_A$

$$=\frac{V}{8}\times 4=\frac{V}{2}\text{ volt}$$

Current through CBD, $I'=\frac{V}{4}$ amp

Potential difference between C and $B = V_C - V_B$

$$=\frac{V}{4}\times 1=\frac{V}{4}\text{ volt.}$$

Potential between A and $B = V_A - V_B$

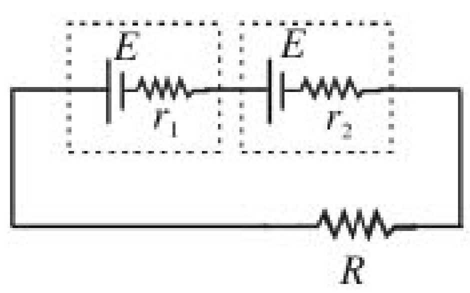
$$\therefore \quad V_A - V_B = V_C - V_B - (V_C - V_A) = \frac{V}{4}-\frac{V}{2}=-\frac{V}{4}.$$

$\Rightarrow$ $V_A - V_B < 0$ or, $V_A < V_B$

As $V_A < V_B$, so direction of current will be from B to A.

44. (c) : Kirchhoff's first law of electrical circuit is based on conservation of charge and Kirchhoff's second law of electrical circuit is based on conservation of energy.

45. (b) : Kirchhoff's law has to be applied to the whole loop.



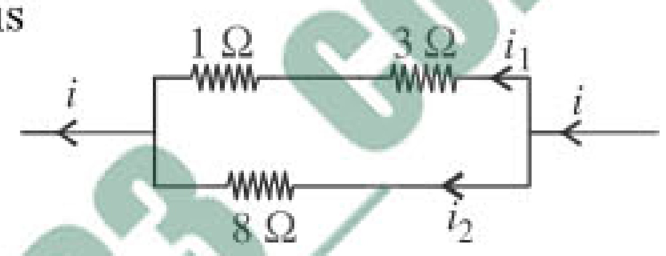
while $i=\frac{2E}{(r_1+r_2+R)}$,

If through one section (here the first battery) has zero potential difference, current cannot flow. The question could have been modified.

The statement that when the circuit is closed, the potential difference across the first cell is zero implies that in a series circuit, one part cannot conduct current which is wrong. Kirchhoff's law is violated.

Assuming that $ir_1 = E$ as given in the question paper, some students could have found that $R = r_1 - r_2$. They have to be given marks.

46. (a) : Resistance of series combination of 3 Ω and 1 Ω is



R_1 = 3 + 1 = 4 Ω, R_2 = 8 Ω

Let i be the total current in the circuit.

Current through R_1 is $i_1=\frac{i\times R_2}{R_1+R_2}=\frac{i\times 8}{12}=\frac{2i}{3}$

Current through R_2 is $i_2=\frac{i\times R_1}{R_1+R_2}=\frac{i\times 4}{12}=\frac{i}{3}$

Power dissipated in 3 Ω resistor is

$P_1 = i_1^2 \times 3$ ... (i)

Power dissipated in 8 Ω resistor is

$P_2 = i_2^2 \times 8$ ... (ii)

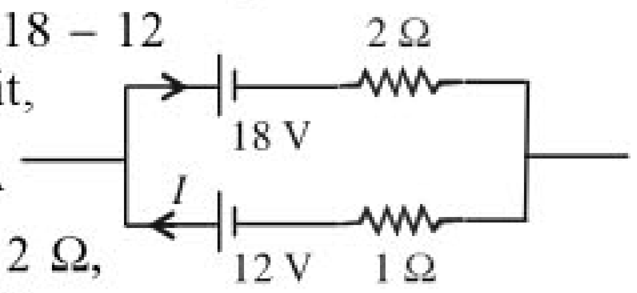
$$\therefore \quad \frac{P_1}{P_2}=\frac{i_1^2\times 3}{i_2^2\times 8} \quad \text{or,} \quad \frac{P_1}{P_2}=\frac{(2i/3)^2\times 3}{(i/3)^2\times 8}=\frac{12}{8}=\frac{3}{2}.$$

$$P_1=\frac{3}{2}\times P_2=\frac{3}{2}\times 2=3\text{ watt}$$

$\therefore$ Power dissipated across 3 Ω resistor is 3 watt.

47. (d) : From Kirchhoff's law,

I × 2 + I × 1 = 18 – 12



Current in the circuit,

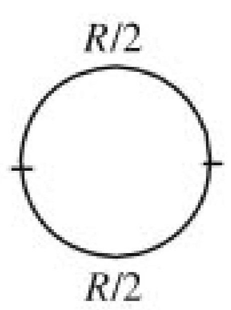
$$I=\frac{V}{R}=\frac{6}{3}=2\text{ A}$$

Voltage drop across 2 Ω,

V_1 = 2 × 2 = 4 V

Voltmeter reading = 18 – 4 = 14 V.

48. (a) : Both are in parallel.



$$\frac{1}{R'}=\frac{2}{R}+\frac{2}{R}=\frac{4}{R} \quad \Rightarrow \quad R'=\frac{R}{4}.$$

49. (d) : Since given circuit is in the form of Wheatstone bridge,

$$\frac{1}{R_{eq}}=\frac{1}{(4+2)}+\frac{1}{(6+3)}; \quad R_{eq} = 18/5\ \Omega$$

$V = iR_{eq} \Rightarrow i = \frac{V}{R_{eq}} = \frac{5V}{18}.$

50. (a) : $P = i^2R$ or $1 = 25 \times R$

$R = \frac{1}{25} = 0.04\ \Omega$

51. (b) : Resistance of wire $= \rho\frac{l}{A}$

$$R \propto \frac{l}{A} = \frac{l}{\pi r^2}$$

When length and radius are both doubled

$$R_1 \propto \frac{2l}{\pi(2r)^2} \Rightarrow R_1 \propto \frac{1}{2}R$$

The specific resistance of wire is independent of geometry of the wire, it only depends on the material of the wire.

52. (a) : When n resistance of r ohm connected in parallel then their equivalent resistance is

$$\Rightarrow \frac{1}{R} = \frac{1}{r} + \frac{1}{r} + \frac{1}{r} + \text{...........}n \text{ times}$$

$$\therefore \frac{1}{R} = \frac{n}{r} \Rightarrow R = \frac{r}{n} \Rightarrow r = nR$$

When these resistance connected in series

$R_s = r + r + \text{...............}n$ times

$= nr = n \times nR = n^2R$

53. (c) : Equivalent circuit of given circuit is shown in figure (i). Also this is equivalent to a balanced Wheatstone's bridge C and D are at equal potential level, no current will flow in this resistance therefore this resistance can be neglected.

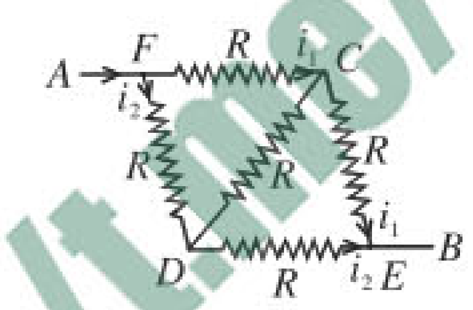


Fig. (i)

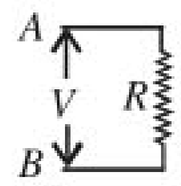


Fig. (ii)

Thus equivalent resistance of this remaining circuit [in fig. (ii)] is R.

Then current in $AFCEB$ branch is

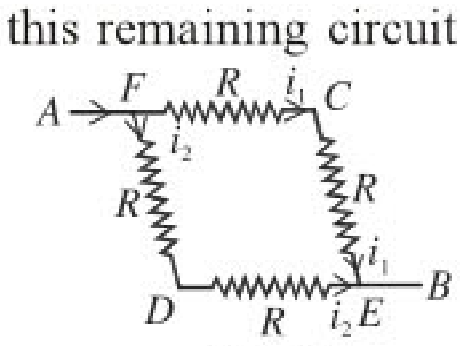


Fig. (iii)

$$i_1 = \frac{V}{R} \times \frac{2R}{2R+2R} = \frac{V}{2R}$$

54. (c) : According to given parameters in question

$$\Rightarrow R = \rho\frac{l}{A} \Rightarrow 100\ \Omega = \rho\frac{3}{A} \Rightarrow \frac{\rho}{A} = \frac{100}{3}.$$

Thus total resistance of 50 cm wire is

$$R_1 = \frac{\rho}{A}l = \frac{100}{3} \times 0.5 = \frac{50}{3}\ \Omega.$$

The total current in the wire is $I = \frac{6}{100}$ A.

Therefore potential difference across the two points on the wire separated by a distance of 50 m is

$$(V) = IR_1 = \frac{50}{3} \times \frac{6}{100} = 1 \text{ V}.$$

55. (d) : The resistance of each bulb is

$$= \frac{V^2}{P} = \frac{(200)^2}{60}\ \Omega$$

When three bulbs are connected in series their resultant resistance $= \frac{3 \times (200)^2}{60}.$

Thus power drawn by bulb when connected across 200 V supply

$$P = \frac{V^2}{R_{re}} = \frac{(200)^2}{3 \times (200)^2 / 60} = 20 \text{ W}.$$

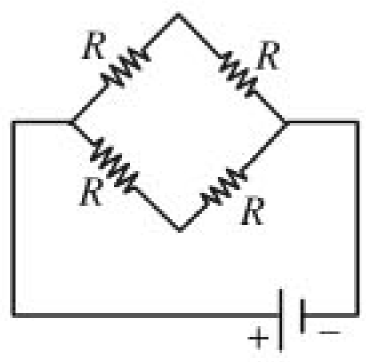
56. (c) : In India, $P_I = \frac{(220)^2}{R}$

In USA, $P_U = \frac{(110)^2}{R_U}$

as $P_I = P_U \Rightarrow \frac{(220)^2}{R} = \frac{(110)^2}{R_U}$

$$\Rightarrow R_U = \frac{110 \times 110}{220 \times 220}R = \frac{R}{4}.$$

57. (c) : In balance Wheatstone bridge, the galvanometer arm can be neglected so equivalent resistance $= R$.



58. (d) : $R = \frac{V^2}{P} = \frac{220 \times 220}{100} = 484\ \Omega$

In series, $R_{eq} = 484 + 484 = 968\ \Omega$

$\therefore P_{eq} = \frac{V^2}{968} = \frac{220 \times 220}{968} = 50$ watt

In parallel, $R_{eq} = 242\ \Omega$

$\therefore P_{eq} = \frac{V^2}{242} = \frac{220 \times 220}{242} = 200$ watt.

59. (a) : Let R_1 and R_2 be the resistance of the two coils and V be the voltage supplied.

Effective resistance of two coils in parallel $= \frac{R_1R_2}{R_1 + R_2}$

Let H be the heat required to begin boiling in kettle.

Then $H = \text{Power} \times \text{time} = \frac{V^2t_1}{R_1} = \frac{V^2t_2}{R_2}$

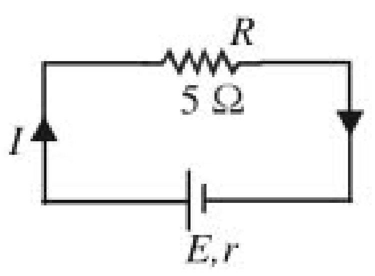
For parallel combination, $H = \frac{V^2(R_1 + R_2)\,t_p}{R_1R_2}$

$$\Rightarrow \frac{1}{t_p} = \left(\frac{t_2 + t_1}{t_2\,t_1}\right)$$

$$\therefore t_p = \frac{t_1t_2}{t_1 + t_2} = \frac{10 \times 40}{10 + 40} = 8 \text{ minute}.$$

60. (b) : Fuse wire should have high resistance and low melting point.

61. (a) : Terminal potential difference is 2.2 V when circuit is open.



$\therefore$ e.m.f. of the cell $= E = 2.2$ volt

Now, when the cell is connected to the external resistance, circuit current I is given by

$I = \dfrac{E}{R+r} = \dfrac{2.2}{5+r}$ ampere, where r is the internal resistance of the cell.

Potential difference across the cell $= IR$

$$= \frac{2.2}{5+r} \times 5 = 1.8.$$

$\therefore$ $5 + r = 11/1.8$.

$\therefore$ $r = \dfrac{11}{1.8} - 5 = \dfrac{110-90}{18} = \dfrac{10}{9}\,\Omega$.

62. (a) : Resistance of a conductor is given by

$R = \rho\dfrac{l}{A}$, where ρ is the specific resistance, l is the length and A is the cross-sectional area of the conductor. Now, when $l = 1$ and $A = 1$, $R = \rho$.

So specific resistance or resistivity of a material may be defined as the resistance of a specimen of the material having unit length and unit cross-section. Hence, specific resistance is a property of a material and it will increase with the increase of temperature, but will not vary with the dimensions (length, cross-section) of the conductor.

63. (a) : For metals specific resistance decrease with decrease in temperature whereas for semiconductors specific resistance increases with decrease in temperature.

64. (a)

65. (a) : $\dfrac{V}{l} = \dfrac{IR}{l} = \dfrac{I\rho l}{Al} = \dfrac{0.1\times10^{-7}}{10^{-6}}$

$= 0.01 = 10^{-2}$ V/m.

66. (b) : This is a balanced Wheatstone's bridge so no current flows through the 7 Ω resistor.

$\therefore$ $\dfrac{1}{R_{eq}} = \dfrac{1}{4+3} + \dfrac{1}{6+8}$ or $R_{eq} = \dfrac{14}{3}\,\Omega$

67. (c) : $\dfrac{V-E}{r} = I \Rightarrow \dfrac{V-12}{5\times10^{-2}} = 60 \Rightarrow V = 15$ V

68. (b) : $P = \dfrac{V^2}{R}$ or, $R \propto \dfrac{1}{P}$

$\therefore$ $R_{40} > R_{100}$.

69. (a)

70. (d) : In given circuit R_B and R_C are in series.

$\therefore$ $R_{BC} = 6 + 6 = 12\ \Omega$.

Now, R_A and R_{BC} are in parallel.

Therefore, equivalent resistance of circuit,

$$R_{eq} = \frac{12\times3}{12+3} = \frac{36}{15}.$$

Using Ohm's law, $I = \dfrac{V}{R_{eq}} = \dfrac{4.8}{36/15} = 2$ A.

71. (a) : $i = \dfrac{2}{4} = 0.5$ Ampere

$V = \varepsilon - ir$

or $V = 2 - 0.5 \times 0.1 = 1.95$ V

72. (d) : Metre bridge works on the principle of Wheatstone bridge.

$\therefore$ $\dfrac{P}{Q} = \dfrac{l}{100-l}$

or, $P = \dfrac{l}{100-l}\times Q = \dfrac{20}{80}\times1 = 0.25\,\Omega$.

73. (c) : $i = \dfrac{2}{10} = 0.2$ A, $\dfrac{R}{l} = 10/4$

Potential difference per unit length

$= 0.2 \times (10/4) = 0.5$ V/m

74. (a)

75. (d) : For series, $R_{eq.} = 3r$

Power $= \dfrac{V^2}{3r} = 10 \Rightarrow \dfrac{V^2}{r} = 30$.

For parallel $R_{eq.} = r/3$

power $= \dfrac{V^2}{r/3} = \dfrac{3V^2}{r} = 3\times30 = 90$ watt.

76. (a) : $H = I^2Rt = ms\Delta T$

$\dfrac{I_1^2}{I_2^2} = \dfrac{\Delta T_1}{\Delta T_2}$ or, $\Delta T_2 = \dfrac{\Delta T_1 I_2^2}{I_1^2}$

$\Delta T_2 = 5\times\dfrac{(2I_1)^2}{I_1^2} = 20$; $\Delta T_2 = 20$°C.

77. (a) : Three wires of lengths and cross-sectional areas $= (l, A)$, $(2l, A/2)$ and $(l/2, 2A)$.

Resistance of a wire $(R) \propto \dfrac{l}{A}$.

For I[st] wire, $R_1 \propto l/A = R$

For II[nd] wire, $R_2 \propto \dfrac{2l}{A/2} = 4R$

For III[rd] wire, $R_3 \propto \dfrac{l/2}{2A} = \dfrac{R}{4}$

Therefore resistance of the wire will be minimum for III[rd] wire.

78. (b) : Applied voltage $(V) = 2$V and resistances $= 3\Omega, 3\Omega, 3\Omega$.

From the given circuit, we find that two resistances are in series and third resistance is in parallel. Therefore equivalent resistance for series resistances $= 3 + 3 = 6\Omega$. Now it is connected parallel with 3Ω resistance. Therefore

$$\frac{1}{R} = \frac{1}{3} + \frac{1}{6} = \frac{3}{6} = \frac{1}{2} \quad \text{or} \quad R = 2\ \Omega.$$

And current flowing in the circuit (I)

$$= \frac{V}{R} = \frac{2}{2} = 1\text{A}.$$

79. (c)

80. (a) : For the negative resistance, when we increase the voltage, the current will decrease. Therefore from the graph, we find that the current in CD is decreased when voltage is increased.

81. (c) : Power = 100 W; Voltage of bulb = 200 V and supply voltage (V_s) = 160 V.
Therefore resistance of bulb (R)

$$= \frac{V^2}{P} = \frac{(200)^2}{100} = 400\ \Omega$$

and power consumption (P)

$$= \frac{V_s^2}{R} = \frac{(160)^2}{400} = 64\ \text{W}.$$

82. (c) : 1 kWh = 1000 Wh
$= (1000\ \text{W}) \times (3600\ \text{s}) = 36 \times 10^5$ J.

83. (d) : Ratio of resistance $R_1 : R_2 = 1 : 2$ or $\frac{R_1}{R_2} = \frac{1}{2}$.

In series combination, power dissipated $(P) = I^2R$

$\Rightarrow\ P \propto R$. Therefore $\frac{P_1}{P_2} = \frac{R_1}{R_2} = \frac{1}{2}$

or $P_1 : P_2 = 1 : 2$.

84. (a) : Lower resistance on extreme left and upper resistance on extreme right are ineffective.
The resistance R_2 and R_3 are in series combination. Therefore their equivalent resistance,

$R' = R_2 + R_3 = 10 + 10 = 20\ \Omega$.

Similarly, the resistance R_5 and R_6 are in series combination. Therefore their equivalent resistance,

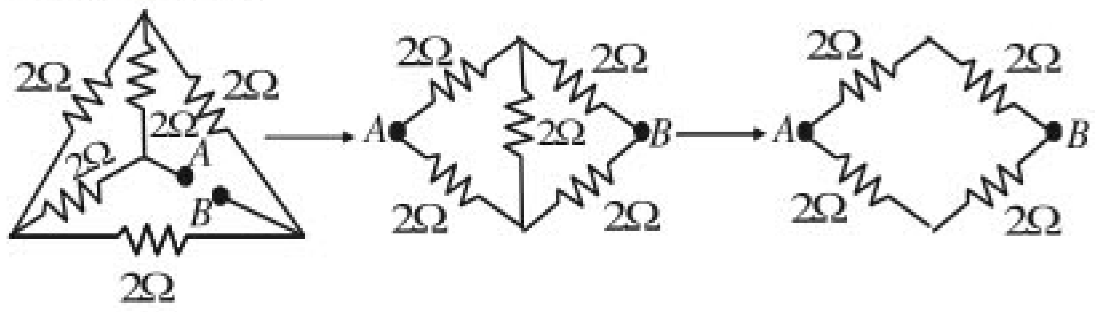
$R'' = R_5 + R_6 = 10 + 10 = 20\ \Omega$.

Now the equivalent resistances R' and R'' are in parallel combination. Therefore their equivalent resistance,

$$R''' = \frac{R'R''}{R'+R''} = \frac{20 \times 20}{20+20} = \frac{400}{40} = 10\ \Omega.$$

Thus equivalent resistance between A and D, R
$= R_1 + R''' + R_4 = 10 + 10 + 10 = 30\ \Omega$
($\because$ series combination)

85. (d) : The circuit is equivalent to a balanced Wheatstone bridge. Therefore resistance between A and B is $2\ \Omega$.



86. (a) : Ratio of cross-sectional areas of the wires = 3 : 1 and resistance of thick wire $(R_1) = 10\ \Omega$.

Resistance $(R) = \rho\,\frac{l}{A} \propto \frac{1}{A}$.

Therefore $\frac{R_1}{R_2} = \frac{A_2}{A_1} = \frac{1}{3}$ or $R_2 = 3R_1 = 3 \times 10 = 30\ \Omega$

and equivalent resistance of these two resistances in series combination

$= R_1 + R_2 = 30 + 10 = 40\ \Omega$.

87. (a)

88. (b) : Power of heating coil = 100 W and voltage $(V) = 220$ volts. When the heating coil is cut into two equal parts and these parts are joined in parallel, the resistance of the coil is reduced to one-fourth of the previous value. Therefore energy liberated per second becomes 4 times. *i.e.* $4 \times 100 = 400$ W.

89. (d) : Capacitance $(C) = 4\ \mu\text{F} = 4 \times 10^{-6}$ F; Voltage $(V) = 400$ volts and resistance $(R) = 2\ \text{k}\Omega = 2 \times 10^3\ \Omega$.

Heat produced = Electrical energy stored $= \frac{1}{2}CV^2$

$$= \frac{1}{2} \times (4 \times 10^{-6}) \times (400)^2 = 0.32\ \text{J}.$$

90. (b) : Length $(l) = 50$ cm = 0.5 m;
Area $(A) = 1\ \text{mm}^2 = 1 \times 10^{-6}\ \text{m}^2$;
Current $(I) = 4$A and voltage $(V) = 2$ volts.

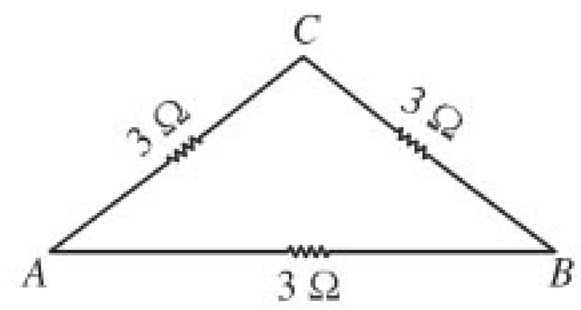
Resistance $(R) = \frac{V}{I} = \frac{2}{4} = 0.5\ \Omega$ and

Resistivity $(\rho) = R \times \frac{A}{l} = 0.5 \times \frac{1 \times 10^{-6}}{0.5}$
$= 1 \times 10^{-6}\ \Omega\text{m}$

91. (a) : Resistances R_{AF} and R_{FE} are in series combination. Therefore their equivalent resistance $R' = R_{AF} + R_{FE} = 3 + 3 = 6\ \Omega$. Now the resistance R_{AE} and equivalent resistance R' are in parallel combination. Therefore relation for their equivalent resistance

$$\frac{1}{R''} = \frac{1}{R'} + \frac{1}{R_{AE}} = \frac{1}{6} + \frac{1}{6} = \frac{2}{6} = \frac{1}{3} \Rightarrow R'' = 3\ \Omega.$$

We can calculate in the same manner for R_{ED}, R_{AC}, R_{DC} etc. and finally the circuit reduces as shown in the figure.



Therefore, the equivalent resistance between A and B

$$= \frac{(3+3)\times 3}{(3+3)+3} = \frac{18}{9} = 2\ \Omega.$$

92. (a) : Flow of electrons, $\frac{n}{t}$ = 10^7/sec.

Therefore, current $(I) = \frac{q}{t} = \frac{ne}{t} = \frac{n}{t}\times e$

$= 10^7 \times (1.6 \times 10^{-19}) = 1.6 \times 10^{-12}$ A

93. (c)

94. (d) : Power $(P) = 60$ W and voltage $(V) = 220$ volts.

Resistance of the filament, $R = \frac{V^2}{P} = \frac{(220)^2}{60} = 807\ \Omega$.

95. (d) : The two resistances are connected in series and the resultant is connected in parallel with the third resistance.

$\therefore\quad R = 4\ \Omega + 4\ \Omega = 8\ \Omega$ and $\frac{1}{R''} = \frac{1}{8} + \frac{1}{4} = \frac{3}{8}$

or $\quad R'' = \frac{8}{3}\ \Omega$

96. (c) : Current across 3 Ω = 0.8 A

6 Ω is in parallel, current across 6 Ω = 0.4 A

Total current = 1.2 A

$\therefore$ potential difference across 4 Ω resistor = 1.2 A × 4 Ω = 4.8 V.

97. (a) : The output power of a cell is given by

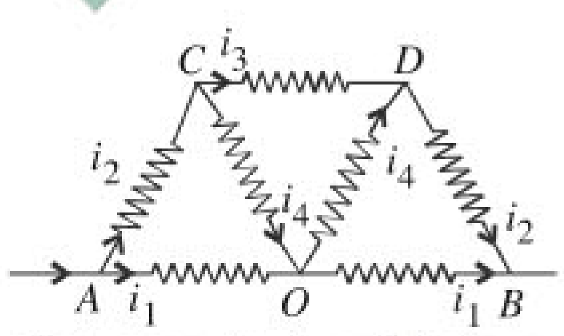
$$P = \frac{V^2}{(r+R)^2}R$$

Maximum power is delivered to the load only when the internal resistance of the source is equal to the load resistance (R). Then

$$P_{max} = \frac{V^2}{4R} = \frac{V^2}{4r} \quad (r = R)$$

98. (a)

99. (d) :



By symmetry, currents i_1 and i_2 from A is the same as i_1 and i_2 reaching B.

As the same current is flowing from A to O and O to B, O can be treated as detached from AB.

Now CO and OD will be in series hence its total resistance = 2 Ω

It is in parallel with CD so equivalent resistance

$$= \frac{2\times 1}{2+1} = \frac{2}{3}\ \Omega$$

This equivalent resistance is in series with AC and DB

So total resistance = $\frac{2}{3} + 1 + 1 = \frac{8}{3}\ \Omega$

Now $\frac{8}{3}\ \Omega$ is parallel to AB that is 2 Ω so total

resistance = $\frac{(8/3)\times 2}{(8/3)+2} = \frac{16/3}{14/3} = \frac{16}{14} = \frac{8}{7}\ \Omega$

100. (b) : For maximum current, the two batteries should be connected in series. The current will be maximum when external resistance is equal to the total internal resistance of cells i.e. 2 Ω. Hence power developed across the resistance R will be

$$I^2R = \left(\frac{2E}{R+2r}\right)^2 R = \left(\frac{2\times 2}{2+2}\right)^2 \times 2 = 2\ \text{W}$$

101. (c) : To carry a current of 4 ampere, we need four path, each carrying a current of one ampere. Let r be the resistance of each path. These are connected in parallel. Hence their equivalent resistance will be $r/4$.

According to the given problem $\frac{r}{4} = 5$ or $r = 20\ \Omega$.

For this purpose two resistances should be connected. There are four such combinations. Hence, the total number of resistance = 4 × 2 = 8

102. (b) : H = I^2Rt or $R = \frac{H}{(I^2 t)} = \frac{80}{(2^2\times 10)} = 2\ \Omega$

103. (b) : Since, the voltage is same for the two combinations, the resistance is less for 39 bulbs. Hence the combination of 39 bulbs will glow more as current is more.

104. (c) : In series $R_s = nR$

In parallel $\frac{1}{R_p} = \frac{1}{R} + \frac{1}{R} + ...n$ terms $= \frac{n}{R}$

$\Rightarrow \quad R_p = \frac{R}{n} \qquad \therefore R_s/R_p = n^2/1$

105. (a) : $I = \frac{8-4}{1+2+9} = \frac{4}{12} = \frac{1}{3}$A

$$V_P - V_Q = 4 - \frac{1}{3}\times 3 = 3\ \text{Volt}$$

106. (d) : $m = l \times$ area × density

Area $\propto \frac{m}{l}$

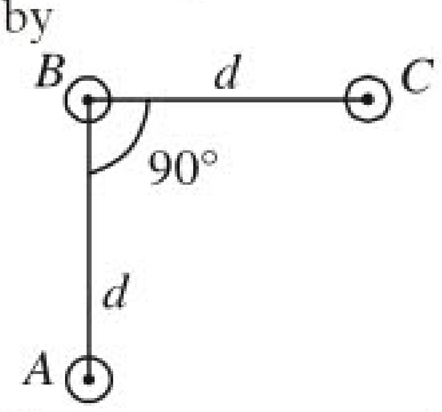
$$R \propto \frac{l}{\text{Area}} \propto \frac{l^2}{m}$$

$$R_1 : R_2 : R_3 = \frac{l_1^2}{m_1} : \frac{l_2^2}{m_2} : \frac{l_3^2}{m_3}$$

$$R_1 : R_2 : R_3 = \frac{25}{1} : \frac{9}{3} : \frac{1}{5} = 125 : 15 : 1$$

Chapter 14 Moving Charges and Magnetism

1. An arrangement of three parallel straight wires placed perpendicular to plane of paper carrying same current 'I' along the same direction as shown in figure. Magnitude of force per unit length on the middle wire 'B' is given by



(a) $\dfrac{2\mu_0 I^2}{\pi d}$ (b) $\dfrac{\sqrt{2}\mu_0 I^2}{\pi d}$

(c) $\dfrac{\mu_0 I^2}{\sqrt{2}\pi d}$ (d) $\dfrac{\mu_0 I^2}{2\pi d}$

(NEET 2017)

2. A long wire carrying a steady current is bent into a circular loop of one turn. The magnetic field at the centre of the loop is B. It is then bent into a circular coil of n turns. The magnetic field at the centre of this coil of n turns will be

(a) nB (b) n^2B

(c) $2nB$ (d) $2n^2B$

(NEET-II 2016)

3. An electron is moving in a circular path under the influence of a transverse magnetic field of 3.57×10^{-2} T. If the value of e/m is 1.76×10^{11} C kg^{-1}, the frequency of revolution of the electron is

(a) 1 GHz (b) 100 MHz

(c) 62.8 MHz (d) 6.28 MHz

(NEET-II 2016)

4. A long straight wire of radius a carries a steady current I. The current is uniformly distributed over its cross-section. The ratio of the magnetic fields B and B', at radial distances $\dfrac{a}{2}$ and $2a$ respectively, from the axis of the wire is

(a) 1 (b) 4

(c) $\dfrac{1}{4}$ (d) $\dfrac{1}{2}$

(NEET-I 2016)

5. A square loop $ABCD$ carrying a current i, is placed near and coplanar with a long straight conductor XY carrying a current I, the net force on the loop will be

(a) $\dfrac{2\mu_0 IiL}{3\pi}$ (b) $\dfrac{\mu_0 IiL}{2\pi}$

(c) $\dfrac{2\mu_0 Ii}{3\pi}$ (d) $\dfrac{\mu_0 Ii}{2\pi}$

(NEET-I 2016)

6. A proton and an alpha particle both enter a region of uniform magnetic field B, moving at right angles to the field B. If the radius of circular orbits for both the particles is equal and the kinetic energy acquired by proton is 1 MeV, the energy acquired by the alpha particle will be

(a) 1.5 MeV (b) 1 MeV

(c) 4 MeV (d) 0.5 MeV

(2015)

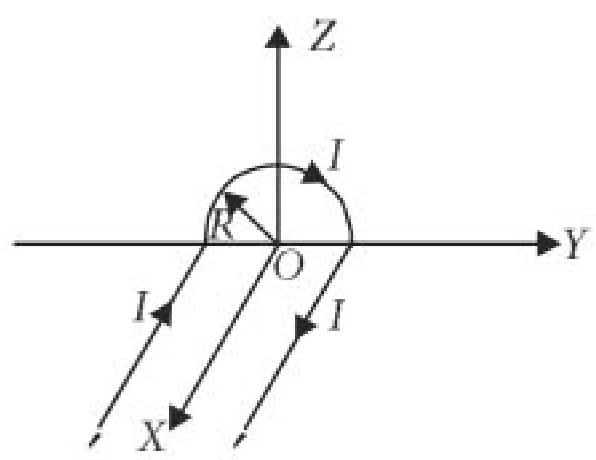
7. An electron moving in a circular orbit of radius r makes n rotations per second. The magnetic field produced at the centre has magnitude

(a) $\dfrac{\mu_0 n^2 e}{r}$ (b) $\dfrac{\mu_0 ne}{2r}$

(c) $\dfrac{\mu_0 ne}{2\pi r}$ (d) Zero

(2015 Cancelled)

8. A wire carrying current I has the shape as shown in adjoining figure.



Linear parts of the wire are very long and parallel to X-axis while semicircular portion of radius R is lying in Y-Z plane. Magnetic field at point O is

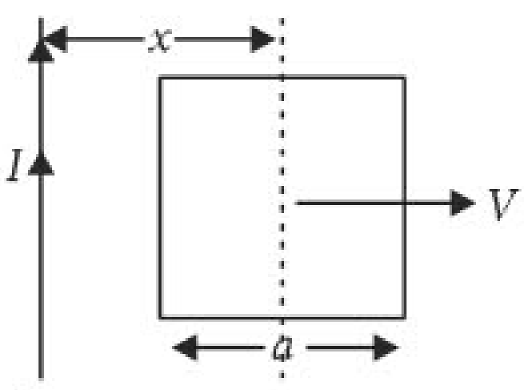
(a) $\vec{B} = -\frac{\mu_0}{4\pi}\frac{I}{R}\left(\pi\hat{i} + 2\hat{k}\right)$

(b) $\vec{B} = \frac{\mu_0}{4\pi}\frac{I}{R}\left(\pi\hat{i} - 2\hat{k}\right)$

(c) $\vec{B} = \frac{\mu_0}{4\pi}\frac{I}{R}\left(\pi\hat{i} + 2\hat{k}\right)$

(d) $\vec{B} = -\frac{\mu_0}{4\pi}\frac{I}{R}\left(\pi\hat{i} - 2\hat{k}\right)$ *(2015 Cancelled)*

9. A conducting square frame of side 'a' and a long straight wire carrying current I are located in the same plane as shown in the figure. The frame moves to the right with a constant velocity 'V'. The emf induced in the frame will be proportional to



(a) $\frac{1}{(2x+a)^2}$ (b) $\frac{1}{(2x-a)(2x+a)}$

(c) $\frac{1}{x^2}$ (d) $\frac{1}{(2x-a)^2}$

(2015 Cancelled)

10. In an ammeter 0.2% of main current passes through the galvanometer. If resistance of galvanometer is G, the resistance of ammeter will be

(a) $\frac{1}{499}G$ (b) $\frac{499}{500}G$

(c) $\frac{1}{500}G$ (d) $\frac{500}{499}G$

(2014)

11. Two identical long conducting wires AOB and COD are placed at right angle to each other, with one above other such that O is their common point for the two. The wires carry I_1 and I_2 currents, respectively. Point P is lying at distance d from O along a direction perpendicular to the plane containing the wires. The magnetic field at the point P will be

(a) $\frac{\mu_0}{2\pi d}\left(\frac{I_1}{I_2}\right)$ (b) $\frac{\mu_0}{2\pi d}(I_1 + I_2)$

(c) $\frac{\mu_0}{2\pi d}(I_1^2 - I_2^2)$ (d) $\frac{\mu_0}{2\pi d}(I_1^2 + I_2^2)^{1/2}$

(2014)

12. When a proton is released from rest in a room, it starts with an initial acceleration a_0 towards west. When it is projected towards north with a speed v_0 it moves with an initial acceleration $3a_0$ toward west. The electric and magnetic fields in the room are

(a) $\frac{ma_0}{e}$ east, $\frac{3ma_0}{ev_0}$ up

(b) $\frac{ma_0}{e}$ east, $\frac{3ma_0}{ev_0}$ down

(c) $\frac{ma_0}{e}$ west, $\frac{2ma_0}{ev_0}$ up

(d) $\frac{ma_0}{e}$ west, $\frac{2ma_0}{ev_0}$ down *(NEET 2013)*

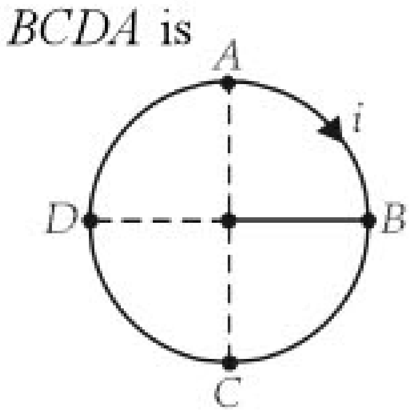
13. A long straight wire carries a certain current and produces a magnetic field 2×10^{-4} Wb m^{-2} at a perpendicular distance of 5 cm from the wire. An electron situated at 5 cm from the wire moves with a velocity 10^7 m/s towards the wire along perpendicular to it. The force experienced by the electron will be (charge on electron 1.6×10^{-19} C)

(a) 3.2 N (b) 3.2×10^{-16} N

(c) 1.6×10^{-16} N (d) zero

(Karnataka NEET 2013)

14. A circular coil $ABCD$ carrying a current 'i' is placed in a uniform magnetic field. If the magnetic force on the segment AB is $\vec{F}$, the force on the remaining segment $BCDA$ is



(a) $-\vec{F}$

(b) $3\vec{F}$

(c) $-3\vec{F}$

(d) $\vec{F}$

(Karnataka NEET 2013)

15. Two similar coils of radius R are lying concentrically with their planes at right angles to each other. The currents flowing in them are I and $2I$, respectively. The resultant magnetic field induction at the centre will be

(a) $\frac{\sqrt{5}\mu_0 I}{2R}$ (b) $\frac{\sqrt{5}\mu_0 I}{R}$

(c) $\frac{\mu_0 I}{2R}$ (d) $\frac{\mu_0 I}{R}$ *(2012)*

16. A milli voltmeter of 25 milli volt range is to be converted into an ammeter of 25 ampere range. The value (in ohm) of necessary shunt will be
(a) 0.001 (b) 0.01
(c) 1 (d) 0.05 *(2012)*

17. An alternating electric field, of frequency υ, is applied across the dees (radius = R) of a cyclotron that is being used to accelerate protons (mass = m). The operating magnetic field (B) used in the cyclotron and the kinetic energy (K) of the proton beam, produced by it, are given by

(a) $B = \frac{m\upsilon}{e}$ and $K = 2m\pi^2\upsilon^2R^2$

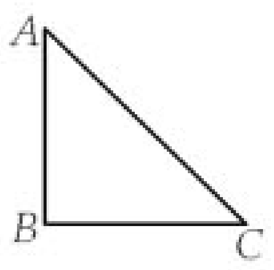
(b) $B = \frac{2\pi m\upsilon}{e}$ and $K = m^2\pi\upsilon R^2$

(c) $B = \frac{2\pi m\upsilon}{e}$ and $K = 2m\pi^2\upsilon^2R^2$

(d) $B = \frac{m\upsilon}{e}$ and $K = m^2\pi\upsilon R^2$ *(2012)*

18. A proton carrying 1 MeV kinetic energy is moving in a circular path of radius R in uniform magnetic field. What should be the energy of an α-particle to describe a circle of same radius in the same field?
(a) 2 MeV (b) 1 MeV
(c) 0.5 MeV (d) 4 MeV
(Mains 2012)

19. A current carrying closed loop in the form of a right angle isosceles triangle ABC is placed in a uniform magnetic field acting along AB. If the magnetic force on the arm BC is $\vec{F}$, the force on the arm AC is



(a) $-\sqrt{2}\,\vec{F}$
(b) $-\vec{F}$
(c) $\vec{F}$
(d) $\sqrt{2}\,\vec{F}$ *(2011)*

20. A uniform electric field and a uniform magnetic field are acting along the same direction in a certain region. If an electron is projected in the region such that its velocity is pointed along the direction of fields, then the electron
(a) will turn towards right of direction of motion
(b) speed will decrease
(c) speed will increase
(d) will turn towards left of direction of motion *(2011)*

21. A galvanometer of resistance, G, is shunted by a resistance S ohm. To keep the main current in the circuit unchanged, the resistance to be put in series with the galvanometer is

(a) $\frac{G}{(S+G)}$ (b) $\frac{S^2}{(S+G)}$

(c) $\frac{SG}{(S+G)}$ (d) $\frac{G^2}{(S+G)}$

(Mains 2011)

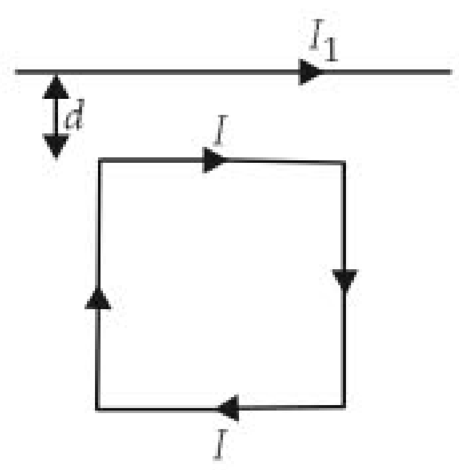
22. Charge q is uniformly spread on a thin ring of radius R. The ring rotates about its axis with a uniform frequency f Hz. The magnitude of magnetic induction at the center of the ring is

(a) $\frac{\mu_0 qf}{2\pi R}$ (b) $\frac{\mu_0 qf}{2R}$

(c) $\frac{\mu_0 q}{2fR}$ (d) $\frac{\mu_0 q}{2\pi fR}$

(Mains 2011, 2010)

23. A square loop, carrying a teady current I, is placed in a horizontal plane near a long straight conductor carrying a steady current I_1 at a distance d from the conductor as shown in figure. The loop will experience



(a) a net attractive force towards the conductor
(b) a net repulsive force away from the conductor
(c) a net torque acting upward perpendicular to the horizontal plane
(d) a net torque acting downward normal to the horizontal plane *(Mains 2011)*

24. A galvanometer has a coil of resistance 100 ohm and gives a full scale deflection for 30 mA current. If it is to work as a voltmeter of 30 volt range, the resistance required to be added will be
(a) 900 Ω (b) 1800 Ω
(c) 500 Ω (d) 1000 Ω *(2010)*

25. A square current carrying loop is suspended in a uniform magnetic field acting in the plane of the loop. If the force on one arm of the loop is the net force on the remaining three arms of the loop is

(a) $3\vec{F}$ (b) $-\vec{F}$
(c) $-3\vec{F}$ (d) $\vec{F}$ *(2010)*

26. A current loop consists of two identical semicircular parts each of radius R, one lying in the x-y plane and the other in x-z plane. If the current in the loop is i. The resultant magnetic field due to the two semicircular parts at their common centre is

(a) $\frac{\mu_0 i}{2\sqrt{2}R}$ (b) $\frac{\mu_0 i}{2R}$
(c) $\frac{\mu_0 i}{4R}$ (d) $\frac{\mu_0 i}{\sqrt{2}R}$ *(Mains 2010)*

27. A closely wound solenoid of 2000 turns and area of cross-section 1.5×10^{-4} m^2 carries a current of 2.0 A. It is suspended through its centre and perpendicular to its length, allowing it to turn in a horizontal plane in a uniform magnetic field 5×10^{-2} tesla making an angle of 30° with the axis of the solenoid. The torque on the solenoid will be

(a) 3×10^{-3} N m (b) 1.5×10^{-3} N m
(c) 1.5×10^{-2} N m (d) 3×10^{-2} N m *(Mains 2010)*

28. A particle having a mass of 10^{-2} kg carries a charge of 5×10^{-8} C. The particle is given an initial horizontal velocity of 10^5 m s^{-1} in the presence of electric field $\vec{E}$ and magnetic field $\vec{B}$. To keep the particle moving in a horizontal direction, it is necessary that

(1) $\vec{B}$ should be perpendicular to the direction of velocity and $\vec{E}$ should be along the direction of velocity
(2) Both $\vec{B}$ and $\vec{E}$ should be along the direction of velocity
(3) Both $\vec{B}$ and $\vec{E}$ are mutually perpendicular and perpendicular to the direction of velocity.
(4) $\vec{B}$ should be along the direction of velocity and $\vec{E}$ should be perpendicular to the direction of velocity

Which one of the following pairs of statements is possible?

(a) (1) and (3) (b) (3) and (4)
(c) (2) and (3) (d) (2) and (4) *(Mains 2010)*

29. A galvanometer having a coil resistance of 60 Ω shows full scale deflection when a current of 1.0 amp passes through it. It can be converted into an ammeter to read currents upto 5.0 amp by

(a) putting in series a resistance of 15 Ω
(b) putting in series a resistance of 240 Ω
(c) putting in parallel a resistance of 15 Ω
(d) putting in parallel a resistance of 240 Ω *(2009)*

30. The magnetic force acting on a charged particle of charge -2 μC in a magnetic field of 2 T acting in y direction, when the particle velocity is $(2\hat{i}+3\hat{j})\times 10^6$ ms^{-1} is

(a) 4 N in z direction
(b) 8 N in y direction
(c) 8 N in z direction
(d) 8 N in $-z$ direction *(2009)*

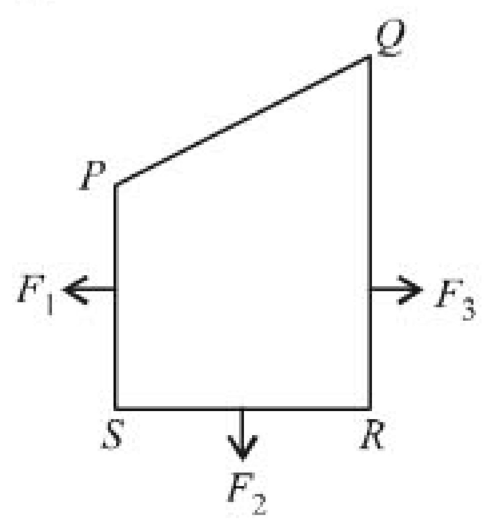
31. Under the influence of a uniform magnetic field, a charged particle moves with constant speed v in a circle of radius R. The time period of rotation of the particle

(a) depends on R and not on v
(b) is independent of both v and R
(c) depends on both v and R
(d) depends on v and not on R *(2009, 2007)*

32. A particle of mass m, charge Q and kinetic energy T enters a transverse uniform magnetic field of induction $\vec{B}$. After 3 seconds the kinetic energy of the particle will be

(a) T (b) $4T$
(c) $3T$ (d) $2T$ *(2008)*

33.



A closed loop $PQRS$ carrying a current is placed in a uniform magnetic field. If the magnetic forces on segments PS, SR and RQ are F_1, F_2 and F_3 respectively and are in the plane of the paper and along the directions shown, the force on the segment QP is

(a) $\sqrt{(F_3 - F_1)^2 - F_2^2}$ (b) $F_3 - F_1 + F_2$
(c) $F_3 - F_1 - F_2$ (d) $\sqrt{(F_3 - F_1)^2 + F_2^2}$ *(2008)*

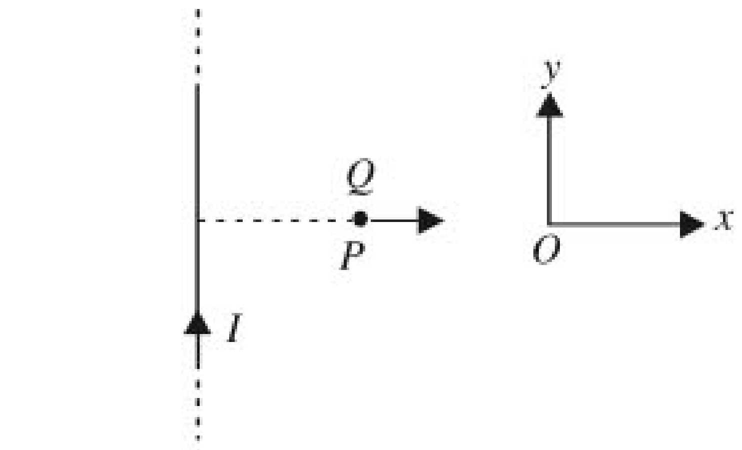
34. A galvanometer of resistance 50 Ω is connected to a battery of 3 V along with a resistance of 2950 Ω in series. A full scale deflection of 30 divisions is obtained in the galvanometer. In order to reduce this deflection to 20 divisions, the resistance in series should be
(a) 6050 Ω (b) 4450 Ω
(c) 5050 Ω (d) 5550 Ω *(2008)*

35. The resistance of an ammeter is 13 Ω and its scale is graduated for a current upto 100 amps. After an additional shunt has been connected to this ammeter it becomes possible to measure currents upto 750 amperes by this meter. The value of shunt-resistance is
(a) 2 Ω (b) 0.2 Ω
(c) 2 kΩ (d) 20 Ω. *(2007)*

36. When a charged particle moving with velocity $\vec{v}$ is subjected to a magnetic field of induction $\vec{B}$, the force on it is non-zero. This implies that
(a) angle between is either zero or 180°
(b) angle between is necessarily 90°
(c) angle between can have any value other than 90°
(d) angle between can have any value other than zero and 180°. *(2006)*

37. Two circular coils 1 and 2 are made from the same wire but the radius of the 1st coil is twice that of the 2nd coil. What potential difference in volts should be applied across them so that the magnetic field at their centres is the same?
(a) 2 (b) 3
(c) 4 (d) 6. *(2006)*

38. A very long straight wire carries a current I. At the instant when a charge $+Q$ at point P has velocity $\vec{v}$, as shown, the force on the charge is



(a) along Oy (b) opposite to Oy
(c) along Ox (d) opposite to Ox. *(2005)*

39. An electron moves in a circular orbit with a uniform speed v. It produces a magnetic field B at the centre of the circle. The radius of the circle is proportional to
(a) $\sqrt{B/v}$ (b) B/v
(c) $\sqrt{v/B}$ (d) v/B *(2005)*

40. A galvanometer of 50 ohm resistance has 25 divisions. A current of 4×10^{-4} ampere gives a deflection of one division. To convert this galvanometer into a voltmeter having a range of 25 volts, it should be connected with a resistance of
(a) 2500 Ω as a shunt (b) 2450 Ω as a shunt
(c) 2550 Ω in series (d) 2450 Ω in series *(2004)*

41. To convert a galvanometer into a voltmeter one should connect a
(a) high resistance in series with galvanometer
(b) low resistance in series with galvanometer
(c) high resistance in parallel with galvanometer
(d) low resistance in parallel with galvanometer. *(2004, 2002)*

42. A charged particle moves through a magnetic field in a direction perpendicular to it. Then the
(a) speed of the particle remains unchanged
(b) direction of the particle remains unchanged
(c) acceleration remains unchanged
(d) velocity remains unchanged *(2003)*

43. A long solenoid carrying a current produces a magnetic field B along its axis. If the current is doubled and the number of turns per cm is halved, the new value of the magnetic field is
(a) $B/2$ (b) B
(c) $2B$ (d) $4B$ *(2003)*

44. A charge q moves in a region where electric field and magnetic field both exist, then force on it is

(a) $q(\vec{v} \times \vec{B})$ (b) $q\vec{E} + q(\vec{v} \times \vec{B})$

(c) $q\vec{E} + \vec{q}\,(\vec{B} \times \vec{v})$ (d) $q\vec{B} + q(\vec{E} \times \vec{v})$.

(2002)

45. The magnetic field of given length of wire for single turn coil at its centre is B then its value for two turns coil for the same wire is

(a) $B/4$ (b) $B/2$

(c) $4B$ (d) $2B$. *(2002)*

46. If number of turns, area and current through a coil is given by n, A and i respectively then its magnetic moment will be

(a) niA (b) n^2iA

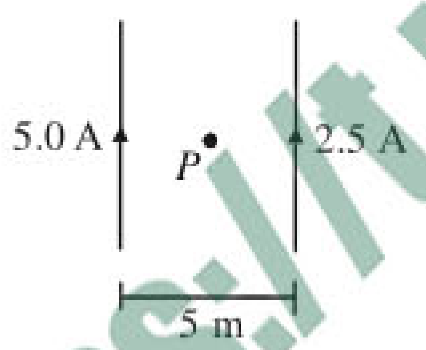
(c) niA^2 (d) $\frac{ni}{\sqrt{A}}$. *(2001)*

47. An electron having mass m and kinetic energy E enter in uniform magnetic field B perpendicularly, then its frequency will be

(a) $\frac{eE}{qvB}$ (b) $\frac{2\pi m}{eB}$

(c) $\frac{eB}{2\pi m}$ (d) $\frac{2m}{eBE}$. *(2001)*

48. The magnetic field at centre, P will be



(a) $\frac{\mu_0}{4\pi}$ (b) $\frac{\mu_0}{\pi}$

(c) $\frac{\mu_0}{2\pi}$ (d) $4\mu_0\pi$. *(2000)*

49. Magnetic field due to 0.1 A current flowing through a circular coil of radius 0.1 m and 1000 turns at the centre of the coil is

(a) 6.28×10^{-4} T (b) 4.31×10^{-2} T

(c) 2×10^{-1} T (d) 9.81×10^{-4} T

(1999)

50. A straight wire of diameter 0.5 mm carrying a current of 1 A is replaced by the another wire of 1 mm diameter carrying the same current. The strength of the magnetic field far away is

(a) one-quarter of the earlier value

(b) one-half of the earlier value

(c) twice the earlier value

(d) same as the earlier value *(1999, 1997)*

51. If a long hollow copper pipe carries a current, then produced magnetic field will be

(a) both inside and outside the pipe

(b) outside the pipe only

(c) inside the pipe only

(d) neither inside nor outside the pipe *(1999)*

52. Magnetic field intensity at the centre of coil of 50 turns, radius 0.5 m and carrying a current of 2 A, is

(a) 3×10^{-5} T (b) 1.25×10^{-4} T

(c) 0.5×10^{-5} T (d) 4×10^{6} T *(1999)*

53. A charge having e/m equal to 10^8 C/kg and with velocity 3×10^5 m/s enters into a uniform magnetic field $B = 0.3$ tesla at an angle 30° with direction of field. The radius of curvature will be

(a) 0.01 cm (b) 0.5 cm

(c) 1 cm (d) 2 cm. *(1999)*

54. Two long parallel wires are at a distance of 1 metre. Both of them carry one ampere of current. The force of attraction per unit length between the two wires is

(a) 5×10^{-8} N/m (b) 2×10^{-8} N/m

(c) 2×10^{-7} N/m (d) 10^{-7} N/m

(1998)

55. A galvanometer having a resistance of 9 ohm is shunted by a wire of resistance 2 ohm. If the total current is 1 amp, the part of it passing through the shunt will be

(a) 0.2 amp (b) 0.8 amp

(c) 0.25 amp (d) 0.5 amp *(1998)*

56. A coil of one turn is made of a wire of certain length and then from the same length a coil of two turns is made. If the same current is passed in both the cases, then the ratio of the magnetic inductions at their centres will be

(a) 4 : 1 (b) 1 : 4

(c) 2 : 1 (d) 1 : 2 *(1998)*

57. Two parallel wires in free space are 10 cm apart and each carries a current of 10 A in the same direction. The force exerted by one wire on the other, per metre length is

(a) 2×10^{-4} N, repulsive

(b) 2×10^{-7}N, repulsive

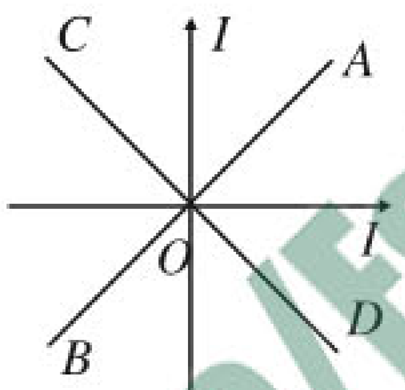
(c) 2×10^{-4} N, attractive

(d) 2×10^{-7}N, attractive. *(1997)*

58. A positively charged particle moving due East enters a region of uniform magnetic field directed vertically upwards. This particle will
(a) move in a circular path with a decreased speed
(b) move in a circular path with a uniform speed
(c) get deflected in vertically upward direction
(d) move in circular path with an increased speed. *(1997)*

59. Tesla is the unit of
(a) electric field (b) magnetic field
(c) electric flux (d) magnetic flux. *(1997, 1988)*

60. Two equal electric currents are flowing perpendicular to each other as shown in the figure. AB and CD are perpendicular to each other and symmetrically placed with respect to the currents. Where do we expect the resultant magnetic field to be zero?



(a) On CD
(b) On AB
(c) On both OD and BO
(d) On both AB and CD. *(1996)*

61. The magnetic field $d\vec{B}$ due to a small current element $d\vec{l}$ at a distance $\vec{r}$ and element carrying current i is

(a) $d\vec{B} = \frac{\mu_0}{4\pi} i^2 \left(\frac{d\vec{l} \times \vec{r}}{r} \right)$

(b) $d\vec{B} = \frac{\mu_0}{4\pi} i \left(\frac{d\vec{l} \times \vec{r}}{r^3} \right)$

(c) $d\vec{B} = \frac{\mu_0}{4\pi} i \left(\frac{d\vec{l} \times \vec{r}}{r} \right)$

(d) $d\vec{B} = \frac{\mu_0}{4\pi} i^2 \left(\frac{d\vec{l} \times \vec{r}}{r^2} \right)$ *(1996)*

62. A 10 eV electron is circulating in a plane at right angles to a uniform field at magnetic induction 10^{-4} Wb/m^2 (= 1.0 gauss), the orbital radius of electron is
(a) 11 cm (b) 18 cm
(c) 12 cm (d) 16 cm. *(1996)*

63. A beam of electrons is moving with constant velocity in a region having electric and magnetic fields of strength 20 Vm^{-1} and 0.5 T at right angles to the direction of motion of the electrons. What is the velocity of the electrons?
(a) 8 ms^{-1} (b) 5.5 ms^{-1}
(c) 20 ms^{-1} (d) 40 ms^{-1}. *(1996)*

64. A circular loop of area 0.01 m^2 carrying a current of 10 A, is held perpendicular to a magnetic field of intensity 0.1 T. The torque acting on the loop is
(a) 0.001 N m (b) 0.8 N m
(c) zero (d) 0.01 N m. *(1994)*

65. A charge moving with velocity v in X-direction is subjected to a field of magnetic induction in negative X-direction. As a result, the charge will
(a) remain unaffected
(b) start moving in a circular path Y-Z plane
(c) retard along X-axis
(d) moving along a helical path around X-axis *(1993)*

66. A coil carrying electric current is placed in uniform magnetic field
(a) torque is formed
(b) e.m.f is induced
(c) both (a) and (b) are correct
(d) none of these *(1993)*

67. To convert a galvanometer into a ammeter, one needs to connect a
(a) low resistance in parallel
(b) high resistance in parallel
(c) low resistance in series
(d) high resistance in series *(1992)*

68. A straight wire of length 0.5 metre and carrying a current of 1.2 ampere is placed in uniform magnetic field of induction 2 tesla. The magnetic field is perpendicular to the length of the wire. The force on the wire is
(a) 2.4 N (b) 1.2 N
(c) 3.0 N (d) 2.0 N *(1992)*

69. The magnetic field at a distance r from a long wire carrying current i is 0.4 tesla. The magnetic field at a distance $2r$ is
(a) 0.2 tesla (b) 0.8 tesla
(c) 0.1 tesla (d) 1.6 tesla *(1992)*

70. A uniform magnetic field acts right angles to the direction of motion of electrons. As a result, the electron moves in a circular path of radius 2 cm. If the speed of electrons is doubled, then the radius of the circular path will be

(a) 2.0 cm (b) 0.5 cm
(c) 4.0 cm (d) 1.0 cm *(1991)*

71. A deuteron of kinetic energy 50 keV is describing a circular orbit of radius 0.5 metre in a plane perpendicular to magnetic field B. The kinetic energy of the proton that describes a circular orbit of radius 0.5 metre in the same plane with the same B is

(a) 25 keV (b) 50 keV
(c) 200 keV (d) 100 keV *(1991)*

72. The magnetic induction at a pont point P which is at the distance of 4 cm from a long current carrying wire is 10^{-3} T. The field of induction at a distance 12 cm from the current will be

(a) 3.33×10^{-4} T (b) 1.11×10^{-4} T
(c) 33×10^{-3} T (d) 9×10^{-3} T
(1990)

73. Energy in a current carrying coil is stored in the form of

(a) electric field only
(b) magnetic field only
(c) dielectric strength
(d) both (a) and (b) *(1989)*

74. A current carrying coil is subjected to a uniform magnetic field. The coil will orient so that its plane becomes

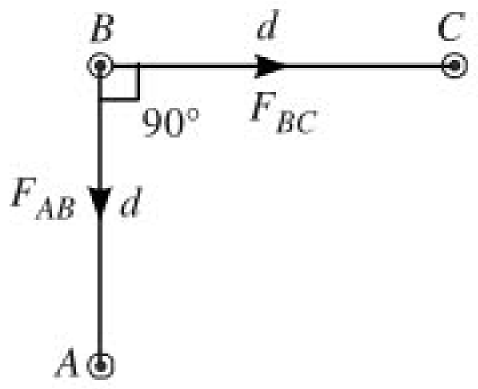
(a) inclined at 45° to the magnetic field
(b) inclined at any arbitrary angle to the magnetic field
(c) parallel to the magnetic field
(d) perpendicular to magnetic field *(1988)*

Answer Key

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

EXPLANATIONS

1. **(c) :** Force between wires A and B = force between wires B and C



$\therefore \quad F_{BC} = F_{AB} = \dfrac{\mu_0 I^2 l}{2\pi d}$

As, $\vec{F}_{AB} \perp \vec{F}_{BC}$ net force on wire B,

$$F_{\text{net}} = \sqrt{2} F_{BC} = \frac{\sqrt{2}\mu_o I^2 l}{2\pi d}$$

$$F_{\text{net}} = \frac{\mu_o I^2 l}{\sqrt{2}\pi d} \quad \text{or} \quad \frac{F_{\text{net}}}{l} = \frac{\mu_o I^2}{\sqrt{2}\pi d}$$

2. **(b) :** Let l be the length of the wire. Magnetic field at the centre of the loop is

$$B = \frac{\mu_0 I}{2R}$$

$$\therefore \quad B = \frac{\mu_0 \pi I}{l} \qquad (\because l = 2\pi R) \qquad \text{...(i)}$$

$$B' = \frac{\mu_0 n I}{2r} = \frac{\mu_0 n I}{2\left(\dfrac{l}{2n\pi}\right)}$$

$$B' = \frac{\mu_0 n^2 \pi I}{l} \qquad \text{...(ii)}$$

From eqns. (i) and (ii), we get

$B' = n^2 B$

3. **(a) :** Here, $B = 3.57 \times 10^{-2}$ T,

$\dfrac{e}{m} = 1.76 \times 10^{11}$ C kg^{-1}

Frequency of revolution of the electron,

$$\upsilon = \frac{1}{T} = \frac{v}{2\pi r} \qquad \text{...(i)}$$

$$\text{Also, } \frac{mv^2}{r} = evB \Rightarrow \frac{v}{r} = \frac{eB}{m} \qquad \text{...(ii)}$$

From eqns. (i) and (ii),

$$\upsilon = \frac{1}{2\pi} \times \frac{eB}{m} = \frac{1}{2 \times 3.14} \times 1.76 \times 10^{11} \times 3.57 \times 10^{-2}$$

$= 10^9$ Hz $= 1$ GHz

4. **(a) :** Magnetic field at a point inside the wire at distance $r\left(= \dfrac{a}{2}\right)$ from the axis of wire is

$$B = \frac{\mu_0 I}{2\pi a^2} r = \frac{\mu_0 I}{2\pi a^2} \times \frac{a}{2} = \frac{\mu_0 I}{4\pi a}$$

Magnetic field at a point outside the wire at distance $r(= 2a)$ from the axis of wire is

$$B' = \frac{\mu_0 I}{2\pi r} = \frac{\mu_0 I}{2\pi} \times \frac{1}{2a} = \frac{\mu_0 I}{4\pi a} \quad \therefore \quad \frac{B}{B'} = 1$$

5. **(c) :** Force on arm AB due to current in conductor XY is

$$F_1 = \frac{\mu_0}{4\pi} \frac{2IiL}{(L/2)} = \frac{\mu_0 Ii}{\pi}$$

acting towards XY in the plane of loop.

Force on arm CD due to current in conductor XY is

$$F_2 = \frac{\mu_0}{4\pi} \frac{2IiL}{3(L/2)} = \frac{\mu_0 Ii}{3\pi}$$

acting away from XY in the plane of loop.

$\therefore$ Net force on the loop = $F_1 - F_2$

$$= \frac{\mu_0 Ii}{\pi}\left[1 - \frac{1}{3}\right] = \frac{2}{3}\frac{\mu_0 Ii}{\pi}$$

6. **(b) :** The kinetic energy acquired by a charged particle in a uniform magnetic field B is

$$K = \frac{q^2 B^2 R^2}{2m} \quad \left(\text{as} \quad R = \frac{mv}{qB} = \frac{\sqrt{2mK}}{qB}\right)$$

where q and m are the charge and mass of the particle and R is the radius of circular orbit.

$\therefore$ The kinetic energy acquired by proton is

$$K_p = \frac{q_p^2 B^2 R_p^2}{2m_p}$$

and that by the alpha particle is

$$K_\alpha = \frac{q_\alpha^2 B^2 R_\alpha^2}{2m_\alpha}$$

$$\text{Thus, } \frac{K_\alpha}{K_p} = \left(\frac{q_\alpha}{q_p}\right)^2 \left(\frac{m_p}{m_\alpha}\right)\left(\frac{R_\alpha}{R_p}\right)^2$$

$$\text{or} \quad K_\alpha = K_p \left(\frac{q_\alpha}{q_p}\right)^2 \left(\frac{m_p}{m_\alpha}\right)\left(\frac{R_\alpha}{R_p}\right)^2$$

Here, $K_p = 1$ MeV, $\dfrac{q_\alpha}{q_p} = 2$, $\dfrac{m_p}{m_\alpha} = \dfrac{1}{4}$

and $\dfrac{R_\alpha}{R_p} = 1$

$\therefore \quad K_\alpha = (1\text{ MeV})(2)^2\left(\frac{1}{4}\right)(1)^2 = 1\text{ MeV}$

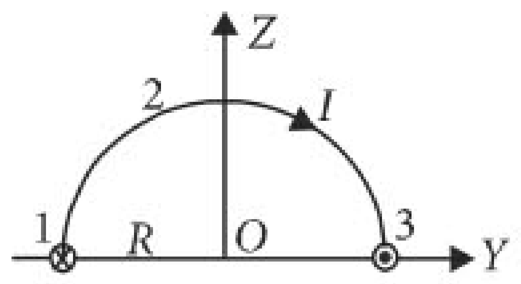
7. **(b)** : Current in the orbit, $I = \frac{e}{T}$

$$I = \frac{e}{(2\pi/\omega)} = \frac{\omega e}{2\pi} = \frac{(2\pi n)e}{2\pi} = ne$$

Magnetic field at centre of current carrying circular coil is given by

$$B = \frac{\mu_0 I}{2r} = \frac{\mu_0 ne}{2r}$$

8. **(a)** : Given situation is shown in the figure.



Parallel wires 1 and 3 are semi-infinite, so magnetic field at O due to them

$$\vec{B}_1 = \vec{B}_3 = -\frac{\mu_0 I}{4\pi R}\hat{k}$$

Magnetic field at O due to semi-circular arc in YZ-plane is given by $\vec{B}_2 = -\frac{\mu_0 I}{4R}\hat{i}$

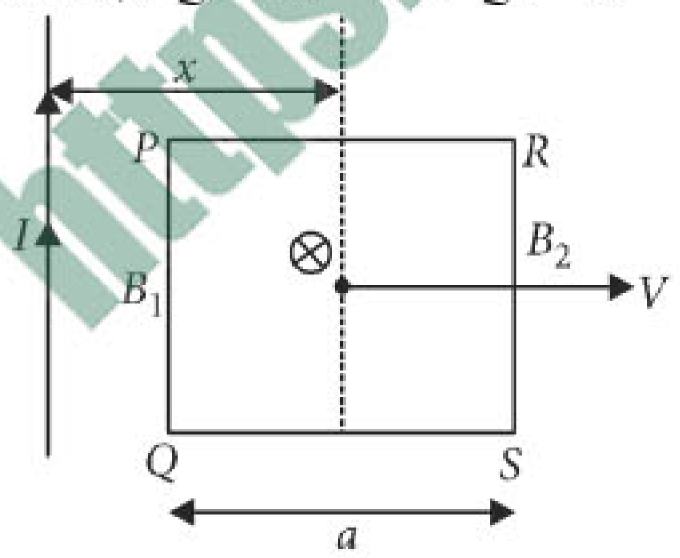
Net magnetic field at point O is given by

$$\vec{B} = \vec{B}_1 + \vec{B}_2 + \vec{B}_3$$

$$= -\frac{\mu_0 I}{4\pi R}\hat{k} - \frac{\mu_0 I}{4R}\hat{i} - \frac{\mu_0 I}{4\pi R}\hat{k}$$

$$= -\frac{\mu_0 I}{4\pi R}(\pi\hat{i} + 2\hat{k})$$

9. **(b)** : Here, $PQ = RS = PR = QS = a$



Emf induced in the frame

$$\varepsilon = B_1(PQ)V - B_2(RS)V$$

$$= \frac{\mu_0 I}{2\pi(x - a/2)}aV - \frac{\mu_0 I}{2\pi(x + a/2)}aV$$

$$= \frac{\mu_0 I}{2\pi}\left[\frac{2}{(2x-a)} - \frac{2}{(2x+a)}\right]aV$$

$$= \frac{\mu_0 I}{2\pi} \times 2\left[\frac{2a}{(2x-a)(2x+a)}\right]aV$$

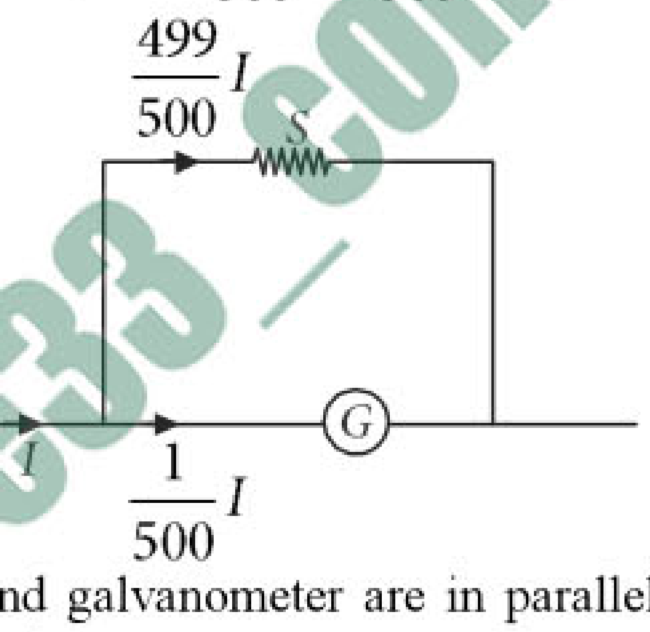
$$\therefore \quad \varepsilon \propto \frac{1}{(2x-a)(2x+a)}$$

10. **(c)** : Here, resistance of the galvanometer = G
Current through the galvanometer,

$$I_G = 0.2\% \text{ of } I = \frac{0.2}{100}I = \frac{1}{500}I$$

$\therefore$ Current through the shunt,

$$I_S = I - I_G = I - \frac{1}{500}I = \frac{499}{500}I$$



As shunt and galvanometer are in parallel

$\therefore \quad I_G G = I_S S$

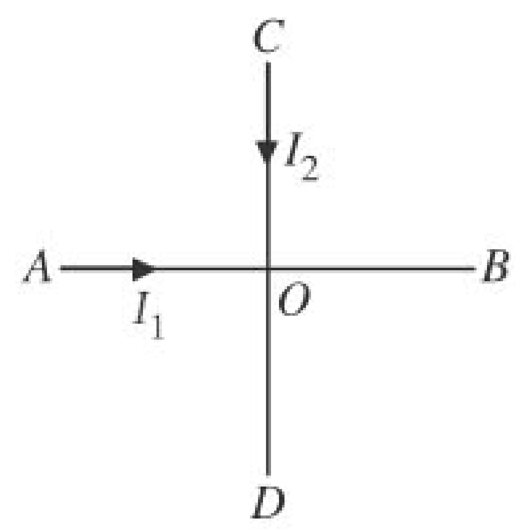
$$\left(\frac{1}{500}I\right)G = \left(\frac{499}{500}\right)S \text{ or } S = \frac{G}{499}$$

Resistance of the ammeter R_A is

$$\frac{1}{R_A} = \frac{1}{G} + \frac{1}{S} = \frac{1}{G} + \frac{1}{\frac{G}{499}} = \frac{500}{G}$$

$$R_A = \frac{1}{500}G$$

11. **(d)** : The magnetic field at the point P, at a perpendicular distance d from O in a direction perpendicular to the plane $ABCD$ due to currents through AOB and COD are perpendicular to each other. Hence,

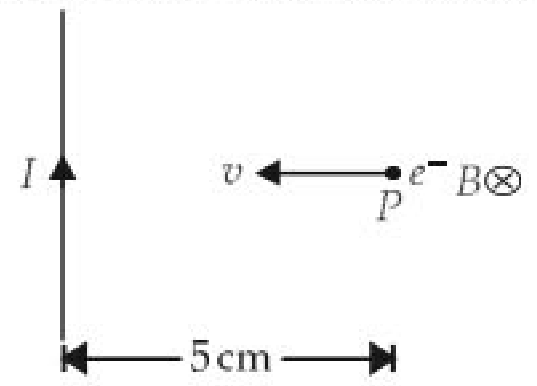


$$B = (B_1^2 + B_2^2)^{1/2} = \left[\left(\frac{\mu_0}{4\pi}\frac{2I_1}{d}\right)^2 + \left(\frac{\mu_0}{4\pi}\frac{2I_2}{d}\right)^2\right]^{1/2}$$

$$= \frac{\mu_0}{2\pi d}(I_1^2 + I_2^2)^{1/2}$$

12. **(d)**

13. (b) : The situation is as shown in the figure.



Here, $v = 10^7$ m/s, $B = 2 \times 10^{-4}$ Wb/m^2

The magnitude of the force experienced by the electron is

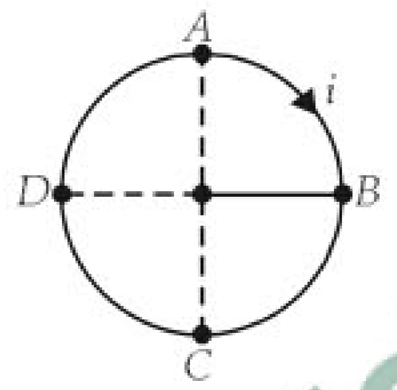
$F = evB\sin\theta$

($\because$ $\vec{v}$ and $\vec{B}$ are perpendicular to each other)

$= evB\sin 90° = 1.6 \times 10^{-19} \times 10^7 \times 2 \times 10^{-4} \times 1$

$= 3.2 \times 10^{-16}$ N

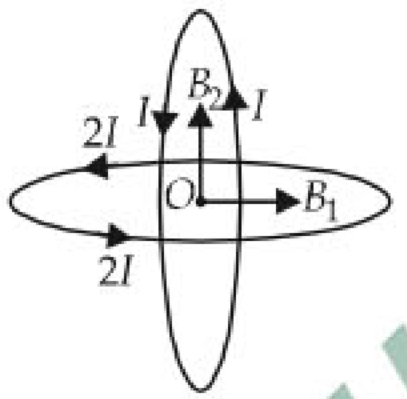
14. (a) : The net magnetic force on a current loop in a uniform magnetic field is always zero.



$\therefore \quad \vec{F}_{AB} + \vec{F}_{BCDA} = 0$

$\vec{F}_{BCDA} = -\vec{F}_{AB} = -\vec{F}$

15. (a) :



Magnetic field induction due to vertical loop at the centre O is

$$B_1 = \frac{\mu_0 I}{2R}$$

It acts in horizontal direction.

Magnetic field induction due to horizontal loop at the centre O is

$$B_2 = \frac{\mu_0 2I}{2R}$$

It acts in vertically upward direction.

As B_1 and B_2 are perpendicular to each other, therefore the resultant magnetic field induction at the centre O is

$$B_{\text{net}} = \sqrt{B_1^2 + B_2^2} = \sqrt{\left(\frac{\mu_0 I}{2R}\right)^2 + \left(\frac{\mu_0 2I}{2R}\right)^2}$$

$$B_{\text{net}} = \frac{\mu_0 I}{2R}\sqrt{(1)^2 + (2)^2} = \frac{\sqrt{5}\mu_0 I}{2R}$$

16. (a) : $S = \dfrac{V_g}{(I - I_g)}$

Neglecting I_g

$$\therefore \quad S = \frac{V_g}{I} = \frac{25 \times 10^{-3}\text{ V}}{25\text{ A}} = 0.001\ \Omega$$

17. (c) : Frequency, $\upsilon = \dfrac{eB}{2\pi m}$

or $B = \dfrac{2\pi m\upsilon}{e}$ ...(i)

As $\dfrac{mv^2}{R} = evB$

or $v = \dfrac{eBR}{m} = \dfrac{e2\pi m\upsilon R}{me}$ (Using (i))

$= 2\pi\upsilon R$ ...(ii)

Kinetic energy, $K = \dfrac{1}{2}mv^2 = \dfrac{1}{2}m(2\pi\upsilon R)^2$ (Using (ii))

$= 2m\pi^2\upsilon^2 R^2$

18. (b) : Kinetic energy of a charged particle,

$K = \dfrac{1}{2}mv^2$ or $v = \sqrt{\dfrac{2K}{m}}$

Radius of the circular path of a charged particle in uniform magnetic field is given by

$$R = \frac{mv}{Bq} = \frac{m}{Bq}\sqrt{\frac{2K}{m}} = \frac{\sqrt{2mK}}{Bq}$$

Mass of a proton, $m_p = m$

Mass of an α-particle, $m_\alpha = 4m$

Charge of a proton, $q_p = e$

Charge of an α -particle, $q_\alpha = 2e$

$$\therefore \quad R_p = \frac{\sqrt{2m_pK_p}}{Bq_p} = \frac{\sqrt{2mK_p}}{Be}$$

and $R_\alpha = \dfrac{\sqrt{2m_\alpha K_\alpha}}{Bq_\alpha} = \dfrac{\sqrt{2(4m)K_\alpha}}{B(2e)} = \dfrac{\sqrt{2mK_\alpha}}{Be}$

$$\therefore \quad \frac{R_p}{R_\alpha} = \sqrt{\frac{K_p}{K_\alpha}}$$

As $R_p = R_\alpha$ (given) $\quad \therefore \quad K_\alpha = K_p = 1$ MeV

19. (b) : Here, $\vec{F}_{BC} = \vec{F}$

$\because \quad \vec{F}_{AB} = 0$

The net magnetic force on a current carrying closed loop in a uniform magnetic field is zero.

$\therefore \quad \vec{F}_{AB} + \vec{F}_{BC} + \vec{F}_{AC} = 0$

$\Rightarrow \quad \vec{F}_{AC} = -\vec{F}_{BC} \qquad (\because \vec{F}_{AB} = 0)$

20. (b) : Force on electron due to electric field,

$\vec{F}_E = -e\vec{E}$

Force on electron due to magnetic field,

$\vec{F}_B = -e(\vec{v} \times \vec{B}) = 0$

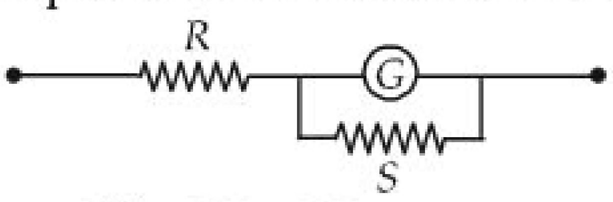
Since $\vec{v}$ and $\vec{B}$ are in the same direction.

Total force on the electron,

$\vec{F} = \vec{F}_E + \vec{F}_B = -e\vec{E}$

Electric field opposes the motion of the electron, hence speed of the electron will decrease.

21. (d) : Let resistance R is to be put in series with galvanometer G to keep the main current in the circuit unchanged.



$\therefore \quad \frac{GS}{G+S} + R = G$

$R = G - \frac{GS}{G+S} \Rightarrow R = \frac{G^2 + GS - GS}{G+S}$

$R = \frac{G^2}{G+S}$

22. (b) : The current flowing in the ring is

$I = qf$ ...(i)

The magnetic induction at the centre of the ring is

$B = \frac{\mu_0 2\pi I}{4\pi R} = \frac{\mu_0 q f}{2R}$ (Using (i))

23. (a)

24. (a) : Here,

Resistance of galvanometer, $G = 100\ \Omega$

Current for full scale deflection, $I_g = 30$ mA $= 30 \times 10^{-3}$ A

Range of voltmeter, $V = 30$ V

To convert the galvanometer into an voltmeter of a given range, a resistance R is connected in series with it as shown in the figure.

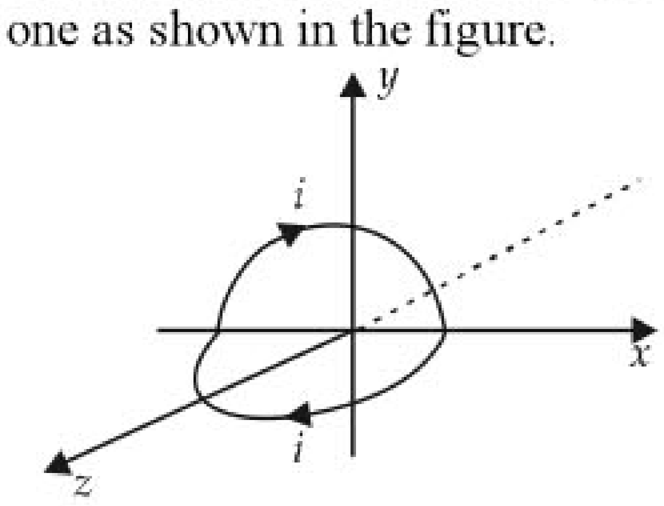
From figure, $V = I_g(G + R)$

or $\quad R = \frac{V}{I_g} - G = \frac{30}{30 \times 10^{-3}} - 100\ \Omega$

$= 1000 - 100 = 900\ \Omega$

25. (b)

26. (a) : The loop mentioned in the question must look like one as shown in the figure.



Magnetic field at the centre due to semicircular loop lying in x-y plane, $B_{xy} = \frac{1}{2}\left(\frac{\mu_0 i}{2R}\right)$ negative z direction.

Similarly field due to loop in x-z plane,

$B_{xz} = \frac{1}{2}\left(\frac{\mu_0 i}{2R}\right)$ in negative y direction.

$\therefore$ Magnitude of resultant magnetic field,

$$B = \sqrt{B_{xy}^2 + B_{xz}^2} = \sqrt{\left(\frac{\mu_0 i}{4R}\right)^2 + \left(\frac{\mu_0 i}{4R}\right)^2}$$

$$= \frac{\mu_0 i}{4R}\sqrt{2} = \frac{\mu_0 i}{2\sqrt{2}R}$$

27. (c) : Magnetic moment of the loop.

$M = NIA = 2000 \times 2 \times 1.5 \times 10^{-4} = 0.6$ J/T

Torque $\tau = MB\sin 30°$

$= 0.6 \times 5 \times 10^{-2} \times \frac{1}{2} = 1.5 \times 10^{-2}$ N m

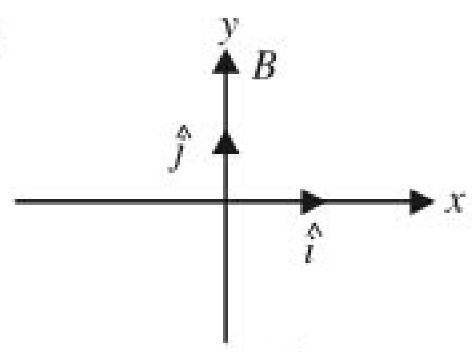
28. (c)

29. (c) : $iG = (I - i)S$ where G is the galvanometer resistance and S is the shunt used with the ammeter.

$1.0 \times 60 = (5 - 1)S$ where S is the shunt used to read a 5 A current when the galvanometer can stand by 1 A.

$S = \frac{1.0 \times 60}{4} = 15\ \Omega$ in parallel.

30. (d) :



Lorentz force $= q(\vec{v} \times \vec{B})$

$= (-2 \times 10^{-6})[(2\hat{i} + 3\hat{j}) \times 10^6 \times 2\hat{j}] = -8\hat{k}$ N.

$= 8$ N in $-z$ direction.

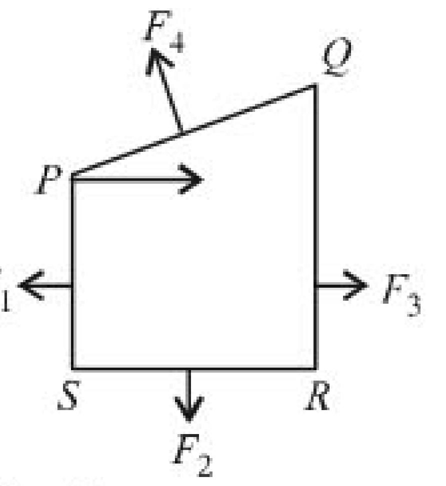
31. (b) : For the circular motion in a cyclotron,

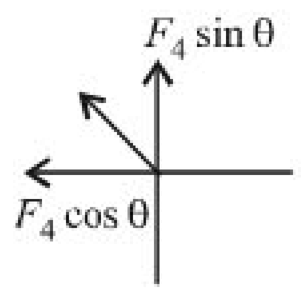
$qvB = \frac{mv^2}{r} \Rightarrow qB = m\omega = \frac{m \times 2\pi}{T}$

$\therefore \quad T = \frac{2\pi m}{qB}$ is independent of v and r.

32. (a) : When a charged particle having a given K.E, T enters in a field of magnetic induction, which is perpendicular to its velocity, it takes a circular trajectory. It does not increase in energy, therefore T is the K.E.

33. (d) :





$F_4 \sin\theta = F_2$

$F_4 \cos\theta = (F_3 - F_1)$

$\therefore \; F_4 = \sqrt{(F_3 - F_1)^2 + F_2^2}$

For a closed loop there is no translation.

34. (b) : Total initial resistance

$= R_G + R_1 = (50 + 2950)\ \Omega = 3000\ \Omega$

$\varepsilon = 3$ V

$\therefore$ Current $= \dfrac{3\text{ V}}{3000\ \Omega} = 1 \times 10^{-3}$ mA

If the deflection has to be reduced to 20 divisions, current $i = 1\text{ mA} \times \dfrac{2}{3}$ as the full deflection scale for 1 mA = 30 divisions.

$3\text{ V} = 3000\ \Omega \times 1\text{ mA} = x\ \Omega \times \dfrac{2}{3}$ mA

$\Rightarrow \; x = 3000 \times 1 \times \dfrac{3}{2} = 4500\ \Omega$

But the galvanometer resistance = 50 Ω

Therefore the resistance to be added

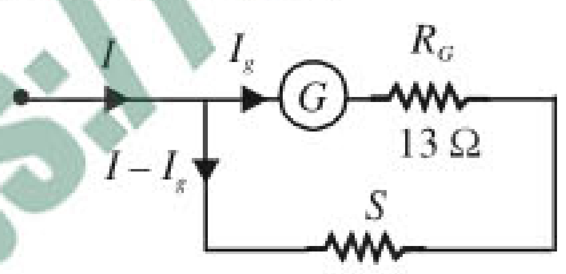
$= (4500 - 50)\Omega = 4450\ \Omega.$

35. (a) : Let the shunt resistance be S.

Given: I = 750 A,

I_g = 100 A, R_G = 13 Ω

From the figure,



$I_g R_G = (I - I_g)S$

or $\quad 100 \times 13 = [750 - 100]S$

or $\quad 1300 = 650\ S$

$\therefore \quad S = 1300/650 = 2\ \Omega.$

36. (d) : Force acting on a charged particle moving with velocity $\vec{v}$ is subjected to magnetic field $\vec{B}$ is given by

$\vec{F} = q(\vec{v} \times \vec{B}) \quad$ or, $\quad F = qvB\sin\theta$

(i) When $\theta = 0°$, $F = qvB\sin 0° = 0$

(ii) When $\theta = 90°$, $F = qvB\sin 90° = qvB$

(iii) When $\theta = 180°$, $F = qvB\sin 180° = 0$

This implies force acting on a charged particle is non-zero, when angle between $\vec{v}$ and $\vec{B}$ can have any value other than zero and 180°.

37. (c) : Question is not correct.

The magnetic field at the centre of the coil,

$B = \dfrac{\mu_0 n i}{2r}$

where r is the radius. $E/R = i$.

$\therefore \quad R \propto 2\pi r \quad \Rightarrow \quad R = cr$, where c is a constant.

$\therefore \quad$ In the first coil,

$B_1 = \dfrac{\mu_0 n i_1}{2r_1} = \dfrac{\mu_0 n E}{2r_1(cr_1)} = \dfrac{\mu_0 n E}{2cr_1^2}$

If $r_1 = 2r_2$, $B_1 = \dfrac{\mu_0 n E_1}{2c(2r_2)^2} = \dfrac{\mu_0 n E_1}{2c \cdot 4r_2^2}$

$B_2 = \dfrac{\mu_0 n E_2}{2cr_2^2}$

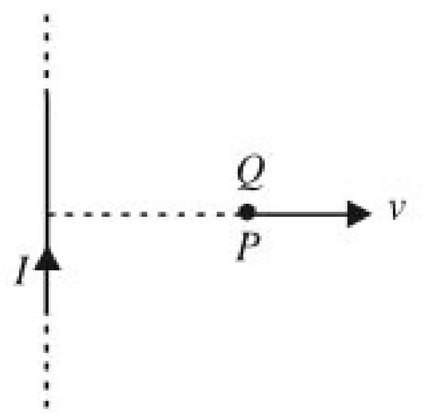
As B_1 will not be equal to B_2 unless E_1 is different from E_2, E_1 and E_2 will not be the same.

It is wrong to ask what potential difference should be applied across them. It should be perhaps the ratio of potential differences.

In that case, $B_1 = B_2$,

$\dfrac{E_1}{4} = E_2 \quad \Rightarrow \quad E_1 = 4E_2. \quad \therefore \; \dfrac{E_1}{E_2} = 4.$

38. (a) : According to Fleming's left hand rule direction of force is along Oy axis which is perpendicular to wire.



$\vec{F} = e(\vec{v} \times \vec{B}).$

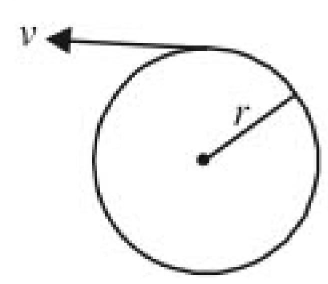
B due to i is acting inwards *i.e.* into the paper. v is along Ox.

$\therefore \quad F = Q^+ \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ v & 0 & 0 \\ 0 & 0 & -B \end{vmatrix} \Rightarrow F = Q^+[-\hat{j}(-vB) + 0]$

$\therefore \quad \vec{F} = +QvB\,\hat{j}.$ *i.e.* in Oy direction.

39. (c) : The magnetic field produce by moving electron in circular path $B = \dfrac{\mu_0 i}{2r}$

where $i = \dfrac{q}{t} = \dfrac{q}{2\pi r} \times v$



$\therefore \quad B = \dfrac{\mu_0 q v}{4\pi r^2} \quad \Rightarrow \quad r \propto \sqrt{\dfrac{v}{B}}.$

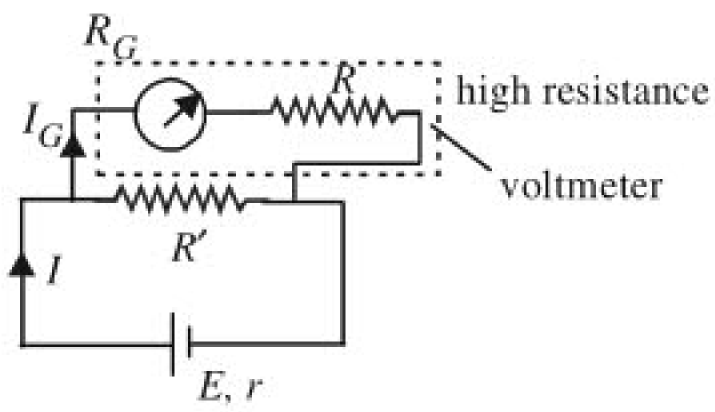
40. (d) : The total current shown by the galvanometer $= 25 \times 4 \times 10^{-4}$ A.

$I_g = 10^{-2}$ A.

The value of resistance connected in series to convert galvanometer into voltmeter of 25 V is

$$R = \frac{V}{I_g} - G = \frac{25}{10^{-2}} - 50 = 2450\ \Omega.$$

41. (a) : Voltmeter is used to measure the potential difference across a resistance and it is connected in parallel with the circuit. A high resistance is connected to the galvanometer in series so that only a small fraction (I_g) of the main circuit current (I) passes through it. If a considerable amount of current is allowed to pass through the voltmeter, then the reading obtained by this voltmeter will not be close to the actual potential difference between the same two points.



42. (a) : If a moving charged particle is subjected to a perpendicular uniform magnetic field, then according to $F = qvB \sin\theta$, it will experience a maximum force which will provide the centripetal force to particle and it will describe a circular path with uniform speed.

43. (b) : Magnetic field induction at point inside the solenoid of length l, having n turns per unit length carrying current i is given by

$B = \mu_0 ni$

If $i \to$ doubled, $n \to$ halved then $B \to$ remains same.

44. (b) : The force experienced by a charged particle moving in space where electric and magnetic field exists is called Lorentz force.

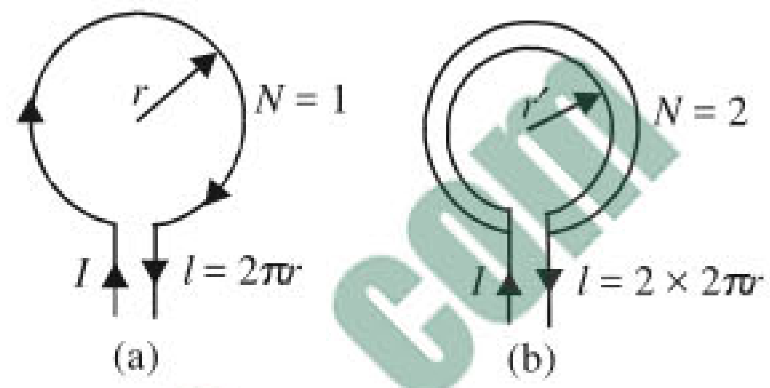
When a charged particle carrying charge q is subjected to an electric field of strength $\vec{E}$, it experiences a force given by $\vec{F}_e = q\vec{E}$ whose direction is same as $\vec{E}$ or opposite of $\vec{E}$ depending on the nature of charge, positive or negative.

If a charged particle is moving in a magnetic field of strength $\vec{B}$ with a velocity $\vec{v}$ it experiences a force given by $\vec{F}_m = q(\vec{v} \times \vec{B})$. The direction of this force is in the direction of $\vec{v} \times \vec{B}$ *i.e.* perpendicular to the plane containing $\vec{v}$ and $\vec{B}$ and is directed as given by right hand screw rule.

Due to both the electric and magnetic fields, the total force experienced by the charge q is given by

$$\vec{F} = \vec{F}_e + \vec{F}_m = q\vec{E} + q(\vec{v} \times \vec{B}).$$

45. (c) : The magnetic field B produced at the centre of a circular coil due to current I flowing through this is given by $B = \frac{\mu_0 NI}{2r}$, N is number of turns and r is radius of the coil. Here $B = \frac{\mu_0 I}{2r}\ [N = 1]$.



$\therefore\ 2 \times 2\pi r' = 2\pi r$ (same length). $\therefore\ r' = r/2$.

$\therefore$ Magnetic field at the centre for two turns ($N = 2$) is given by

$$B' = \frac{\mu_0 \times 2I}{2r'} = \frac{\mu_0 \times 2I}{2r/2} = \frac{4\mu_0 I}{2r} = 4B.$$

46. (a) : Magnetic moment $M = niA$

47. (c) : The frequency of revolution of charged particle in a perpendicular magnetic field is

$$\upsilon = \frac{1}{T} = \frac{1}{2\pi r/v} = \frac{v}{2\pi r} = \frac{v}{2\pi} \times \frac{eB}{mv} = \frac{eB}{2\pi m}.$$

48. (c) : $B = \frac{\mu_0}{4\pi}\frac{2i_2}{(r/2)} - \frac{\mu_0}{4\pi}\frac{2i_1}{(r/2)} = \frac{\mu_0}{4\pi}\frac{4}{r}(i_2 - i_1)$

$$= \frac{\mu_0}{4\pi}\frac{4}{5}(2.5 - 5.0) = -\frac{\mu_0}{2\pi}.$$

–ve sign show that B is acting inwards *i.e.* into the plane.

49. (a) :

$$B = \frac{\mu_0 Ni}{2r} = \frac{4\pi \times 10^{-7} \times 1000 \times 0.1}{2 \times 0.1} = 6.28 \times 10^{-4}\ \text{T}$$

50. (d) : Diameter of first wire (d_1) = 0.5 mm; Current in first wire (I_1) = 1A; Diameter of second wire (d_2) = 1 mm and current in second wire (I_2) = 1A.

Strength of magnetic field due to current flowing in a conductor, $(B) = \frac{\mu_0}{4\pi} \times \frac{2I}{a}$ or $B \propto I$.

Since the current in both the wires is same, therefore there is no change in the strength of the magnetic field.

51. (b) : Use Ampère's law

$$\oint B.dl = \mu_0\ i_{\text{enclosed}}.$$

Outside : $i_{\text{enclosed}} \neq 0$ (some value) $\Rightarrow B \neq 0$

Inside $= i_{\text{enclosed}} = 0 \Rightarrow B = 0$.

52. (b) :

$$B = \frac{\mu_0(Ni)}{2r} = \frac{4\pi\times10^{-7}\times50\times2}{2\times0.5} = 1.256\times10^{-4}\ \text{T}$$

53. (d) : $qvB\sin\theta = \frac{mv^2}{R}$

$$R = \frac{mv}{qB\sin\theta} = \frac{3\times10^5}{10^8\times0.3\times\frac{1}{2}} = 2\ \text{cm}$$

54. (c) : $F = \frac{\mu_0}{4\pi}\frac{2I_1I_2}{r}$

$$= \frac{10^{-7}\times2(1)\times(1)}{1} = 2\times10^{-7}\ \text{N/m}$$

55. (b) : The shunt and galvanometer are in parallel.

Therefore, $\frac{1}{R_{eq}} = \frac{1}{9}+\frac{1}{2}$ or, $R_{eq} = \frac{18}{11}\ \Omega$.

Using Ohm's law, $V = IR_{eq} = 1\times\frac{18}{11} = \frac{18}{11}$ V.

$\therefore$ Current through shunt $= \frac{V}{R_s}$

$$= \frac{18/11}{2} = \frac{9}{11} \simeq 0.8\ \text{amp.}$$

56. (b) : Magnetic field at the centre of the coil,

$$B = \frac{\mu_0}{2\pi}\frac{NI}{a}$$

Let l be the length of the wire, then

$$B_1 = \frac{\mu_0}{2\pi}\cdot\frac{1\times I}{l/2\pi} = \frac{\mu_0 I}{l}$$

and $B_2 = \frac{\mu_0}{2\pi}\cdot\frac{2\times I}{l/4\pi} = \frac{4\mu_0 I}{l}$

Therefore, $\frac{B_1}{B_2} = \frac{1}{4}$ or, $B_1 : B_2 = 1 : 4$.

57. (c) : Distance between two parallel wires $(x) = 10$ cm $= 0.1$ m;
Current in each wire $= I_1 = I_2 = 10$ A and length of wire $(l) = 1$ m.

Force on the wire $(F) = \frac{\mu_0 I_1\cdot I_2\times l}{2\pi x}$

$$= \frac{(4\pi\times10^{-7})\times10\times10\times1}{2\pi\times0.1} = 2\times10^{-4}\ \text{N.}$$

Since the current is flowing in the same direction, therefore the force will be attractive.

58. (b) : When a positively charged particle enters in a region of uniform magnetic field, directed vertically upwards, it experiences a centripetal force which will move it in circular path with a uniform speed.

59. (b)

60. (b) : The direction of the magnetic field, due to current, is given by the right-hand rule. At axis AB, the components of magnetic field will cancel each other and the resultant magnetic field will be zero.

61. (b) : According to Biot-Savart's law,

$$d\vec{B} \propto i\left(\frac{d\vec{l}\times\vec{r}}{r^3}\right) = \frac{\mu_0}{4\pi}i\left(\frac{d\vec{l}\times\vec{r}}{r^3}\right).$$

62. (a) : Kinetic energy of electron $\left(\frac{1}{2}\times mv^2\right) = 10$ eV and magnetic induction $(B) = 10^{-4}$ Wb/m^2.

Therefore $\frac{1}{2}(9.1\times10^{-31})v^2 = 10\times(1.6\times10^{-19})$

or, $v^2 = \frac{2\times10\times(1.6\times10^{-19})}{9.1\times10^{-31}} = 3.52\times10^{12}$

or, $v = 1.876\times10^6$ m.

Centripetal force $= \frac{mv^2}{r} = Bev$.

Therefore $r = \frac{mv}{Be} = \frac{(9.1\times10^{-31})\times(1.876\times10^6)}{10^{-4}\times(1.6\times10^{-19})}$

$= 11\times10^{-2}$ m $= 11$ cm.

63. (d) : Electric field $(E) = 20$ V/m and magnetic field $(B) = 0.5$ T.
The force on electron in a magnetic field $= evB$
Force on electron on an electric field $= eE$
Since the electron is moving with constant velocity, therefore the resultant force on electron is zero.
i.e., $eE = evB \Rightarrow v = E/B = 20/0.5 = 40$ ms^{-1}

64. (c) : Area $(A) = 0.01$ m^2; Current $(I) = 10$ A;
Angle $(\phi) = 90°$ and magnetic field $(B) = 0.1$ T.
Therefore acutal angle $\theta = (90° - \phi) = (90° - 90°) = 0°$.
And torque acting on the loop $(\tau) = IAB\sin\theta$
$= 10\times0.01\times0.1\times\sin 0° = 0$.

65. (a) : The force acting on a charged particle in magnetic field is given by

$$\vec{F} = q(\vec{v}\times\vec{B}) \text{ or } F = qvB\sin\theta$$

$\therefore F = 0$
when angle between v and B is 180°.

66. (a) : A current carrying coil has magnetic dipole moment. Hence a torque $p_m\times B$ acts on it in magnetic field.

67. (a) : To convert a galvanometer into ammeter, one needs to connect a low resistance in parallel so that maximum current passes through the shunt wire and ammeter remains protected.

68. (b) : $F = il\times B = 1.2\times0.5\times2 = 1.2$ N.

69. **(a) :** $B = \frac{\mu_0 i}{2\pi r}$ or $B \propto \frac{1}{r}$

When r is doubled, the magnetic field becomes halved *i.e.*,now the magnetic field will be 0.2 T.

70. **(c) :** $r = \frac{mv}{qB}$ or $r \propto v$

As v is doubled, the radius also becomes doubled. Hence radius = 2 × 2 = 4 cm.

71. **(d) :** For a charged particle orbiting in a circular path in a magnetic field

$$\frac{mv^2}{r} = Bvq \Rightarrow v = \frac{Bqr}{m}$$

$$mv^2 = Bqvr$$

$$E_K = \frac{1}{2}mv^2 = \frac{1}{2}Bqvr = Bq\frac{r}{2}\cdot\frac{Bqr}{m} = \frac{B^2q^2r^2}{2m}$$

For deuteron, $E_1 = \frac{B^2q^2 \times r^2}{2 \times 2m}$

For proton, $E_2 = \frac{B^2q^2r^2}{2m}$

$$\frac{E_1}{E_2} = \frac{1}{2} \Rightarrow \frac{50\text{ keV}}{E_2} = \frac{1}{2} \Rightarrow E_2 = 100\text{ keV}$$

72. **(a) :** $B \propto 1/r$. By Ampère's law.

As the distance is increased to three times, the magnetic induction reduces to one third.

Hence $B = \frac{1}{3} \times 10^{-3}$ tesla = 3.33×10^{-4} tesla

73. **(d) :** When current flows in a coil, its electric field is perpendicular to the magnetic field always.

Therefore (a) and (b).

74. **(b) :** The plane of coil will orient itself so that area vector aligns itself along the magnetic field.

Chapter 15 Magnetism and Matter

1. If θ_1 and θ_2 be the apparent angles of dip observed in two vertical planes at right angles to each other, then the true angle of dip θ is given by

(a) $\tan^2\theta = \tan^2\theta_1 + \tan^2\theta_2$
(b) $\cot^2\theta = \cot^2\theta_1 - \cot^2\theta_2$
(c) $\tan^2\theta = \tan^2\theta_1 - \tan^2\theta_2$
(d) $\cot^2\theta = \cot^2\theta_1 + \cot^2\theta_2$ *(NEET 2017)*

2. A 250-turn rectangular coil of length 2.1 cm and width 1.25 cm carries a current of 85 μA and subjected to a magnetic field of strength 0.85 T. Work done for rotating the coil by 180° against the torque is

(a) 4.55 μJ (b) 2.3 μJ
(c) 1.15 μJ (d) 9.1 μJ *(NEET 2017)*

3. A bar magnet is hung by a thin cotton thread in a uniform horizontal magnetic field and is in equilibrium state. The energy required to rotate it by 60° is W. Now the torque required to keep the magnet in this new position is

(a) $\frac{W}{\sqrt{3}}$ (b) $\sqrt{3}W$ (c) $\frac{\sqrt{3}W}{2}$ (d) $\frac{2W}{\sqrt{3}}$ *(NEET-II 2016)*

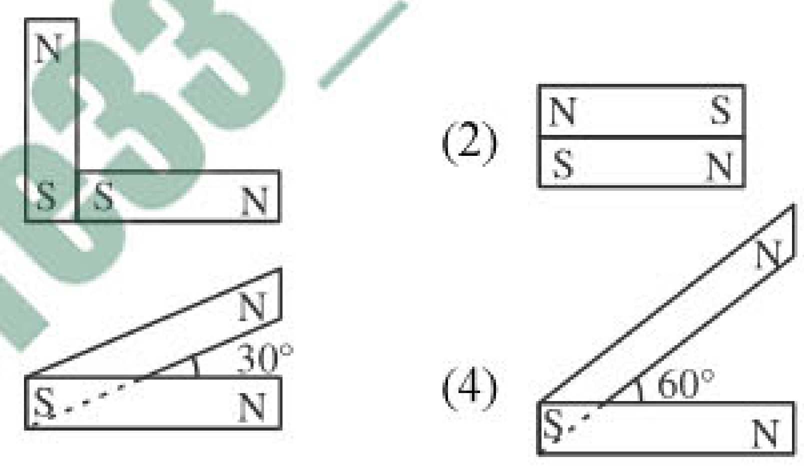
4. The magnetic susceptibility is negative for

(a) ferromagnetic material only
(b) paramagnetic and ferromagnetic materials
(c) diamagnetic material only
(d) paramagnetic material only *(NEET-I 2016)*

5. A rectangular coil of length 0.12 m and width 0.1 m having 50 turns of wire is suspended vertically in a uniform magnetic field of strength 0.2 Weber/m^2. The coil carries a current of 2 A. If the plane of the coil is inclined at an angle of 30° with the direction of the field, the torque required to keep the coil in stable equilibrium will be

(a) 0.24 Nm (b) 0.12 Nm
(c) 0.15 Nm (d) 0.20 Nm *(2015)*

6. Following figures show the arrangement of bar magnets in different configurations. Each magnet has magnetic dipole moment $\vec{m}$. Which configuration has highest net magnetic dipole moment?

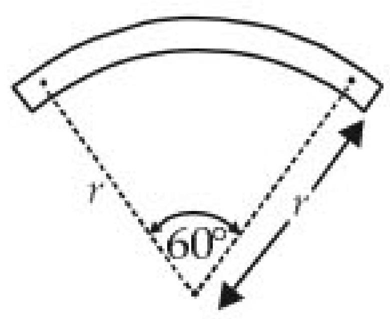


(a) (1) (b) (2)
(c) (3) (d) (4) *(2014)*

7. A current loop in a magnetic field

(a) can be in equilibrium in two orientations, both the equilibrium states are unstable.
(b) can be in equilibrium in two orientations, one stable while the other is unstable.
(c) experiences a torque whether the field is uniform or non uniform in all orientations.
(d) can be in equilibrium in one orientation. *(NEET 2013)*

8. A bar magnet of length 'l' and magnetic dipole moment 'M' is bent in the form of an arc as shown in figure. The new magnetic dipole moment will be



(a) $\frac{2}{\pi}M$
(b) $\frac{M}{2}$
(c) M
(d) $\frac{3}{\pi}M$ *(NEET 2013)*

9. A bar magnet of magnetic moment M is placed at right angles to a magnetic induction B. If a force F is experienced by each pole of the magnet, the length of the magnet will be

(a) MB/F (b) BF/M
(c) MF/B (d) F/MB
(Karnataka NEET 2013)

10. A compass needle which is allowed to move in a horizontal plane is taken to a geomagnetic pole. It
(a) will become rigid showing no movement
(b) will stay in any position
(c) will stay in north-south direction only
(d) will stay in east-west direction only *(2012)*

11. A magnetic needle suspended parallel to a magnetic field requires $\sqrt{3}$ J of work to turn it through 60°. The torque needed to maintain the needle in this position will be
(a) $2\sqrt{3}$ J (b) 3 J (c) $\sqrt{3}$ J (d) $\frac{3}{2}$ J
(Mains 2012)

12. There are four light-weight-rod samples A, B, C, D separately suspended by threads. A bar magnet is slowly brought near each sample and the following observations are noted
(i) A is feebly repelled
(ii) B is feebly attracted
(iii) C is strongly attracted
(iv) D remains unaffected
Which one of the following is true?
(a) B is of a paramagnetic material
(b) C is of a diamagnetic material
(c) D is of a ferromagnetic material
(d) A is of a non-magnetic material *(2011)*

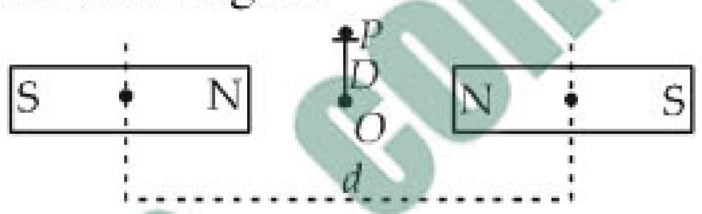
13. A short bar magnet of magnetic moment 0.4 J T^{-1} is placed in a uniform magnetic field of 0.16 T. The magnet is in stable equilibrium when the potential energy is
(a) 0.064 J (b) – 0.064 J
(c) zero (d) – 0.082 J
(Mains 2011)

14. Electromagnets are made of soft iron because soft iron has
(a) low retentivity and high coercive force
(b) high retentivity and high coercive force
(c) low retentivity and low coercive force
(d) high retentivity and low coercive force *(2010)*

15. A vibration magnetometer placed in magnetic meridian has a small bar magnet. The magnet executes oscillations with a time period of 2 sec in earth's horizontal magnetic field of 24 microtesla. When a horizontal field of 18 microtesla is produced opposite to the earth's field by placing a current carrying wire, the new time period of magnet will be
(a) 1 s (b) 2 s
(c) 3 s (d) 4 s *(2010)*

16. The magnetic moment of a diamagnetic atom is
(a) much greater than one
(b) 1
(c) between zero and one
(d) equal to zero *(Mains 2010)*

17. Two identical bar magnets are fixed with their centres at a distance d apart. A stationary charge Q is placed at P in between the gap of the two magnets at a distance D from the centre O as shown in the figure



The force on the charge Q is
(a) zero
(b) directed along OP
(c) directed along PO
(d) directed perpendicular to the plane of paper
(Mains 2010)

18. If a diamagnetic substance is brought near the north or the south pole of a bar magnet, it is
(a) repelled by the north pole and attracted by the south pole
(b) attracted by the north pole and repelled by the south pole
(c) attracted by both the poles
(d) repelled by both the poles *(2009, 1999)*

19. A bar magnet having a magnetic moment of 2×10^4 J T^{-1} is free to rotate in a horizontal plane. A horizontal magnetic field $B = 6 \times 10^{-4}$ T exists in the space. The work done in taking the magnet slowly from a direction parallel to the field to a direction 60° from the field is
(a) 12 J (b) 6 J (c) 2 J (d) 0.6 J
(2009)

20. Curie temperature above which
(a) paramagnetic material becomes ferromagnetic material
(b) ferromagnetic material becomes diamagnetic material
(c) ferromagnetic material becomes paramagnetic material
(d) paramagnetic material becomes diamagnetic material *(2008, 2006)*

21. Nickel shows ferromagnetic property at room temperature. If the temperature is increased beyond Curie temperature, then it will show

(a) anti ferromagnetism
(b) no magnetic property
(c) diamagnetism
(d) paramagnetism. *(2007)*

22. A charged particle (charge q) is moving in a circle of radius R with uniform speed v. The associated magnetic moment μ is given by
(a) qvR^2 (b) $qvR^2/2$
(c) qvR (d) $qvR/2$. *(2007)*

23. If the magnetic dipole moment of an atom of diamagnetic material, paramagnetic material and ferromagnetic material are denoted by μ_d, μ_p and μ_f respectively, then
(a) $\mu_d = 0$ and $\mu_p \neq 0$
(b) $\mu_d \neq 0$ and $\mu_p = 0$
(c) $\mu_p = 0$ and $\mu_f \neq 0$
(d) $\mu_d \neq 0$ and $\mu_f \neq 0$. *(2005)*

24. A coil in the shape of an equilateral triangle of side l is suspended between the pole pieces of a permanent magnet such that $\vec{B}$ is in plane of the coil. If due to a current i in the triangle a torque τ acts on it, the side l of the triangle is
(a) $\frac{2}{\sqrt{3}}\left(\frac{\tau}{Bi}\right)$ (b) $2\left(\frac{\tau}{\sqrt{3}Bi}\right)^{1/2}$
(c) $\frac{2}{\sqrt{3}}\left(\frac{\tau}{Bi}\right)^{1/2}$ (d) $\frac{1}{\sqrt{3}}\frac{\tau}{Bi}$ *(2005)*

25. A diamagnetic material in a magnetic field moves
(a) from stronger to the weaker parts of the field
(b) from weaker to the stronger parts of the field
(c) perpendicular to the field
(d) in none of the above directions *(2003)*

26. According to Curie's law, the magnetic susceptibility of a substance at an absolute temperature T is proportional to
(a) $1/T$ (b) T
(c) $1/T^2$ (d) T^2 *(2003)*

27. A bar magnet is oscillating in the Earth's magnetic field with a period T. What happens to its period and motion if its mass is quadrupled ?
(a) motion remains simple harmonic with time period = $T/2$
(b) motion remains S.H.M with time period = $2T$
(c) motion remains S.H.M with time period = $4T$
(d) motion remains S.H.M and period remains nearly constant *(2003, 1994)*

28. Two bar magnets having same geometry with magnetic moments M and $2M$, are firstly placed in such a way that their similar poles are same side then its time period of oscillation is T_1. Now the polarity of one of the magnet is reversed then time period of oscillation is T_2, then
(a) $T_1 < T_2$ (b) $T_1 = T_2$
(c) $T_1 > T_2$ (d) $T_2 = \infty$. *(2002)*

29. Among which the magnetic susceptibility does not depend on the temperature?
(a) diamagnetism (b) paramagnetism
(c) ferromagnetism (d) ferrite. *(2001)*

30. Tangent galvanometer is used to measure
(a) potential difference (b) current
(c) resistance (d) charge. *(2001)*

31. A bar magnet of magnetic moment $\vec{M}$, is placed in a magnetic field of induction $\vec{B}$. The torque exerted on it is
(a) $\vec{M} \times \vec{B}$ (b) $-\vec{M} \cdot \vec{B}$
(c) $\vec{M} \cdot \vec{B}$ (d) $-\vec{B} \times \vec{M}$ *(1999)*

32. For protecting a sensitive equipment from the external magnetic field, it should be
(a) surrounded with fine copper sheet
(b) placed inside an iron can
(c) wrapped with insulation around it when passing current through it
(d) placed inside an aluminium can. *(1998)*

33. A bar magnet of magnetic moment M is cut into two parts of equal length. The magnetic moment of each part will be
(a) M (b) $2M$ (c) zero (d) $0.5\ M$. *(1997)*

34. The work done in turning a magnet of magnetic moment M by an angle of 90° from the meridian, is n times the corresponding work done to turn it through an angle of 60°. The value of n is given by
(a) 1/2 (b) 1/4 (c) 2 (d) 1. *(1995)*

Answer Key

1. (d)	**2.** (d)	**3.** (b)	**4.** (c)	**5.** (d)	**6.** (c)	**7.** (b)	**8.** (d)	**9.** (a)	**10.** (b)
11. (b)	**12.** (a)	**13.** (b)	**14.** (c)	**15.** (d)	**16.** (d)	**17.** (a)	**18.** (d)	**19.** (b)	**20.** (c)
21. (d)	**22.** (d)	**23.** (a)	**24.** (b)	**25.** (a)	**26.** (a)	**27.** (b)	**28.** (a)	**29.** (a)	**30.** (b)
31. (a, d)	**32.** (b)	**33.** (d)	**34.** (c)						

EXPLANATIONS

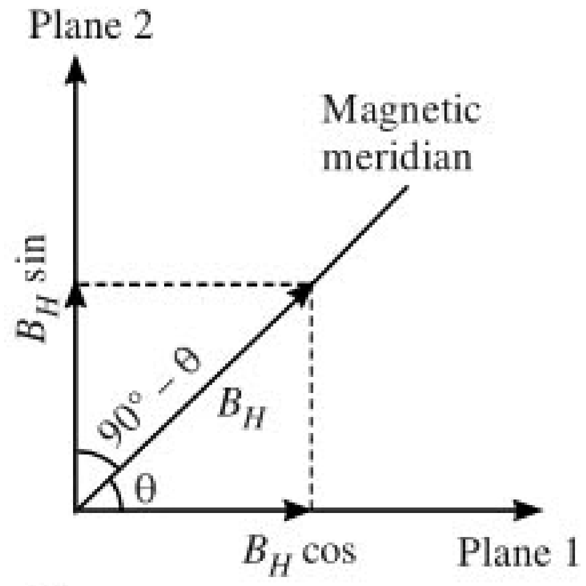
1. **(d) :** Let B_H and B_V be the horizonal and vertical components of earth's magnetic field $\vec{B}$. Since θ is the angle of dip

$$\therefore \quad \tan\theta = \frac{B_V}{B_H} \text{ or } \cot\theta = \frac{B_H}{B_V} \quad \ldots(i)$$

Suppose planes 1 and 2 are two mutually perpendicular planes and respectively make angles θ and 90°– θ with the magnetic meridian. The vertical components of earth's magnetic field remain same in the two planes but the effective horizontal components in the planes will be

$$B_1 = B_H \cos\theta \text{ and } B_2 = B_H \sin\theta$$

The angles of dip θ_1 and θ_2 in the two planes are given by



$$\tan\theta_1 = \frac{B_V}{B_1}$$

$$\tan\theta_1 = \frac{B_V}{B_H\cos\theta}$$

$$\text{or} \quad \cot\theta_1 = \frac{B_H\sin\theta}{B_V} \quad \ldots(ii)$$

$$\text{Similarly, } \cot\theta_2 = \frac{B_H\sin\theta}{B_V} \quad \ldots(iii)$$

From eqns. (ii) and (iii)

$$\cot^2\theta_1 + \cot^2\theta_2 = \frac{B_H^2}{B_V^2}(\cos^2\theta + \sin^2\theta) = \frac{B_H^2}{B_V^2}$$

$$\therefore \quad \cot^2\theta_1 + \cot^2\theta_2 = \cot^2\theta \quad \text{[from eqn. (i)]}$$

2. **(d) :** Work done in a coil

$$W = mB(\cos\theta_1 - \cos\theta_2)$$

When it is rotated by angle 180° then

$$W = 2mB = 2(NIA)B \quad \ldots(i)$$

Given: $N = 250$, $I = 85\ \mu A = 85 \times 10^{-6}$ A

$A = 1.25 \times 2.1 \times 10^{-4}\ m^2 \approx 2.5 \times 10^{-4}\ m^2$

$B = 0.85$ T

Putting these values in eqn. (i), we get

$$W = 2 \times 250 \times 85 \times 10^{-6} \times 2.5 \times 10^{-4} \times 0.85$$
$$\approx 9.1 \times 10^{-6}\ J = 9.1\ \mu J$$

3. **(b) :** At equilibrium, potential energy of dipole

$$U_i = -MB_H$$

Final potential energy of dipole,

$$U_f = -MB_H\cos 60° = -\frac{MB_H}{2}$$

$$W = U_f - U_i = -\frac{MB_H}{2} - (-MB_H) = \frac{MB_H}{2} \quad \ldots(i)$$

Required torque, $\tau = MB_H \sin 60°$

$$\tau = 2W \times \frac{\sqrt{3}}{2} \quad \text{[Using eqn. (i)]}$$
$$= \sqrt{3}W$$

4. **(c) :** Magnetic susceptibility is negative for diamagnetic material only.

5. **(d) :** The required torque is $\tau = NIAB\sin\theta$ where N is the number of turns in the coil, I is the current through the coil, B is the uniform magnetic field, A is the area of the coil and θ is the angle between the direction of the magnetic field and normal to the plane of the coil.

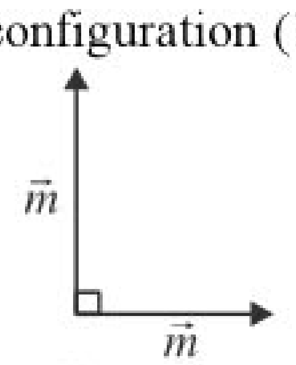
Here, $N = 50$, $I = 2$ A, $A = 0.12\ m \times 0.1\ m = 0.012\ m^2$

$B = 0.2\ Wb/m^2$ and $\theta = 90° - 30° = 60°$

$$\therefore \quad \tau = (50)(2\ A)(0.012\ m^2)(0.2\ Wb/m^2)\sin 60°$$
$$= 0.20\ N\ m$$

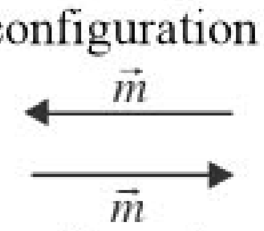
6. **(c) :** The direction of magnetic dipole moment is from south to north pole of the magnet.

In configuration (1),



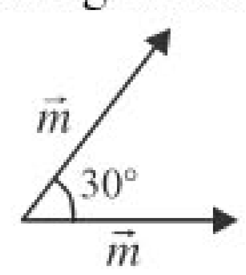
$$m_{net} = \sqrt{m^2 + m^2 + 2mm\cos 90°}$$
$$= \sqrt{m^2 + m^2} = 2\sqrt{m}$$

In configuration (2),



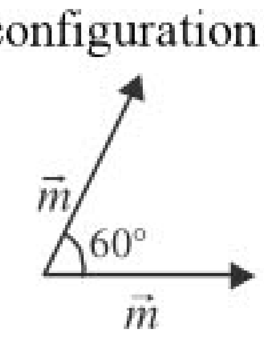
$$m_{net} = m - m = 0$$

In configuration (3),



$$m_{net} = \sqrt{m^2 + m^2 + 2mm\cos 30°}$$
$$= \sqrt{2m^2 + 2m^2\left(\frac{\sqrt{3}}{2}\right)} = m\sqrt{2+\sqrt{3}}$$

In configuration (4),



$$m_{net} = \sqrt{m^2 + m^2 + 2mm\cos 60°}$$
$$= \sqrt{2m^2 + 2m^2\left(\frac{1}{2}\right)} = m\sqrt{3}$$

7. (b) : When a current loop is placed in a magnetic field it experiences a torque. It is given by

$$\vec{\tau} = \vec{M} \times \vec{B}$$

where, $\vec{M}$ is the magnetic moment of the loop and $\vec{B}$ is the magnetic field.

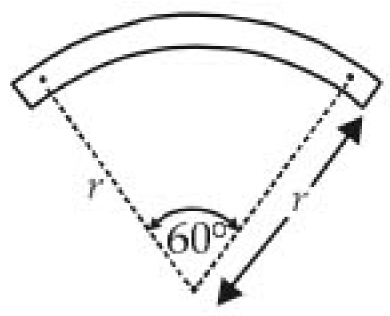
or $\tau = MB \sin\theta$ where θ is angle between M and B

When $\vec{M}$ and $\vec{B}$ are parallel (*i.e.* $\theta = 0°$) the equilibrium is stable and when they are antiparallel (*i.e.* $\theta = \pi$) the equilibrium is unstable.

8. (d) : Let m be strength of each pole of bar magnet of length l. Then

$$M = m \times l \qquad \text{...(i)}$$

When the bar magnet is bent in the form of an arc as shown in figure



Then

$$l = \frac{\pi}{3} \times r = \frac{\pi r}{3}$$

or $\quad r = \dfrac{3l}{\pi}$

New magnetic dipole moment

$M' = m \times 2r \sin 30°$

$$= m \times 2 \times \frac{3l}{\pi} \times \frac{1}{2} = \frac{3ml}{\pi} = \frac{3M}{\pi} \qquad \text{(Using (i))}$$

9. (a)

10. (b) : A compass needle which is allowed to move in a horizontal plane is taken to a geomagnetic pole. It will stay in any position as the horizontal component of earth's magnetic field becomes zero at the geomagnetic pole.

11. (b) : Work done in changing the orientation of a magnetic needle of magnetic moment M in a magnetic field B from position θ_1 to θ_2 is given by

$$W = MB(\cos\theta_1 - \cos\theta_2)$$

Here, $\theta_1 = 0°$, $\theta_2 = 60°$

$$= MB\left(1 - \frac{1}{2}\right) = \frac{MB}{2} \qquad \text{...(i)}$$

The torque on the needle is

$$\vec{\tau} = \vec{M} \times \vec{B}$$

In magnitude,

$$\tau = MB\sin\theta = MB\sin 60° = \frac{\sqrt{3}}{2}MB \qquad \text{...(ii)}$$

Dividing (ii) by (i), we get

$$\frac{\tau}{W} = \sqrt{3}$$

$$\tau = \sqrt{3}W = \sqrt{3} \times \sqrt{3}\text{ J} = 3\text{ J}$$

12. (a) : Diamagnetic will be feebly repelled.
Paramagnetic will be feebly attracted.
Ferromagnetic will be strongly attracted.
Therefore, A is of diamagnetic material. B is of paramagnetic material. C is of ferromagnetic material. D is of non-magnetic material.

13. (b) : Here, Magnetic moment, $M = 0.4\text{ J T}^{-1}$

Magnetic field, $B = 0.16$ T

When a bar magnet of magnetic moment is placed in a uniform magnetic field , its potential energy is

$$U = -\vec{M} \cdot \vec{B} = -MB\cos\theta$$

For stable equilibrium, $\theta = 0°$

$\therefore \quad U = -MB = -(0.4\text{ J T}^{-1})(0.16\text{ T}) = -0.064$ J

14. (c) : Electromagnets are made of soft iron because soft iron has low retentivity and low coercive force or low coercivity. Soft iron is a soft magnetic material.

15. (d) : The time period T of oscillation of a magnet is given by

$$T = 2\pi\sqrt{\frac{I}{MB}}$$

where,

I = Moment of inertia of the magnet about the axis of rotation

M = Magnetic moment of the magnet

B = Uniform magnetic field

As I, B remains the same

$$\therefore \quad T \propto \frac{1}{\sqrt{B}} \quad \text{or} \quad \frac{T_2}{T_1} = \sqrt{\frac{B_1}{B_2}}$$

According to given problem,

$B_1 = 24\ \mu$T

$B_2 = 24\ \mu\text{T} - 18\ \mu\text{T} = 6\ \mu$T

$T_1 = 2$ s

$$\therefore \quad T_2 = (2\text{ s})\sqrt{\frac{(24\ \mu\text{T})}{(6\ \mu\text{T})}} = 4\text{ s}$$

16. (d) : The magnetic moment of a diamagnetic atom is equal to zero.

17. (a) : Magnetic field due to bar magnets exerts force on moving charges only. Since the charge is at rest, zero force acts on it.

18. (d) : A diamagnet is always repelled by a magnetic field. Therefore it is repelled by both the north pole as well as the south pole.

19. (b) : Here, $M = 2 \times 10^4\text{ J T}^{-1}$

$B = 6 \times 10^{-4}$ T, $\theta_1 = 0°$, $\theta_2 = 60°$

$W = MB(\cos\theta_1 - \cos\theta_2) = MB(1 - \cos 60°)$

$W = 2 \times 10^4 \times 6 \times 10^{-4}\left(1 - \frac{1}{2}\right) = 6$ J.

20. (c) : At Curie temperature, there is a change from ferromagnetic to paramagnetic behaviour. Above this temperature, the paramagnetic substance obeys Curie Weiss law, even those resistances which are not ferromagnetic but only paramagnetic also obey Curie Weiss law above the Curie temperature only.

21. (d) : Above Curie temperature, ferromagnetic material become paramagnetic.

22. (d) : Magnetic moment $\mu = IA$

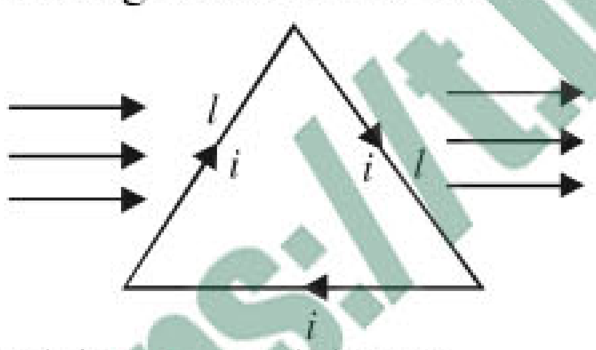
Since $T = \frac{2\pi R}{v}$ Also, $I = \frac{q}{T} = \frac{qv}{2\pi R}$

$\therefore \quad \mu = \left(\frac{qv}{2\pi R}\right)(\pi R^2) = \frac{qvR}{2}.$

23. (a) : Materials with no unpaired, or isolated electrons are considered diamagnetic. Diamagnetic substances do not have magnetic dipole moments and have negative susceptibilities. However, materials having unpaired electrons whose spins do not cancel each other are called paramagnetic. These substances have positive magnetic moments and susceptibilities.

$\mu_d = 0, \ \mu_p \neq 0.$

24. (b) : The current flowing clockwise in the equilateral triangle has a magnetic field in the direction $\hat{k}$



$\tau = BiNA\sin\theta = B\,iA\sin 90°$

$\tau = Bi \times \frac{\sqrt{3}}{4} l^2$ (area of equilateral triangle

$= \frac{\sqrt{3}}{4} l^2)$ (as it appears that $N = 1$)

$\left(\frac{4\tau}{\sqrt{3}Bi}\right) = l^2 \quad \Rightarrow \quad l = 2\left(\frac{\tau}{Bi\sqrt{3}}\right)^{1/2}.$

25. (a)

26. (a) : According to Curie's law $\chi \propto \frac{1}{T}$

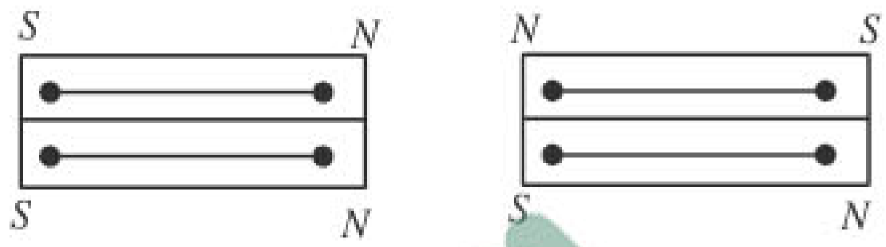
27. (b) : Initial mass of the magnet $(m_1) = m$ and final mass of the magnet $(m_2) = 4\ m$. The time period

$$(T) = 2\pi\sqrt{\frac{I}{MB}} = 2\pi\sqrt{\frac{mk^2}{MB}} \propto \sqrt{m}.$$

Therefore $\frac{T_1}{T_2} = \frac{\sqrt{m_1}}{\sqrt{m_2}} = \frac{\sqrt{m}}{\sqrt{4m}} = \frac{1}{2}$

or $T_2 = 2T_1 = 2T$.

28. (a) :



(i) $M = M_1 + M_2$ (ii) $M = M_1 - M_2$

$I = I_1 + I_2$ $I = I_1 + I_2$

(i) Similar poles are placed at the same side (sum position)

(ii) Opposite poles are placed at the same side (difference position)

I_1 and I_2 are the moments of inertia of the magnets and M_1 and M_2 are the moments of the magnets.

Here $M_1 = M$ and $M_2 = 2M$, $I_1 = I_2 = I$ (say), for same geometry.

$\therefore \quad T_1 = 2\pi\sqrt{\frac{I_1 + I_2}{(M_1 + M_2)H}} = 2\pi\sqrt{\frac{2I}{(M + 2M)H}}$

for same position.

and $T_2 = 2\pi\sqrt{\frac{I_1 + I_2}{(M_2 - M_1)H}} = 2\pi\sqrt{\frac{2I}{(2M - M)H}}$

for difference position.

$\therefore \quad \frac{T_1}{T_2} = \sqrt{\frac{M}{3M}} = \frac{1}{\sqrt{3}} < 1 \quad \therefore \quad T_1 < T_2.$

29. (a)

30. (b) : $I = K\tan\theta$

31. (a, d)

32. (b)

33. (d) : Magnetic moment = pole strength × length

$\therefore \quad M' = M/2 = 0.5\ M.$

34. (c) : Angle of magnet $(\theta) = 90°$ and $60°$. Work done in turning the magnet through $90°$.

$(W_1) = MB(\cos 0° - \cos 90°) = MB(1 - 0) = MB.$

Similarly

$W_2 = MB(\cos 0° - \cos 60°) = MB\left(1 - \frac{1}{2}\right)$

$= \frac{MB}{2}.$

Therefore $W_1 = 2W_2$ or $n = 2$.