FINAL JEE–MAIN EXAMINATION – JANUARY, 2023

(Held On Tuesday 31st January, 2023) TIME : 9 : 00 AM to 12 : 00 NOON

PHYSICS — TEST PAPER WITH SOLUTION

SECTION-A

1. A bar magnet with a magnetic moment 5.0 Am^2 is placed in parallel position relative to a magnetic field of 0.4 T. The amount of required work done in turning the magnet form parallel to antiparallel position relative to the field direction is _____.

(1) 4 J (2) 1 J

(3) 2 J (4) Zero

Official Ans. by NTA (1)

Ans. (1)

Sol. $u = -MB\cos\theta$

$W = \Delta u$

$W = -MB\cos180^o - (-mB\cos0^o)$

$W = 2MB = 2 \times 5 \times 0.4 = 4J$

Option 1

2. If a source of electromagnetic radiation having power 15 kW produces 10^{16} photons per second, the radiation belongs to a part of spectrum is.

(Take Planck constant $h = 6 \times 10^{-34}$ Js**)**

(1) Micro waves

(2) Ultraviolet rays

(3) Gamma rays

(4) Radio waves

Official Ans. by NTA (3)

Ans. (3)

Sol. Energy of one photon $= \dfrac{\text{Power}}{\text{Photon frequency}}$

$$E = h\nu = \frac{15\times10^3}{10^{16}}$$

$$\nu = \frac{15\times10^{-13}}{6\times10^{-34}} = 2.5 \times 10^{21}$$

So gamma Rays. Option 3

3. The amplitude of $15\sin(1000\pi t)$ is modulated by $10\sin(4\pi t)$ signal. The amplitude modulated signal contains frequency(ies) of

(A) 500 Hz

(B) 2 Hz

(C) 250 Hz

(D) 498 Hz

(E) 502 Hz

Choose the correct answer from the options given below:

(1) A only

(2) A, D and E only

(3) B only

(4) A and B only

Official Ans. by NTA (2)

Ans. (2)

Sol. Carrier wave frequency

$$V_C = \frac{100\pi}{2\pi} = 500\,\text{Hz}$$

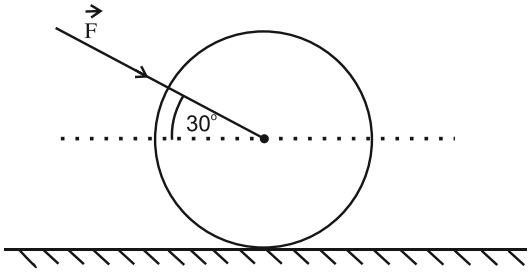
Modulating wave frequency

$$V_m = \frac{4\pi}{2\pi} = 2\,\text{Hz}$$

$\therefore \quad V_C - V_m, V_C, V_C + V_m$

$= 498$ Hz. 500 Hz, 502 Hz.

4. As shown in figure, a 70 kg garden roller is pushed with a force of $\vec{F} = 200\,N$ at an angle of 30^o with horizontal. The normal reaction on the roller is (Given $g = 10\ m\ s^{-2}$)



(1) $800\sqrt{2}$ N

(2) 600 N

(3) 800 N

(4) $200\sqrt{3}$ N

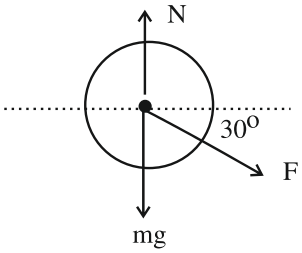
Official Ans. by NTA (3)

Ans. (3)

Sol.

$N = mg + F\sin30^o$

$= 700 + 200 \times \dfrac{1}{2} = 800$ newton.



Sol. $\frac{GM}{R^2}\left[1-\frac{d}{R}\right]=\frac{4\times GM}{(4R)^2}$

$1-\frac{d}{R}=\frac{1}{4}\Rightarrow\frac{d}{R}=\frac{3}{4}\Rightarrow d\frac{3}{4}R$

d = 4800 km

15. If 1000 droplets of water of surface tension 0.07 N/m. having same radius 1 mm each, combine to from a single drop. In the process the released surface energy is-

$\left(\text{Take }\pi=\frac{22}{7}\right)$

(1) 7.92×10^{-6} J

(2) 7.92×10^{-4} J

(3) 9.68×10^{-4} J

(4) 8.8×10^{-5} J

Official Ans. by NTA (2)

Ans. (2)

Sol. 1000 x $\frac{4\pi}{3}(1)^3=\frac{4\pi}{3}R^3$

R = 10 mm

T x 1000 x 4π $(10^{-3})^2$ – T x 4π $(10 \text{ x } 10^{-3})^2$ = ΔE

ΔE = 4 x π x 7 x 10^{-2} [1000 – 100] x 10^{-6}

ΔE = 7.92 x 10^{-4} J

Option 2.

16. A rod with circular cross-section area 2 cm^2 and length 40 cm is wound uniformly with 400 turns of an insulated wire. If a current of 0.4 A flows in the wire windings, the total magnetic flux produced inside windings is $4\pi\times10^{-6}$ Wb. The relative permeability of the rod is

(Given : Permeability of vacuum $\mu_0=4\pi\times10^{-7}NA^{-2}$)

(1) 12.5

(2) $\frac{32}{5}$

(3) 125

(4) $\frac{5}{16}$

Official Ans. by NTA (3)

Ans. (3)

Sol. $\phi=\mu_r\mu_o\frac{N}{\ell}$ I x A

μ_r = 125

Option 3.

17. The correct relation between $\gamma=\frac{C_p}{c_v}$ and temperature T is :

(1) $\gamma\propto\frac{1}{\sqrt{T}}$ (2) $\gamma\propto T^o$

(3) $\gamma\propto\frac{1}{T}$ (4) $\gamma\propto T$

Official Ans. by NTA (2)

Ans. (2)

Sol. γ is independent of temperature

Option 2

18. Two polaroide A and B are placed in such a way that the pass-axis of polaroids are perpendicular to each other. Now, another polaroid C is placed between A and B bisecting angle between them. If intensity of unpolarised light is I_0 then intensity of transmitted light after passing through polaroid B will be :

(1) $\frac{I_0}{4}$ (2) $\frac{I_0}{2}$

(3) $\frac{I_0}{8}$ (4) Zero

Official Ans. by NTA (3)

Ans. (3)

Sol. $I_A=\frac{I_o}{2}$

$IC=\frac{I_o}{2}\cos^2 45=\frac{I_o}{4}$

$I_B=I_C\cos^2 45=\frac{I_o}{8}$

Option 3.

19. If R, X_L. and X_C represent resistance, inductive reactance and capacitive reactance. Then which of the following is dimensionless:

(1) $R X_L X_C$ (2) $\frac{R}{\sqrt{X_L X_C}}$

(3) $\frac{R}{X_L X_C}$ (4) $R\frac{X_L}{X_C}$

Official Ans. by NTA (2)

Ans. (2)

Sol. All three have same dimension therefore $\frac{R}{\sqrt{X_L X_C}}$ is dimensionless.

Option 2

20. 100 balls each of mass m moving with speed v simultaneously strike a wall normally and reflected back with same speed, in time t s. The total force exerted by the balls on the wall is

(1) $\frac{100mv}{t}$ (2) $\frac{200mv}{t}$

(3) 200 mvt (4) $\frac{mv}{100t}$

Official Ans. by NTA (2)

Ans. (2)

Sol. $P_i = Nmv\hat{i}$ $\vec{P}_f = -Nmv\hat{i}$

N is Number of balls strikes with wall

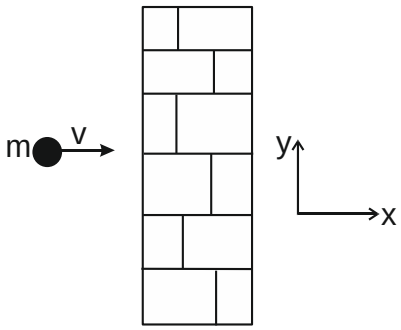
N = 100

$\Delta\vec{P} = \vec{P}_f - \vec{P}_i = -2Nmv\hat{i}$

$= -200\ Nmv\hat{i}$

$\vec{F}_{Total} = \frac{\Delta\vec{P}}{\Delta t} = -\frac{200mvt}{t}$

$|\vec{F}| = \frac{200mv}{t}$



SECTION-B

21. A thin rod having a length of 1 m and area of cross-section $3\times10^{-6}\,m^2$ is suspended vertically from one end. The rod is cooled from 210°C to 160°C. After cooling, a mass M is attached at the lower end of the rod such that the length of rod again becomes 1 m. Young's modulus and coefficient of linear expansion of the rod are $2\times10^{11}\,N\,m^{-2}$ and $2\times10^{-5}K^{-1}$, respectively. The value of M is_____ kg. (Take g = 10 m s^{-2})

Official Ans. by NTA (60)

Ans. (60)

Sol. If $\Delta\ell$ is decease in length of rod due to decease in temperature

$\Delta\ell = \ell\,\alpha\,\Delta T$

$\alpha = 2\times10^{-5}K^{-1}, \Delta T = (210-160)$

$= 50\ K$

$\Delta\ell = 1\times2\times10^{-5}\times50 = 10^{-3}\,m$

Young Modulus = $Y = \frac{F/A}{\Delta\ell/\ell}$ $A = 3\times10^{-6}\,m^2$

$2\times10^{11} = \frac{Mg/3\times10^{-6}}{10^{-3}/1}$

$Mg = 2\times10^{11}\times3\times10^{-9} = 6\times10^{-2}$

M = 60 kg

is 60.

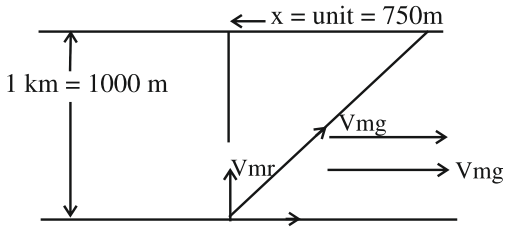
22. The speed of a swimmer is 4 km h^{-1} in still water. If the swimmer makes his strokes normal to the flow of river of width 1 km, he reaches a point 750 m down the stream on the opposite bank.

The speed of the river water is _____km h^{-1}.

Official Ans. by NTA (3)

Ans. (3)

Sol.



time to cross the River width ω = 1000 m

is = $\frac{1\ km}{4\ km/h}$

Drift x = Vm/g × t

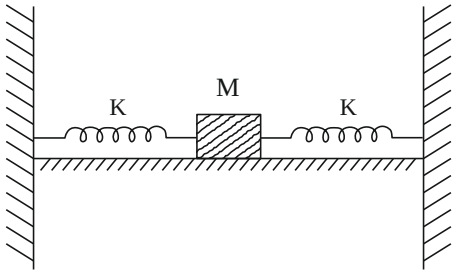
Where Vm/g is velocity of River w.r. to ground.

$x = Vm / g \times \frac{1}{4} = 750m = \frac{3}{4}km$

$Vm / g = 3km / hr$

Ans is 3 km/hr.

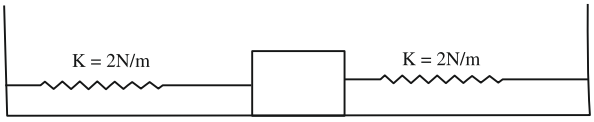
23. In the figure given below. a block of mass M = 490 g placed on a frictionless table is connected with two springs having same spring constant (K = 2 N m^{-1}). If the block is horizontally displaced through 'X'm then the number of complete oscillations it will make in 14π seconds will be_____



Official Ans. by NTA (20)

Ans. (20)

Sol.



Keff = K + K as both springs are in use in parallel

= 2k

= 2×2 = 4 N/m m = 490 gm

= 0.49 kg

$$T = 2\pi\sqrt{\frac{m}{Keff}} = 2\pi\sqrt{\frac{0.49kg}{4}}$$

$$= 2\pi\sqrt{\frac{49}{400}} = 2\pi\frac{7}{20} = \frac{7\pi}{10}$$

No. of oscillation in the 14π is

$$N = \frac{time}{T} = \frac{14\pi}{7\pi/10} = 20$$

Ans in 20.

24. In a medium the speed of light wave decreases to 0.2 times to its speed in free space The ratio of relative permittivity to the refractive index of the medium is x : 1. The value of x is _____.

(Given speed of light in free space = 3 × 10^8 m s^{-1} and for the given medium $\mu_r = 1$)

Official Ans. by NTA (5)

Ans. (5)

Sol. $V = \frac{C}{\mu} \Rightarrow \mu = \frac{C}{V} = \frac{C}{0.2C}$

$\boxed{\mu = 5}$

$\mu = \sqrt{\epsilon_r \mu_r}$

$\Rightarrow \epsilon_r = \frac{\mu^2}{\mu_r}$

$\therefore \frac{\epsilon_r}{\mu} = \frac{\mu}{\mu_r} = 5$

25. A solid sphere of mass 1 kg rolls without slipping on a plane surface. Its kinetic energy is 7 × 10^{-3} J. The speed of the centre of mass of the sphere is _____ cm s^{-1}.

Official Ans. by NTA (10)

Ans. (10)

Sol. $\frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 = 7\times10^{-3}$

$\frac{1}{2}mv^2 + \frac{1}{2}\left(\frac{2}{5}MR^2\right)\left(\frac{V}{R}\right)^2 = 7\times10^{-3}$

$\frac{1}{2}MV^2\left[1+\frac{2}{5}\right] = 7\times10^{-3}$

$\frac{1}{2}(1)(V^2)\left(\frac{7}{5}\right) = 7\times10^{-3}$

$V^2 = 10^{-2}$

$V = 10^{-1} = 0.1 m/s = 10 cm/s$

Ans : 10

26. An inductor of 0.5 mH, a capacitor of 20 μF and resistance of 20 Ω are connected in series with a 220 V ac source. If the current is in phase with the emf, the amplitude of current of the circuit is $\sqrt{x}$ A. The value of x is -

Official Ans. by NTA (242)

Ans. (242)

Sol. $X_L = X_C$

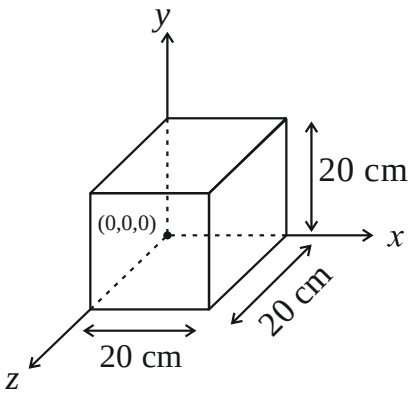
So, $Z = R = 20\ \Omega$

$i_{rms} = \frac{220}{20} = 11$

$i_{max} = 11\sqrt{2} = \sqrt{242}$

Ans : 242

27. Expression for an electric field is given by $\vec{E} = 4000\,x^2\hat{i}\,\frac{V}{m}$. The electric flux through the cube of side 20 cm when placed in electric field (as shown in the figure) is _____ V cm.



Official Ans. by NTA (640)

Ans. (640)

Sol. Flux = $\vec{E}\cdot\vec{A}$

$= 4000\ (0{\cdot}2)^2\ \frac{V}{m}\cdot(0{\cdot}2)^2 m^2$

$= 4000\times16\times10^{-4}\,Vm$

$= 640\ Vcm$

Ans. 640

28. A lift of mass M = 500 kg is descending with speed of 2 ms^{-1}. Its supporting cable begins to slip thus allowing it to fall with a constant acceleration of 2 ms^{-2}. The kinetic energy of the lift at the end of fall through to a distance of 6 m will be ____kJ.

Official Ans. by NTA (7)

Ans. (7)

Sol. $v^2 = u^2 + 2as$

$= 2^2 + 2\,(2)(6)$

$= 4 + 24 = 28$

$KE = \frac{1}{2}mv^2$

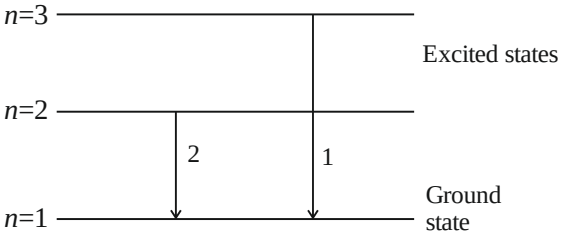
$= \frac{1}{2}(500)28$

$= 7000\ J$

$= 7\ kJ$

Ans. 7

29. For hydrogen atom, λ_1 and λ_2 are the wavelengths corresponding to the transitions 1 and 2 respectively as shown in figure. The ratio of λ_1 and λ_2 is $\frac{x}{32}$. The value of x is _____.



Official Ans. by NTA (27)

Ans. (27)

Sol. $\frac{1}{\lambda} = Rz^2\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

$\frac{1}{\lambda_1} = Rz^2\left[\frac{1}{1^2} - \frac{1}{3^2}\right] = \frac{8}{9}Rz^2$ ..... (1)

$\frac{1}{\lambda_2} = Rz^2\left[\frac{1}{1^2} - \frac{1}{2^2}\right] = \frac{3}{4}Rz^2$ ..... (2)

$$1/2 \Rightarrow \frac{\lambda_2}{\lambda_1} = \frac{8}{9} \times \frac{4}{3} = \frac{32}{27}$$

$$\frac{\lambda_1}{\lambda_2} = \frac{27}{32}$$

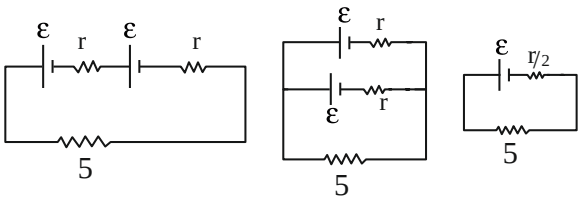
Ans. 27

30. Two identical cells, when connected either in parallel or in series gives same current in an external resistance 5Ω. The internal resistance of each cell will be _____ Ω.

Official Ans. by NTA (5)

Ans. (5)

Sol. Parallel



$$i = \frac{2\varepsilon}{5+2r} \quad \ldots. (1) \qquad i = \frac{\varepsilon}{\frac{r}{2}+5} \quad \ldots. (2)$$

Equating (1) and (2)

$$\frac{2\varepsilon}{5+2r} = \frac{\varepsilon}{\frac{r}{2}+5} \Rightarrow r+10 = 5+2r$$

$r = 5$ **Ans. 5**