FINAL JEE–MAIN EXAMINATION – JULY, 2022

(Held On Monday 25th July, 2022) **TIME : 9 : 00 AM to 12 : 00 NOON**

SECTION-A

1. If momentum [P], area [A] and time [T] are taken as fundamental quantities, then the dimensional formula for coefficient of viscosity is :

(A) $[P\ A^{-1}\ T^{0}]$ (B) $[P\ A\ T^{-1}]$

(C) $[P\ A^{-1}\ T]$ (D) $[P\ A^{-1}\ T^{-1}]$

Official Ans. by NTA (A)

Ans. (A)

Sol. Viscosity = pascal.second

$P^x\ A^y\ T^z = [M^1\ L^{-1}\ T^{-1}]$

$[M^1\ L^{+1}\ T^{-1}]^x\ [L^2]^y[T^1]^z = M^1L^{-1}\ T^{-1}$

$M^xL^{+x+2y}\ T^{-x+z} = M^1\ L^{-1}\ T^{-1}$

$x = 1 \quad x + 2y = -1 \quad -x + z = -1$

$y = -1$

$z = 0$

Viscosity $= P^1\ A^{-1}\ T^0$

2. Which of the following physical quantities have the same dimensions ?

(A) Electric displacement ($\vec{D}$) and surface charge density

(B) Displacement current and electric field

(C) Current density and surface charge density

(D) Electric potential and energy

Official Ans. by NTA (A)

Ans. (A)

Sol. Electric displacement

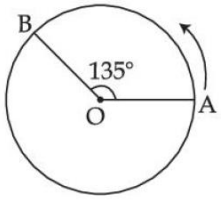
$\vec{D} = \epsilon_0\ \vec{E}$

$$[D] = [\epsilon_0\ E] = \left[\epsilon_0\ \frac{\sigma}{\epsilon_0}\right]$$

$[D] = [\sigma]$

$\rightarrow$ Surface change density = σ.

3. A person moved from A to B on a circular path as shown in figure. If the distance travelled by him is 60 m, then the magnitude of displacement would be : (Given cos135° = - 0.7)



(A) 42 m (B) 47 m

(C) 19 m (D) 40 m

Official Ans. by NTA (B)

Ans. (B)

Sol. $d = R\theta$

$$60 = R\left(\frac{3\pi}{4}\right)$$

$$R = \frac{60\times 4}{3\pi} = \frac{80}{\pi}\text{m}$$

$$\text{Displacement} = \sqrt{R^2 + R^2 - 2R^2\cos 135}$$

$$\Rightarrow \sqrt{2R^2 - 2R^2(-0.7)}$$

$$\Rightarrow \sqrt{3.4R^2} = \sqrt{3.4\left(\frac{80}{\pi}\right)^2}$$

≈ 47 m

4. A body of mass 0.5 kg travels on straight line path with velocity $v = (3x^2 + 4)$m/s. The net workdone by the force during its displacement from x = 0 to x = 2 m is :

(A) 64 J (B) 60 J

(C) 120 J (D) 128 J

Official Ans. by NTA (B)

Ans. (B)

Sol. $v_i = 3(0^2) + 4 = 4 \quad \cong \quad x = 0$

$v_F = 3(2)^2 + 4 \quad \cong \quad x = 2$

$= 16$

$$W = \Delta K = \frac{1}{2}m\left(16^2 - 4^2\right)$$

$$= \frac{1}{2}\times\frac{1}{2}(256 - 16)$$

$$= \frac{240}{4} = 60\text{J}$$

5. A solid cylinder and a solid sphere, having same mass M and radius R, roll down the same inclined plane from top without slipping. They start from rest. The ratio of velocity of the solid cylinder to that of the solid sphere, with which they reach the ground, will be :

(A) $\sqrt{\frac{5}{3}}$ (B) $\sqrt{\frac{4}{5}}$

(C) $\sqrt{\frac{3}{5}}$ (D) $\sqrt{\frac{14}{15}}$

Official Ans. by NTA (D)

Ans. (D)

Sol. $V = \sqrt{\frac{2gH}{1+k^2/R^2}}$

$$\frac{V_{cylinder}}{V_{sphere}} = \sqrt{\frac{(1+k^2/R^2)_{sphere}}{(1+k^2/R^2)_{cylinder}}}$$

$$= \sqrt{\frac{1+2/5}{1+1/2}} = \sqrt{\frac{7}{5}\times\frac{2}{3}} = \sqrt{\frac{14}{15}}$$

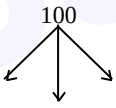
6. Three identical particle A, B and C of mass 100 kg each are placed in a straight line with AB = BC = 13 m. The gravitational force on a fourth particle P of the same mass is F, when placed at a distance 13 m from the particle B on the perpendicular bisector of the line AC. The value of F will be approximately :

(A) 21 G (B) 100 G

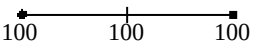
(C) 59 G (D) 42 G

Official Ans. by NTA (B)

Ans. (B)



Sol.



$$F = \frac{GMM}{r^2} + \sqrt{2}\frac{GMM}{(\sqrt{2}r)^2}$$

$$= \frac{GMM}{}\left(1+\frac{1}{\sqrt{2}}\right)$$

$$= \frac{G\times10^4}{13^2}\left(1+\frac{1}{\sqrt{2}}\right)$$

$$F \simeq 100G$$

7. A certain amount of gas of volume V at 27°C temperature and pressure 2×10^7 Nm^{-2} expands isothermally until its volume gets doubled. Later it expands adiabatically until its volume gets redoubled. The final pressure of the gas will be (Use $\gamma = 1.5$)

(A) 3.536×10^5 Pa (B) 3.536×10^6 Pa

(C) 1.25×10^6 Pa (D) 1.25×10^5 Pa

Official Ans. by NTA (B)

Ans. (B)

Sol. $P_1 = 2\times10^7$ Pa

$P_1V_1 = P_2V_2$

Since $V_2 = 2V_1$ Hence $P_2 = P_1/2$ (isothermal expansion)

$P_2 = 1\times10^7$ Pa

$P_2(V_2)^\gamma = P_3(2V_2)^\gamma$

$$P_3 = \frac{1\times10^7}{2^{1.5}} = 3.536\times10^6$$

8. Following statements are given :

(1) The average kinetic energy of a gas molecule decreases when the temperature is reduced.

(2) The average kinetic energy of a gas molecule increases with increase in pressure at constant temperature.

(3) The average kinetic energy of a gas molecule decreases with increases in volume.

(4) Pressure of a gas increases with increase in temperature at constant pressure.

(5) The volume of gas decreases with increase in temperature.

Choose the correct answer from the options given below :

(A) (1) and (4) only (B) (1), (2) and (4) only

(C) (2) and (4) only (D) (1), (2) and (5) only

Official Ans. by NTA (A)

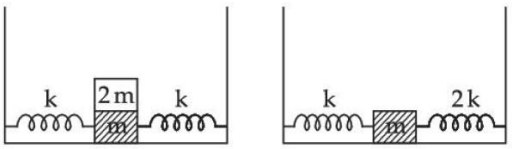
Ans. (A)

Sol. $KE_{avg} = \frac{3}{2}KT$

$$P = \frac{1}{3}\rho V_{rms}^2$$

Note : Statement (4) is correct only if we consider it at constant volume and not constant pressure. Ideally, this question must be bonus but most appropriate answer is option (A)

9. In figure (A), mass '2 m' is fixed on mass 'm' which is attached to two springs of spring constant k. In figure (B), mass 'm' is attached to two spring of spring constant 'k' and '2k'. If mass 'm' in (A) and (B) are displaced by distance 'x' horizontally and then released, then time period T_1 and T_2 corresponding to (A) and (B) respectively follow the relation.



(A) $\frac{T_1}{T_2}=\frac{3}{\sqrt{2}}$ (B) $\frac{T_1}{T_2}=\sqrt{\frac{3}{2}}$

(C) $\frac{T_1}{T_2}=\sqrt{\frac{2}{3}}$ (D) $\frac{T_1}{T_2}=\frac{\sqrt{2}}{3}$

Official Ans. by NTA (A)

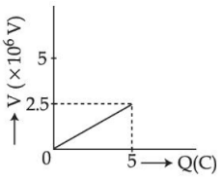
Ans. (A)

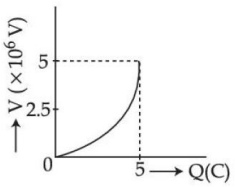
Sol. $T_1=2\pi\sqrt{\frac{3m}{2k}}$

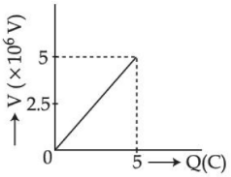
$T_2=2\pi\sqrt{\frac{m}{3k}}$

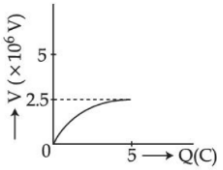
$\frac{T_1}{T_2}=\frac{2\pi\sqrt{\frac{3m}{2k}}}{2\pi\sqrt{\frac{m}{3k}}}=\frac{3}{\sqrt{2}}$

10. A condenser of 2 μF capacitance is charged steadily from 0 to 5C. Which of the following graph represents correctly the variation of potential difference (V) across it's plates with respect to the charge (Q) on the condenser ?

(A) 

(B) 

(C) 

(D) 

Official Ans. by NTA (A)

Ans. (A)

Sol. $Q=CV$

$V=\frac{1}{C}Q$

Straight line with slope $=\frac{1}{C}$

Slope $=\frac{1}{C}=\frac{1}{2\times10^{-6}}=5\times10^5$

11. Two charged particles, having same kinetic energy, are allowed to pass through a uniform magnetic field perpendicular to the direction of motion. If the ratio of radii of their circular paths is 6 : 5 and their respective masses ratio is 9 : 4. Then, the ratio of their charges will be :

(A) 8 : 5 (B) 5 : 4

(C) 5 : 3 (D) 8 : 7

Official Ans. by NTA (B)

Ans. (B)

Sol. Radius of circular path $R=\frac{\sqrt{2mk}}{qB}$

$q=\frac{\sqrt{2mk}}{RB}$

$\frac{q_1}{q_2}=\sqrt{\frac{m_1}{m_2}}\times\frac{R_2}{R_1}=\sqrt{\frac{9}{4}}\times\frac{5}{6}=\frac{5}{4}$

12. To increase the resonant frequency in series LCR circuit,

(A) Source frequency should be increased

(B) Another resistance should be added in series with the first resistance.

(C) Another capacitor should be added in series with the first capacitor

(D) The source frequency should be decreased

Official Ans. by NTA (C)

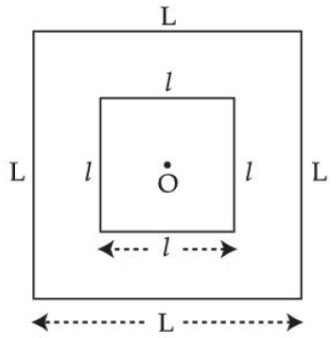
Ans. (C)

Sol. $f=\frac{1}{2\pi\sqrt{LC}}$

To increase the resonating frequency product of L and C should decrease.

By joining capacitor in series, capacitor will decrease

13. A small square loop of wire of side l is placed inside a large square loop of wire L (L >> l). Both loops are coplanar and their centres coincide at point O as shown in figure. The mutual inductance of the system is :



(A) $\frac{2\sqrt{2}\mu_0 L^2}{\pi\ell}$ (B) $\frac{\mu_0\ell^2}{2\sqrt{2}\pi L}$

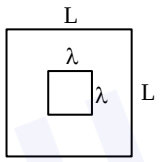
(C) $\frac{2\sqrt{2}\mu_0\ell^2}{\pi L}$ (D) $\frac{\mu_0 L^2}{2\sqrt{2}\pi\ell}$

Official Ans. by NTA (C)

Ans. (C)

Sol. Assuming current I in outer loop magnetic field at

$$\text{centre} = 4\times\frac{\mu_0 i}{4\pi\times\frac{L}{2}}\times(2\sin 45°) = \frac{2\sqrt{2}\mu_0 i}{\pi L}$$



$$M = \frac{\text{Flux through inner loop}}{i}$$

$$M = \frac{2\sqrt{2}\mu_0\ell^2}{\pi L}$$

14. The rms value of conduction current in a parallel plate capacitor is 6.9 μA. The capacity of this capacitor, if it is connected to 230 V ac supply with an angular frequency of 600 rad/s, will be :

(A) 5 pF (B) 50 pF

(C) 100 pF (D) 200 pF

Official Ans. by NTA (B)

Ans. (B)

Sol. Current in capacitor $I = \frac{V}{\quad}$

$$I = (V)\times(\omega C)$$

$$C = \frac{I}{V\omega} = \frac{6.9\times10^{-6}}{230\times600} = 50\text{pF}$$

15. Which of the following statement is correct ?

(A) In primary rainbow, observer sees red colour on the top and violet on the bottom

(B) In primary rainbow, observer sees violet colour on the top and red on the bottom

(C) In primary rainbow, light wave suffers total internal reflection twice before coming out of water drops

(D) Primary rainbow is less bright than secondary rainbow.

Official Ans. by NTA (A)

Ans. (A)

Sol. In primary rainbow, red colour is at top and violet is at bottom.

Intensity of secondary rainbow is less in comparison to primary rainbow.

16. Time taken by light to travel in two different materials A and B of refractive indices μ_A and μ_B of same thickness is t_1 and t_2 respectively. If $t_2 - t_1 = 5\times10^{-10}$ s and the ratio of μ_A to μ_B is 1 : 2. Then the thickness of material, in meter is : (Given v_A and v_B are velocities of light in A and B materials respectively).

(A) $5\times10^{-10}\ v_a$ m (B) 5×10^{-10} m

(C) 1.5 10^{-10} m (D) $5\times10^{-10}\ v_B$ m

Official Ans. by NTA (A)

Ans. (A)

Sol. $\frac{\mu_A}{\mu_B} = \frac{c/V_A}{c/V_B} = \frac{V_B}{V_A} = \frac{1}{2}$

Let the thickness is d

$$\frac{d}{v_B} - \frac{d}{v_A} = 5\times10^{-10}$$

$$d = \frac{5\times10^{-10}\times v_A v_B}{v_A - v_B}$$

As $v_A = 2v_B \Rightarrow d = 5\times10^{-10}\times 2v_B$

Or $d = 5\times10^{-10}\times v_A$

17. A metal exposed to light of wavelength 800 nm and emits photoelectrons with a certain kinetic energy. The maximum kinetic energy of photo-electron doubles when light of wavelength 500 nm is used. The work function of the metal is (Take hc = 1230 eV-nm).

(A) 1.537 eV (B) 2.46 eV

(C) 0.615 eV (D) 1.23 eV

Official Ans. by NTA (C)

Ans. (C)

Sol. $k_1 = \frac{1230}{800} - \phi$ …(1)

$k_2 = 2k_1 = \frac{1230}{500} - \phi$ …(2)

Eliminating k_1 from (1) and (2) we get

$0 = \frac{1230}{500} - \frac{1230}{400} + \phi$

$\phi = 0.615 eV$

18. The momentum of an electron revolving in n^{th} orbit is given by : (Symbols have their usual meanings)

(A) $\frac{nh}{2\pi r}$ (B) $\frac{nh}{2r}$

(C) $\frac{nh}{2\pi}$ (D) $\frac{2\pi r}{nh}$

Official Ans. by NTA (A)

Ans. (A)

Sol. Angular momentum is integral multiple of $\frac{h}{2\pi}$

$mvr = \frac{nh}{2\pi}$

So momentum $mv = \frac{nh}{2\pi r}$

19. The magnetic moment of an electron (e) revolving in an orbit around nucleus with an orbital angular momentum is given by :

(A) $\vec{\mu}_L = \frac{e\vec{L}}{2m}$ (B) $\vec{\mu}_L = -\frac{e\vec{L}}{2m}$

(C) $\vec{\mu}_l = -\frac{e\vec{L}}{m}$ (D) $\vec{\mu}_l = \frac{2e\vec{L}}{m}$

Official Ans. by NTA (B)

Ans. (B)

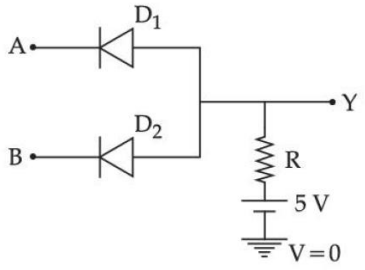
Sol. Ratio of magnetic moment and angular momentum

$\frac{\vec{\mu}}{\vec{L}} = \frac{q}{2m}$

For e^-

$\vec{\mu} = -\frac{e}{2m}\vec{L}$

20. In the circuit, the logical value of A = 1 or B = 1 when potential at A or B is 5V and the logical value of A = 0 or B = 0 when potential at A or B is 0 V.



The truth table of the given circuit will be :

	A	B	Y
	0	0	0
(A)	1	0	0
	0	1	0
	1	1	1

	A	B	Y
	0	0	0
(B)	1	0	1
	0	1	1
	1	1	1

	A	B	Y
	0	0	0
(C)	1	0	0
	0	1	0
	1	1	0

	A	B	Y
	0	0	1
(D)	1	0	1
	0	1	1
	1	1	0

Official Ans. by NTA (A)

Ans. (A)

Sol. When both A and B have logical value '1' both diode are reverse bias and current will flow in resistor hence output will be 5 volt i.e. logical value '1'.

In all other case conduction will take place, hence output will be zero volt i.e. logical value '0'.

So truth table is

A	B	Y	
0	0	0	
0	1	0	(AND gate)
1	0	0	
1	1	1	

SECTION-B

1. A car is moving with speed of 150 km/h and after applying the brake it will move 27 m before it stops. If the same car is moving with a speed of one third the reported speed then it will stop after travelling _____ m distance.

Official Ans. by NTA (3)

Ans. (3)

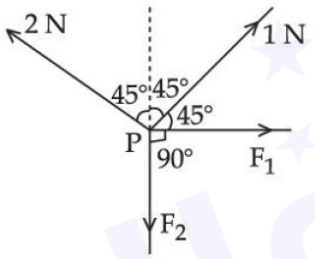
Sol. Stopping distance $= \frac{v^2}{2a} = d$

If speed is made $\frac{1}{3}$rd

$d' = \frac{1}{9}d.$ $\quad d' = \frac{27}{9} = 3.$

Braking acceleration remains same

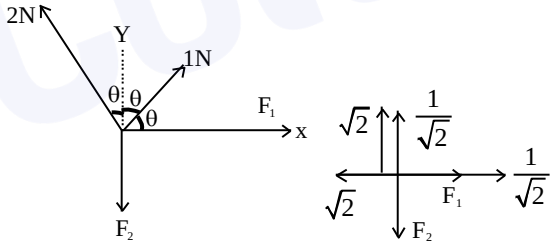
2. Four forces are acting at a point P in equilibrium as shown in figure. The ratio of force F_1 to F_2 is 1 : x where x = _____ .



Official Ans. by NTA (3)

Ans. (3)

Sol.



$\theta = 45°$

Taking components along x & y

$F_1 = \sqrt{2} - \frac{1}{\sqrt{2}} = \frac{2-1}{\sqrt{2}} = \frac{1}{\sqrt{2}}$

$F_2 = \sqrt{2} + \frac{1}{\sqrt{2}} = \frac{2+1}{\sqrt{2}} = \frac{3}{\sqrt{2}}$

$F_1 : F_2 = 1 : 3$

x = 3

3. A wire of length L and radius r is clamped rigidly at one end. When the other end of the wire is pulled by a force F, its length increases by 5 cm. Another wire of the same material of length 4L and radius 4r is pulled by a force 4F under same conditions. The increase in length of this wire is _____ cm.

Official Ans. by NTA (5)

Ans. (5)

Sol. $\Delta\ell_1 = \frac{F\ell}{AY} = \frac{F\ell}{\pi r^2 Y} = 5\text{cm}$

$\Delta\ell_2 = \frac{4F4\ell}{\pi 16r^2 Y} = \frac{F\ell}{\pi r^2 Y} = 5\text{cm}$

4. A unit scale is to be prepared whose length does not change with temperature and remains 20 cm, using a bimetallic strip made of brass and iron each of different length. The length of both components would change in such a way that difference between their lengths remains constant. If length of brass is 40 cm and length of iron will be _____cm.

($\alpha_{iron} = 1.2 \times 10^{-5}\ K^{-1}$ and $\alpha_{brass} = 1.8 \times 10^{-5}\ K^{-1}$).

Official Ans. by NTA (60)

Ans. (60)

Sol. $\ell_B(1+\alpha_B\Delta T) - \ell_i(1+\alpha_i\Delta T) = \ell_B - \ell_i$

$\alpha_B\ell_B = \ell_i\alpha_i$

$1.8\times10^{-5}\times40 = \ell_i \times 1.2\times10^{-5}$

$\ell_i = \frac{1.8\times10^{-5}\times40}{1.2\times10^{-5}} = \frac{3\times40}{2} = 60$

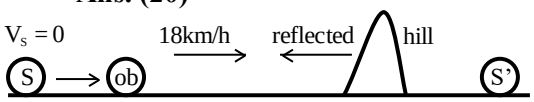
$\ell_i = 60\text{cm}$

5. An observer is riding on a bicycle and moving towards a hill at 18 kmh^{-1}. He hears a sound from a source at some distance behind him directly as well as after its reflection from the hill. If the original frequency of the sound as emitted by source is 640 Hz and velocity of the sound in air is 320 m/s, the beat frequency between the two sounds heard by observer will be _____ Hz.

Official Ans. by NTA (20)

Ans. (20)

Sol.



$V_S = 0,\ V_{ob} = 5\text{m/s}$

$f_{direct} = \left(\frac{320-5}{320}\right)640 = 630\text{Hz}$

$f_{reflected} = \left(\frac{320+5}{320}\right)640 = 650\text{Hz}$

$f_{beat} = 650 - 630 = 20\text{Hz}$

6. The volume charge density of a sphere of radius 6 m is 2 μC cm^{-3}. The number of lines of force per unit surface area coming out from the surface of the sphere is _____ × 10^{10} NC^{-1}.

[Given : Permittivity of vacuum

$\in_0 = 8.85 \times 10^{-12}\ C^2\ N^{-1} - m^{-2}$]

Official Ans. by NTA (45)

Ans. (45)

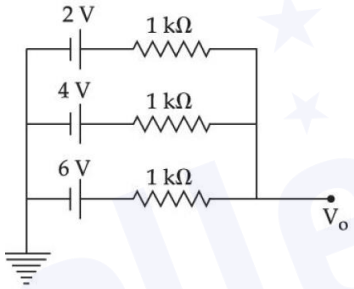
Sol. No. of electric field lines per unit area = electric field.

$$E = \frac{\rho r}{3 \in_0}, \text{ for } r = R$$

$$E = \frac{\rho R}{3 \in_0} = \frac{2 \times 6}{3 \times 8.85 \times 10^{-12}} = 0.45 \times 10^{12}\ NC^{-1}$$

$$= 45 \times 10^{10}\ N/C$$

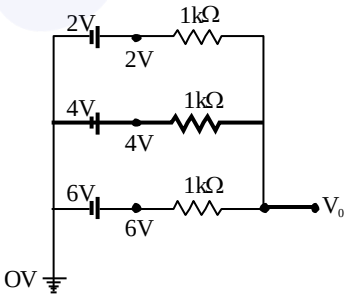
7. In the given figure, the value of V_0 will be ____ V.



Official Ans. by NTA (4)

Ans. (4)

Sol.



By nodal analysis $\frac{V_0 - 2}{k\Omega} + \frac{V_0 - 4}{1k\Omega} + \frac{V_0 - 6}{1k\Omega} = 0$

$$3V_0 - 12 = 0$$

$$V_0 = 4$$

8. Eight copper wire of length *l* and diameter d are joined in parallel to form a single composite conductor of resistance R. If a single copper wire of length 2*l* have the same resistance (R) then its diameter will be _____ d.

Official Ans. by NTA (4)

Ans. (4)

Sol. Each wire has resistance $= \rho \frac{4\ell}{\pi d^2} = r$

Eight wire in parallel, then equivalent resistance is

$$\frac{r}{8} = \frac{\rho \ell}{2\pi d^2}$$

Single copper wire of length 2*l* has resistance

$$R = \rho \frac{2\ell \times 4}{\pi d_1^2} = \frac{\rho \ell}{2\pi d^2}$$

$$\Rightarrow d_1 = 4d$$

9. The energy band gap of semiconducting material to produce violet (wavelength = 4000 Å) LED is _____ eV. (Round off to the nearest integer).

Official Ans. by NTA (3)

Ans. (3)

Sol. $E_g = \frac{hc}{\lambda} = \frac{1242}{\lambda(nm)} = \frac{1242}{400} = 3.105$

Answer rounded to 3 eV

10. The required height of a TV tower which can cover the population of 6.03 lakh is h. If the average population density is 100 per square km and the radius of earth is 6400 km, then the value of h will be _____ m.

Official Ans. by NTA (150)

Ans. (150)

Sol. $d = \sqrt{2Rh}$

$d = \sqrt{2 \times 6400 \times h \times 10^{-3}}$ (h in m)

Area = πd^2

= $(\pi \times 2 \times 6400 \times h \times 10^{-3})$ km^2

$6.03 \times 100000 = 100 \times \pi \times 2 \times 6400 \times 10^{-3}\ h$

$$h = \frac{6.03 \times 10^5}{\times \pi \times 128}$$

h = 150 m