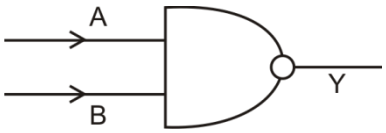
JEE Mains Paper-2022

PHYSICS

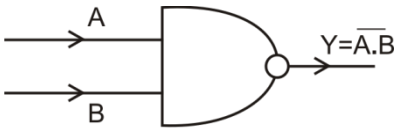
1. For the following gate, the output Y is given by



(1) A + B (2) $\overline{A+B}$

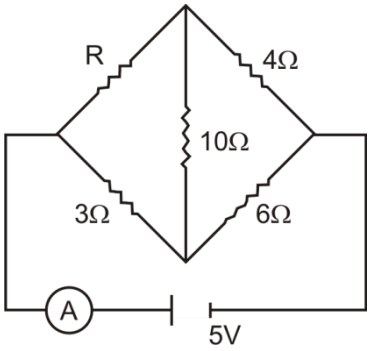
(3) AB (4) $\overline{A \cdot B}$

Sol. Answer (4)



NAND GATE

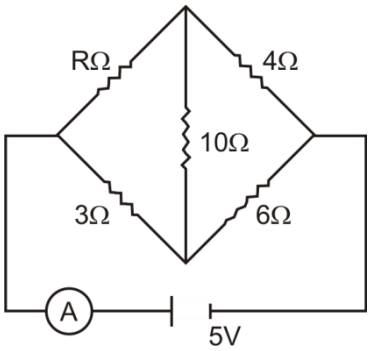
2. For what value of R, current in 10Ω resistance should be zero.



(1) 1 Ω (2) 2 Ω

(3) 3 Ω (4) 4 Ω

Sol. Answer (2)



If Wheatstone bridge is balanced then current in 10 Ω resistor is zero.

So, $\frac{R}{4}=\frac{3}{6}$

$\Rightarrow$ R = 2 Ω

3. Resolving power of a telescope for the aperture 24.4 cm for the wavelength $\lambda = 2440\text{Å}$ is

(1) 2.5×10^{-5}

(2) 8.2×10^{5}

(3) 5.0×10^{-4}

(4) 7.5×10^{6}

Sol. Answer (2)

Given: a = 24.4 cm

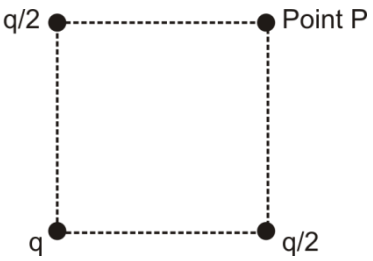
$\lambda = 2440\text{Å}$

Resolving power = $\frac{a}{1.22\lambda}$

$=\frac{24.4\times10^{-2}}{1.22\times2440\times10^{-10}}$

$= 8.2 \times10^{5}$

4. Three point charges are arranged at the three corners of a square as shown:

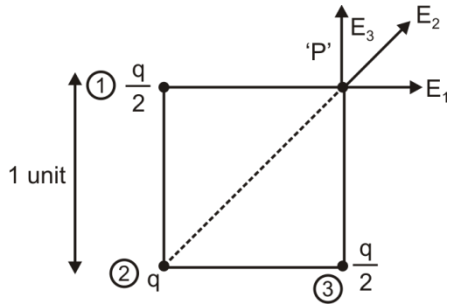


If the side of the square is unity, find the electric field at P.

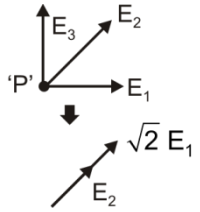
(1) $\frac{kq}{2}(1+\sqrt{2})$ (2) $\frac{kq}{\sqrt{2}}(1+\sqrt{2})$

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

Sol. Answer (1)



$$\left|\vec{E}_1\right| = \frac{k\left(\frac{q}{2}\right)}{(1)^2} = \frac{kq}{2}$$



$$\left|\vec{E}_3\right| = \frac{k\left(\frac{q}{2}\right)}{(1)^2} = \frac{kq}{2}$$

$$\left|\vec{E}_2\right| = \frac{k(q)}{(\sqrt{2})^2} = \frac{kq}{2}$$

So, $E_{net} = \sqrt{2}E_1 + E_2$

$= \sqrt{2}\frac{kq}{2} + \frac{kq}{2}$

$= \frac{kq}{2}(\sqrt{2}+1)$

5. A water drop of diameter 2 cm is divided into 64 small drops. If surface tension is 0.0075 N/m then gain is surface energy is

(1) 8.1×10^{-4}J (2) 3.6×10^{-5} J

(3) 2.8×10^{-5} J (4) 4.2×10^{-4} J

Sol. Answer (3)

Let the radius of small water drop formed is 'r'

$$\frac{4}{3}\pi R^3 = 64\times\frac{4}{3}\pi r^3$$

$$R^3 = (4r^3) \Rightarrow r = \frac{R}{4}$$

Gain in surface energy = $u_f - u_i$

$= 64[4\pi r^2 T] - 4\pi R^2 T$

$= 4\pi T\left(64\times\frac{R^2}{16} - R^2\right)$

$= 4\pi\times0.0075\times3\times10^{-4}$

$=2.8\times10^{-5}$

6. Statement 1(s_1) : npn transistor conducts more current than pnp.

Statement 2 (s_2) : electrons have more mobility than holes.

(1) Both statements are true

(2) S_1 is true and S_2 is false

(3) S_1 is false and S_2 is true

(4) Both statements are false.

Sol. Answer (1)

NPN transistor conduct more current than PNP because majority charge carries in NPN transistor is electrons which has higher mobility than holes.

So, both statements are true.

7. If a positive charge is moved against an electric field then its

(1) Energy will increase

(2) Energy will decrease

(3) Energy will remains same

(4) Behaviour of energy is unpredictable

Sol. Answer (1)

We know $\Delta u = W_{ext} = q(V_f - V_i)$

But $V_f > V_i$

Energy will increase

8. Two planets revolve around sun such that their time periods of revolution T_A and T_B are related by $T_A = 2T_B$. If their radii of revolution are r_A and r_B, then :

(1) $4r_A^3 = r_B^3$ (2) $r_A^3 = 4r_B^3$

(3) $4r_A^2 = r_B^2$ (4) $r_A^2 = 4r_B^2$

Sol. Answer (2)

Time period of revolution of planet around sun is;

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

$$\frac{T_A}{T_B} = \left(\frac{r_A}{r_B}\right)^{3/2}$$

$$\Rightarrow 2 = \left(\frac{r_A}{r_B}\right)^{3/2}$$

$$\Rightarrow \left(\frac{r_A}{r_B}\right)^3 = 4$$

$$\Rightarrow r_A^3 = 4r_B^3$$

9. The minimum deviation for a prism having refractive index $\mu = \cot\left(\frac{A}{2}\right)$ and A is angle of prism is

(1) $180^0 - 2A$ (2) $180^0 - 3A$

(3) $90^0 - A$ (4) $180^0 - 4A$

Sol. Answer (1)

$$\text{given} \rightarrow \mu = \cot\left(\frac{A}{2}\right)$$

$$\mu = \frac{\sin\left(\frac{\delta_m + A}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

$$\cot\left(\frac{A}{2}\right) = \frac{\sin\left(\frac{\delta_m + A}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

$$\cos\left(\frac{A}{2}\right) = \sin\left(\frac{\delta_m + A}{2}\right)$$

$$\sin\left(\frac{\pi}{2} - \frac{A}{2}\right) = \sin\left(\frac{\delta_m + A}{2}\right)$$

$$\frac{\pi}{2} - \frac{A}{2} = \frac{\delta_m + A}{2}$$

$$\pi - A = \delta_m + A$$

$$\delta_m = \pi - 2A$$

10. A man of mass 60 kg is running and then jumps into a trolley of mass 120 kg initially at rest and goes at the speed of 2 m/s find initial speed of man.

(1) 12 m/s (2) 6 m/s

(3) 20 m/s (4) 3 m/s

Sol. Answer (2)

Considering man and trolley as the system, there is no external force. So,

$P_i = P_f$

$$\Rightarrow 60 \times v_0 = (60 + 120) \times 2$$

$$\Rightarrow v_0 = 6\,m/s$$

11. Column-1 contains description of axis and column-2 contains its moment of inertia. Then, choose the **correct** option.

	Column-1		**Column-2**
(A)	Moment of inertia of solid cylinder about its tangent (parallel to axis)	(1)	$\frac{7}{5}mR^2$
(B)	Moment of inertia of solid sphere about its tangent	(2)	$\frac{mR^2}{2}$
(C)	Moment of inertia of ring about its diameter	(3)	$\frac{mR^2}{4}$
(D)	Moment of inertia of disc about its diameter	(4)	$\frac{3}{2}mR^2$

(1) A(1), B(2), C(3), D(4)

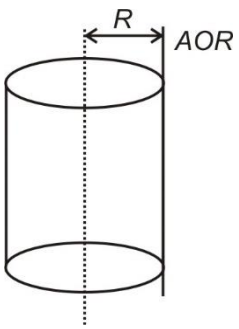
(2) A(1), B(4), C(2), D(3)

(3) A(4), B(3), C(1), D(2)

(4) A(4), B(1), C(2), D(3)

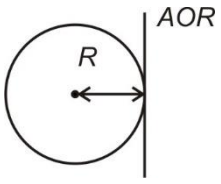
Sol. Answer (4)

(1)



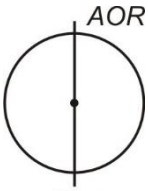
$$I = \frac{MR^2}{2} + MR^2 = \frac{3}{2}MR^2$$

(2)



$$I = \frac{2}{5}MR^2 + MR^2 = \frac{7}{5}MR^2$$

(3)



$$I = \frac{MR^2}{2}$$

(4)

$$I = \frac{MR^2}{4}$$

12. If work function of metal is $\phi = 6.63$ eV, then its cut-off wavelength is

(1) 363 nm

(2) 187 nm

(3) 285 nm

(4) 91 nm

Sol. Answer (2)

Work function (ϕ) = $\frac{hv}{\lambda_0}$

$$\Rightarrow 6.63 \text{ eV} = \frac{12400 \text{ eVÅ}}{\lambda_0}$$

$$\Rightarrow \lambda_0 = \frac{12400}{6.63} \text{Å}$$

$$\Rightarrow \lambda_0 = 1870 \text{ Å} = 187 \text{ nm}$$

13. Co-ordinates of a particle are given by :

$$x = 4\sin\left(\frac{\pi}{2} - \omega t\right) = 4\cos\omega t$$

$$y = 4\sin\omega t$$

What is the trajectory of the particle in x-y plane?

(1) Parabolic

(2) Elliptical

(3) Circular

(4) Colled

Sol. Answer (3)

$$x = 4\sin\left(\frac{\pi}{2} - \omega t\right) = 4\cos\omega t$$

$$y = 4\sin\omega t$$

$$x^2 + y^2 = 16(\sin^2\omega t + \cos^2\omega t)$$

$$x^2 + y^2 = 16$$

Represent equation of circle.

14. Energy of photon and kinetic energy of electron are same. If λ_p and λ_e denotes wavelength of photon and de-broglie wavelength of electron respectively, then

(1) $\lambda_e \propto \lambda_p$

(2) $\lambda_e \propto \sqrt{\lambda_p}$

(3) $\lambda_e \propto \frac{1}{\sqrt{\lambda_p}}$

(4) $\lambda_e \propto \lambda_p^2$

Sol. Answer (2)

De-Broglie wavelength (λ) = $\frac{h}{mv} = \frac{h}{\sqrt{2mk}}$

For electron;

$$\lambda_e = \frac{h}{\sqrt{2m_e k_e}} \Rightarrow k_e = \frac{h^2}{\lambda_e^2 2m_e} \quad ....(i)$$

For photon; $E_p = \frac{hc}{\lambda_p}$ .....(*ii*)

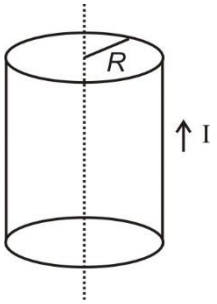
Comparing (i) and (ii)

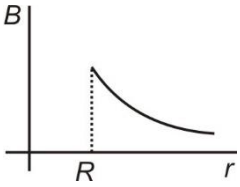
$$\frac{h^2}{\lambda_e^2 2m_e} = \frac{hc}{\lambda_p}$$

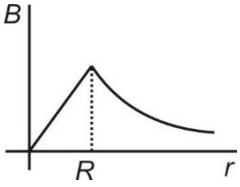
$$\Rightarrow h^2\lambda_p = hc\lambda_e^2 2m_e$$

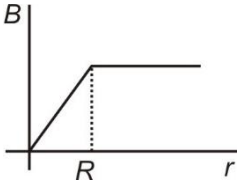
$$\Rightarrow \lambda_e \propto \sqrt{\lambda_p}$$

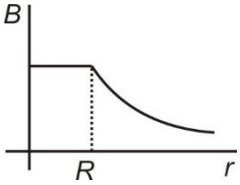
15. A hollow cylinder contains current uniformly distributed over the circumference parallel to the axis. Then correct graph between magnetic field (R) and distance from the axis (R) is



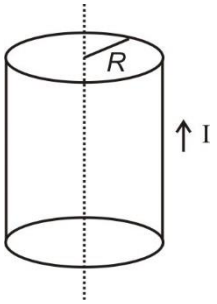
(1)


(2)


(3)


(4)


Sol. Answer (1)



According to Ampere circuit law

$\oint \vec{B}.\vec{dl} = \mu_0 I_{en}$

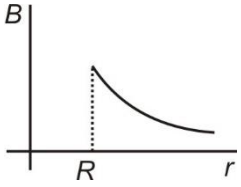
$B(2\pi r) = \mu_0 I_{en}$

For $r < R$ (Inside) $\Rightarrow I_{en} = 0$

$\Rightarrow B = 0$

For $r > R$ (outside) $I_{en} = I$

$B = \dfrac{\mu_0 I}{2\pi r}$



16. One mole of a gas expands adiabatically work done by the gas is W_0. Find out change in temperature during process. (ν = adiabatic coefficient of gas)

(1) $\dfrac{\gamma W_0}{R}$

(2) $(\gamma+1)\dfrac{W_0}{R}$

(3) $(\gamma-1)\dfrac{W_0}{R}$

(4) $(1-\gamma)\dfrac{W_0}{R}$

Sol. Answer (4)

Work done by gas in adiabatic process,

$W = \dfrac{nR\Delta T}{1-\gamma}$

$\text{So, } W_0 = \dfrac{(1)(R)(\Delta T)}{1-\gamma}$

$\Rightarrow \Delta T = \dfrac{(1-\gamma)(W_0)}{R}$

17. If centripetal acceleration of a particle of mass m in a circular path of radius r is $a_c = k^2rt$, where k is constant and t is the time, then power is given by

(1) Zero

(2) mk^2r^2t

(3) $mk^2r^2t^2$

(4) mk^2rt^2

Sol. Answer (2)

$a_c = k^2rt^2$

$\dfrac{v^2}{r} = k^2rt^2 \Rightarrow v = krt$

$a_t = \dfrac{dv}{dt} = kr$

Power $= F_t \times v$

$= mk^2r^2t$

18. Choose the correct option

(1) Diode has 3 terminals

(2) Diode carry current in one direction

(3) diode carry current in both direction

(4) None of these

Sol. Answer (2)

A diode has two terminals which allow current only in one direction when it is forward biased.

19. A container has 2 moles of a monoatomic gas at temperature of 300 K. Find the internal energy of this sample of the gas.

(1) 1800 R

(2) 1500 R

(3) 900 R

(4) 450 R

Sol. Answer (3)

Given, n = 2 moles

T = 300 K

$$C_v = \frac{3R}{2}(\text{monoatomic})$$

$$u = nC_vT$$

$$= 2 \times \frac{3R}{2} \times 300$$

$$= 900R$$

20. Column-1 contains wave of different type and column-2 contains thin maximum frequency. Then choose the **correct** option

(a)	Television wave	(1)	3 kHz
(b)	Radio wave	(2)	20 kHz
(c)	Human voice	(3)	30 MHz
(d)	High pitch music	(4)	60 MHz

(1) A(4), B(3), C(1), D(2)

(2) A(4), B(3), C(2), D(1)

(3) A(3), B(4), C(1), D(2)

(4) A(3), B(4), C(2), D(1)

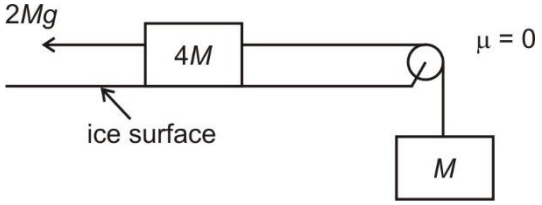
Sol. Answer (1)

(a) Television wave $\rightarrow$ 60 MHz (4)

(b) Radio wave $\rightarrow$ 30 MHz (3)

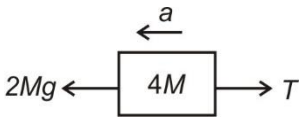
(c) Human voice $\rightarrow$ 3 kHz (1)

(d) High pitch music $\rightarrow$ 20 kHz (2)

21. 

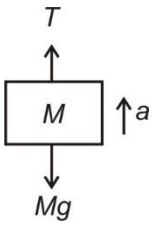
In the shown diagram, if tension in string is $\frac{x}{5}Mg$. Find value of x.

Sol. Answer (06.00)



For 4M block

$$2Mg - T = 4Ma \quad .....(1)$$



For M block

$$T - Mg = Ma \quad .....(2)$$

Adding (1) and (2)

$$Mg = 5Ma$$

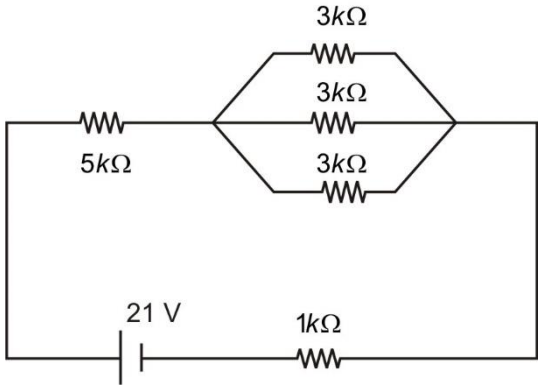
$$a = \frac{g}{5}$$

$$T = Mg + Ma = M\left(g + \frac{g}{5}\right) = \frac{6Mg}{5}$$

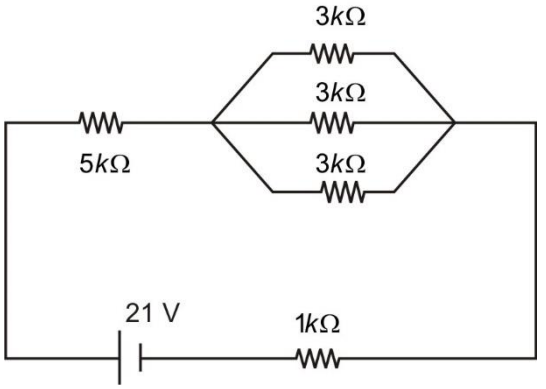
Given, $T = \frac{xMg}{5}$

$\therefore x = 6$

22. The current in $5k\Omega$ resistor in mA is



Sol. Answer (03.00)



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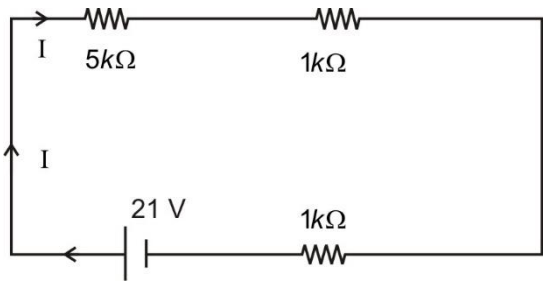


$$I = \frac{21}{(5+1+1)\times 1000} A = 3 \text{ mA}$$

23. Wavelength of a wave in vaccum is 7200Å. If the wave enters a medium of refractive index 1.5, the new wavelength is 100*x* Å. Find the value of *x*.

Sol. Answer (48.00)

Wavelength of wave in a medium

$$\lambda' = \frac{\lambda}{\mu} = \frac{7200}{1.5} = 4800\text{Å}$$

Given, $\lambda' = 100x$ Å

$x = 48$

24. Two waves having wavelength 4.08 m, 4.16 m produce 40 beats in 12 sec. Velocity of the medium is 10*x*, find the value of *x*.

Sol. Answer (70.70)

Beat frequency = $\frac{40}{12}$

$\lambda_1 = 4.08$ m, $\lambda_2 = 4.16$ m

$$\Rightarrow f_1 - f_2 = \frac{10}{3}$$

$$\Rightarrow \frac{v}{\lambda_1} - \frac{v}{\lambda_2} = \frac{10}{3}$$

$$\Rightarrow v\left[\frac{1}{4.08} - \frac{1}{4.16}\right] = \frac{10}{3}$$

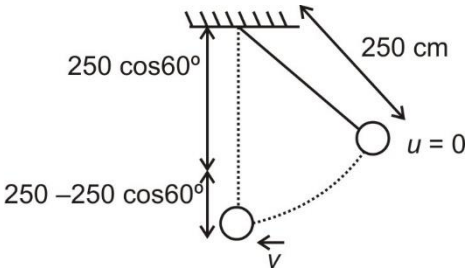
$$\Rightarrow v\frac{[4.16-4.08]}{4.08\times 4.16} = \frac{10}{3}$$

$$\Rightarrow v = \frac{10}{3}\times\frac{4.08\times 4.16}{0.08}$$

$$\Rightarrow v = 707 \text{ m/s}$$

25. A pendulum of length 250 cm is release from rest when string makes angle of 60º with vertical. Final its maximum velocity.

Sol. Answer (05.00)



Maximum velocity will be reached at the bottom most position. So, using work energy theorem,

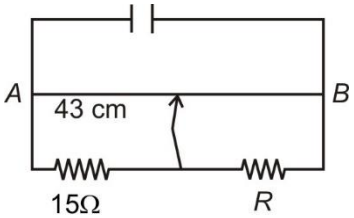
$$\frac{1}{2}mv^2 - \frac{1}{2}mu^2 = W_{gravity} + W_{tension}$$

$$\Rightarrow \frac{1}{2}mv^2 - \frac{1}{2}m(0)^2 = mg(2.5 - 2.5\cos 60^\circ) + 0$$

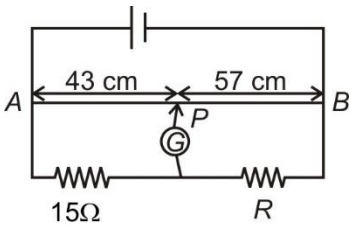
$$\Rightarrow v = \sqrt{2g\times 2.5\left(1-\frac{1}{2}\right)}$$

$$= \sqrt{25} = 5 \text{ m/s}$$

26. In the given meter bridge, find the value of *R*. End correction is 2 cm at point *A*.



Sol. Answer (19.00)



End correction at '*A*' is 2 cm.

So, effective length of AP = 43 + 2 = 45 cm.

Hence, $\frac{45}{57}=\frac{15}{R}$

$\Rightarrow R=19\,\Omega$

27. If $\vec{v}=(3\hat{j}-\hat{k})$m/s , $\vec{r}=(3\hat{i}+\hat{j})m$ and $m=1$kg , then angular momentum $|\vec{L}|=\sqrt{x}$ Nm , find the value of x

Sol. Answer (91.00)

$\vec{r}=(3\hat{i}+\hat{j})m$

$\vec{v}=(3\hat{j}-\hat{k})$m/s

$m=1$kg

$\vec{L}=\vec{r}\times m\vec{v}$

$=(3\hat{i}+\hat{j})\times((1)(3\hat{j}-\hat{k}))$

$\vec{L}=\begin{vmatrix}\hat{i}&\hat{j}&\hat{k}\\3&1&0\\0&3&-1\end{vmatrix}$

$=\hat{i}(-1)-\hat{j}(-3)+\hat{k}(9)$

$=-\hat{i}+3\hat{j}+9\hat{k}$

$|\vec{L}|=\sqrt{(1)^2+(3)^2+(9)^2}$

$=\sqrt{91}$