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JEE (Main)

PAPER-1 (B.E./B. TECH.)

2022

COMPUTER BASED TEST (CBT)
Questions & Solutions

Date: 29 July, 2022 (SHIFT-1) | TIME : (9.00 a.m. to 12.00 p.m)

Duration: 3 Hours | Max. Marks: 300

SUBJECT: PHYSICS

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PART : PHYSICS

1. Given below are two statements : 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 $T = K\sqrt{\rho r^3 / S^{3/2}}$ 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

NTA Ans. (D)
Reso Ans. (D)
Sol.

2. A ball is thrown up vertically with a certain velocity so that, it reaches a maximum height

Find the ratio of the times in which it is at height $\frac{h}{3}$ while going up and coming dow

respectively.

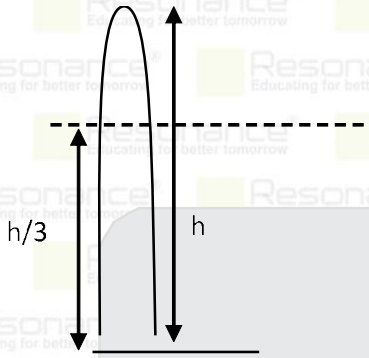
A $\frac{\sqrt{2}-1}{\sqrt{2}+1}$

B $\frac{\sqrt{3}-\sqrt{2}}{\sqrt{3}+\sqrt{2}}$

C $\frac{\sqrt{3}-1}{\sqrt{3}+1}$

D $\frac{1}{3}$

NTA Ans. (B)
Reso Ans. (B)
Sol.



$$V = \sqrt{2gh}$$

$$\frac{h}{3} = \sqrt{2gh}t - \frac{1}{2}gt^2$$

$$gt^2 - 2\sqrt{2gh}t + \frac{2h}{3} = 0$$

$$t = \frac{2\sqrt{2gh} \pm \sqrt{8gh - 4g \times \frac{2h}{3}}}{2g} = \frac{2\sqrt{2gh} \pm \sqrt{\frac{16gh}{3}}}{2g} = \frac{2\sqrt{2gh} \pm 4\sqrt{\frac{gh}{3}}}{2g}$$

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

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

A 4

B zero

C 8

D 16

NTA Ans. (B)
Reso Ans. (B)

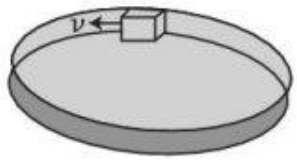
Sol. $x = (t-4)^2$

$$v = \frac{dx}{dt} = 2(t-4)$$

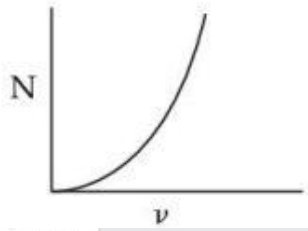
$v = 2(4-4) = 0$

at $t = 4$

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



A



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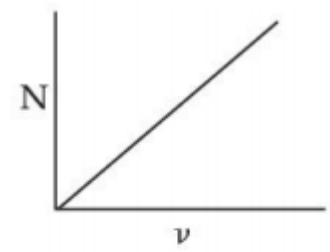

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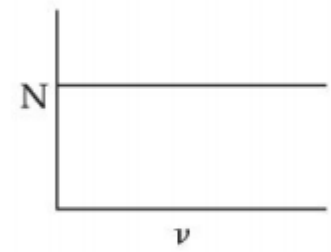

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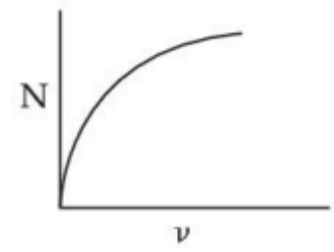


NTA Ans. (A)
Reso Ans. (A)

Sol. $N = \frac{mv^2}{R}$

$N \propto v^2$

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

NTA Ans. (C)
Reso Ans. (C)

Sol. $En = \frac{1}{2}mu^2\cos^2 60° = \frac{E}{4}$

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

NTA Ans. (A)
Reso Ans. (A)

Sol. $\vec{r}_{com} = \frac{m_1\vec{r}_1 + m_2\vec{r}_2}{m_1 + m_2}$,

$= \frac{1(\hat{i} + 2\hat{j} + \hat{k}) + 3(-3\hat{i} - 2\hat{j} + \hat{k})}{4} = \frac{-8\hat{i} - 4\hat{j} + 4\hat{k}}{4} = \vec{r}_{com} = -2\hat{i} - \hat{j} + \hat{k}$

$|\vec{r}_{com}| = |-2\hat{i} - \hat{j} + \hat{k}| = \sqrt{6}$

$|\hat{i} + 2\hat{j} + \hat{k}| = \sqrt{6}$

7. Given below are two statements : One is labelled as **Assertion (A)** and the 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

NTA Ans. (A)
Reso Ans. (A)

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 times its initial value

C become $\frac{1}{4}^{th}$ of its initial value

D become 4 times its initial value

NTA Ans. (A)
Reso Ans. (A)

Sol. Young's modulus is the property of material and not the geometry.

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 $2\pi\sqrt{L/(g\tan\alpha)}$

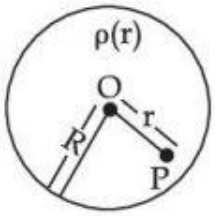
NTA Ans. (A)
Reso Ans. (A)

Sol. $T = 2\pi\sqrt{\dfrac{\ell}{g\cos\alpha}}$

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

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

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 $\frac{\rho_0 r}{5\varepsilon_0}\left(1-\frac{r}{R}\right)$

NTA Ans. (C)
Reso Ans. (C)

Sol. $dq = \rho \times 4\pi r^2.dr$

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

$q = 4\pi\rho_0 \int_0^2 \left(\frac{3}{4}r^2-\frac{r^3}{R}\right)dr$

$= 4\pi\rho_0\left[\frac{r^3}{4}-\frac{r^4}{4R}\right]$

$\int \vec{e}\cdot d\vec{s} = \frac{q}{\in_0}$

$E \times 4\pi r^2 = \frac{4\pi\rho_0}{\in_0}\left(\frac{r^3}{4}-\frac{r^4}{4R}\right)$; $E = \frac{\rho_0}{\in_0}\left(\frac{r}{4}-\frac{r^2}{4R}\right) = \frac{\rho_0 r}{4\in_0}\left(1-\frac{r}{R}\right)$

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

NTA Ans. (A)
Reso Ans. (A)
Sol.

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 :

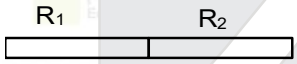
A $\dfrac{\sigma_1\sigma_2}{\sigma_1+\sigma_2}$

B $\dfrac{2\sigma_1\sigma_2}{\sigma_1+\sigma_2}$

C $\dfrac{\sigma_1+\sigma_2}{2\sigma_1\sigma_2}$

D $\dfrac{\sigma_1+\sigma_2}{\sigma_1\sigma_2}$

NTA Ans. (B)
Reso Ans. (B)
Sol.



$$\rho_{eq}\frac{(2\ell)}{A} = R_{eq} = R_1 + R_2 = \frac{\rho_1\ell}{A}+\frac{\rho_2\ell}{A}$$

$$\frac{2\ell}{\sigma_{eq}A}+\frac{\ell}{\sigma_1 A}+\frac{\ell}{\sigma_2 A}$$

$$\frac{2}{\sigma_{eq}}+\frac{\ell}{\sigma_1}+\frac{\ell}{\sigma_2}$$

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

13. An alternating emf $E = 440 \sin 100\pi t$ 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 2.2 A

D 3.11 A

NTA Ans. (C)
Reso Ans. (C)

Sol. $I_{rms} = \frac{V_{rms}}{Z} = \frac{440}{\sqrt{2} \times (\omega L)}$

$$I_{rms} = \frac{440}{\sqrt{2} \times 100\pi \times \frac{\sqrt{2}}{\pi}} = \frac{220}{100} = 2.2A$$

14. A coil of inductance 1 H and resistance 100 Ω 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 is 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

NTA Ans. (C)
Reso Ans. (C)

Sol. $I = \frac{\varepsilon}{R}\left(1 - e^{-\frac{Rt}{L}}\right)$, $I_0 = \frac{\varepsilon}{R}$

$$I = \frac{I_0}{2} = \frac{\varepsilon}{2R} = \frac{\varepsilon}{R}(1 - e^{-Rt/L})$$

$$\frac{1}{2} = e^{-Rt/L}$$

$$\frac{Rt}{L} = \ell n2$$

$$t = \frac{L}{R}\ell n2 = \frac{1\times 0.693}{100}$$

$$t = 7 \text{ ms}$$

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

$$\frac{1}{2}\times 1\times\left[\frac{6}{100}\left(1-e^{-3/2}\right)^2\right]$$

$$\frac{1}{2}\left[\frac{6}{100}\times\left(\frac{3}{4}\right)\right]^2 = 1\text{mJ}$$

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)

NTA Ans. (B)
Reso Ans. (B)
Sol.

16. The kinetic energy of emitted electron is E when the light incident on the metal has wavelen 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 $\frac{hc\lambda}{E\lambda - hc}$

NTA Ans. (B)
Reso Ans. (B)

Sol. $\frac{hc}{\lambda} = \phi + E$

$\frac{hc}{\lambda_1} = \phi + 2E$

$hc\left(\frac{1}{\lambda_1} - \frac{1}{\lambda}\right) = E$

$\frac{1}{\lambda_1} = \frac{1}{\lambda} + \frac{E}{hc}$

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

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

A 3 : 4

B 4 : 3

C 1 : 4

D 4 : 1

NTA Ans. (A)
Reso Ans. (A)

Sol. $E_P = 13.6\left[1-\frac{1}{4}\right] = 13.6\times\left(\frac{3}{4}\right)$

$E_P' = 13.6\left(1-\frac{1}{\infty}\right) = 13.6$

$\frac{E_P}{E_P'} = \frac{3}{4}$

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

A 0.8

B 0.5

C 0.2

D 0.1

NTA Ans. (A)

Reso Ans. (A)

Sol. $(A_{eq})_{max} = A_c + A_m = 9$

$(A_{eq})_{min} = A_c - A_m = 9 - 8 = 1$

Solving $A_c = S$, $A_m = 4$

$\mu = \frac{Am}{Ac} = \frac{4}{5} = 0.8$

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

NTA Ans. (C)

Reso Ans. (C)

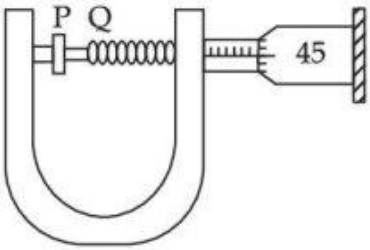
Sol. Least Count = 1MSD – 1VSD

25 VSD = 24 MSD

1 VSD = $\frac{24}{25}$MSD

LC = $\left(1-\frac{24}{25}\right)$MSD = 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

NTA Ans. (C)

Reso Ans. (C)

Sol. Least count = $\frac{\text{ptich}}{\text{number of divisions on circular scale}} = \frac{0.5\text{mm}}{50}$ = 0.01 mm

measured diameter = (main scale reading) + (circular scale reading) (least count)

= 2.5 mm + (45) (0.01mm) = 2.95 mm

Actual diameter = measured diameter – zero error

= (2.95 mm) – (–0.03 mm)

= 2.98 mm

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

NTA Ans. 15

Reso Ans. 15° and 75° both correct Answer

Sol. $R_{max} = \frac{4^2}{2}$

$$R_2 = \frac{4^2 \sin 2Q}{2} = \frac{\frac{4^2}{2}}{2} \Rightarrow \sin 2Q = \frac{1}{2} = \sin 30°$$

Q =15° and Q = 75° is also possible, so both 15° and 75° are the correct answer

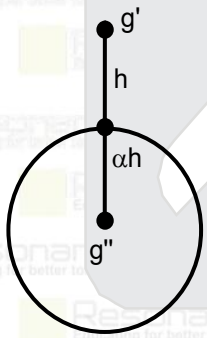
22. If the acceleration due to gravity experienced by a point mass at a height h above the surface of earth is same as that of the acceleration due to gravity at a depth αh ($h << R_e$) from earth surface. The value of α will be _____.

(use $R_e = 6400$ km)

NTA Ans. (2)

Reso Ans. (2)

Sol.



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

$$g' = g\left(1 - \frac{\alpha h}{R}\right)$$

$1h = \alpha h$

$\Rightarrow \alpha = 2$

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

NTA Ans. (4)
Reso Ans. (4)

Sol. $PV^{\gamma} = \text{Constant} \Rightarrow \left(\frac{nRT}{v}\right)(v)^{\gamma} = \text{cons tant}$

$$T \propto \frac{1}{V^{\gamma-1}} \Rightarrow T \propto \rho^{\gamma-1}$$

$$\frac{T_f}{T_i} = \left(\frac{\rho_f}{\rho_i}\right)^{\gamma-1} = (32)^{\frac{7}{5}-1} = (2^5)^{\frac{2}{5}} = 4$$

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 $\frac{\alpha^2}{4}R$ J/mol K; then the value of α will be _____. (Assume that the given diatomic gas has no vibrational mode).

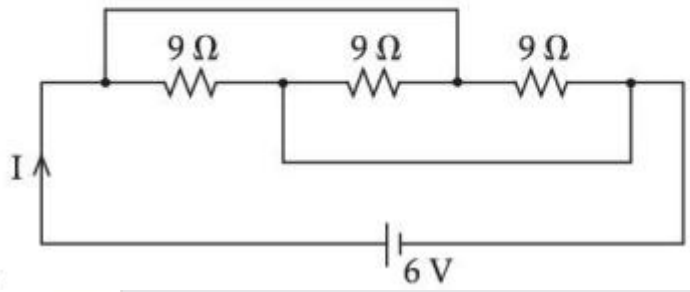
NTA Ans. (3)
Reso Ans. (3)

Sol. $$\frac{n_1Cv_1 + n_2Cv_2}{n_1 + n_2} = \frac{1\times\frac{R.3}{2} + 3\times\frac{R.5}{2}}{1+3}$$

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

$[\alpha^2 = 9] \Rightarrow \alpha = 3$

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



NTA Ans. (2)
Reso Ans. (2)

Sol. $\frac{1}{R_{eq}} = \frac{1}{9} + \frac{1}{9} + \frac{1}{9}$

$R_{eq} = 3\Omega$

$I = \frac{V}{R_{eq}}$

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

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 $\pi = 3.14$]

NTA Ans. (3)
Reso Ans. (3)

Sol. $N \times \frac{\mu_0 I}{2R} = (B)$

37.68×10^{-4}

$I = \frac{B \times 2R}{\left(\frac{\mu_0}{4\pi}\right)(4\pi) \times 100} = \frac{37. \times 10^{-4} \times 10\,cm}{10^{-7} \times (4\pi) \times 100}$

$I = \frac{3 \times 10^{-5}}{10^{-5}} = 3A$

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.

NTA Ans. (24)
Reso Ans. (24)

Sol. $I_0 = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2 = 25I$

$I_\pi = \left(\sqrt{I_1} - \sqrt{I_2}\right)^2 = I$

$I_0 - I_\pi = 24I$

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-m^2. [Given $\pi = 3.14$]

NTA Ans. (11)

Reso Ans. (11)

Sol. $\ell = 314 \times 10^{-2} = 3.14$ M

$I = 14A$

$M = IA = 14 \times \pi R^2$

$2\pi R = 3.14$

$R = 0.5$ m

$M = 14 \times \frac{22}{7} \times \frac{1}{4} = 11$

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.

NTA Ans. (15)

Reso Ans. (15)

Sol. $\vec{P} = 4\sqrt{3}\hat{i} - 3\sqrt{3}\hat{j} - 5\hat{k}$

Angle with Z–axis is $\cos\alpha = \left|\frac{-5}{\sqrt{48+27+25}}\right|$

α = angle of incidence = $60° = \left|-\frac{1}{2}\right| = \frac{1}{2}$

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

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

$\sin r = \frac{1}{\sqrt{2}} \Rightarrow r = 45°$

$i - r = 60 - 45 = 15$

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 _____ $\times10^5$ N/C.

NTA Ans. (1)

Reso Ans. (1)

Sol. $E=\frac{V}{d}=\frac{0.6\text{volt}}{6\times10^{-6}}=10^5\text{v/m}$

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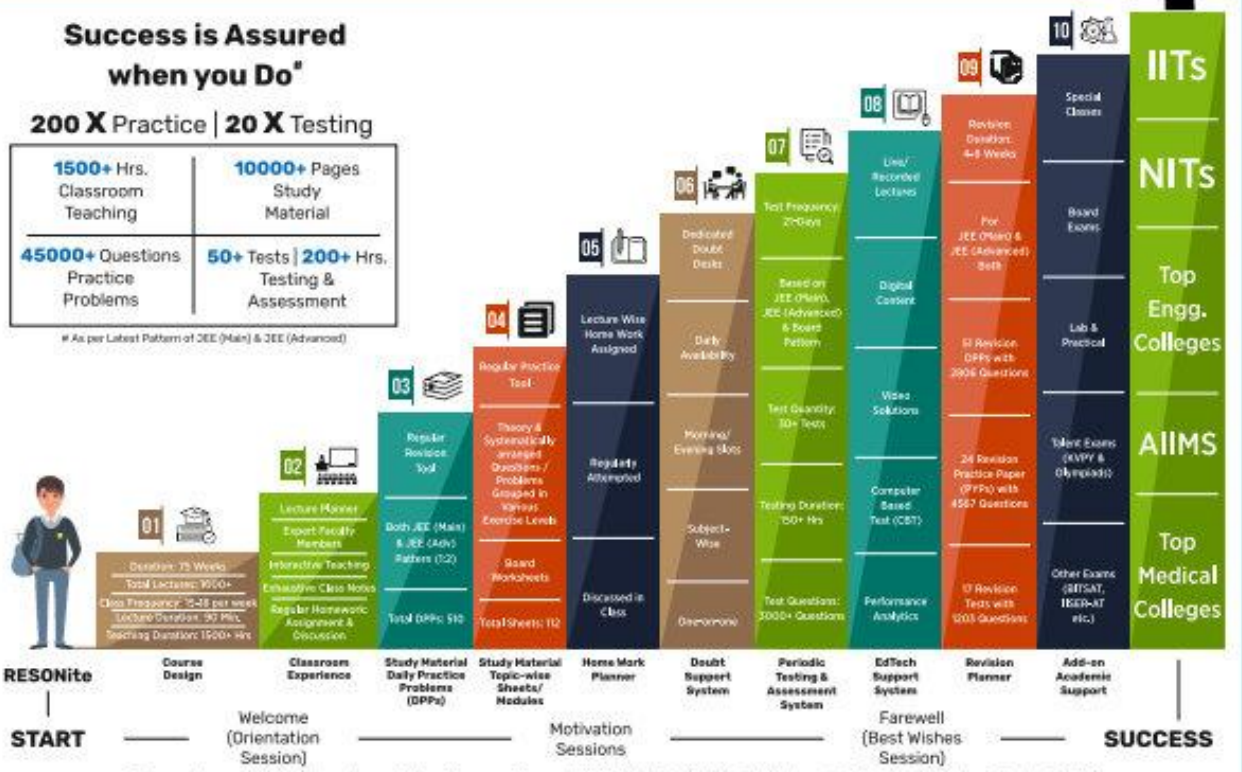

The figures (approx.) shown in the graph are of 2 Years Classroom Program (VIKAAS-XI & VIJETA-XII) for JEE (Advanced) @ Resonance in Academic Session 2021-22.
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Photo Taken on 20th June 2022 | Some Faculty Members were not present in the Photo Session.

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