JEE Main February 2021

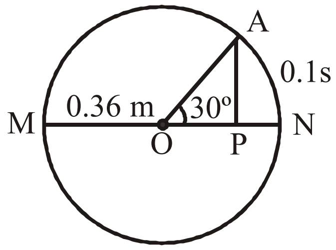
Question Paper With Text Solution

25 Feb.| Shift-2

PHYSICS

JEE MAIN FEB 2021 | 25TH FEB SHIFT-2

1. The point A moves with a uniform speed along the circumference fo a circle of radius 0.36 m and covers 30º in 0.1 s. The perpendicular propendicular projection 'P' from 'A' on the diameter MN respresents the simple harmonic motion of 'P'. The restoration force per unit mass when P touches M will be :



(1) 0.49 N (2) 50 N (3) 9.87 (4) 100 N

Ans. Offical answer by NTA (3)

Sol. $w = \sqrt{\frac{k}{m}} \Rightarrow k = m\omega^2 = \frac{4\pi^2 m}{T^2}$

$\Rightarrow k = \frac{4\pi^2 m}{T^2}$

and $F = kA = \frac{4\pi^2 mA}{T^2}$

$\therefore \frac{F}{M} = \frac{4\pi^2 A}{T^2}$

$\frac{4 \times (3.14)^2 \times 0.36}{(12)^2} = 9.87N$

2. An LCR circuit contains resistance of 110 Ω and a supply of 220 V at 300 rad/ s angular frequency. If only capacitance is removed from the circuit, current lags behind the voltage by 45º. If on the other hand , only inductor is removed the current leads by 45º with the applied voltage. The rms current flowing in the circuit will be:

(1) 2.5 A (2) 2 A (3) 1 A (4) 1.5 A

Ans. Offical answer by NTA (2)

Sol. $X_L = X_C = R = 110\Omega$

$i_{rms} = \frac{V_{rms}}{Z} = \frac{V_{rms}}{R} = \frac{220}{110} = 2A$

3. Given below are two statements:

Statement I: In a diatomic molecule, the rotational energy at a given temperature obeys Mexwell's distribution.

Statement II. In a diatomic molecule, the rotational energy at a given temperatue equals the translational kinetic energy for each molecule.

In the light of the above statements, choose the correct answswer from the options given below:

(1) Statement I is true but Statement II is false.

(2) Both Statement I and Statement II are true.

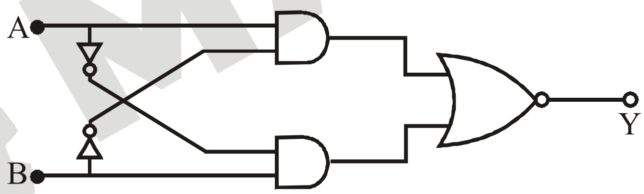
(3) Statement I is false but Statement II is true.

(4) Both Statement I and Statement II are false.

Ans. Offical answer by NTA (1)

Sol. Part of Theory.

4. The truth table for the following logic circuit is:



(1) (2)

(3) (4)

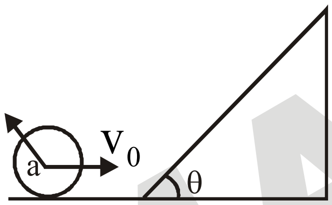
Ans. Offical answer by NTA (3)

Sol. $y = \overline{\left(A\overline{B} + \overline{A}B\right)} = \overline{A\overline{B}}.\overline{\overline{A}B} = \left(\overline{A} + B\right).\left(A + \overline{B}\right)$

$\Rightarrow y = \overline{A}.A + \overline{A}\overline{B} + A.B + B\overline{B}$

$\Rightarrow y = AB + \overline{A}\overline{B}$

5. Asphere of radius 'a' and mass 'm' rolls along a horizontal plane with constant speed υ_0. It encounters an inclined plane at angle θ and climbs upward. Assuming that it rolls without silpping, how far up the sphere will travel?



(1) $\frac{2}{5}\frac{v_0^2}{g\sin\theta}$ (2) $\frac{v_0^2}{2g\sin\theta}$ (3) $\frac{v_0^2}{5g\sin\theta}$ (4) $\frac{10v_0^2}{7g\sin\theta}$

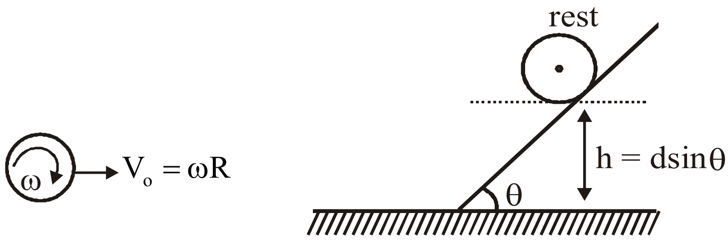
Question ID :70819118756
Option 1 ID :70819161422
Option 2 ID :70819161419
Option 3 ID :70819161420
Option 4 ID :70819161421

Ans. Official answer by NTA (4)

Official answer by matrix is Bonus

Sol. Let sphere sphere travells d distance up the incline.

Initially fInally



From energy conservation

$$\frac{1}{2}mv_0^2 + \frac{1}{2}\left(\frac{2}{5}mR^2\right)\left(\frac{V_0}{R}\right)^2 = mgh$$

$$\frac{1}{2}mv_0^2 + \frac{1}{5}mv_0^2 = mgh$$

$$\therefore d\sin\theta = h = \frac{7{v_0}^2}{10g}$$

$$\Rightarrow d = \frac{7V_0^2}{10g\sin\theta}$$

6. The wavelength of the photon emitted by a hydrogen atom when an electron makes a transition from n = 2 to n = 1 state is:

(1) 490.7 nm (2) 121.8 nm (3) 913.3 nm (4) 194.8 nm

Question ID :70819118769
Option 1 ID :70819161473
Option 2 ID :70819161471
Option 3 ID :70819161474
Option 4 ID :70819161472

Ans. Offical answer by NTA (2)

$$\frac{hc}{\lambda} = E = (13.6ev)z^2\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

$$\Rightarrow \frac{12400}{\lambda(\text{in } A^o)} = (13.6ev)(1)\left[\frac{1}{1^2} - \frac{1}{2^2}\right]$$

$$\lambda = \frac{12400 \times 4}{13.6 \times 3} = 1218A^o = 121.8nm$$

7. In a ferromasgnetic material, below the curie temperature, a domain is defined as:

(1) A macroscopic region with consecutive magnetic dipoles oriented in opposite direction.

(2) A macroscopic region with zero magnetization.

(3) A macroscopic region with saturation magnetization.

(4) A macroscopic region with randomly oriented magnetic dipoles.

Ans. Offical answer by NTA (3)

Sol. Part of Theory.

8. $Y = A\sin(wt + \phi_0)$ is the time-displacement equation of SHM. At t = 0 the displacement of the particle is $Y = \frac{A}{2}$ and it is moving along negative x-direction. Then the initial phase angle ϕ_0 will be:

(1) $\frac{5\pi}{6}$ (2) $\frac{2\pi}{3}$ (3) $\frac{\pi}{6}$ (4) $\frac{\pi}{3}$

Ans. Offical answer by NTA (1)

Sol. $y = A\sin(\omega t + \phi_0)$

$\downarrow t = 0, y = A/2$

$\frac{A}{2} = A\sin\phi_0$

$\Rightarrow \sin\phi_0 = \frac{1}{2}$

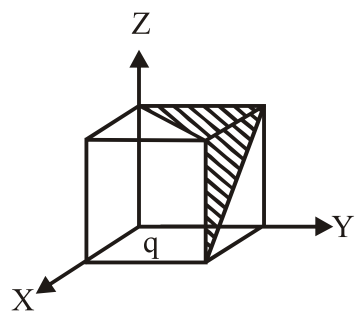
$\Rightarrow \phi_0 = 30^\circ$ or 150°

and $V = A\omega\cos(\omega t + \phi_0)$

$\because$ At t = 0 velocity is in –ve direction

$\therefore \theta = 150^\circ$

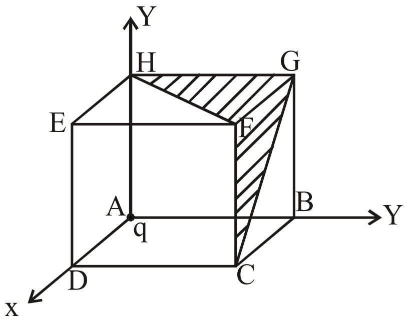
9. A charge 'q' is placed at one corner of a cube as shown in figure. The flux of electrostatic field $\vec{E}$ through the shaded area is :



(1) $\frac{q}{4\varepsilon_0}$ (2) $\frac{q}{8\varepsilon_0}$ (3) $\frac{q}{24\varepsilon_0}$ (4) $\frac{q}{48\varepsilon_0}$

Ans. Offical answer by NTA (3)

Sol.



Flux through shaded area = flux through surface BCFG.

Total flux through cube $=\dfrac{q}{8\varepsilon_0}$

flux through surface ABCD = $\phi_{ADEH} = \phi_{ABGH} = 0$ and

$$\phi_{BCGF} = \phi_{EFGH} = \phi_{CDEF} = \frac{\phi_{cube}}{3} = \frac{1}{3}\left(\frac{q}{8\varepsilon_0}\right)$$

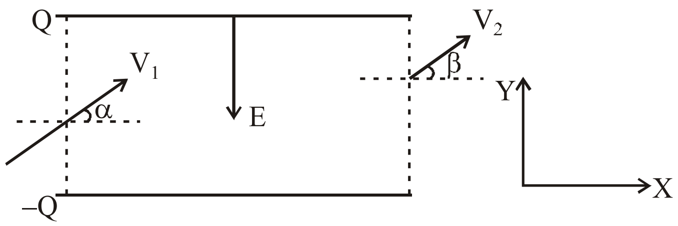
$$= \frac{q}{24\varepsilon_0}$$

10. An electron with kinetic energy K_1 enters between parallel plates of a capacitor at an angle 'α' with the plates. it leaves the plates at angle 'β' with kinetic energy K_2. then the ratio of kinetic energies $K_1 : K_2$ will be:

(1) $\dfrac{\cos\beta}{\sin\alpha}$ (2) $\dfrac{\cos\beta}{\cos\alpha}$ (3) $\dfrac{\sin^2\beta}{\cos^2\alpha}$ (4) $\dfrac{\cos^2\beta}{\cos^2\alpha}$

Ans. Offical answer by NTA (4)

Sol.



$\because a_x = 0$

$\therefore$ velcity in X direction will remain constant.

$V_1 \cos\alpha = V_2 \cos\beta$ ....(i)

and $\frac{K_1}{K_2} = \frac{\frac{1}{2}mV_1^2}{\frac{1}{2}mV_2^2} = \left(\frac{V_1}{V_2}\right)^2 = \frac{\cos^2\beta}{\cos^2\alpha}$

11. For extrinsic semiconductors; when doping level is increased;

(1) Fermi- level of p and n-type semiconductors will not be affected.

(2) fermi - level of p-type semiconductor will go upward and fermi-level of n-type semiconductors will go downward.

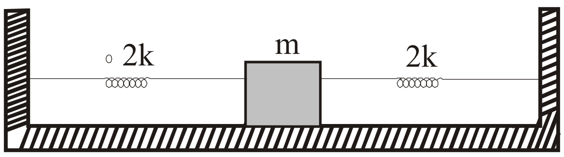
(3) Fermi-level of p-type semiconductors will go downward and femi-level of n-type semiconductor will go upward.

(4) Fermi-level of both p-type and n-type semiconductors will go upward for $T > T_F$K and downward for $T < T_F$ K, where T_F is fermi temperature.

Ans. Offical answer by NTA (3)

Sol. Part of Theory.

12. Two identical springs of spring constant '2k' are attached to a block of mass m and to fixed support (see figure). When the mass is displaced from equilibrium position on either side, it executes simple harmonic motion. the time period of oscillations of this system is:



(1) $2\pi\sqrt{\frac{m}{k}}$ (2) $\pi\sqrt{\frac{m}{k}}$ (3) $2\pi\sqrt{\frac{m}{2k}}$ (4) $\pi\sqrt{\frac{m}{2k}}$

Ans. Offical answer by NTA (2)

Sol. Let Block is displaced towards right by x.

$\therefore F_{net} = 4kx$ (towards Left)

$\Rightarrow ma = 4kx$

$\Rightarrow a = \left(\frac{4k}{m}\right)x \Rightarrow$ S.H.M

$\therefore\ \omega = \sqrt{\frac{4k}{m}}$

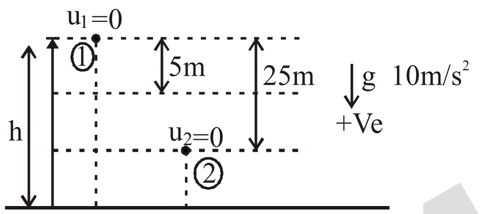
$\therefore T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{m}{4k}} = \pi\sqrt{\frac{m}{k}}$

13. A stone is dropped from the top of a building When it crosses a point 5 m below the top, another stone starts to fall from a point 25 m below the top. Both stones reach the bottom of building simultaneously. The height of the building is:

(1) 50 m (2) 25 m (3) 35 m (4) 45 m

Ans. Offical answer by NTA (4)

Sol.



Let 2nd particle reaches ground after t seconds.

For Ist particle :- $V_1^2 = u_1^2 + 2as$

$\Rightarrow V_1^2 = 0 + 2g(s)$

$\Rightarrow V_1 = 10m/s$

and $h - 5 = (10)t + \frac{g}{2}t^2$ ....(1)

For 2nd particle:- $h - 25 = 0 + \frac{1}{2}gt^2$ ....(2)

From (1) &(2) $20 = 10t$

$\Rightarrow t = 2\,sec$

$\therefore$ from (2) $\Rightarrow$ $h - 25 = \frac{1}{2}\times 10\times (2)^2 = 20m$

$\therefore\ \therefore h = 45m$

14. If e is the electronic charge, c is the speed of light in free space and h is plancks constant, the quantity $\frac{1}{4\pi\varepsilon_0}\frac{|e|^2}{hc}$ has dimensions of :

(1) $[M^0 L^0 T^0]$ (2) $[M L T^0]$ (3) $[L C^{-1}]$ (4) $[M L T^{-1}]$

Ans. Offical answer by NTA (1)

Sol. $F = \left(\frac{1}{4\pi\varepsilon_0}\right)\frac{q^2}{r^2} \Rightarrow Fr^2 = \left(\frac{1}{4\pi\varepsilon_0}\right)q^2$

and $E = \frac{hC}{\lambda} \Rightarrow hC = E\lambda$

$\therefore \left(\frac{1}{4\pi\varepsilon_0}\right)\frac{q^2}{hC} = \frac{Fr^2}{E\lambda}$

$= \frac{[M^1L^1T^{-2}][L^2]}{[M^1L^2T^{-2}][L^1]} = [M^oL^oT^o]$

15. An electron of mass m_e and a proton of mass $m_p = 1836\ m_e$ are moving with the same speed. The ratio of their de Broglie wavelength $\frac{\lambda_{electron}}{\lambda_{proton}}$ will be :

(1) 918 (2) $\frac{1}{1836}$ (3) 1 (4) 1836

Ans. Offical answer by NTA(4)

Sol. we know that,

$\lambda = \frac{h}{mv}$

$\therefore \frac{\lambda_{electron}}{\lambda_{proton}} = \frac{M_{proton}}{M_{electron}} = 1836$

16. Match List I with List II.

List I	List II
(a) Rectifier	(i) Used either for stepping up or stepping down the a.c. voltage
(b) Stabilizer	(ii) Used to convert a.c. voltage into d.c voltage
(c) Transformer	(iii) Used to remove any ripple in the rectified output voltage
(d) Filter	(iv) Used for constant output voltage even when the input voltage or

load current change

Choose the correct answer from the options given below:

(1) (a)- (iii), (b)-(iv), (c)-(i), (d)-(ii)

(2) (a)- (ii), (b)-(i), (c)-(iii), (d)-(iv)

(3) (a)- (ii), (b)-(i), (c)-(iv), (d)-(iii)

(4) (a)- (ii), (b)-(iv), (c)-(i), (d)-(iii)

Ans. Offical answer by NTA(4)

Sol. Part of theory.

17. If a message signal of frequency 'f_m' is amplitude modulated with a carrier signal of frequency 'f_c' and radiated through an antenna, the wavelength of the corresponding signal in air is :

(1) $\frac{c}{f_c - f_m}$ (2) $\frac{c}{f_m}$ (3) $\frac{c}{f_c + f_m}$ (4) $\frac{c}{f_c}$

Ans. Offical answer by NTA (4)

Sol. $d = \frac{v}{f} = \frac{c}{f_c}$

18. Consider the diffraction pattern obtained from the sunlight incident on a pinhole of diameter 0.1 μm. If the diameter of the pinhole is slightly increased, it well affect the diffraction pattem such that:

(1) Its size increases, but intensity decreases

(2) Its size increases, and intensity decreases

(3) Its size increases, but intensity increases

(4) Is size decreases, but intensity increases

Ans. Offical answer by NTA (4)

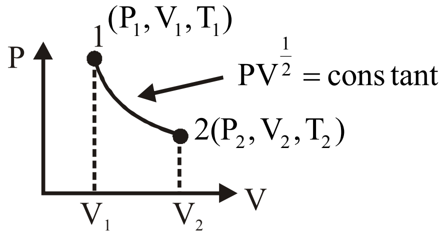
Sol. Angular width of central fringe, $\theta = \frac{1.22d}{a}$

$\therefore$ As a $\uparrow = \theta\downarrow$

and intencity α Area of hole

$\therefore$ As a$\uparrow \Rightarrow$ Area of hole $\uparrow$ and Intencity $\uparrow$

19. Thermodynamic process is shown below on a P-V diagram for one mole of an ideal gas If $V_2 = 2V_1$ then the ratio of temperature T_2/T_1 is :



(1) $\frac{1}{2}$ (2) 2 (3) $\sqrt{2}$ (4) $\frac{1}{\sqrt{2}}$

Ans. Offical answer for NTA (3)

Sol. $PV^{1/2}$ = constant

$\left(\frac{nRT}{V}\right)V^{1/2}$ = constant

$\Rightarrow T\alpha V^{1/2}$

$\therefore \frac{T_2}{T_1} = \left(\frac{V_2}{V_1}\right)^{1/2} = \sqrt{2}$

20. The stopping potential for electrons emitted from a photosensitive surface illuminated by light of wave-length 491 nm is 0.710 V When the incident wavelength is changed to a new value, the stopping potential is 1.43 V. the new wavelength is :

(1) 309 nm (2) 329 nm (3) 382 nm (4) 400 nm

Ans. Offical answer by NTA (3)

Sol. We know that,

$k_{max} = ev_s$ and $\frac{hc}{\lambda} = k_{max} + \phi$

$\therefore \frac{hc}{\lambda} = ev_s + \phi$

$\frac{1240}{491} = \phi + 0.71$ ... (1) and

$\frac{1240}{\lambda} = \phi + 1.43$ ... (2)

(2) – (1)

$\frac{1240}{\lambda} - \frac{1240}{491} = 1.43 - 0.71$

$\Rightarrow \frac{1240}{\lambda} - \frac{1240}{491} = 0.72$

$\Rightarrow \frac{1240}{\lambda} = 0.72 + 2.52 = 3.24$

$\Rightarrow \lambda = \frac{1240}{3.24} \approx 382\text{nm}$

Section-B

1. The percentage increase in the speed of transverse waves produced in a stretched string if the tension is increased by 4% will be _________ %.

Ans. Offical answer by NTA (2)

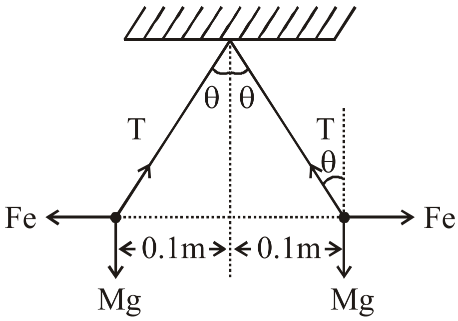
Sol. $V = \sqrt{\frac{T}{\mu}}$

$\Rightarrow \frac{\Delta V}{V} \times 100\% = \frac{1}{2}\left(\frac{\Delta T}{T} \times 100\%\right) = \frac{1}{2} \times 4\% = 2\%$

2. Two small spheres each of mass 10 mg are suspended from a point by threads 0.5 m long. They are equally charged and repel each other to a distance of 0.20 m. The charge on each of teh sphere is $\frac{a}{21} \times 10^{-8}$ C. The value of 'a' will be ________ .

Ans. Offical answer by NTA (20)

Sol.



$$\sin\theta = \frac{0.1}{0.5} = \frac{1}{5}$$

$$\therefore \tan\theta = \frac{1}{\sqrt{24}}$$

Tcosθ = mg and Tsinθ = Fe

$$\tan\theta = \frac{Fe}{mg}$$

$$\Rightarrow \frac{1}{\sqrt{24}} = \frac{9\times10^{9}\times q^{2}}{(0.2)^{2}\times(10\times10^{-6})\times10}$$

$$\Rightarrow q^{2} = \frac{4\times10^{-6}}{\sqrt{24}\times9\times10^{9}}$$

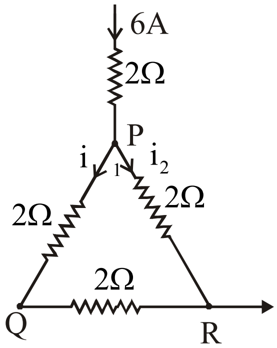
$$\Rightarrow q^{2} = \frac{40}{9\sqrt{24}}\times10^{-16}$$

$$\Rightarrow q = 0.95\times10^{-8}$$

$$\therefore \frac{9}{21}\times10^{-8} = q = 0.95\times10^{-8}$$

$$\Rightarrow a = 21\times0.95 \approx 20$$

3. A current of 6 A enters one corner P of an equilateral triange PQR having 3 wires of resistance 2 Ω each and leaves by the corner R. The currents i_i in ampere is _______.



Ans. Offical answer by NTA (2)

Sol. $i_1 = \left(\frac{1/4}{3/4}\right) \times 6 = \frac{1}{3} \times 6 = 2A$

4. A reversible heat engine converts one-fourth of the heat input into work. When the temperature of the sink is reduced by 52 K, its efficiency is doubled the temperature in kelvin of the source will be ____.

Ans. Offical answer by NTA (208)

Sol. $\eta = \frac{1}{4} = 1 - \frac{T_L}{T_H} \Rightarrow \frac{T_L}{T_H} = \frac{3}{4}$ .....(1)

and $\eta = \frac{1}{2} = 1 - \frac{T_L - 52}{T_H} \Rightarrow \frac{T_L - 52}{T_H} = \frac{1}{2}$ .....(2)

from (1) & (2) $\Rightarrow$ $T_L = 156$ kelvin

& $T_H = 208$ kelvin

5. The peak electric field produced by the radiation coming from the 8 W bulb at a distance of 10 m is $\frac{x}{10}\sqrt{\frac{\mu_0 c}{\pi}}\frac{V}{m}$. The efficiency of the bulb is 10% and it is a point source. The value of x is _____.

Ans. Offical answer by NTA (2)

Sol. We know that

$I = \frac{P}{4\pi d^2} = \frac{8}{4\pi(10)^2}$ and $c = \frac{1}{\sqrt{\mu_0 c_0}} \Rightarrow \epsilon_o = \frac{1}{\mu_0 c^2}$

and

Energy stored in electric field $= \frac{I}{2}$

$\Rightarrow \frac{1}{2} \epsilon_0 E^2_{rms} c = \frac{I}{2}$

$\Rightarrow \frac{1}{2} \epsilon_0 \left(\frac{E_0}{\sqrt{2}}\right)^2 c = \frac{8}{2 \times 4\pi \times 10^2}$

$\Rightarrow \frac{1}{4}\left(\frac{1}{\mu_0 c^2}\right) E_0^2 \, c = \frac{1}{\pi \times 10^2}$

$\Rightarrow E_0^2 = \frac{\mu_0 c}{\pi} \times \frac{4}{10^2} \Rightarrow E_0 = \frac{2}{10}\sqrt{\frac{\mu_0 c}{\pi}} \Rightarrow x = 2$

26. If $\vec{P} \times \vec{Q} = \vec{Q} \times \vec{P}$, the angle between $\vec{P}$ and $\vec{Q}$ is θ (0º<360º). The value of 'θ' will be _________ .

Ans. Offical answer by NTA (180)

Sol. $\because \vec{P} \times \vec{Q} = \vec{Q} \times \vec{P}$

$\therefore \left|\vec{P} \times \vec{Q}\right| = \left|\vec{Q} \times \vec{P}\right| = 0$

$\therefore$ angle between $\vec{P}$ & $\vec{Q}$ will be 180°

7 Two particles having masses 4 g and 16 g respectively are moving with equal kinetic energies the ratio of the magnitudes of their linear momentum is n :2. The value of n will be _______.

Ans. Offical answer by NTA (10)

Sol. $k = \frac{P_1^2}{2m_1} = \frac{P_2^2}{2m_2}$

$\Rightarrow \frac{P_1^2}{2 \times 4} = \frac{P_2^2}{2 \times 16}$

$\Rightarrow \frac{P_1}{P_2} = \frac{1}{2}$

$\therefore n = 1$

28 The wavelength of an X-ray beam is 10Å. The mass of a fictitious particle having the same energy as that of the x-ray photons is $\frac{x}{3}h$ kg. The value of x is _________.(h = planck's constant)

Ans. Offical answer by NTA (10)

Sol. $E = \frac{hc}{\lambda} = mc^2$

$\Rightarrow m = \frac{h}{c\lambda}$

and $\frac{x}{3}h = m = \frac{h}{3\times10^8\times10\times10^{-10}}$

$\Rightarrow x = 10$

9 The initial velocity v_i required to project a body vertically upward from the surface of the earth to reach a height of 10R, where R is the radius of the earth may be described in tems of escape velocity v_e such that $v_i = \sqrt{\frac{x}{y}} \times v_e$. The value of x will be ________.

Ans. Offical answer by NTA (10)

Sol. From mechanical energy conservation:

$\frac{1}{2}mv_i^2 - \frac{GMm}{R} = -\frac{GMm}{11R}$

$\Rightarrow V_i = \sqrt{\frac{20GM}{11R}} = \sqrt{\frac{10}{11}\left(\frac{2GM}{R}\right)}$

$\Rightarrow V_i = \sqrt{\frac{10}{11}}\ v_e$

$\therefore x = 10$

10. Two identical conducting spheres with negligible volume have 2.1 nC and = –0.1 nC charges, respectively. They are brought into contact and then separated by a distance of 0.5 m. The electrostatic force acting between the spheres is _______ $\times10^{-9}$ N

[Given : $4\pi\varepsilon_0 = \frac{1}{9\times10^9}$ sI unit]

Ans. Offical answer by NTA (36)

Sol. Total charge (Q) = 2.1 – 0.1 = 2nc

final charge (q) an each sphere after contact will be

same. so q $= \frac{Q}{2} = 1\text{nc}$

$\therefore F = \frac{kq^2}{r^2} = \frac{9\times10^9\times(10^{-9})^2}{(0.5)^2}$

$\Rightarrow F = 36\times10^{-9}$ N