VIDYAPEETH ACADEMY
IIT JEE | NEET | OLYMPIAD | KVPY | NTSE

JEE MAIN 2021

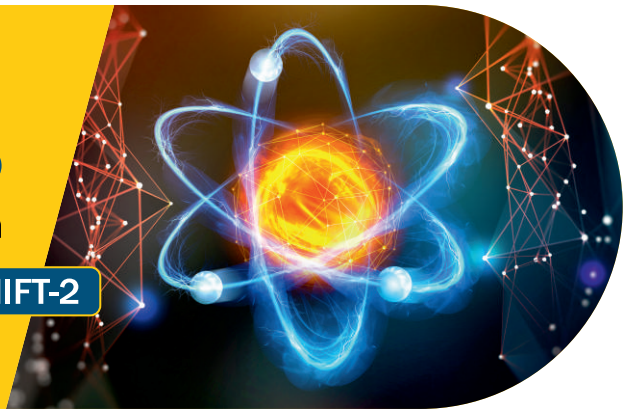
PAPER-1 (B.E. / B.TECH)

QUESTIONS & SOLUTIONS

Reproduced from Memory Retention

16 March, 2021 SHIFT-2

03:00 pm to 06:00 pm



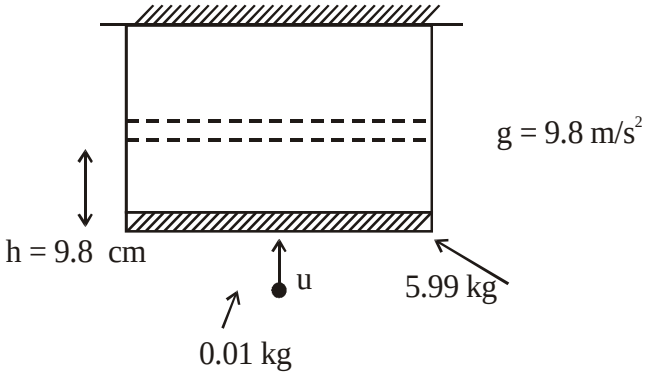
Duration : 3 Hours Max. Marks : 300

SUBJECT - PHYSICS

JEE-MAIN 2021 (16 MARCH ATTEMPT) SHIFT-2

PHYSICS

1. A bullet of mass 0.01 kg collides with a stick hanging with string and sticks to it as shown in figure. Stick rises to 9.8 cm. If gravitational acceleration is 9.8 m/s^2. Find initial velocity of bullet (in m/s).



(1) $490\sqrt{2}$ m/s (2) $588\sqrt{2}$ m/s (3) $294\sqrt{2}$ m/s (4) $98\sqrt{2}$ m/s

Ans. **(2)**

Sol. $P_i = 0.01 \times u + 0 = P_f = 6 \times v$

$$v = \frac{0.01u}{6}$$

using energy conservation

$$\frac{1}{2}\times 6\times\left(\frac{u}{600}\right)^2 = 6\times 9.8\times 9.8\times 10^{-2}$$

$u = 6 \times 98 \times \sqrt{2} = 588\sqrt{2}$ m/s

2. A particle of mass 2kg is placed at rest at origin. A force $\vec{F} = 2\hat{i} + 3\hat{j} + 5\hat{k}$ is acting on particle. At t = 4sec the position vector of particle is found to be $8\hat{i} + b\hat{j} + 20\hat{k}$. Find b.

(1) 12 (2) –6 (3) 2 (4) 10

Ans. **(1)**

Sol. $\vec{a} = \frac{\vec{F}}{m} = \frac{2\hat{i} + 3\hat{j} + 5\hat{k}}{2}$

$$\vec{r}_f - \vec{r}_i = \vec{u}t + \frac{1}{2}\vec{a}t^2$$

$$(x\hat{i} + y\hat{j} + 2\hat{k}) - (0\hat{i} + 0\hat{j} + 0\hat{k}) = \frac{1}{2}\times\left(\frac{2\hat{i} + 3\hat{j} + 5\hat{k}}{2}\right)(4)^2$$

$$x\hat{i} + y\hat{j} + z\hat{k} = 8\hat{i} + 12\hat{j} + 20\hat{k}$$

3. Heat produced in a resistance if 1.5A current is passed through it is 500J in 20 sec. If the current is 3A, the heat produced in the same resistor in the same duration will be :

(1) 500 J (2) 1000 J (3) 1500 J (4) 2000 J

Ans. **(4)**

Sol. $I^2RT = H$

$$\frac{H_1}{H_2} = \left(\frac{I_1}{I_2}\right)^2$$

$$\Rightarrow H_2 = 500 \times \left(\frac{3}{3/2}\right)^2 = 2000 \text{ J}$$

4. Half life for a radioactive sample is 20 min. Find the time interval in between decaying from 33% to 66 % occurs:

(1) 40 min. (2) 60 min (3) 20 min (4) 4 min

Ans. **(3)**

Sol. $T_{1/2} = 20$ min $\Rightarrow \frac{\ln 2}{\lambda} = 20$ min

$$\Rightarrow \lambda = \frac{\ln 2}{20(\text{min})}$$

$\because N_t = N_0 e^{-\lambda t}$

$\frac{N_t}{N_0} = e^{-\lambda_1}$ $\Rightarrow 0.67 = e^{-\lambda t_1}$

$\Rightarrow \ln(0.67) = -\lambda t_1$

$$\Rightarrow \ln\left(\frac{100}{67}\right) = \lambda t_1 \Rightarrow t_1 = \frac{\ln\left(\frac{100}{67}\right) \times 20(\text{min})}{(\ln 2)}$$

Similarly $t_2 = \frac{\ln\left(\frac{100}{34}\right) \times 20(\text{min})}{\ln(2)}$

$t_2 - t_1 = 19.57$ min ≈ 20 min.

5. In the line of sight communication maximum separation between two antennas is 45 km. Find the height of each antenna assuming they are of same height and radius of earth is 6400 km.

(1) 20.65 m (2) 39.55 m (3) 18.45 m (4) 64.39 m

Ans. **(2)**

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

$$H = \frac{D^2}{8R} = \frac{45^2}{8\times 6400}\text{ km} = 39.55\text{ m}$$

6. If the energy required to dissemble particles of earth upto infinite distance is $\frac{xGM_e^2}{5R_e}$

Where M_e = Mass of earth

R_e = Radius of earth

Evaluate x

Ans. 3

Sol. $E = U_f - U_i$

$$E = 0 - \left(\frac{3}{5}\frac{GM_e^2}{R_e}\right) = \frac{3}{5}\frac{GM_e^2}{R_e}$$

So x = 3

7. If electron and proton are accelerated by same potential difference 100 V, then find the ratio of their de-Broglie wavelength

$M_e = 9.1 \times 10^{-31}$ kg

$M_p = 1.6825 \times 10^{-27}$ kg

(1) 43 (2) $\frac{1}{43}$ (3) $\frac{40}{1}$ (4) $\frac{1}{40}$

Ans. **(1)**

Sol. $\lambda_e = \frac{12.27}{\sqrt{V}}A^\circ$ $\qquad \frac{\lambda_e}{\lambda_p} = \frac{12.27}{0.286} = 43$

$$\lambda_p = \frac{0.286}{\sqrt{V}}A^\circ$$

8. Find the magnitude of torque produced by a force $\vec{F} = 4\hat{i} + 3\hat{j} + \hat{k}$ about point (2,3,5).

Ans. 22.44

Sol. $|\vec{\tau}| = |\vec{r} \times \vec{F}|$

$$|\vec{\tau}| = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2 & 3 & 5 \\ 4 & 3 & 1 \end{vmatrix}$$

$$|\vec{\tau}| = \hat{i}(3-15) - \hat{j}(2-20) + \hat{k}(6-12)$$

$$|\vec{\tau}| = -12\hat{i} + 18\hat{j} - 6\hat{k}$$

$|\vec{\tau}| = \sqrt{(-12)^2 + (18)^2 + (-6)^2} = \sqrt{504}$

$= 22.44$

9. A particle moves with a velocity depends on time as

$\vec{v} = 0.5t^2.\hat{i} + 3t\hat{j} + 9\hat{k}$

Find the position vector at t = 2 sec.

(1) $\tan^{-1}\left(\frac{2}{3}\right)$ with x-axis (2) $\tan^{-1}(3)$ with y-axis

(2) $\tan^{-1}\left(\frac{1}{3}\right)$ with x-axis (3) $\tan^{-1}\left(\frac{3}{5}\right)$ with y-axis

Ans. **(2)**

Sol. $\frac{dx}{dt} = 0.5t^2\hat{i} + 3t\hat{j} + 9\hat{k}$

$x = \int_0^2 0.5t^2\hat{i}dt + \int_0^2 3t.\hat{j}dt + \int_0^2 9\hat{k}dt$

$x = 0.5\times\frac{8}{3}\hat{i} + 6\hat{j} + 18\hat{k}$

Dot product of x with unit vector of y-direction gives angle $\tan^{-1}(3)$ with y-axis

10. In carnot engine temperature of source is 127°C with efficiency 60%. Find out temperature of sink (°C).

(1) 143 (2) –105 (3) –113 (4) 113

Ans. **(3)**

Sol. $\eta = \left(1 - \frac{T_2}{T_1}\right) = 0.6 = 1 - \frac{T_2}{400}$

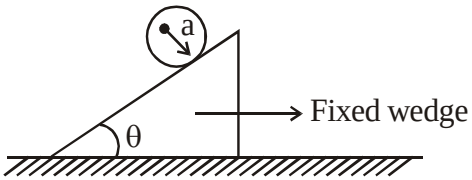
$\frac{T_2}{400} = 0.4$

$T_2 = 160k$

$T_2 = 160 - 273$

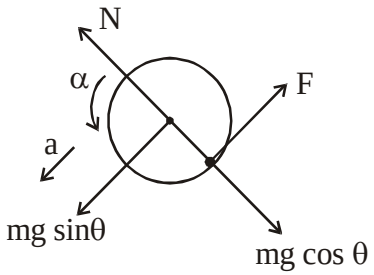
$T_2 = -113°C$

11. A disc having radius "a" is rising on an inclined plane as shown in figure. If the acceleration of disc is $\frac{2}{b}.g\sin\theta$, then find the value of "b" ?



Ans. 3

Sol.



$mg\sin\theta - f = na_{cm}$ _____(1)

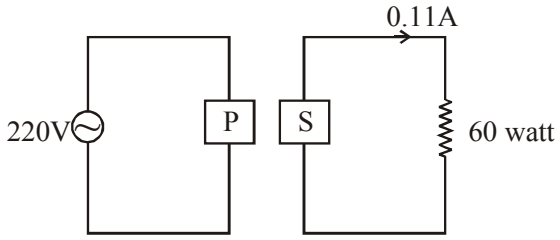
$f.a = \frac{ma^2}{2}.\alpha$ _____(3)

$a_{am} = \alpha\, a$ _____(4)

on solving

$a_{cm} = \frac{2}{3}g\sin\theta \qquad \Rightarrow b = 3$

12. In a transformer primary voltage is 220V and secondary current is 0.11A with output power 60W.



(1) Transformer is step up. (2) Transformer is step down

(3) Transformer is auxiliary (4) None of these

Ans. **(1)**

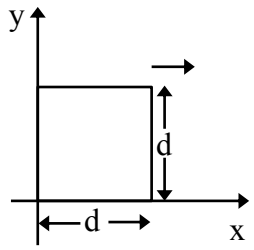
Sol. $P_s = V_s \times I_s$

$60 = V_s \times 0.11$

$V_s = \frac{60}{0.11} = \frac{6000}{11}$, $V_p = 220$ volt

$V_s > V_p$ so it is step up transformer

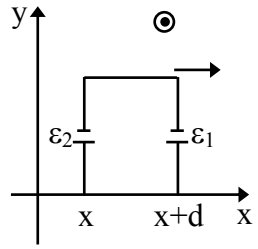
13. A conducting square loop of side length 'd' with its edges parallel to x-axis and y-axis move with velocity $v_0\hat{i}$ in a region having magnetic field $\vec{B}=\frac{B_0x}{a}\hat{k}$. Find the induced emf.



(1) $\frac{Bd^2v_0}{2a}$ (2) $\frac{Bd^2v_0}{a}$ (3) $\frac{Bd^2v_0^2}{2a}$ (4) $\frac{Bd^2v_0^2}{a}$

Ans. **(2)**

Sol.



$$\varepsilon_1=\frac{B_0(x+d)}{a}v_0d$$

$$\varepsilon_2=\frac{B_0x}{a}v_0d$$

$$\varepsilon_{net}=\varepsilon_1-\varepsilon_2=\frac{B_0v_0d^2}{a}$$

14. Statement-1 → A cyclist can move on a horizontal road with speed 7 km/hr in a circle of radius 2 m and coefficient of static friction is 0.2.

Statement-2 → maximum speed with which a cyclist can move in a circle on same banked road having inclination of 45° is 18.5 km/hr.

(1) Statement-1 is true, statement 2 is false

(2) Statement-1 is true, statement 2 is true

(3) Statement-1 is false, statement 2 is true

(4) Statement-1 is false, statement 2 is false

Ans. **(2)**

Sol. On a horizontal ground,

$v_{max} = \sqrt{\mu Rg} = \sqrt{0.2 \times 2 \times 9.8} = 1.97$ m/s

$1.97 \times \frac{18}{5}$

= 7.12 km/hr = 7.2 km/hr

Statement-2

$$v_{max} = \sqrt{gr\left(\frac{\tan\theta + \mu}{1 - \mu\tan\theta}\right)} = \sqrt{2 \times 9.8 \times \frac{1.2}{0.8}} = 19.5 \text{ km/hr}$$

$$v_{min} = \sqrt{rg\left(\frac{\tan\theta - \mu}{1 + \mu\tan\theta}\right)} = \sqrt{2 \times 9.8 \times \frac{0.8}{1.2}} = 13.01 \text{ km/hr}$$

15. A swimmer can swim with speed 12 m/s in still water. Speed of river is 6 m/s. Find the angle at which he should swim with downstream so that he reaches directly opposite point on the other side

(1) 90° (2) 150° (3) 60° (4) 120°

Ans. (4)

Sol. $\text{Cos}\theta = \frac{6}{12} = \frac{1}{2}$

$\theta = 60°$

16. In a damped oscillation, damping constant is 20 gm/sec and mass of an object is 500 gm. Find out time when amplitude of oscillation becomes half.

(1) 34.6 sec. (2) 44.6 sec. (3) 65.1 sec. (4) 55.6 sec.

Ans. **(1)**

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

$$\frac{bt}{2m} = \ln 2 = 0.693$$

$$\mathbf{t} = \frac{2m}{b} \times \mathbf{0.693}$$

$$\mathbf{t} = 2 \times \frac{500}{20} \times 0.693$$

$t = 50 \times 0.693 = 34.6$ sec.

17. Radioactive substance A has half life 54 min and B has half life 18 min. Initially both have same number of nuclei. Find time (min) when A will become 16 times of B.

Ans. 108

Sol. $N_A = N_0$ and $N_B = N_0$ initially

$$N_B = \frac{N_A}{16}$$

$$N_0 e^{-\lambda_2 t} = \frac{N_0}{16} e^{-\lambda_1 t}$$

$$16 = e^{-\lambda_1 t + \lambda_2 t}$$

$$2^4 = e^{(-\lambda_1 + \lambda_2)t}$$

$$\left(\frac{\ell n2}{18} - \frac{\ell n2}{54}\right) t = 4\ell n2$$

$T = 27 \times 4 = 108$ min

18. 1.5 miligram of gold (molar mass 198 gram/mole) is undergoing radioactive decay having half life of 2.7 days. Find initial activity of substance.

(1) 366 curie (2) 466 curie (3) 536 curie (4) 636 curie

Ans. **(1)**

Sol. Initial activity = $A_0 = \lambda N_0$.

$$= \frac{\ln 2}{T_{1/2}} \times \frac{1.5\times10^{-3}}{198} \times 6.023 \times 10^{23}$$

$$= \frac{\ln 2}{2.7\times3600\times24} \times \frac{1.5\times10^{-3}}{198} \times \frac{6.023\times10^{23}}{3.7\times10^{10}} \text{Ci}$$

= 366 Ci

19. Heat produced per second is 10 m J through a resistor if current 2 mA passes by it. Find its resistance.

Ans. **2500**

Sol. $H = i^2 R t$

$$10 \times 10^{-3} = 4 \times 10^{-6} R$$

$$\therefore 10 \times \frac{10^3}{4} = R$$

$\therefore R = 2500\ \Omega$

20. If converging lens is placed in the same medium, from which lens is made. If Radius of curvature is R_1 and R_2 then focal length of lens will be inside it.

(1) Infinite (2) Zero (3) 1 (4) $\frac{R_1R_2}{R_1-R_2}$

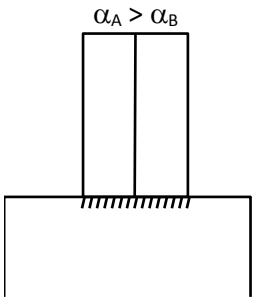
Ans. (1)

Sol. $\frac{1}{f}=\left[\frac{n_2}{n_5}-1\right]\left[\frac{1}{R_1}-\frac{1}{R_2}\right]$

$\frac{1}{f}=0$

f = infinite.

21. A thin bimetallic strip is rigidly attached on its bottom surface as shown. Coefficient of linear expansion of strip A is more than strip B. If temperature of system is decreased, find correct option among the following.



(1) Bends towards left (2) Bends towards right

(3) Neither bends nor shrinks (4) Shrinks but does not bends

Ans. (1)

22. A charge q is moved in magnetic field by distance dl. Find the work done by magnetic field.

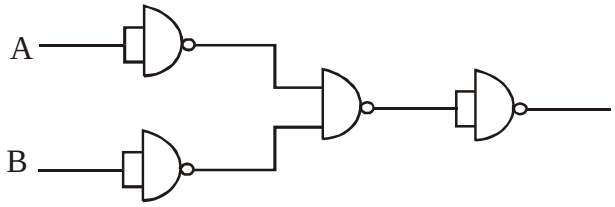
(1) zero (2) infinity (3) 1 (4) –1

Ans. (1)

Sol. $\vec{F}=q\vec{V}\times\vec{B}$

$P=\vec{F}\cdot\vec{V}=0 \quad \Rightarrow W=0$

23.



identifly the given logic gater

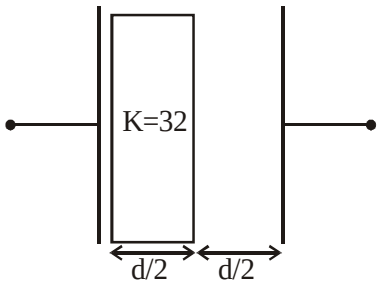
(1) NAND (2) NOR (3) OR (4) AND

Ans. (2)

Sol. $Y = \overline{\overline{A}.\overline{B}} = \overline{A}.\overline{B}$

So given logic gates circuit is a Nor gate

24. A parallel plate capacitor has area of plates $2m^2$ and distance between plates 1m. It is half filled with dielectric of dielectric constant K = 3.2 as shown in figure. Its capacitance is _____ε_0.



Ans. 3.04

Sol. $C_1 = \dfrac{K\varepsilon_0 A}{d/2}; C_2 = \dfrac{\varepsilon_0 A}{d/2}$

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} = \frac{d}{2K\varepsilon_0 A} + \frac{d}{2\varepsilon_0 A}$$

$$\frac{1}{C} = \frac{d}{2\varepsilon_0 A}\left(\frac{K+1}{K}\right)$$

$$\mathbf{C} = \frac{2\varepsilon_0 AK}{d(K+1)} = \frac{2\times 2\times 3.2}{1\times 4.2}\varepsilon_0 = 3.04\varepsilon_0$$

25. In a vessel containing an ideal gas the pressure is 1.1×10^5 pa, temperature is 27ºc & diameter of molecules is 0.8 nm. Find the mean free path of the molecules if Boltzman constant is 1.38×10^{-23}.

(1) 13.2 nm (2) 132 nm (3) 32 nm (4) 1.32 nm

Ans. (1)

Sol. $\lambda_{mean} = \dfrac{1}{\sqrt{2}\pi d^2\left(\dfrac{N}{V}\right)}$ & $PV = NK_B T$

$$\therefore \lambda_{mean} = \frac{K_B T}{\sqrt{2}\pi d^2 p}$$

$$= \frac{1.38\times10^{-23}\times300}{\sqrt{2}\times3.14\times0.64\times10^{-18}\times1.1\times10^{5}}$$

$= 132 \times 10^{-10}$ m

$= 132$ Aº

13.2 nm

26. Coming Soon

27. Coming Soon

28. Coming Soon

29. Coming Soon

30. Coming Soon