JEE Main February 2021

Question Paper With Text Solution

24 Feb.| Shift-2

PHYSICS

MATRIX

JEE Main & Advanced | XI-XII Foundation| VI-X Pre-Foundation

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JEE MAIN FEB 2021 | 24TH FEB SHIFT-II

1. Which of the following equation represents a travelling wave ? **(Waves on String)**

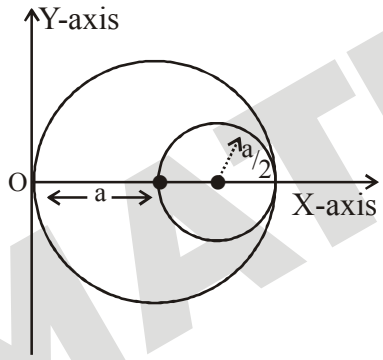
(1) $y = A\sin(15x - 2t)$ (2) $y = A\sin x \cos \omega t$

(3) $y = Ae^{-x^2}\ (vt + \theta)$ (4) $y = Ae^{x}\cos(\omega t - \theta)$

Ans. Official Answer for NTA (1)

Sol: $Y = A \sin(kx - \omega t)$ is the standard form of equation of sinusoidal travelling wave

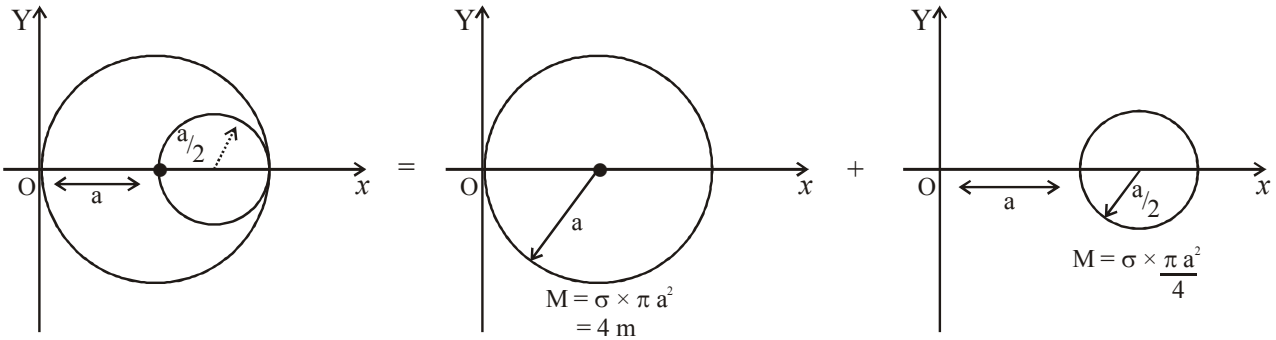
2. A circular hole of radius $\left(\frac{a}{2}\right)$ is cut out of a circular disc of radius 'a' as shown in figure. The centroid of the remaining circular portion with respect to point 'O' will be : **(COM)**



(1) $\frac{2}{3}a$ (2) $\frac{5}{6}a$ (3) $\frac{1}{6}a$ (4) $\frac{10}{11}a$

Ans. Official Answer for NTA (2)

Sol: For a body having uniform mass density, centroid will coincide with centre of mass.



$$Xcom = \frac{4m \times a - m \times \frac{3a}{2}}{3m}$$

$= \frac{5a}{6}$

3. A soft ferromagnetic material is placed in an external magnetic field. The magnetic domains : **(Magnetism & Matter)**

(1) Have no relation with external magnetic field.

(2) Decrease in size and changes orientation

(3) Increase in size but no change in orientation

(4) May increase or decrease in size and change its orientation

Ans. Official Answer for NTA (4)

Sol: When placed in an external magnetic field, domains aligned in the direction of the field grow in size and those aligned in the direction opposite to the field reduce in size.

4. When a particle executes SHM, the nature of graphical representation of velocity as a function of displacement is : **(Simple Harmonic Motion SHM)**

(1) Straight line (2) Parabolic (3) Elliptical (4) Circular

Ans. Official Answer for NTA (3)

Sol: $\upsilon^2 = \omega^2(A^2 - x^2)$

Shape will be elliptical

5. Match List – I with List – II. **(Electromagnetic Waves)**

List – I	List – II
(a) Source of microwave frequency	(i) Radioactive decay of nucleus
(b) Source of infrared frequency	(ii) Magnetron
(c) Source of Gamma Rays	(iii) Inner shell electrons
(d) Source of X-rays	(iv) Vibration of atoms and molecules
	(v) LASER
	(vi) RC circuit

Choose the correct answer from the options given below :

(1) (a)-(vi), (b)-(iv), (c)-(i), (d)-(v) (2) (a)-(vi), (b)-(v), (c)-(i), (d)-(iv)

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

Ans. Official Answer for NTA (4)

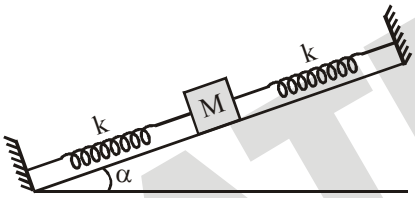
Sol: (a) Magnetron is a device used for producing microwaves.

(b) Vibration frequency of atoms and molecules usually matches with infrared frequency, which leads to infrared spectroscopy.

(c) Gamma rays are streams of photons produced from radioactive decay of nucleus

(d) Characteristic X-rays are produced when innershell electrons are knocked out.

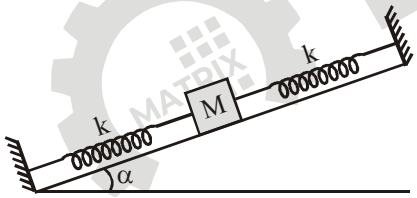
6. In the given figure, a body of mass M is held between two massless springs, on a smooth inclined plane. The free ends of the springs are attached to firm supports. If each spring has spring constant k, the frequency of oscillation of given body is : **(Simple Harmonic Motion)**



(1) $\frac{1}{2\pi}\sqrt{\frac{2k}{Mg\sin\alpha}}$ (2) $\frac{1}{2\pi}\sqrt{\frac{2k}{M}}$ (3) $\frac{1}{2\pi}\sqrt{\frac{k}{2M}}$ (4) $\frac{1}{2\pi}\sqrt{\frac{k}{Mg\sin\alpha}}$

Ans. Official Answer for NTA (2)

Sol:



This system is equivalent to 2 springs connected in parallel Therefore,

$K_{eq} = K_1 + K_2 = 2K$

$$f = \frac{1}{2\pi}\sqrt{\frac{K_{eq}}{M}} = \frac{1}{2\pi}\sqrt{\frac{2K}{M}}$$

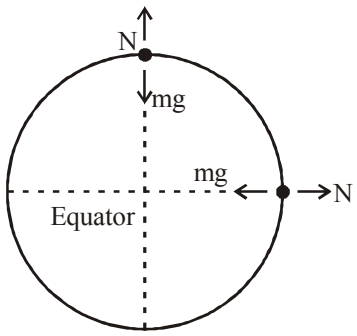
7. A body weighs 49 N on a spring balance at the north pole. What will be its weight recorded on the same weighing machine, if it is shifted to the equator ? **(Gravitation)**

[Use $g = \frac{GM}{R^2} = 9.8\ ms^{-2}$ and radius of earth, R = 6400 km.]

(1) 48.83 N (2) 49 N (3) 49.17 (4) 49.83 N

Ans. Official Answer for NTA (1)

Sol:



At pole : N = mg = 49 N

At equator : $mg - N = m\omega^2 R$

$N = mg - m\omega^2 R < 49$ N

8. An X-ray tube is operated at 1.24 million volt. The shortest wavelength of the produced photon will be

(X-Rays)

(1) 10^{-3} nm (2) 10^{-2} nm (3) 10^{-4} nm (4) 10^{-1} nm

Ans. Official Answer for NTA (1)

Sol: $K_{max} = eV = 1.24 \times 10^6$ eV $= \dfrac{hc}{\lambda_{min}}$

$$\lambda_{min} = \frac{hc}{1.24\times10^6 eV}$$

$$= \frac{1240 eV - nm}{1.24\times10^6 eV} = 10^{-3} nm$$

9. The period of oscillation of a simple pendulum is $T = 2\pi\sqrt{\dfrac{L}{g}}$. Measured value of 'L' is 1.0 m from meter scale having a minimum division of 1 mm and time of one complete oscillation is 1.95 s measured from stopwatch of 0.01 s resolution. The percentage error in the determination of 'g' will be :

(Measurements & Errors)

(1) 1.03% (2) 1.30% (3) 1.33% (4) 1.13%

Ans. Official Answer for NTA (4)

Sol: $T = 2\pi\sqrt{\frac{L}{g}}$

$g = 4\pi^2 \frac{L}{T^2}$

$\frac{\Delta g}{g} = \frac{\Delta L}{L} + \frac{2\Delta T}{T}$

$= \frac{0.001}{1} + \frac{2\times 0.01}{1.95}$

$\frac{\Delta g}{g}\times 100 = \frac{21.95}{1.95}\times 10^{-1}$

= 1.13%

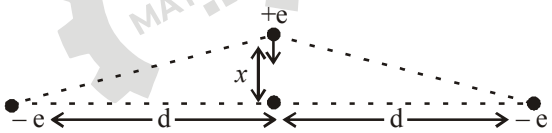
10. Two electrons each are fixed at a distance '2d'. A third charge proton placed at the midpoint is displaced slightly by a distance x ($x << d$) perpendicular to the line joining the two fixed charges, Proton will execute simple harmonic motion having angular frequency : **(Simple Harmonic Motion)**

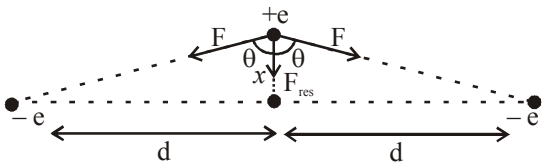
(m = mass of charged particle)

(1) $\left(\frac{2q^2}{\pi\varepsilon_0 md^3}\right)^{\frac{1}{2}}$ (2) $\left(\frac{2\pi\varepsilon_0 md^3}{q^2}\right)^{\frac{1}{2}}$ (3) $\left(\frac{q^2}{2\pi\varepsilon_0 md^3}\right)^{\frac{1}{2}}$ (4) $\left(\frac{\pi\varepsilon_0 md^3}{2q^2}\right)^{\frac{1}{2}}$

Ans. Official Answer for NTA (3)

Sol:





$F_{res} = 2F\cos\theta = \frac{2q^2}{4\pi\in_0 (\sqrt{d^2+x^2})^2}\frac{x}{\sqrt{d^2+x^2}}$

$= \frac{q^2}{2\pi\in_0}\frac{x}{(x^2+d^2)^{3/2}}$

$$F = \frac{q^2 x}{2\pi \in_0 d^3} = ma$$

$$a = -\left(\frac{q^2}{2\pi \in_0 md^3}\right)x$$

$$\omega = \sqrt{\frac{q^2}{2\pi \in_0 md^3}}$$

11. A particle is projected with velocity υ_0 along x-axis. A damping force is acting on the particle which is proportional to the square of the distance from the origin i.e. $ma = -ax^2$. The distance at which the particle stops : **(Newton's Laws of Motion)**

(1) $\left(\frac{2\upsilon_0^2}{3\alpha}\right)^{\frac{1}{2}}$ (2) $\left(\frac{2\upsilon_0}{3\alpha}\right)^{\frac{1}{3}}$ (3) $\left(\frac{3\upsilon_0^2}{2\alpha}\right)^{\frac{1}{2}}$ (4) $\left(\frac{3\upsilon_0^2}{2\alpha}\right)^{\frac{1}{3}}$

Ans. Official Answer for NTA (4)

Sol: $ma = -\alpha x^2$

$$\frac{Vdv}{dx} = \frac{-\alpha}{m}x^2$$

$$\int_{V_0}^{O} Vdv = \frac{-\alpha}{m}\int_0^x x^2 dx$$

$$\frac{-V_0^2}{2} = \frac{-\alpha}{m}\frac{x^3}{3}$$

$$x = \left(\frac{3mV_0^2}{2\alpha}\right)^{\frac{1}{3}}$$

12. Zener breakdown occurs in a p – n junction having p and n both : **(Semiconductors)**

(1) Heavily doped and have wide depletion layer

(2) Lightly doped and have narrow depletion layer

(3) Lightly doped and have wide depletion layer

(4) Heavily doped and have narrow depletion layer

Ans. Official Answer for NTA (4)

Sol: Memory based Question

13. Given below are two statements : **(Semiconductors)**

Statement I : PN junction diodes can be used to function as transistor, simply by connecting two diodes, back to back, which acts as the base terminal.

Statement : In the study of transistor, the amplification factor β indicates ratio of the collector current to the base current.

In the light of the above statement, choose the correct answer from the options given below.

(1) Both Statement I and Statement II are false

(2) Statement I is true but Statement II is false

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

(4) Both Statement I and Statement II are true

Ans. Official Answer for NTA (3)

Sol: Memory based Question

14. The logic circuit shown above is equivalent to : **(Semiconductors)**

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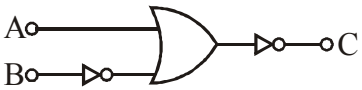
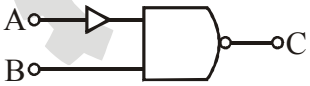
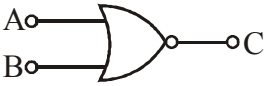
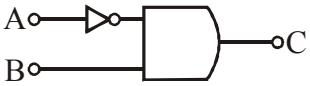
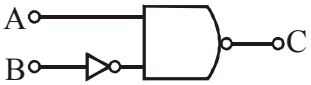


(1) 

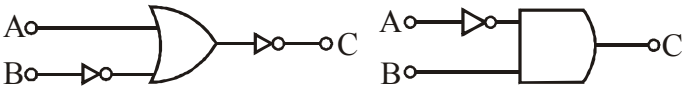
(2) 

(3) 

(4) 

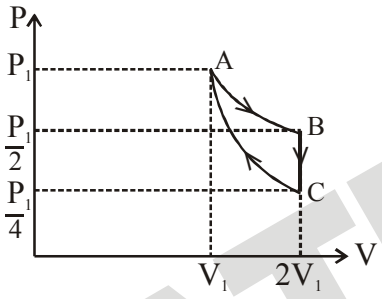
Ans. Official Answer for NTA (3)

Sol:



15. If one mole of an ideal gas at (P_1, V_1) is allowed to expand reversibly and isothermally (A to B) its pressure is reduced to one-half of the original pressure (see figure). This is followed by a constant volume cooling till its pressure is reduced to one-fourth of the initial value (B $\rightarrow$ C). The it is restored to its initial state by a reversible adiabatic compression (C to A). The net workdone by the gas is equal to

(KTG & Thermodynamics)



(1) RT In 2

(2) RT $\left(\text{In}2-\frac{1}{2(\gamma-1)}\right)$

(3) 0

(4) $-\frac{RT}{2(\gamma-1)}$

Ans. Official Answer for NTA (2)

Sol: $W_{AB} = nRT\, ln2 = P_1V_1\, ln2$

$W_{BC} = O$

$$W_{CA} = \frac{\frac{P_1}{4}\times 2V_1 - P_1V_1}{\gamma-1} = \frac{-P_1V_1}{2(\gamma-1)}$$

$$W_{net} = P_1V_1\left[ln2 - \frac{1}{2(\gamma-1)}\right]$$

$$= RT\left[ln2 - \frac{1}{2(\gamma-1)}\right]$$

16. On the basis of kinetic theory of gases, the gas exerts pressure because its molecules :

(KTG & Thermodynamics)

(1) Are attracted by the walls of container

(2) Suffer change in momentum when impinge on the walls of container

(3) Continuously lose their energy till it reaches wall

(4) Continuously stick to the walls of container

Ans. Official Answer for NTA (2)

Sol: Memory based question

17. The de Broglie wavelength of a proton and α particle are equal. The ratio of their velocities is :

(Dual nature of Radiation & Matter)

(1) 4 : 3 (2) 1 : 4 (3) 4 : 2 (4) 4 : 1

Ans. Official Answer for NTA (4)

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

$$\frac{h}{mv_p} = \frac{h}{4mv_\alpha}$$

$$\frac{V_p}{v_\alpha} = \frac{4}{1}$$

18. If the source of light used in a Young's double slit experiment is changed from red to violet :

(Wave Optics)

(1) The central bright fringe will become a dark fringe

(2) The fringes will become brighter

(3) The intensity of minima will increase

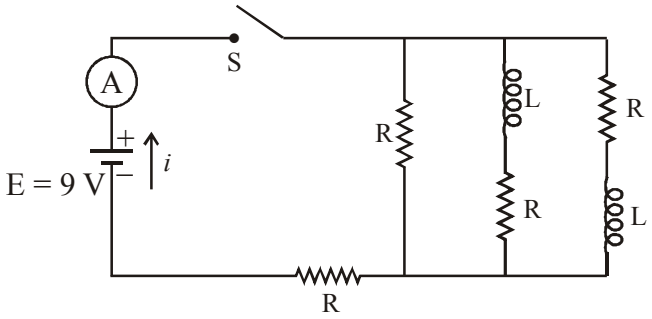
(4) consecutive fringe lines will come closer

Ans. Official Answer for NTA (4)

Sol: Fringe width = $\frac{\lambda D}{d}$

If λ decreases, fringe width decreases, consecutive fringes will come closer.

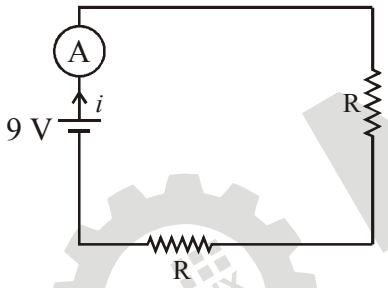
19. Figure shows a circuit that contains four identical resistors with resistance R = 2.0 Ω, two identical inductors with inductance L = 2.0 mH and an ideal battery with *emf* E = 9 V. The current 'i' just after the switch 'S' is closed will be : **(Electromagnatic Induction)**



(1) 3.37 A (2) 9A (3) 3.0 A (4) 2.25 A

Ans. Official Answer for NTA (4)

Sol: Equivalent circuit just after switch is closed



$$i = \frac{9}{2R} = \frac{9}{4} = 2.25A$$

20. According to Bohr atom model, in which of the following transitions will be frequency be maximum ? **(Atomic Structure)**

(1) n = 4 to n = 3 (2) n = 3 to n = 2 (3) n = 5 to n = 4 (4) n = 2 to n = 1

Question Type : MCQ
Question ID : 70819116340
Option 1 ID : 70819154187
Option 2 ID : 70819154186
Option 3 ID : 70819154188
Option 4 ID : 70819154185

Ans. Official Answer for NTA (4)

Sol: $h\nu = (13.6\,eV)\,z^2\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right)$

Energy gap between consecutive energy states decreases as we go higher energy state.

Section - B

1. A signal of 0.1 kW is transmitted in a cable. The attenuation of cable is –5 dB per km and cable length is 20 km. The power received at reciever is 10^{-x} W. The value of x is _____. **(Sound Waves)**

[Gain in dB = $10\log_{10}\left(\frac{P_o}{P_i}\right)$]

Ans. Official Answer for NTA (8)

Sol: Attenuation = $-5\frac{dB}{km}\times 20km = -100dB$

$-100 = 10\log_{10}\left(\frac{P}{100}\right)$

$\frac{P}{100} = 10^{-10}$

$P = 10^{-8}$

$x = 8$

2. An electromagnetic wave of frequency 3 GHz enters a dielectric medium of relative electric permittivity 2.25 from vaccum. The wavelength of this wave in that medium will be _____ × 10^{-2} cm.

(Electromagnetic Waves)

Ans. Official Answer for NTA (667)

Sol: $\lambda = \frac{V}{f} = \frac{3\times10^8}{3\times10^9} = 0.1m$

$\mu = \sqrt{\epsilon_r\,\mu_r} = \sqrt{2.25\times1} = 1.5$ ($\mu_r = 1$ assumed)

$\lambda' = \frac{\lambda}{\mu} = \frac{0.1}{1.5} = 0.0667m$

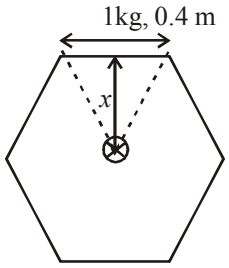
$= 667\times10^{-2}cm$

3. A uniform thin bar of mass 6 kg and length 24 meter is bent to make an equilateral hexagon.

The moment of inertia about an axis passing through the centre of mass and perpendicular to the plane of hexagon is _____× 10^{-1} kg m^2. **(Rotation)**

Ans. Official Answer for NTA (8)

Sol:



$$x = 0.4 \times \frac{\sqrt{3}}{2}$$

$$I = 6 \times \left(\frac{mL^2}{12} + mx^2 \right)$$

m = mass of 1 side

$$I = 6 \times \left(\frac{1 \times 0.16}{12} + 1 \times 0.16 \times \frac{3}{4} \right)$$

$$= 6 \times \frac{10}{12} \times 0.16 = 0.80$$

4. A cylindrical wire of radius 0.5 mm and conductivity 5×10^7 S/m is subjected to an electric field of 10 mV/m. The expected value of current in the wire will be $x^3\pi$ mA. The value of x is _____.

(Current Electricity)

Ans. Official Answer for NTA (5)

Sol: $E = \rho J$

$$10 \times 10^{-3} = \frac{1}{5 \times 10^7} \times \frac{i}{\pi \times 0.25 \times 10^{-6}}$$

$i = 1.25 \times \pi \times 10^{-1}$

$i = 5^3 \times \pi \times 10^{-3}$ A

$x = 5$

5. A uniform metallic wire is elongated by 0.04 m when subjected to a linear force F. The elongation, if its length and diameter is doubled and subjected to the same force will be _____ cm. **(Elasticity)**

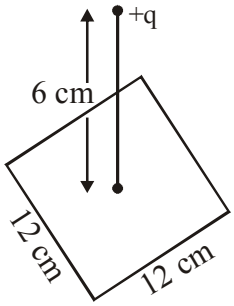
Ans. Official Answer for NTA (2)

Sol: $$\Delta L = \frac{FL}{AY} = 0.04m$$

$$\Delta L' = \frac{F \times 2L}{4A \times Y} = \frac{\Delta L}{2} = 0.02m = 2cm$$

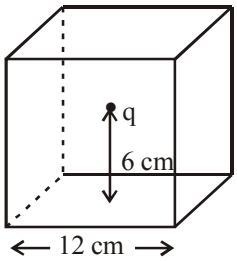
6. A point charge of + 12 μC is at a distance 6 cm vertically above the centre of square of side 12 cm as shown in figure. The magnitude of the electric flux through the square will be _____ × 10^3 Nm^2/C.

(Electrostatics)



Ans. Official Answer for NTA (226)

Sol:



Considering a cube of side 12 cm as shown total flux = $\frac{q}{\epsilon_0}$

Flux through 1 face = $\frac{q}{6\epsilon_0} = \frac{12\times10^{-6}}{6\times8.85\times10^{-12}}$

= 226 × 10^3

7. Two cars are approaching each other at an equal speed of 7.2 km/hr. When they see each other, both blow horns having frequency of 676 Hz. The beat frequency heard by each driver will be _____ Hz.

[Velocity of sound in air is 340 m/s.] **(Sound Waves)**

Ans. Official Answer for NTA (8)

Sol: $f = 676\left(\frac{340+2}{340-2}\right) = 684$ Hz

Driver will hear correct frequency (676Hz) of the horn of his own car & apparent frequency (684Hz) of other car.

Beat frequency = 684 – 676 = 8

8. The root mean square speed of molecules of a given mass of a gas at 27ºC and 1 atmosphere pressure is 200 ms^{-1}. The root mean square speed of molecules of the gas at 127ºC and 2 atmosphere pressure is $\frac{x}{\sqrt{3}}$ ms^{-1}. The value of x will be _____. **(KTG & Thermodynamics)**

Ans. Official Answer for NTA (400)

Sol: $V_{RMS} = \sqrt{\frac{3R \times 300}{M}} = 200$

$V_{RMS} = \sqrt{\frac{3R \times 400}{M}} = v$

$v = 200\sqrt{\frac{4}{3}} = \frac{x}{\sqrt{3}}$

$x = 400$

9. Two solids A and B of mass 1 kg and 2 kg respectively are moving with equal linear momentum. The ratio of their kinetic energies $(K.E.)_A : (K.E.)_B$ will be $\frac{A}{1}$, so the value of A willl be _____. **(COM)**

Ans. Official Answer for NTA (2)

Sol: $\frac{K_A}{K_B} = \frac{P^2/2m_A}{P^2/2m_B} = \frac{2}{1}$

$A = 2$

10. A series LCR circuit is designed to resonate at an angular frequency $\omega_0 = 10^5$ rad/s. The circuit draws 16 W power from 120 V source at resonance. The value of resistance 'R' in the circuit is _____ Ω.

(Alternating Current)

Ans. Official Answer for NTA (900)

Sol: At resonance,

$P = \frac{V^2}{R}$

$16 = \frac{120^2}{R}$

$R = \frac{120^2}{16} = 900$