PHYSICS
JEE-MAIN (July-Attempt)
29 July (Shift-1) Paper Solution

SECTION - A

1. Given below are two statement : One is labelled as Assertion (A) and other is labelled as Reason (R).

Assertion (A) : Time period of oscillation of a liquid drop depends on surface tension (S), if density of the liquid is ρ and radius of the drop is r, then $T = K\sqrt{\frac{\rho r^3}{S^{\frac{3}{2}}}}$ is dimensionally correct, where K is dimensionless.

Reason (R): Using dimensional analysis we get R.H.S. having different dimension than that of time period.

In the light of above statements, choose the correct answer from the options given below.

(A) Both (A) and (R) are true and (R) is the correct explanation of (A)

(B) Both (A) and (R) are true but (R) is not the correct explanation of (A)

(C) (A) is true but (R) is false

(D) (A) is false but (R) is true

Sol. **D**

$$T = K\sqrt{\frac{\rho r^3}{S^{\frac{3}{2}}}}$$

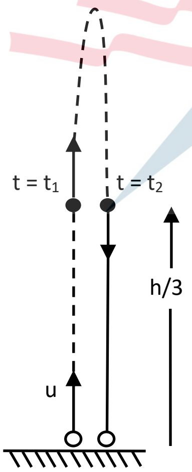
Dimensions of RHS = $\frac{\left[M^{\frac{1}{2}}L^{-\frac{3}{2}}\right]\left[L^{\frac{3}{2}}\right]}{[MT^{-2}]^{\frac{3}{4}}} = M^{\frac{1}{8}}L^0T^{\frac{3}{2}}$

Dimensions of L.H.S. ≠ Dimensions of R.H.S.

2. A ball is thrown up vertically with a certain velocity so that, it reaches a maximum height h. Find the ratio of the times in which it is at height $\frac{h}{3}$ while going up and coming down respectively.

(A) $\frac{\sqrt{2}-1}{\sqrt{2}+1}$ (B) $\frac{\sqrt{3}-\sqrt{2}}{\sqrt{3}+\sqrt{2}}$ (C) $\frac{\sqrt{3}-1}{\sqrt{3}+1}$ (D) $\frac{1}{3}$

Sol. **B**



Max. Height = h = $\frac{u^2}{2g}$

$\Rightarrow u = \sqrt{2gh}$

$S = ut + \frac{1}{2}at^2$

$\frac{h}{3} = \sqrt{2gh}\,t + \frac{1}{2}(-g)t^2$

$\frac{gt^2}{2} - \sqrt{2gh}\,t + \frac{h}{3} = 0$ (Roots are t_1 & t_2)

$$\frac{t_2}{t_1} = \frac{\sqrt{2gh}+\sqrt{2gh-4\times\frac{g}{2}\times\frac{h}{3}}}{\sqrt{2gh}-\sqrt{2gh-4\times\frac{g}{2}\times\frac{h}{3}}} = \frac{\sqrt{2gh}+\sqrt{\frac{4gh}{3}}}{\sqrt{2gh}-\sqrt{\frac{4gh}{3}}} = \frac{\sqrt{3}+\sqrt{2}}{\sqrt{3}-\sqrt{2}}$$

3. If t = $\sqrt{x} + 4$, then $\left(\frac{dx}{dt}\right)_{t=4}$ is :

(A) 4 (B) zero (C) 8 (D) 16

Sol. **B**

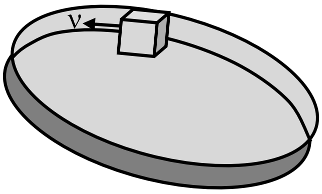
t = $\sqrt{x} + 4$

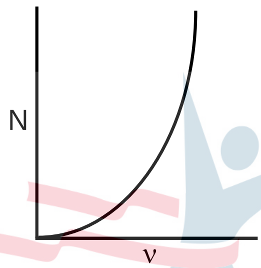
$\Rightarrow$ x = $(t - 4)^2 = t^2 - 8t + 16$

$\Rightarrow \frac{dx}{dt} = 2t - 8$

$\Rightarrow \frac{dx}{dt}|_{t=4} = 2 \times 4 - 8 = 0$

4. A smooth circular groove has a smooth vertical wall as shown in figure. A block of mass m moves against the wall with a speed ν. Which of the following curve represents the correct relation between the normal reaction on the block by the wall (N) and speed of the block (ν) ?



(A)


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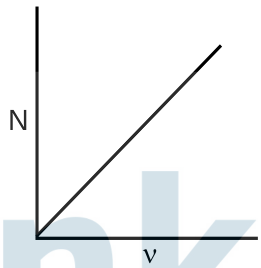
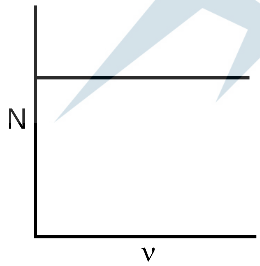
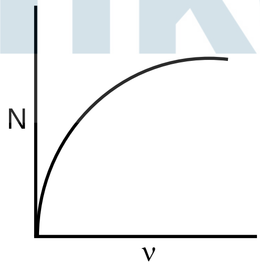


(C)


(D)


Sol. **A**

N = $\frac{mv^2}{r}$

Curve is parabola

Y = kx^2

5. A ball is projected with kinetic energy E, at an angle of 60° to the horizontal. The kinetic energy of this ball at the highest point of its flight will become:

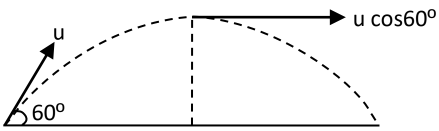
(A) Zero (B) $\frac{E}{2}$ (C) $\frac{E}{4}$ (D) E

Sol. **C**

E = $\frac{1}{2}mu^2$

At Highest point, Velocity V = u cos60° = $\frac{u}{2}$

$\therefore$ K.E at topmost point = $\frac{1}{2}m\left(\frac{u}{2}\right)^2 = \frac{E}{4}$



6. Two bodies of mass 1 kg and 3 kg have position vectors $\hat{i} + 2\hat{j} + \hat{k}$ and $-3\hat{i} - 2\hat{j} + \hat{k}$ respectively. The magnitude of position vector of centre of mass of this system will be similar to the magnitude of vector:

(A) $\hat{i} + 2\hat{j} + \hat{k}$ (B) $-3\hat{i} - 2\hat{j} + \hat{k}$ (C) $-2\hat{i} + 2\hat{k}$ (D) $-2\hat{i} - \hat{j} + 2\hat{k}$

Sol. **A**

$\overrightarrow{r_{com}} = \frac{m_1\vec{r_1}+m_2\vec{r_2}}{m_1+m_2} = \frac{1(\hat{\imath}+2\hat{\jmath}+\hat{k})+3(-3\hat{\imath}-2\hat{\jmath}+\hat{k})}{1+3}$

$= -2\hat{\imath} - \hat{\jmath} + \hat{k}$

$|2\hat{\imath} - \hat{\jmath} + \hat{k}| = \sqrt{(2)^2 + (1)^2 + (1)^2} = \sqrt{6}$

7. Given below are two statement : One is labelled as Assertion (A) and other is labelled as Reason (R).

Assertion (A) : Clothes containing oil or grease stains cannot be cleaned by water wash.

Reason (R): Because the angle of contact between the oil/grease and water is obtuse.

In the light of the above statements, choose the correct answer from the option given below.

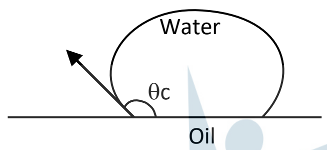
(A) Both (A) and (R) are true and (R) is the correct explanation of (A)

(B) Both (A) and (R) are true but (R) is not the correct explanation of (A)

(C) (A) is true but (R) is false

(D) (A) is false but (R) is true

Sol. **A**



$\theta c > 90^o$

For water oil interface

8. If the length of a wire is made double and radius is halved of its respective values. Then, the Young's modulus of the material of the wire will:

(A) remain same (B) become 8 time its initial value

(C) become $\frac{1}{4}^{th}$ of its initial value (D) become 4 times its initial value

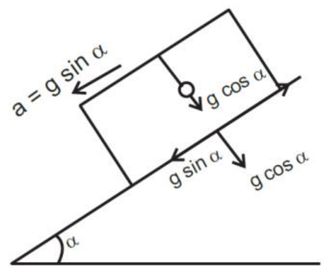
Sol. **A**

Y depends on material of wire

9. The time period of oscillation of a simple pendulum of length L suspended from the roof of a vehicle, which moves without friction down an inclined plane of inclination α, is given by:

(A) $2\pi\sqrt{L/(g\cos\alpha)}$ (B) $2\pi\sqrt{L/(g\sin\alpha)}$ (C) $2\pi\sqrt{L/g}$ (D) $2\pi\sqrt{L/(g\tan\alpha)}$

Sol. **A**



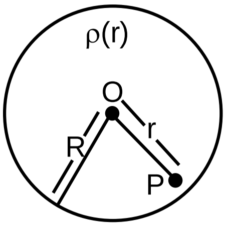
$g_{cff} = g\cos\alpha$

$T = 2\pi\sqrt{\frac{L}{g\cos\alpha}}$

10. A spherically symmetric charge distribution is considered with charge density varying as

$$\rho(r) = \begin{cases} \rho_0\left(\frac{3}{4} - \frac{r}{R}\right) & \text{for } r \le R \\ \text{zero} & \text{for } r > R \end{cases}$$

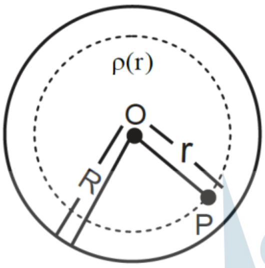
Where, r (r < R) is the distance from the centre O (as shown in figure). The electric field at point P will be



(A) $\frac{\rho_0 r}{4\varepsilon_0}\left(\frac{3}{4} - \frac{r}{R}\right)$ (B) $\frac{\rho_0 r}{3\varepsilon_0}\left(\frac{3}{4} - \frac{r}{R}\right)$ (C) $\frac{\rho_0 r}{4\varepsilon_0}\left(1 - \frac{r}{R}\right)$ (D) $\frac{\rho_0 r}{5\varepsilon_0}\left(1 - \frac{r}{R}\right)$

sol. **C**

By Gauss law



$\oint \vec{E}.d\vec{s} = \frac{Q_{in}}{\varepsilon_0}$

$E.4\pi r^2 = \frac{\int_0^r \rho_0(\frac{3}{4} - \frac{r}{R})4\pi r^2 dr}{\varepsilon_0}$

$E.4\pi r^2 = \frac{\rho_0 4\pi}{\varepsilon_0}\left(\frac{3}{4}\frac{r^3}{3} - \frac{r^4}{4R}\right)$

$Er^2 = \frac{\rho_0 r^3}{4\varepsilon_0}\left\{1 - \frac{r}{R}\right\}$

$E = \frac{\rho_0 r}{4\varepsilon_0}\left\{1 - \frac{r}{R}\right\}$

11. Given below are two statements.

Statement I : Electric potential is constant within and at the surface of each conductor.

Statement II : Electric field just outside a charged conductor is perpendicular to the surface of the conductor at every point.

In the light of the above statements choose the most appropriate answer from the options given below.

(A) Both statement I and statement II are correct

(B) Both statement I and statement II are incorrect

(C) Statement I is correct but statement II is incorrect

(D) Statement I is incorrect but statement II is correct

Sol. **A**

(Properties of conductor)

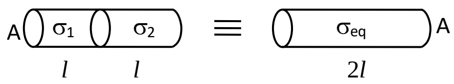
Statement-I : True as body of conductor acts as equipotential surface.

Statement-II : True, as conductor is equipotential. Tangential component of electric field should be zero. Therefore electric field should be perpendicular to surface.

12. Two metallic wires of identical dimensions are connected in series. If σ_1 and σ_2 are the conductivities of the these wires respectively, the effective conductivity of the combination is :

(A) $\frac{\sigma_1\sigma_2}{\sigma_1+\sigma_2}$ (B) $\frac{2\sigma_1\sigma_2}{\sigma_1+\sigma_2}$ (C) $\frac{\sigma_1+\sigma_2}{2\sigma_1\sigma_2}$ (D) $\frac{\sigma_1+\sigma_2}{\sigma_1\sigma_2}$

Sol. **B**



Let length of wire be 'l'

Area of wire as 'A'

For equivalent wire length = 2l & area will be A

Thermal resistance

$R_{eq} = R_1 + R_2$

$$\frac{2l}{\sigma_{eq}A} = \frac{l}{\sigma_1 A} + \frac{l}{\sigma_1 A}$$

$$\frac{2l}{\sigma_{eq}} = \frac{l}{\sigma_1} + \frac{l}{\sigma_2}$$

$$\Rightarrow \sigma_{eq} = \frac{2\sigma_1\sigma_2}{\sigma_1+\sigma_2}$$

13. An alternating emf E = 440 sin 100πt is applied to a circuit containing an inductance of $\frac{\sqrt{2}}{\pi}$ H . If an a.c. ammeter is connected in the circuit, its reading will be :

(A) 4.4 A (B) 1.55 A (C) 2.2A (D) 3.11 A

Sol. **C**

$E = 440 \sin 100\pi t$, $L = \frac{\sqrt{2}}{\pi}H$

$X_L = \omega L = 100\pi\frac{\sqrt{2}}{\pi} = 100\sqrt{2}\Omega$

Peak current $I_0 = \frac{E_0}{X_L} = \frac{440}{100\sqrt{2}} = 2.2\sqrt{2}A$

AC ammeter reads RMS value therefore reading will be I_{rms}

$I_{rms} = \frac{I_0}{\sqrt{2}} = 2.2A$

14. A coil of inductance 1 H and resistance 10Ω is connected to a battery of 6 V. Determine approximately :

(a) The time elapsed before the current acquires half of its steady-state value.

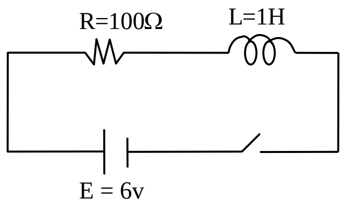
(b) The energy stored in the magnetic field associated with the coil at an instant 15 ms after the circuit it switched on. (Given $\ln 2 = 0.693$, $e^{-3/2} = 0.25$)

(A) t = 10 ms; U = 2 mJ (B) t = 10 ms; U = 1 mJ

(C) t = 7 ms; U = 1 mJ (D) t = 7 ms; U = 2 mJ

Sol. **C**

Given circuit is R–L growth circuit



i = $\frac{E}{R}\left(1-e^{-t/\tau}\right)$

i = $\frac{E}{2R}=\frac{E}{R}\left(1-e^{-t/\tau}\right)$

Solving t = $\tau\ln 2$

t = $\frac{1}{R}\ln 2=\frac{1}{100}0.693=0.00693$

= 7 ms

i(15 ms) = $\frac{E}{R}\left(1-e^{-\frac{15}{10}}\right)$

$i=\frac{6}{100}\left(1-\frac{1}{4}\right)=\frac{3}{4}\times\frac{6}{100}$

U = $\frac{1}{2}LI^2$

by Solving we get U = 1 mJ

15. Match List – I with List – II :

	List – I		**List – II**
(a)	UV rays	(i)	Diagnostic tool in medicine
(b)	X-rays	(ii)	Water purification
(c)	Microwave	(iii)	Communication, Radar
(d)	Infrared wave	(iv)	Improving visibility in foggy days

Choose the correct answer from the options given below :

(A) (a)-(iii), b-(ii), (c) – (i), d-(iv)
(B) (a)-(ii), b-(i), (c) – (iii), d-(iv)
(C) (a)-(ii), b-(iv), (c) – (iii), d-(i)
(D) (a)-(iii), b-(i), (c) – (ii), d-(iv)

Sol. **B**

(a) uv rays- used for water purification
(b) x-rays used for diagnosing fracture
(c) Microwaves are used for mobile and rader communication
(d) Infrared waves show less scattering therefore used in foggy days
(a – ii), (b – i), (c – iii), (d – iv)

16. The kinetic energy of emitted electron is E when the light incident on the metal has wavelength λ. To double the kinetic energy, the incident light must have wavelength:

(A) $\frac{hc}{E\lambda-hc}$ (B) $\frac{hc\lambda}{E\lambda+hc}$ (C) $\frac{h\lambda}{E\lambda+hc}$ (D) $\frac{hc\lambda}{E\lambda-hc}$

Sol. **B**

$E = \frac{hc}{\lambda} - \phi$ ....(i)

$2E = \frac{hc}{\lambda'} - \phi$ .....(ii)

(ii) – (i)

$E = hc(\frac{1}{\lambda'} - \frac{1}{\lambda})$

$\Rightarrow \lambda' = \frac{hc\lambda}{E\lambda + hc}$

17. Find the ratio of energies of photons produced due to transition of an electron of hydrogen atom from its (i) second permitted energy level to the first level, and (ii) the highest permitted energy level to the first permitted level.

(A) 3 : 4 (B) 4 : 3 (C) 1 : 4 (D) 4 : 1

Sol. **A**

$E_n = \frac{-13.6}{n^2} eV$

$\Rightarrow \frac{E_2 - E_1}{E_\infty - E_1} = \frac{13.6(1-\frac{1}{4})}{13.6} = \frac{3}{4}$

18. Find the modulation index of an AM wave having 8 V variation where maximum amplitude of the AM wave is 9V.

(A) 0.8 (B) 0.5 (C) 0.2 (D) 0.1

Sol. **A**

Modulation index : $m = \frac{A_m}{A_c}$

Given $2A_m = 8$

$A_m + A_c = 9 \Rightarrow A_c = 5$

$\therefore \quad m = \frac{4}{5} = 0.8$

19. A travelling microscope has 20 divisions per cm on the main scale while its vernier scale has total 50 divisions and 25 vernier scale divisions are equal to 24 main scale divisions, what is the least count of the travelling microscope?

(A) 0.001 cm (B) 0.002 mm (C) 0.002 cm (D) 0.005 cm

Sol. **C**

$1 \text{ MSD} = \frac{1}{20} cm$

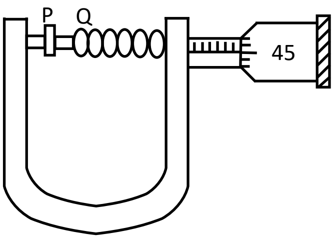
$1 \text{ VSD} = \frac{24}{25} MSD = \frac{24}{25} \times \frac{1}{20} cm$

$\therefore$ Least count $= \frac{1}{20}\left(1 - \frac{24}{25}\right) cm$

$= \frac{1}{20} \times \frac{1}{25} = \frac{1}{500} cm$

$= 0.002$ cm

20. In an experiment to find out the diameter of wire using screw gauge, the following observations were noted :



(a) Screw moves 0.5 mm on main scale in one complete rotation
(b) Total divisions on circular scale = 50
(c) Main scale reading is 2.5 mm
(d) 45^{th} division of circular scale is in the pitch line
(e) Instrument has 0.03 mm negative error
Then the diameter of wire is :
(A) 2.92 mm (B) 2.54 mm (C) 2.98 mm (D) 3.45 mm

Sol. **C**
MSR = 2.5 mm
CSR = $45 \times \frac{0.5}{50} mm$
= 0.45 mm
Diameter reading = MSR + CSR – zero error
= 2.5 + 0.45 – (–0.03)
= 2.98 mm

SECTION - B

21. An object is projected in the air with initial velocity u at an angle θ. The projectile motion is such that the horizontal range R, is maximum. Another object is projected in the air with a horizontal range half of the range of first object. The initial velocity remains same in both the case. The value of the angle of projection, at which the second object is projected, will be ____________degree.

Sol. **15**
$R_{max} = \frac{u^2 \sin 2(45°)}{g} = \frac{u^2}{g}$
$\frac{R}{2} = \frac{u^2}{2g} = \frac{u^2 \sin 2\theta}{g}$
$\sin 2\theta = \frac{1}{2}$
$2\theta = 30°, 150°$
$\theta = 15°, 75°$

22. If the acceleration due to gravity experienced by a point mass at a height h above the surface of earth is same as that of the acceleration due to gravity at a depth αh (h << R_e) from the earth surface. The value of α will be____________.
(use R_e =6400 km)

Sol. **2**

$g\left(1-\frac{2h}{R}\right)=g\left(1-\frac{d}{R}\right)$

$\frac{2h}{R}=\frac{d}{R}$

αh = d

α = 2

23. The pressure P_1 and density d_1 of diatomic gas $\left(\gamma=\frac{7}{5}\right)$ changes suddenly to P_2 (> P_1) and d_2 respectively during an adiabatic process. The temperature of the gas increases and becomes _____________times of its initial temperature. (given $\frac{d_2}{d_1}=32$)

Sol. **4**

PV^{γ} = const

$d=\frac{m}{v}$

$P\left(\frac{m}{d}\right)^{\gamma}$ = const

$\frac{P}{d^{\gamma}}=const$

$\frac{d_2}{d_1}=32$

$\frac{P_1}{P_2}=\left(\frac{d_1}{d_2}\right)^{\gamma}=\left(\frac{1}{32}\right)^{\frac{7}{5}}=\frac{1}{128}$

$\frac{T_1}{T_2}=\frac{P_1V_1}{P_2V_2}=\frac{1}{128}32=\frac{1}{4}$

24. One mole of a monoatomic gas is mixed with three moles of a diatomic gas. The molecular specific heat of mixture at constant volume is $\frac{\alpha^2}{4}$RJ/mol K ; then the value of α will be ____________. (Assume that the given diatomic gas has no vibrational mode).

Sol. **3**

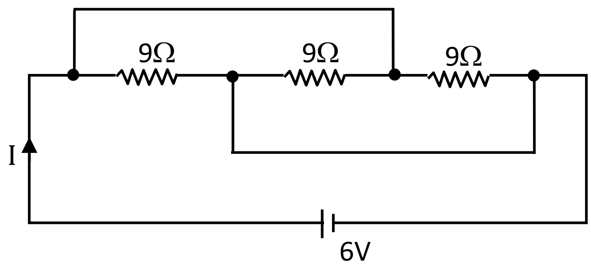
$C_V/\text{mix}=\frac{n_1Cv_1+n_2Cv_2}{n_1+n_2}$

$=\frac{1\cdot\frac{3R}{2}+3\cdot\frac{5R}{2}}{1+3}$

$=\frac{9R}{4}=\frac{\alpha^2}{4}R$

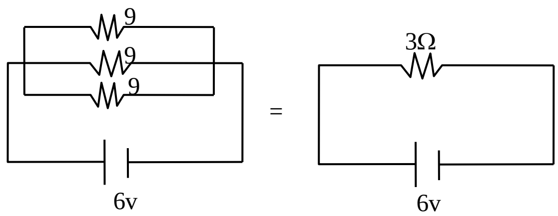
α = 3

25. The current I flowing through the given circuit will be ______________A.



Sol. **2**

Equivalent circuit



$I = \frac{6}{3} = 2A$

26. A closely wounded circular coil of radius 5 cm produces a magnetic field of 37.68×10^{-4}T at its center. The current through the coil is __________ A.

[Given, number of turns in the coil is 100 and π = 3.14]

Sol. **3**

$B_{centre} = \frac{N\mu_0 I}{2R}$

$37.68 \times 10^{-4} = \frac{100\times4\pi\times10^{-7}\times I}{2\times5\times10^{-2}}$

I = 3A

27. Two light beams of intensities 4I and 9I interfere on a screen. The phase difference between these beams on the screen at point A is zero and at point B is π. The difference of resultant intensities, at the point A and B, will be ___________ I.

Sol. **24**

$I_{net} = I_1 + I_2 + 2\sqrt{I_1}\sqrt{I_2}\cos\phi$

I_{max} for $\phi = 0$ & I_{min} for $\phi = \pi$

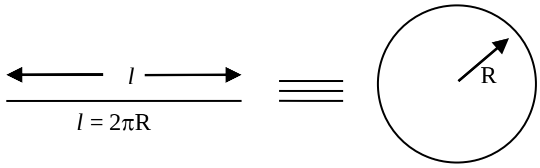
$I_{max} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2 = \left(\sqrt{9I} + \sqrt{4I}\right)^2 = 25I$

$I_{min} = (\sqrt{I_1} - \sqrt{I_2})^2 = (\sqrt{9I} - \sqrt{4I})^2 = I$

$I_{max} - I_{min} = 25I - I = 24\ I$

28. A wire of length 314 cm carrying current of 14 A is bent to form a circle. The magnetic moment of the coil is ________ A–m². [Given π = 3.14]

Sol. **11**



$\frac{314}{100} = 2\pi R$ R = 0.5m

Magnetic Moment = IA

= 14 × πR^2

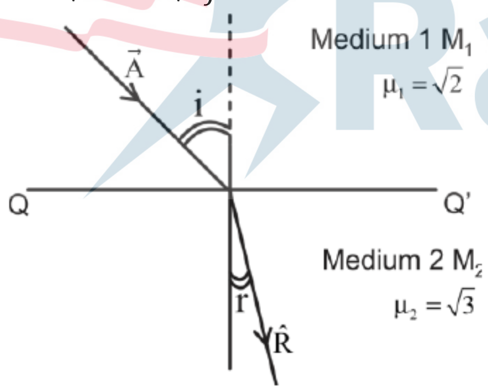
= 14 × (3.14) × $\frac{1}{4}$

= 10.99 ≈ 11.00

29. The X-Y plane be taken as the boundary between two transparent media M_1 and M_2. M_1 in $Z \geq 0$ has a refractive index of $\sqrt{2}$ and M_2 with $Z < 0$ has a refractive index of $\sqrt{3}$. A ray of light travelling in M_1 along the direction given by the vector $\vec{P} = 4\sqrt{3}\hat{i} - 3\sqrt{3}\hat{j} - 5\hat{k}$, is incident on the plane of separation. The value of difference between the angle of incident in M_1 and the angle of refraction in M_2 will be ________ degree.

Sol. **15**

$\vec{A} = 4\sqrt{3}\hat{\imath} - 3\sqrt{3}\hat{\jmath} - 5\hat{k}$



$\mu_1 \sin i = \mu_2 \sin r$

As incident vector A makes i angle with normal z-axis & refracted vector R makes r angle with normal z-axis with help of direction cosine

$$i = \cos^{-1}\left(\frac{A_z}{A}\right) = \cos^{-1}\left(\frac{5}{\sqrt{(4\sqrt{3})^2 + (3\sqrt{3})^2 + 5^2)}}\right)$$

$= \cos^{-1}\left(\frac{5}{10}\right) \Rightarrow i = 60°$

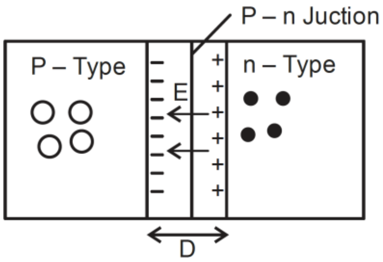
$\sqrt{2}\sin 60 = \sqrt{3} \times \sin r$

r = 45°

Difference between i & r = 60 – 45 = 15

30. If the potential barrier across a p-n junction is 0.6 V. Then the electric field intensity, in the depletion region having the width of 6×10^{-6} m, will be ____________ $\times 10^{5}$ N/C.

Sol. **1**



$E = \frac{V}{d} = \frac{Potential\ barrier\ Across\ Junction}{width\ of\ Depletion\ layer}$

$= \frac{0.6V}{6\times10^{-6}m} = 1 \times 10^{5} V/m$

$= 1 \times 10^{5}$ N/C