PHYSICS	TEST PAPER WITH SOLUTION

SECTION-A

1. In AM modulation, a signal is modulated on a carrier wave such that maximum and minimum amplitude are found to be 6V and 2V respectively. The modulation index is

(A) 100%   (B) 80%

(C) 60%   (D) 50%

Official Ans. by NTA (D)

Ans. (D)

Sol. modulation index $= \dfrac{V_{max} - V_{min.}}{V_{max} + V_{min.}} \times 100\%$

$= \dfrac{6-2}{6+2} \times 100\% = 50\%$

2. The electric current in a circular coil of 2 turns produces a magnetic induction B_1 at its centre. The coil is unwound and is rewound into a circular coil of 5 turns and the same current produces a magnetic induction B_2 at its centre.

The ratio of $\dfrac{B_2}{B_1}$ is :

(A) $\dfrac{5}{2}$ (B) $\dfrac{25}{4}$

(C) $\dfrac{5}{4}$ (D) $\dfrac{25}{2}$

Official Ans. by NTA (B)

Ans. (B)

Sol. $B = \dfrac{N\mu_0 i}{2R}$

$B_1 = \dfrac{N_1 \mu_0 i}{2R_1}$

For $N_2 = 5$

Radius of coil $= R_2 = \dfrac{N_1 \times R_1}{N_2}$

$B_2 = \dfrac{N_2 \mu_0 i}{R_2}$

$\dfrac{B_2}{B_1} = \dfrac{N_2}{N_1} \cdot \dfrac{R_1}{R_2} = \dfrac{N_2}{N_1} \times \dfrac{N_2}{N_1};$ $\dfrac{B_2}{B_1} = \dfrac{25}{4}$
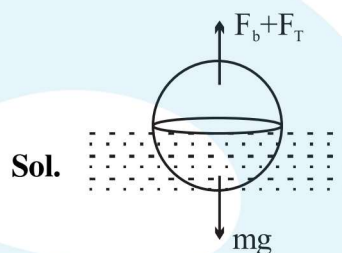
3. A drop of liquid of density ρ is floating half immersed in a liquid of density σ and surface tension 7.5×10^{-4} Ncm^{-1}. The radius of drop in cm will be : (Take : g = 10 m/s^2)

(A) $\dfrac{15}{\sqrt{2\rho - \sigma}}$ (B) $\dfrac{15}{\sqrt{\rho - \sigma}}$

(C) $\dfrac{3}{2\sqrt{\rho - \sigma}}$ (D) $\dfrac{3}{20\sqrt{2\rho - \sigma}}$

Official Ans. by NTA (A)

Ans. (A)

Sol.

Boyant force + surace tension = mg

$\sigma \dfrac{V}{2} g + 2\pi RT = \rho Vg$

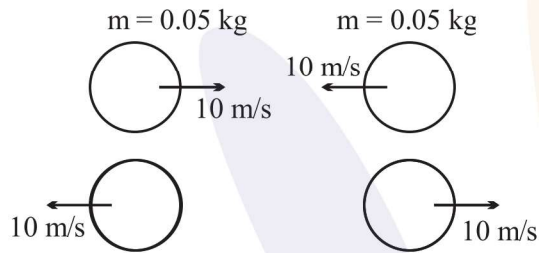$2\pi RT = \dfrac{(2\rho - \sigma)}{2} \dfrac{4}{3} \pi R^3 g;$ $\left[V = \dfrac{4}{3} \pi R^3 \right]$

$R^3 = \dfrac{3T}{(2\rho - \sigma)g} \Rightarrow R = \sqrt{\dfrac{3 \times 7.5 \times 10^{-2} N - m^{-1}}{(2\rho - \sigma) \times 10}}$

$R = \dfrac{3}{20\sqrt{(2\rho - \sigma)}}$ m $= \dfrac{15}{\sqrt{2\rho - \sigma}}$ cm

4. Two billiard balls of mass 0.05 kg each moving in opposite directions with 10 ms^{-1} collide and rebound with the same speed. If the time duration of contact is t = 0.005 s, then what is the force exerted on the ball due to each other?

(A) 100 N   (B) 200 N

(C) 300 N   (D) 400 N

Official Ans. by NTA (B)
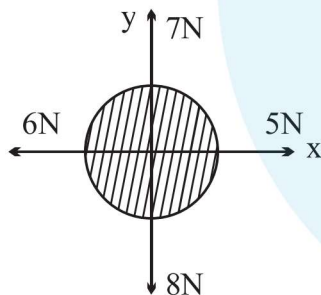
Ans. (B)

Change in momentum of any one ball

$\left|\Delta\vec{P}\right| = 2 \times 0.05 \times 10$

$|\Delta\vec{P}| = 1$

$\left|\vec{F}_{av}\right| = \dfrac{|\Delta\vec{P}|}{\Delta t}$

$F_{av.} = 200$ N

5. For a free body diagram shown in the figure, the four forces are applied in the 'x' and 'y' directions. What additional force must be applied and at what angle with positive x-axis so that the net acceleration of body is zero?

(A) $\sqrt{2}$ N, 45°   (B) $\sqrt{2}$ N, 135°

(C) $\dfrac{2}{\sqrt{3}}$ N , 30°   (D) 2 N, 45°

Official Ans. by NTA (A)

Ans. (A)

Sol. Let addition force required is = $\vec{F}$

$\vec{F} + 5\hat{i} - 6\hat{i} + 7\hat{j} - 8\hat{j} = 0$

$\vec{F} = \hat{i} + \hat{j}, |\vec{F}| = \sqrt{2}$

Angle with x-axis: $\tan\theta = \dfrac{y\ \text{component}}{x\ \text{component}} = \dfrac{1}{1}$

$\theta = 45°$

6. Capacitance of an isolated conducting sphere of radius R$_1$ becomes n times when it is enclosed by a concentric conducting sphere of radius R$_2$ connected to earth. The ratio of their radii $\left(\dfrac{R_2}{R_1}\right)$ is:

(A) $\dfrac{n}{n-1}$ (B) $\dfrac{2n}{2n+1}$

(C) $\dfrac{n+1}{n}$ (D) $\dfrac{2n+1}{n}$

Official Ans. by NTA (A)

Ans. (A)

Sol. Capacitance of isolated Conducting sphere
$= 4\pi\varepsilon_0 R_1$

By enclosing inside another sphere of radius R$_2$, new capacitance $= \dfrac{4\pi\varepsilon_0 R_1 R_2}{(R_2 - R_1)}$

Given: $\dfrac{4\pi\varepsilon_0 R_1 R_2}{(R_2 - R_1)} = n \times 4\pi\varepsilon_0 R_1$

$\Rightarrow \dfrac{R_2}{(R_2 - R_1)} = n \Rightarrow \dfrac{\dfrac{R_2}{R_1}}{\left(\dfrac{R_2}{R_1} - 1\right)} = n$

$\Rightarrow \dfrac{R_2}{R_1} = n\dfrac{R_2}{R_1} - n \Rightarrow \dfrac{R_2}{R_1} = \dfrac{n}{(n-1)}$

7. The ratio of wavelengths of proton and deuteron accelerated by potential V_p and V_d is $1 : \sqrt{2}$. Then, the ratio of V_p to V_d will be

(A) 1 : 1   (B) $\sqrt{2} : 1$
(C) 2 : 1   (D) 4 : 1

Official Ans. by NTA (D)

Ans. (D)

Sol. Kinetic energy gained by a charged particle accelerated by a potential V is qV

KE = qV

$$\Rightarrow \frac{p^2}{2m} = qV \Rightarrow p = \sqrt{2mqV}$$

$$p = \frac{h}{\lambda}, \text{ thus } \lambda = \frac{h}{\sqrt{2mqV}}$$

now $\dfrac{\lambda_p}{\lambda_d} = \sqrt{\dfrac{m_d V_d}{m_p V_p}}$

$$\Rightarrow \frac{1}{\sqrt{2}} = \sqrt{\frac{2V_d}{V_p}} \Rightarrow \frac{V_p}{V_d} = 4$$

8. For an object placed at a distance 2.4 m from a lens, a sharp focused image is observed on a screen placed at a distance 12 cm from the lens. A glass plate of refractive index 1.5 and thickness 1 cm is introduced between lens and screen such that the glass plate plane faces parallel to the screen. By what distance should the object be shifted so that a sharp focused image is observed again on the screen?

(A) 0.8 m   (B) 3.2 m
(C) 1.2 m   (D) 5.6 m

Official Ans. by NTA (B)

Ans. (B)

Sol.
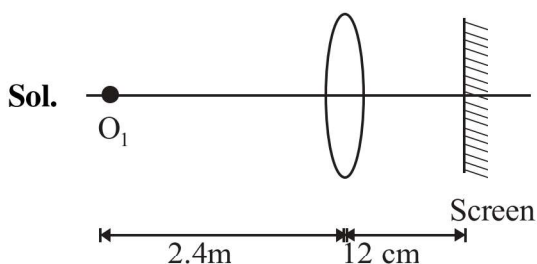
Applying lens formula

$$\frac{1}{0.12} + \frac{1}{2.4} = \frac{1}{f} \Rightarrow \frac{1}{f} = \frac{210}{24}$$

Upon putting the glass slab, shift of image is

$$\Delta x = t\left(1 - \frac{1}{\mu}\right) = \frac{1}{3} \text{ cm}$$

Now $v = 12 - \dfrac{1}{3} = \dfrac{35}{3}$ cm

Again apply lens formula

$$\frac{1}{0.12} + \frac{1}{u} = \frac{1}{f} = \frac{210}{24}$$

Solving u = – 5.6 m
Thus shift of object is
5.6 – 2.4 = 3.2 m

9. Light wave traveling in air along x-direction is given by $E_y = 540 \sin \pi \times 10^4 (x - ct)$ Vm^{-1}. Then, the peak value of magnetic field of wave will be (Given c = 3 × 10^8 ms^{-1})

(A) 18 × 10^{-7} T   (B) 54 × 10^{-7} T
(C) 54 × 10^{-8} T   (D) 18 × 10^{-8} T

Official Ans. by NTA (A)

Ans. (A)

Sol. $E_y = 540 \sin \pi \times 10^4 (x - ct)$ Vm^{-1}
$E_0 = 540$ Vm^{-1}

$$B_0 = \frac{E_0}{C} = \frac{540}{3 \times 10^8} = 18 \times 10^{-7} \text{ T}$$

10. When you walk through a metal detector carrying a metal object in your pocket, it raises an alarm. This phenomenon works on

(A) Electromagnetic induction
(B) Resonance in ac circuits
(C) Mutual induction in ac circuits
(D) interference of electromagnetic waves

Official Ans. by NTA (B)

Ans. (B)

Sol. Metal detector works on the principle of transmitting an electromagnetic signal and analyses a return signal from the target. So it works on the principle of resonance in AC circuit.

11. An electron with energy 0.1 keV moves at right angle to the earth's magnetic field of 1×10^{-4} Wbm^{-2}. The frequency of revolution of the electron will be
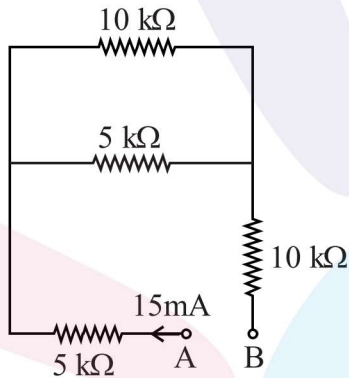(Take mass of electron = 9.0×10^{-31} kg)
(A) 1.6×10^5 Hz
(B) 5.6×10^5 Hz
(C) 2.8×10^6 Hz
(D) 1.8×10^6 Hz
Official Ans. by NTA (C)
Ans. (C)

Sol. $f = \dfrac{1}{T} = \dfrac{eB}{2\pi m}$

$= \dfrac{1.6 \times 10^{-19} \times 10^{-4}}{2\pi \times 9 \times 10^{-31}} = 2.8 \times 10^6$ Hz

12. A current of 15 mA flows in the circuit as shown in figure. The value of potential difference between the points A and B will be
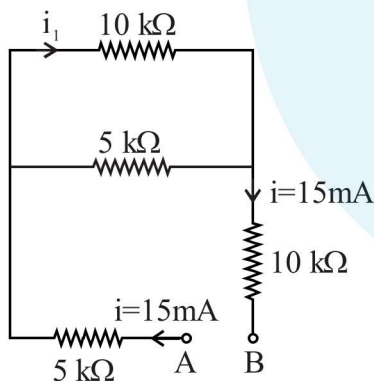

(A) 50V
(B) 75V
(C) 150V
(D) 275V
Official Ans. by NTA (D)
Ans. (D)

Sol.

$i_1 = \dfrac{5}{10+5} \times 15\,mA = 5\,mA$

$V_A - 5i_1 - 10i_1 - 10i = V_B$

$V_A - V_B = 75 + 50 + 150 = 275$ V

13. The length of a seconds pendulum at a height $h = 2R$ from earth surface will be:
(Given: R=Radius of earth and acceleration due to gravity at the surface of earth $g = \pi^2$ m/s^{-2})
(A) $\dfrac{2}{9}$ m
(B) $\dfrac{4}{9}$ m
(C) $\dfrac{8}{9}$ m
(D) $\dfrac{1}{9}$ m
Official Ans. by NTA (D)
Ans. (D)

Sol. $T = 2\pi \sqrt{\dfrac{L}{g}}$, $g' = \dfrac{GM}{9R^2} = \dfrac{g}{9} = \dfrac{\pi^2}{9}$

$2 = 2\pi \sqrt{\dfrac{L}{\pi^2} \times 9}$

$\Rightarrow 1 = \pi \sqrt{L} \times \dfrac{3}{\pi} \Rightarrow L = \dfrac{1}{9}$ m

14. Sound travels in a mixture of two moles of helium and n moles of hydrogen. If rms speed of gas molecules in the mixture is $\sqrt{2}$ times the speed of sound, then the value of n will be
(A) 1
(B) 2
(C) 3
(D) 4
Official Ans. by NTA (B)
Ans. (B)

Sol. $v_s = \sqrt{\dfrac{\gamma RT}{M}}$

$v_{rms} = \sqrt{\dfrac{3RT}{M}}$

$\dfrac{v_s}{v_{rms}} = \sqrt{\dfrac{\gamma}{3}} = \dfrac{1}{\sqrt{2}} \Rightarrow \dfrac{\gamma}{3} = \dfrac{1}{2} \Rightarrow \gamma = \dfrac{3}{2}$

$\gamma = 1 + \dfrac{2}{f_{mix.}}$

$f_{mix.} = \dfrac{2 \times 3 + n \times 5}{n+2} = \dfrac{6 + n \times 5}{(n+2)}$

$\gamma = 1 + \dfrac{2(n+2)}{6 + n \times 5} = \dfrac{6 + 5n + 2n + 4}{6 + 5n}$

$\gamma = \dfrac{7n + 10}{6 + 5n} = \dfrac{3}{2}$

$14n + 20 = 18 + 15n$

$n = 2$

15. Let η_1 is the efficiency of an engine at $T_1 = 447°C$ and $T_2 = 147°C$ while η_2 is the efficiency at $T_1 = 947°C$ and $T_2 = 47°C$. The ratio $\dfrac{\eta_1}{\eta_2}$ will be :

(A) 0.41   (B) 0.56

(C) 0.73   (D) 0.70

Official Ans. by NTA (B)

Ans. (B)

Sol. Efficiency $\eta = 1 - \dfrac{T_L}{T_H}$

$\eta_1 = 1 - \dfrac{147 + 273}{447 + 273} = 1 - \dfrac{420}{720}$

$\eta_1 = \dfrac{300}{720}$

$\eta_2 = 1 - \dfrac{47 + 273}{947 + 273} = 1 - \dfrac{320}{1220}$

$\eta_2 = \dfrac{900}{1220}$

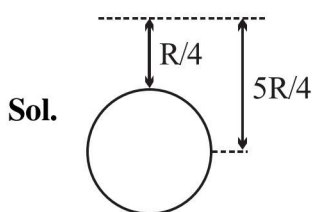$\dfrac{\eta_1}{\eta_2} = \dfrac{300}{720} \times \dfrac{1220}{900} = \dfrac{122}{72 \times 3}$

$\dfrac{\eta_1}{\eta_2} = 0.56$

16. An object is taken to a height above the surface of earth at a distance $\dfrac{5}{4}R$ from the centre of the earth. Where radius of earth, $R = 6400$ km. The percentage decrease in the weight of the object will be

(A) 36%   (B) 50%

(C) 64%   (D) 25%

Official Ans. by NTA (A)

Ans. (A)

Sol.

$g_{eff} = \dfrac{g}{\left(1 + \dfrac{h}{R}\right)^2}$; $g_{eff} = \dfrac{g}{\left(1 + \dfrac{1}{4}\right)^2} = \dfrac{16g}{25}$

change $= \dfrac{g_{eff} - g}{g} \times 100 = \dfrac{\dfrac{16}{25} - 1}{1} \times 100$

$= \dfrac{-9}{25} \times 100 = -36\%$

Hence % decrease in the weight = 36%

17. A bag of sand of mass 9.8 kg is suspended by a rope. A bullet of 200 g travelling with speed 10 ms^{-1} gets embedded in it, then loss of kinetic energy will be

(A) 4.9 J   (B) 9.8 J

(C) 14.7   (D) 19.6 J

Official Ans. by NTA (B)

Ans. (B)

Sol. $P_i = P_f$ (no any external force)

$0.2 \times 10 = 10 \times v$

$v = 0.2$ m/sec

Loss in K.E. $= \dfrac{1}{2} \times (0.2) \times 10^2 - \dfrac{1}{2} \times 10 (0.2)^2$

$= \dfrac{1}{2} \times 10 \times (0.2)[10 - 0.2]$

$= 9.8$ J

18. A ball is projected from the ground with a speed 15 ms^{-1} at an angle θ with horizontal so that its range and maximum height are equal, then 'tan θ' will be equal to

(A) $\dfrac{1}{4}$ (B) $\dfrac{1}{2}$

(C) 2   (D) 4

Official Ans. by NTA (D)

Ans. (D)

Sol. R = H

$\dfrac{2v_x \times v_y}{g} = \dfrac{v_y^2}{2g}$

$v_x = \dfrac{v_y}{4}$; $u \cos \theta = \dfrac{u \sin \theta}{4}$

$\tan \theta = 4$

19. The maximum error in the measurement of resistance, current and time for which current flows in an electrical circuit are 1%, 2% and 3% respectively. The maximum percentage error in the detection of the dissipated heat will be:

(A) 2 (B) 4

(C) 6 (D) 8

Official Ans. by NTA (D)

Ans. (D)

Sol. $E_H = I^2R \times t$

$$\frac{\Delta E}{E} \times 100 = \frac{2\Delta I}{I} \times 100 + \frac{\Delta R}{R} \times 100 + \frac{\Delta T}{T} \times 100$$

$$= 2 \times 2 + 1 + 3 = 8$$

20. Hydrogen atom from excited state comes to the ground by emitting a photon of wavelength λ. The value of principal quantum number 'n' of the excited state will be : (R : Rydberg constant)
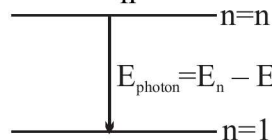
(A) $\sqrt{\dfrac{\lambda R}{\lambda - 1}}$ (B) $\sqrt{\dfrac{\lambda R}{\lambda R - 1}}$

(C) $\sqrt{\dfrac{\lambda}{\lambda R - 1}}$ (D) $\sqrt{\dfrac{\lambda R^2}{\lambda R - 1}}$

Official Ans. by NTA (B)

Ans. (B)

Sol.

$$E_n = \frac{-Rch}{n^2} \quad (1)$$

———————— n=n

$E_{photon} = E_n - E_1$

———————— n=1

$$E_1 = \frac{-Rch}{(1)^2} \quad (1)$$

$$\frac{-Rch}{(n)^2} + \frac{Rch}{1} = \frac{hc}{\lambda}$$

$$\frac{-R}{n^2} + R = \frac{1}{\lambda}$$

$$R - \frac{1}{\lambda} = \frac{R}{n^2}$$

$$\frac{\lambda R - 1}{\lambda} = \frac{R}{n^2}$$

$$n^2 = \frac{\lambda R}{\lambda R - 1} \implies n = \sqrt{\frac{\lambda R}{\lambda R - 1}}$$

SECTION-B

1. A particle is moving in a straight line such that its velocity is increasing at 5 ms^{-1} per meter. The acceleration of the particle is _____ ms^{-2} at a point where its velocity is 20 ms^{-1}.

**Official Ans. by NTA (100)**

Ans. (100)

Sol. $\dfrac{dv}{ds} = 5$

$$a = v\frac{dv}{ds} = 20 \times 5 = 100 \text{ m/sec}^2$$

2. Three identical spheres each of mass M are placed at the corners of a right angled triangle with mutually perpendicular sides equal to 3 m each. Taking point of intersection of mutually perpendicular sides as origin, the magnitude of position vector of centre of mass of the system will be $\sqrt{x}$ m. The value of x is

Official Ans. by NTA (2)

Ans. (2)

Sol.

(0, 3)

3m   3√3

(0, 0) 3m (3,0)
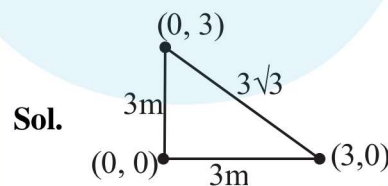
$$\vec{r}_{com} = \frac{M(0\hat{i} + 0\hat{j}) + M(3\hat{i}) + M(3\hat{j})}{3M}$$

$$\vec{r}_{com} = \hat{i} + \hat{j}$$

$$|\vec{r}_{com}| = \sqrt{2} = \sqrt{x}$$

$$x = 2$$

3. A block of ice of mass 120 g at temperature 0°C is put in 300 gm of water at 25°C. The xg of ice melts as the temperature of the water reaches 0°C. The value of x is

[Use: Specific heat capacity of water = 4200 $Jkg^{-1}K^{-1}$, Latent heat of ice = 3.5×10^5 Jkg^{-1}]

Official Ans. by NTA (90)

Ans. (90)

Sol. Energy released by water

$= 0.3 \times 25 \times 4200 = 31500$ J

let m kg ice melts

$m \times 3.5 \times 10^5 = 31500$

$m = \dfrac{31500 \times 10^{-5}}{3.5} = 9000 \times 10^{-5}$

$m = 0.09$ kg $= 90$ gm

$x = 90$

4. $\dfrac{x}{x+4}$ is the ratio of energies of photons produced due to transition of an electron of hydrogen atom from its

(i) third permitted energy level to the second level and

(ii) the highest permitted energy level to the second permitted level.

The value of x will be

Official Ans. by NTA (5)

Ans. (5)

Sol. $\dfrac{13.6\left(\dfrac{1}{2^2}-\dfrac{1}{3^2}\right)}{13.6\left(\dfrac{1}{2^2}-0\right)} = \dfrac{x}{x+4}$; $\dfrac{\dfrac{1}{4}-\dfrac{1}{9}}{\dfrac{1}{4}} = \dfrac{x}{x+4}$

$\dfrac{5}{9} = \dfrac{x}{x+4}$

$5x + 20 = 9x$

$4x = 20$

$x = 5$

5. In a potentiometer arrangement, a cell of emf 1.20 V gives a balance point at 36 cm length of wire. This cell is now replaced by another cell of emf 1.80 V. The difference in balancing length of potentiometer wire in above conditions will be _____ cm.

Official Ans. by NTA (18)

Ans. (18)

Sol. 1.2 = (Potential Gradient) × 36

1.8 = (Potential Gradient) × x
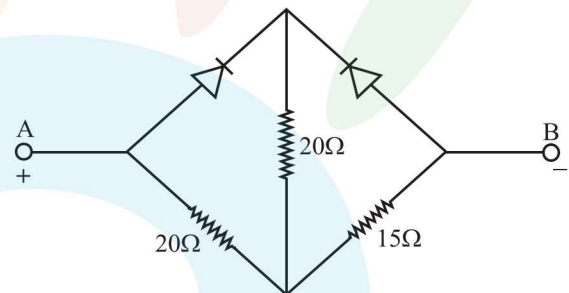
On dividing, we get

$\dfrac{2}{3} = \dfrac{36}{x}$

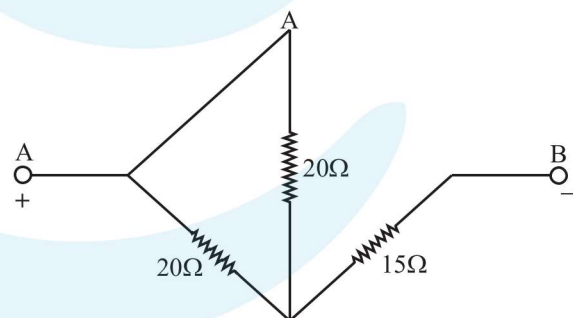$x = 18 \times 3 = 54$ cm

Hence difference = 54 – 36 = 18 cm

6. Two ideal diodes are connected in the network as shown in figure. The equivalent resistance between A and B is _____ Ω.
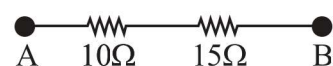

Official Ans. by NTA (25)

Ans. (25)

Sol.

The forward biased diode will conduct while the reverse biased will not

∴ Equivalent resistance = 10 + 15 = 25Ω

7. Two waves executing simple harmonic motion travelling in the same direction with same amplitude and frequency are superimposed. The resultant amplitude is equal to the $\sqrt{3}$ times of amplitude of individual motions. The phase difference between the two motions is _____ (degree)

Official Ans. by NTA (60)

Ans. (60)

Sol. $A_{resultant} = \sqrt{A_1^2 + A_2^2 + 2A_1A_2\cos\phi}$

$\Rightarrow \sqrt{3}A = \sqrt{A^2 + A^2 + 2A^2\cos\phi}$

$\Rightarrow 3A^2 = 2A^2 + 2A^2\cos\phi$

$\Rightarrow \cos\phi = \dfrac{1}{2}$

$\therefore \phi = 60°$

$\therefore$ Phase difference = 60 degree

8. Two parallel plate capacitors of capacity C and 3C are connected in parallel combination and charged to a potential difference 18V. The battery is then disconnected and the space between the plates of the capacitor of capacity C is completely filled with a material of dielectric constant 9. The final potential difference across the combination of capacitors will be _____ V

Official Ans. by NTA (6)

Ans. (6)

Sol.
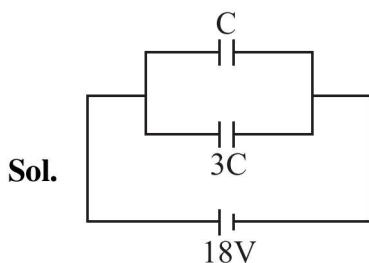
Initial charge on C = 18 CV

initial charge on 3C = 54 CV

Let final common potential difference = V'

9CV' + 3CV' = 18CV + 54CV

$\Rightarrow$ 12CV' = 72 CV $\Rightarrow$ V' = 6 V

9. A convex lens of focal length 20 cm is placed in front of convex mirror with principal axis coinciding each other. The distance between the lens and mirror is 10 cm. A point object is placed on principal axis at a distance of 60 cm from the convex lens. The image formed by combination coincides the object itself. The focal length of the convex mirror is _____ cm.

Official Ans. by NTA (10)

Ans. (10)

Sol.
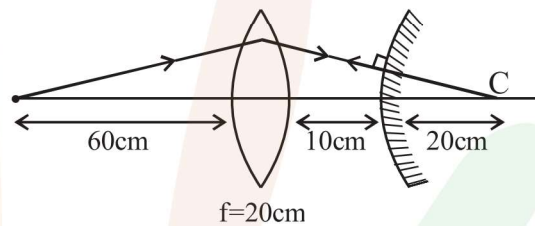
For lens

$\dfrac{1}{v} - \dfrac{1}{u} = \dfrac{1}{f}$

$\Rightarrow \dfrac{1}{v} - \dfrac{1}{(-60)} = \dfrac{1}{20} \Rightarrow \dfrac{1}{v} + \dfrac{1}{60} = \dfrac{1}{20}$

v = 30 cm

For final image to be formed on the object itself, after refraction from lens the ray should meet the mirror perpendicularly and the image by lens should be on the centre of curvature of mirror

R = 30 − 10 = 20 cm

Focal length of mirror = R/2 = 10 cm

10. Magnetic flux (in weber) in a closed circuit of resistance 20 Ω varies with time t(s) as $\phi = 8t^2 - 9t + 5$. The magnitude of the induced current at t = 0.25 s will be _____ mA **Official Ans. by NTA (250)**

Ans. (250)

Sol. $\phi = 8t^2 - 9t + 5$

$emf = -\dfrac{d\phi}{dt} = -(16t - 9)$

At t = 0.25 s

Emf = −[(16 × 0.25)−9] = 5V

$Current = \dfrac{Emf}{Resistance} = \dfrac{5V}{20\Omega}$

$= \dfrac{1}{4}A = \dfrac{1000}{4}mA = 250mA$