JEE Main March 2021

Question Paper With Text Solution

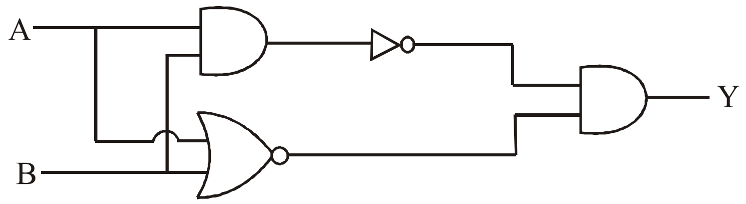
17 March. | Shift-2

PHYSICS

JEE MAIN MARCH 2021 | 17TH MARCH SHIFT-2

SECTION – A

1. Which one of the following will be the output of the given circuit ?



(1) XOR Gate

(2) AND Gate

(3) NAND gate

(4) NOR Gate

Ans. Official Answer by NTA (1)

Sol.
$$Y = \overline{AB}.(A+B)$$
$$Y = (\overline{A}+\overline{B})(A+B)$$
$$Y = A\overline{A}+\overline{A}B+A\overline{B}+B\overline{B}$$
$$Y = \overline{A}B+A\overline{B}$$

2. A geostationary satellite is orbiting around an arbitary planet 'P' at height of 11R above the surface of 'P', R being the radius of 'P'. The time period of another satellite in hours at a height of 2R from the surface of 'P' is ________. 'P' has the time period of 24 hours.

(1) 3

(2) $\frac{6}{\sqrt{2}}$

(3) $6\sqrt{2}$

(4) 5

Ans. Official Answer by NTA (1)

Sol. $T \propto r^{3/2}$

Where T = Time period

r = Distance from centre of the planet

Here $T_1 = 24$ hrs. $r_1 = 12/2$

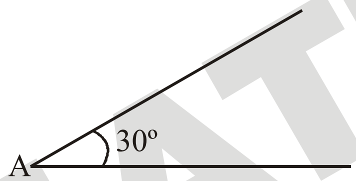
$T_2 = ?$ $r_2 = 3/2$

$$\frac{T_2}{T_1} = \left(\frac{r_2}{r_1}\right)^{3/2}$$

$$\frac{T_2}{24} = \left(\frac{3R}{12R}\right)^{3/2}$$

$T_2 = 3$ hrs.

3. A sphere of mass 2 kg and radius 0.5 m is rolling with an initial speed of 1 ms^{-1} goes up an inclined plane which makes an angle of 30^o with the horizontal plane, without slipping. How long will the sphere take to return to the starting point A ?



(1) 0.57 s

(2) 0.52 s

(3) 0.80 s

(4) 0.60 s

Ans. Official Answer by NTA (1)

Sol. $$a = \frac{g\sin\theta}{1+\frac{I}{MR^2}}$$

$$a = \frac{g\sin 30^o}{1+\frac{2MR^2}{5MR^2}}$$

$$a = \frac{25}{7} \text{ m/s}^2$$

$$t = \frac{2u}{a} = \frac{2\times1\times7}{25} = \frac{14}{25} = 0.57 \text{ sec.}$$

4. An object is located at 2 km beneath the surface of the water. If the fractional compression $\frac{\Delta V}{V}$ is 1.36%, the ratio of hydraulic stress to the corresponding hydraulic strain will be ________.

[Given : density of water is 1000 kgm^{-3} and g = 9.8 ms^{-2}.]

(1) 1.96×10^7 Nm^{-2}

(2) 1.44×10^9 Nm^{-2}

(3) 1.44×10^7 Nm^{-2}

(4) 2.26×10^9 Nm^{-2}

Ans. Official Answer by NTA (2)

Sol. Given $\frac{\Delta V}{V} = 1.36\% = 1.36\times10^{-2}$

$$\frac{\text{Hydraulic Stress}}{\text{Hydraulic Strain}} = \beta$$

$$\beta = \frac{P}{\left(\frac{\Delta V}{V}\right)}$$

Here $P = \rho gh$

So $\beta = \frac{1000\times9.8\times2000}{1.36\times10^{-2}}$

$\beta = 1.44\times10^9$ N/m^2

5. The atomic hydrogen emits a line spectrum consisting of various series. Which series of hydrogen atomic spectra is lying in the visible region ?

(1) Lyman series

(2) Paschen series

(3) Brackett series

(4) Balmer series

Ans. Official Answer by NTA (4)

Sol. Theory Based

6. Two particles A and B of equal masses are suspended from two massless springs of spring constants K_1 and K_2 respectively. If the maximum velocities during oscilliations are equal, the ratio of the amplitude of A and B is

(1) $\sqrt{\frac{K_2}{K_1}}$

(2) $\frac{K_2}{K_1}$

(3) $\frac{K_1}{K_2}$

(4) $\sqrt{\frac{K_1}{K_2}}$

Ans. Official Answer by NTA (1)

Sol.
$$A_1\omega_1 = A_2\omega_2$$
$$A_1\sqrt{\frac{K_1}{m}} = A_2\sqrt{\frac{K_2}{m}}$$
$$\frac{A_1}{A_2} = \sqrt{\frac{K_2}{K_1}}$$

7. Two identical photocathodes receive the light of frequencies f_1 and f_2 respectively. If the velocities of the photo-electrons coming out are υ_1 and υ_2 respectively, then

(1) $\upsilon^2_1 - \upsilon^2_2 = \frac{2h}{m}[f_1 - f_2]$

(2) $\upsilon^2_1 + \upsilon^2_2 = \frac{2h}{m}[f_1 + f_2]$

(3) $\upsilon_1 + \upsilon_2 = \left[\frac{2h}{m}(f_1 + f_2)\right]^{\frac{1}{2}}$

(4) $\upsilon_1 - \upsilon_2 = \left[\frac{2h}{m}(f_1 - f_2)\right]^{\frac{1}{2}}$

Ans. Official Answer by NTA (1)

Sol.
$KE_{max} = hf - \phi$

$\frac{1}{2}mv_1^2 = hf_1 - \phi$ ____(1)

$\frac{1}{2}mv_2^2 = hf_2 - \phi$ ____(2)

By Equation (1) – (2)

$\frac{1}{2}m(v_1^2 v^2_2) = hf_1 - hf_2$

$v_1^2 - v^2_2 = \frac{2h(f_1 - f_2)}{m}$

8. If one mole of the polyatomic gas is having two vibrational modes and β is the ratio of molar specific heats for polyatomic gas $\left(\beta = \frac{C_P}{C_V}\right)$ then the value of β is :

(1) 1.02

(2) 1.35

(3) 1.25

(4) 1.2

Ans. Official Answer by NTA (4)

Sol. Each vibrational mode will have two degrees of freedom corresponding to kinetic & potential energy.
So here degress of freedom due to vibrations will be four.
So total degrees of freedom f = 3 + 3 + 4 = 10

$\beta = \frac{\left(\frac{f}{2} + 1\right)}{f/2} = \frac{5+1}{5} = 1.2$

9 The velocity of a particle is $\upsilon = \upsilon_0 + gt + Ft^2$. Its position is $x = 0$ at $t = 0$; then its displacement after time (t = 1) is :

(1) $\upsilon_0 + 2g + 3F$

(2) $\upsilon_0 + \frac{g}{2} + \frac{F}{3}$

(3) $\upsilon_0 + \frac{g}{2} + F$

(4) $\upsilon_0 + g + F$

Ans. Official Answer by NTA (2)

Sol.
$$V = V_0 + gt + Ft^2$$
$$\frac{ds}{dt} = V_0 + gt + Ft^2$$
$$\int ds = \int_0^1 (v_0 + gt + Ft^2)\,dt$$
$$s = V_0 + \frac{g}{2} + \frac{F}{3}$$

10. A sound wave of frequency 245 Hz travels with the speed of 300 ms^{-1} along the positive x-axis. Each point of the wave moves to and fro through a total distance of 6 cm. What will be the mathematical expression of this travelling wave ?

(1) $Y(x, t) = 0.06[\sin 0.8\,x - (0.5 \times 10^3)\,t]$

(2) $Y(x, t) = 0.03[\sin 5.1\,x - (0.2 \times 10^3)\,t]$

(3) $Y(x, t) = 0.03[\sin 5.1\,x - (1.5 \times 10^3)\,t]$

(4) $Y(x, t) = 0.06[\sin 5.1\,x - (1.5 \times 10^3)\,t]$

Ans. Official Answer by NTA (3)

Sol. f = 245 Hz, v = 300 m/s

Amplitude $= \frac{6}{2} = 3\,cm = 0.03m$

$$\omega = 2\pi f = 2\pi \times 245 = 1539.38 \approx 1.5 \times 10^3 / sec.$$
$$k = \frac{\omega}{v} = \frac{2\pi f}{v} = 5.1\ m^{-1}$$
$$y(x, t) = A\ \sin(kx - wt)$$
$$y(x, t) = 0.03\ \sin(5.1\,x - (1.5 \times 10_3)\,t)$$

11. A rubber ball is released from a height of 5 m above the floor. It bounces back repeatedly, always rising to $\frac{81}{100}$ of the height through which it falls. Find the average speed of the ball.

(Take g = 10 ms^{-2})

(1) 3.0 ms^{-1}

(2) 2.50 ms^{-1}

(3) 2.0 ms^{-1}

(4) 3.50 ms^{-1}

Ans. Official Answer by NTA (2)

Sol.
$$h' = e^2 h$$
$$\frac{81h}{100} = e^2 \times h$$
$$e^2 = 0.81$$
$$e = 0.9$$

Total distance = $h + 2[e^2h + e^4h + e^6h ......]$

$$= h + 2h\frac{e^2}{1-e^2}$$

Total distance = $h\left(\frac{1+e^2}{1-e^2}\right)$

Total time = $\sqrt{\frac{2h}{h}} + 2\left[\sqrt{\frac{2e^2h}{g}} + \sqrt{\frac{2e^4h}{g}} + \sqrt{\frac{2e^6h}{g}} ......\right.$

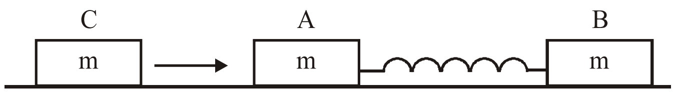
$$= \sqrt{\frac{2h}{g}}\left[1 + \frac{2e}{1-e}\right]$$

Total time = $\sqrt{\frac{2h}{g}}\left(\frac{1+e}{1-e}\right)$

Any speed = $\frac{\text{Total Distance}}{\text{Total Time}} = \frac{h\left(\frac{1+e^2}{1-e^2}\right)}{\sqrt{\frac{2h}{g}}\left(\frac{1+e}{1-e}\right)}$

Any speed = $\sqrt{\frac{gh}{2}} \times \frac{1+e^2}{(1+e)^2} = \sqrt{\frac{10\times5}{2}} \times \frac{(1+.81)}{(1.9)^2} = 2.50\,m/s$

12. Two identical blocks A and B each of mass m resting on the smooth horizontal floor are connected by a light spring of natural length L and spring constant K. A third block C of mass m moving with a speed υ along the line joining A and B collides with A. The maximum compression in the spring is



(1) $\sqrt{\frac{m\upsilon}{K}}$

(2) $\sqrt{\frac{m}{2K}}$

(3) $\sqrt{\frac{m\upsilon}{2K}}$

(4) $\upsilon\sqrt{\frac{m}{2K}}$

Ans. Official Answer by NTA (4)

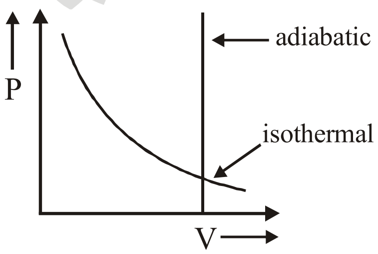
Sol. For maximum compression collision has be elastic; then velocity of C after collision becomes zero.
Velocity of A after collision $V_A = V$
For max compression

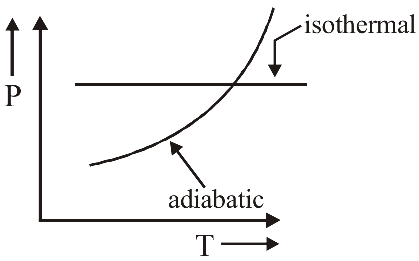
$$\frac{1}{2}kx^2_{max} = \frac{1}{2}\mu V^2_{rel}$$

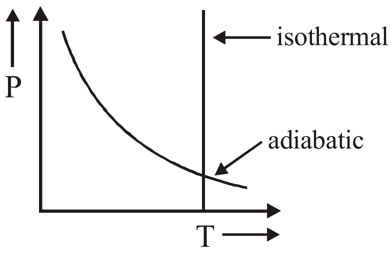
$$\frac{1}{2}kx^2_{max} = \frac{1}{2}\frac{mm}{m+m}(v-0)^2$$

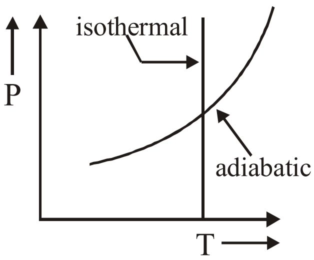
$$x_{max} = v\sqrt{\frac{m}{2K}}$$

13. Which one is the correct option for the two different thermodynamic processes ?

(a)


(b)


(c)


(d)


(1) (C) and (a)

(2) (c) and (d)

(3) (b) and (c)

(4) (a) only

Ans. Official Answer by NTA (2)

Sol. Option (a) is incorrect as for adiabatic process volume cannot be constant

Option (b) is incorrect as for isothermal process temperature has to be constant

Option (c) is correct as for isothermal process temperature is constant & for adiabatic process $TV^{\gamma-1}$ = cosntant

Option (d) is correct as for isothermal process temperature is constant & for adiabatic process $P^{1-\gamma}T^{\gamma}$ = constant

14. Match List – I with List – II

List – I	List – II
(a) Phase difference between current and voltage in a purely resistive AC circuit	(i) $\frac{\pi}{2}$; current leads voltage
(b) Phase difference between current and voltage in a pure inductive AC circuit	(ii) zero
(c) Phase difference between current and voltage in a pure capacitive AC circuit	(iii) $\frac{\pi}{2}$; current lags voltage
(d) Phase difference between current and voltage in an LCR series circuit	(iv) $\tan^{-1}\left(\frac{X_C - X_L}{R}\right)$

Choose the most appropriate answer from the options given below :

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

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

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

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

Ans. Official Answer by NTA (3)

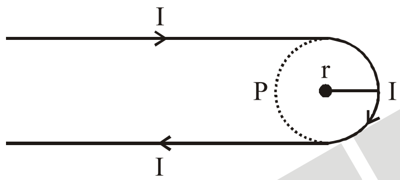
Sol. (a) In purely resistive AC circuit phase difference between current & voltage is zero.

(b) In purely inductive circuit current lags voltage by $\pi/2$

(c) In purely capacitive circuit curtrent leads voltage by $\pi/2$

(d) in LCR circuit $\phi = \text{term}^{-1}\left(\frac{X_C - X_L}{R}\right)$

15. A hairpin like shape as shown in figure is made by bending a long current carrying wire. What is the magnitude of a magnetic field at point P which lies on the centre of the semicircle ?



(1) $\frac{\mu_0 I}{4\pi r}(2-\pi)$

(2) $\frac{\mu_0 I}{2\pi r}(2+\pi)$

(3) $\frac{\mu_0 I}{2\pi r}(2-\pi)$

(4) $\frac{\mu_0 I}{4\pi r}(2+\pi)$

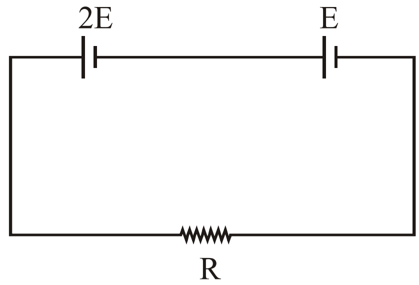
Ans. Official Answer by NTA (4)

Sol. $B_{net} = B_1$ (due to both the wires) + B_2 (due to semi-circle)

$$B_{net} = 2.\frac{\mu_0 I}{4\pi R} + \frac{\mu_0 I}{4R}$$

$$= \frac{\mu_0 I}{4\pi R}(2+\pi)$$

16. Two cells of emf 2E and E with internal resistance r_1 and r_2 respectively are connected in series to an external resistor R (see figure). The value of R, at which the potential difference across the terminals of the first cell becomes zero is



(1) $\frac{r_1}{2} - r_2$

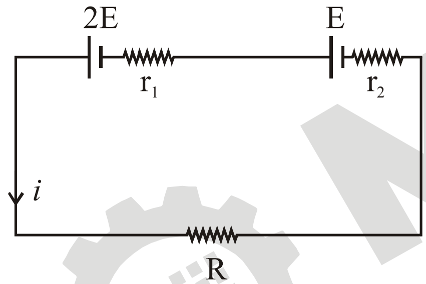
(2) $r_1 - r_2$

(3) $r_1 + r_2$

(4) $\frac{r_1}{2} + r_2$

Ans. Official Answer by NTA (1)

Sol.



$i = \frac{3E}{R + r_1 + r_2}$

Potential difference across cell of emf 2E is

$2E - ir_1 = 0$

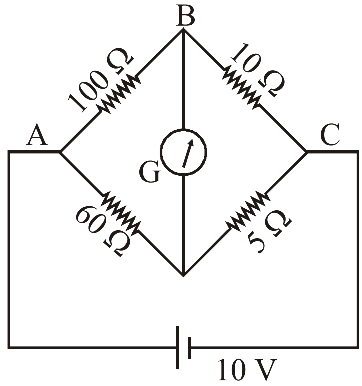
$2E = ir_1$

$2E = \frac{3Er_1}{(R + r_1 + r_2)}$

$2R + 2r_1 + 2r_2 = 3r_1$

$R = \frac{r_1}{2} - r_2$

17. The four arms of a Wheatstone bridge have resistances as shown in the figure. A galvanometer of 15 Ω resistance is connected across BD. Calculate the current through the galvanometer when a potential difference of 10 V is maintaned across AC.



(1) 2.44 μA

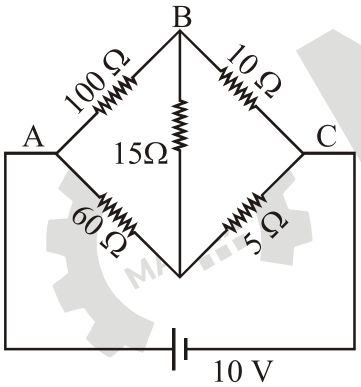
(2) 4.87 μA

(3) 2.44 μA

(4) 4.87 μA

Ans. Official Answer by NTA (2)

Sol.



het $V_B = x \ \& \ V_D = y$

by kirchoff's junction law at B & D

$$\frac{x-10}{100}+\frac{x-0}{10}+\frac{x-y}{15}=0$$

$53x-20y=30$ ______(1)

$$\frac{y-10}{60}+\frac{y-x}{15}+\frac{y-0}{5}=0$$

$17y-4x=10$ ______(2)

On solving eq (1) and (2)

$V_B = x = 0.865$ Volt

$V_D = y = 0.792$ Volt

$V_B - V_D = 0.073$ Volt

Current in galvano meter = $\frac{V_B - V_D}{R_g} = \frac{0.073}{15} \approx 4.87\,\text{mA}$

18. A block of mass 1 kg attached to a spring is made to oscillate with a initial amplitude of 12 cm. After 2 minutes the amplitude decreases to 6 cm. Determine the value of the damping constant for this motion. (take ln 2 = 0.693)

(1) $0.6\times10^{2}\ \text{kg}\,\text{s}^{-1}$

(2) $5.7\times10^{-3}\ \text{kg}\,\text{s}^{-1}$

(3) $1.16\times10^{2}\ \text{kg}\,\text{s}^{-1}$

(4) $3.3\times10^{2}\ \text{kg}\,\text{s}^{-1}$

Ans. Official Answer by NTA (NA)

Sol. $A = A_0 e^{-\frac{bt}{2m}}$

damping constant = b

A_0 = 12 cm, A = 6 cm, t = 120 sec., m = 1 kg.

$6 = 12\, e^{-\frac{b\times120}{2\times(1)}}$

$e^{60b} = 2$

$60b = \ln 2$

$b = \frac{\ln 2}{60} = \frac{0.693}{60} = 0.01155$

$b = 1.15\times10^{-2}\ \text{kg}/\text{sec}$

19. A carries signal C(t) = 25 sin(2.512×10^{10}t) is amplitude modulated by a message signal m(t) = 5 sin (1.57×10^{8}t) and transmitted through an antenna. What will be the bandwidth of the modulated signal ?

(1) 2.01 GHz

(2) 1987.5 MHz

(3) 50 MHz

(4) 8 GHz

Ans. Official Answer by NTA (3)

Sol. Carrier signal frequency = $\frac{2.512\times10^{10}}{2\pi} = 0.4\times10^{10} = 4\,\text{GHz}$

Message signal frequency = $\frac{1.57\times10^{8}}{2\pi} = 25\times10^{6} = 25\,\text{MHz}$

Band width = 2 (Message signal frequency)

$= 2\text{fm} = 2\times 25\ \text{MHz} = 50\ \text{MHz}$

20. What happens to the inductinve reactance and the current in a purely inductive circuit if the frequency is halved ?

(1) Both, inductive reactance and current will be halved.

(2) Inductive reactance will be doubled and current will be halved.

(3) Both, inducting reactance and current will be doubled.

(4) Inductive reactance will be halved and current will be doubled.

Ans. Official Answer by NTA (4)

Sol. $X_L = \omega L$

$i = \frac{V}{X_L}$

if frequency is halved, then inductive reactance will be halved & current will be doubled.

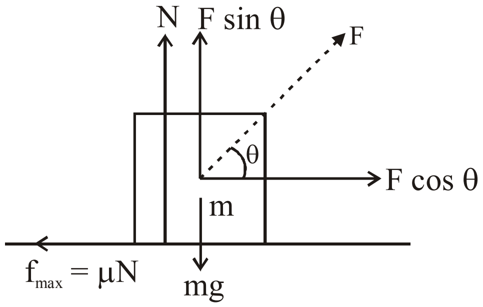
SECTION – B

1. A body of mass 1 kg rests on a horizontal floor with which it has a coefficient of static friction $\frac{1}{\sqrt{3}}$. It is desired to make the body move by applying the minumum possible force F N. The value of F will be __________. (Round off to the Nearest Integer)

[Take g = 10 ms^{-2}]

Ans. Official Answer by NTA (5)

Sol.



$N = \sin\theta = mg$

$N = mg - f\sin\theta$ ____(1)

$F\cos\theta = \mu N$______(2)

From (1) and (2)

$$F = \frac{\mu mg}{\cos\theta + \mu\sin\theta}$$

$$F_{min} = \frac{\mu mg}{\sqrt{1+\mu^2}} = \frac{1}{f^3} \times \frac{1\times 10}{\sqrt{1+\frac{1}{3}}} = 5\,\text{newtons}$$

2. The electric field intensity produces by the radiation coming from a 100 W bulb at a distance of 3 m is E. The electric field intensity produced by the radiation coming from 60 W at the same distance is $\sqrt{\frac{x}{5}}E$. Where the value of x = __________.

Ans. Official Answer by NTA (3)

Sol.

$$\frac{1}{2}\varepsilon_0 E_0{}^2 C = \frac{P}{4\pi r^2}$$

$$\frac{1}{2}\varepsilon_0 E^2 C = \frac{100}{4\pi(3)^2} \text{ \_\_\_\_\_(1)}$$

$$\frac{1}{2}\varepsilon_0 (E')^2 C = \frac{60}{4\pi(3)^2} \text{ \_\_\_\_(2)}$$

by eq (1) & (2)

$$\left(\frac{E}{E'}\right)^2 = \frac{100}{60}$$

$$E' = \sqrt{\frac{60}{100}}E = \sqrt{\frac{x}{5}}E$$

$$x = 3$$

3. The electric field in a region is given $\vec{E} = \frac{2}{5}E_0\hat{i} + \frac{3}{5}E_0\hat{j}$ with $E_0 = 4.0\times10^3 \frac{N}{C}$. The flux of this field through a rectangular surface area 0.4 m^2 parallel to the Y – Z plane is ________ $Nm^2\ C^{-1}$.

Ans. Official Answer by NTA (640)

Ans. ()

Sol.

$$\vec{E} = \frac{2}{5}E_0\hat{i} + \frac{3}{5}E_0\hat{j}$$

$$E_0 = 4\times10^3 \text{ N/C}$$

$$\vec{A} = 0.4\hat{i} \text{ (parallel to y–z plane)}$$

$$\phi = \vec{E}.\vec{A}$$

$$\phi = \left(\frac{2}{5}E_0\hat{i} + \frac{3}{5}E_0\hat{j}\right).(0.4\hat{i})$$

$$\phi = \frac{2}{5}\times E_0 \times 0.4$$

$$\phi = \frac{2}{5}\times 4\times10^3\times0.4 = 640 \text{ N} - \text{m}^2\text{C}^{-1}$$

4. A particle of mass m moves in a circular orbit in a central potential field $U(r) = U_0 r^4$. If Bohr's quantization conditions are applied, radii of possible orbitals r_n vary with $n^{\frac{1}{\alpha}}$, where α is ________.

Ans. Official Answer by NTA (3)

Ans. ()

Sol. $U = U_0 r^4$

$F = -\frac{dU}{dr} = -4U_0 r^3$

This force F provides contripetal force for circulas motion

$4U_0 r^3 = \frac{mv^2}{r}$

$mv^2 = 4U_0 r^4 \Rightarrow v \propto r^2$

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

So $r^3 \propto n$

$r \propto (n)^{1/3}$

So $\alpha = 3$

5. The image of an object placed in air formed by a convex refracting surface is at a distance of 10 m behind the surface. The image is real and is at $\frac{2^{rd}}{3}$ of the distance of the object from the surface. The wavelength of light inside the surface is $\frac{2}{3}$ times the wavelengt in air. The radius of the curved surface is $\frac{x}{13}$m. The value of 'x' is _________.

Ans. Official Answer by NTA (30)

Ans. ()

Sol. $\mu = \frac{\lambda_a}{\lambda_m} = \frac{\lambda_a}{\frac{2}{3}\lambda_a}$

$\mu = 3/2$

$V = 10m$

Given $V = \frac{-2}{3}u$

$u = \frac{-3}{2}v = \frac{-3}{2} \times 10 = -15\ m$

$$\frac{\mu_2}{v}-\frac{\mu_1}{u}=\frac{\mu_2-\mu_1}{R}$$

$$\frac{3}{2\times10}-\frac{1}{(-15)}=\frac{\frac{3}{2}-1}{R}$$

$$\frac{3}{20}+\frac{1}{15}=\frac{1}{2R}$$

$$2R=\frac{60}{9+4}$$

$$R=\frac{30}{13}=\frac{x}{13}\Rightarrow x=30$$

6. Suppose you have taken a dilute solution of oleic acid in such a way that its concentration becomes 0.01 cm^3 of oleic acid per cm^3 of the solution. Then you make a thin film of this solution (monomolecular thickness) of area 4 cm^2 by considering 100 spherical drops of radius $\left(\frac{3}{40\pi}\right)^{\frac{1}{3}}\times10^{-3}$ cm. Then the thickness of oleic acid layer will be $x \times 10^{-14}$ m.

Ans. Official Answer by NTA (25)

Sol. Volume of thinfilm = volue of 100 drops

$$4cm^2\times t\,cm=100\times\frac{4}{3}\pi r^3$$

$$4t=100\times\frac{4}{3}\pi\times\frac{3}{40\pi}\times10^{-9}$$

$t=25\times10^{-10}$ cm (Here t = thickness of solution layer)

thickness of oleic acid layer = $0.01t=0.01\times25\times10^{-10}$ cm

$=25\times10^{-14}$ m

then $x=25$

7. Seawater at a frequency $f = 9 \times 10^2$ Hz, has permittivity $\varepsilon=80\varepsilon_0$ and resistivity $\rho=0.25\ \Omega m$. Imagine a parallel plate capacitor is immersed in seawater and is driven by an alternating voltage source $V(t)=V_0\sin(2\pi ft)$. Then the conduction current density becomes 10^x times the displacement current density after time $t=\frac{1}{800}$ s. The value of x is ____________.

Ans. Official Answer by NTA (6)

Sol. Given $f = 9 \times 10^2$ Hz, $\varepsilon = 80\varepsilon_0$, $p = 0.25\ \Omega - m$

Displacement current density

$$J_d = \frac{1}{A}\frac{dq}{dt}$$

for capacitor $q = CV$ & $C = \frac{\varepsilon A}{d}$

$$J_d = \frac{\varepsilon A}{Ad}\frac{dv}{dt}$$

given $V = V_0 \sin(2\pi ft) \Rightarrow \frac{dv}{dt} = 2\pi fv_0 \cos(2\pi ft)$

$$J_d = \frac{\varepsilon}{d} \times 2\pi fv_0 \cos 2\pi f$$

Conduction current density $J_c = \frac{E}{\rho} = \frac{V}{d\rho}$

given at $t = \frac{1}{800}$ s

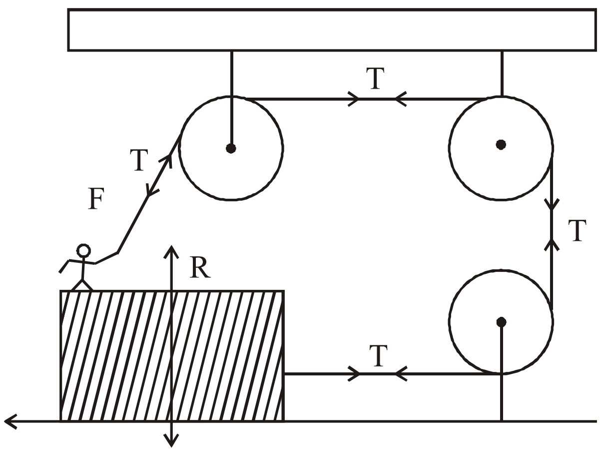
$$J_c = 10^x J_d$$

$$\frac{V_0 \sin 2\pi ft}{\rho d} = 10^x \times \frac{80\varepsilon_0}{d} \times 2\pi fv_0 \cos 2\pi ft$$

$x = 6$

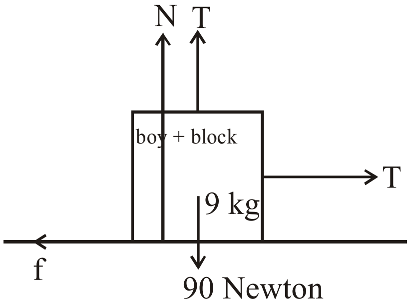
8. A boy of mass 4 kg is standing on a piece of wood having mass 5 kg. If the coefficient of friction between the wood and the floor is 0.5, the maximum force that the boy can exert on the rope so that the piece of wood does not move from its place is __________ N. (Round off to the Nearest Integer)

[Take $g = 10\ ms^{-2}$]



Ans. Official Answer by NTA (30)

Sol.



$N + T = 90$

$N = 90 - T$

for no slipping

$T = f$

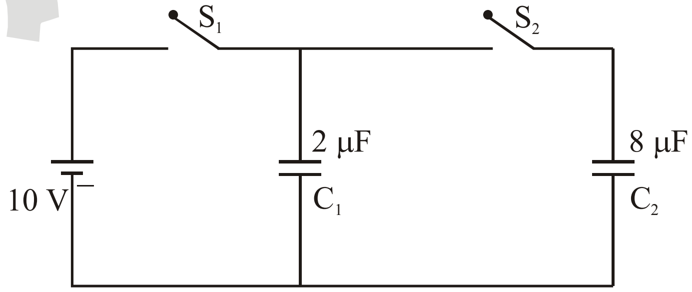
$T = \mu N$

$T = 0.5(90 - T)$

$1.5\,T = 0.5 \times 90$

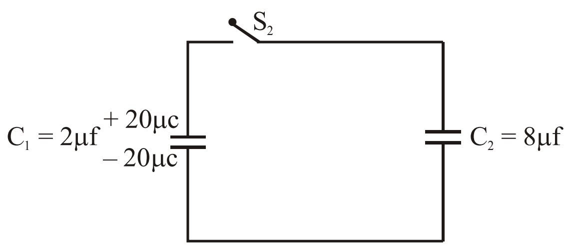
$T = 30$ Newton

9. A $2\,\mu F$ capacitor C_1 is first charged to a potential difference of 10 V using a battery. Then the battery is removed and the capacitor is connected to an uncharged capacitor C_2 of $8\,\mu F$. The charge in C_2 on equilibrium condition is _________ μC. (Round off to the Neares Integer)

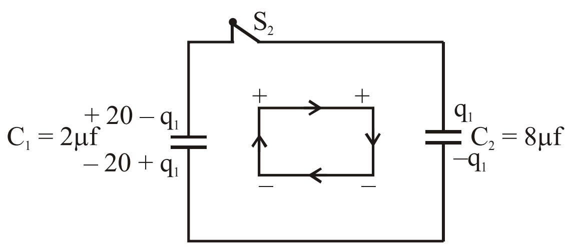


Ans. Official Answer by NTA (16)

Sol.



(S_2 is open)



(S_2 is closed and in equilibrium)

Change on C_1 before removing battery $q_1 = 2 \times 10 = 20 \mu C$

by looplaw

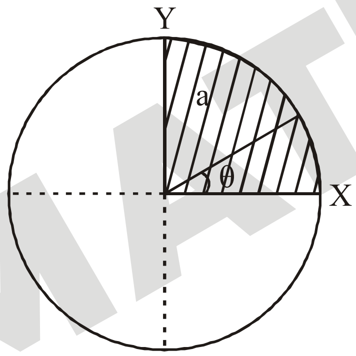
$\frac{20-q_1}{2}-\frac{q_1}{8}=0$

$80-4q_1-q_1=0$

$q_1=16\mu C$

10. The disc of mass M with uniform surface mass density σ is shown in the figure. The centre of mass of the quarter disc (the shaded area) is at the position $\frac{x}{3}\frac{a}{\pi},\frac{x}{3}\frac{a}{\pi}$ where *x* is ____________. (Round off to the Nearest Integer)

[a is an area as shown in the figure]



Ans. Official Answer by NTA (4)

Sol. Centre of mass of quarter disc

$\left(x_c, y_c\right)=\left(\frac{4R}{3\pi},\frac{4R}{3\pi}\right)$

Here Radius R = a

So $\frac{x}{3}\frac{a}{\pi}=\frac{4a}{3\pi}$

$x=4$