FINAL JEE–MAIN EXAMINATION – APRIL, 2023

(Held On Thursday 11th April, 2023) **TIME : 9 : 00 AM to 12 : 00 NOON**

SECTION-A

31. The electric field in an electromagnetic wave is given as $\vec{E} = 20\sin\omega\left(t - \frac{x}{c}\right)\vec{j}NC^{-1}$

Where ω and c are angular frequency and velocity of electromagnetic wave

(Given $\varepsilon_0 = 8.85\times10^{-12}C^2/Nm^2$)

(1) 28.5×10^{-13} J (2) 17.7×10^{-13} J

(3) 8.85×10^{-13} J (4) 88.5×10^{-13} J

Official Ans. by NTA (3)

Ans. (3)

Sol. $\vec{E} = 20\sin\omega\left(t - \frac{x}{C}\right)\hat{j}N/C$

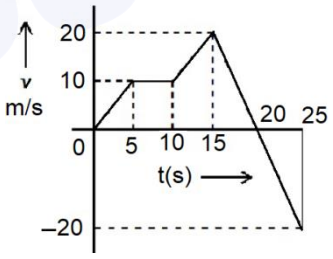
Average energy density of an em wave = $\frac{1}{2}\epsilon_0 E_0^2$

Energy stored = $\left(\frac{1}{2}\epsilon_0 E_0^2\right)(\text{volume})$

$= \frac{1}{2}\times8.85\times10^{-12}\times(20)^2\times(5\times10^{-4})J$

$= 8.85\times10^{-13}$ J

32. From the v - t graph shown. the ratio of distance to displacement in 25 s of motion



(1) $\frac{3}{5}$ (2) $\frac{1}{2}$

(3) $\frac{5}{3}$ (4) 1

Official Ans. by NTA (3)

Ans. (3)

Sol. Area under the graph from t = 0 to t = 20 sec = 200 m

Area under the graph from t = 20 to t = 25 sec = 50 m

So distance covered = (200 + 50) m = 250 m

Displacement = (200 – 50)m= 150 m

$\frac{250}{150} = \frac{5}{3}$

33. The radii of two planets 'A' and 'B' are 'R' and '4R' and their densities are ρ and $\rho/3$ respectively. The ratio of acceleration due to gravity at their surfaces (g_A : g_B) will be:

(1) 1 : 16 (2) 3 : 16

(3) 3 : 4 (4) 4 : 3

Official Ans. by NTA (3)

Ans. (3)

Sol. $g = \frac{GM}{R^2} = \frac{G}{R^2}\times\rho\times\frac{4\pi}{3}R^3 = \left(\frac{4\pi}{3}G\right)\rho R$

$\frac{g_A}{g_B} = \frac{R\times\rho}{4R\times\frac{\rho}{3}} = \frac{3}{4}$

34. A coin placed on a rotating table just slips when it is placed at a distance of 1 cm from the center. If the angular velocity of the table in halved, it will just slip when placed at a distance of_____ from the centre:

(1) 2 cm (2) 1 cm

(3) 8 cm (4) 4 cm

Official Ans. by NTA (4)

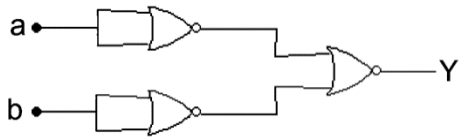
Ans. (4)

Sol. $f_{s\,max} = \mu mg = m\omega^2 R \Rightarrow R = \frac{\mu g}{\omega^2}$

So if ω becomes $\frac{\omega}{2}$, R will become 4R.

So distance from the center will be 4 cm.

35. The logic performed by the circuit shown in figure is equivalent to :



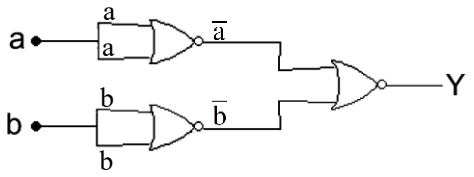
(1) AND (2) NAND

(3) OR (4) NOR

Official Ans. by NTA (1)

Ans. (1)

Sol.



$Y = \overline{\bar{a} + \bar{b}} = a \cdot b$

The truth table for the given circuit will be

sdf

Hence it will be equivalent to AND gate.

36. A parallel plate capacitor of capacitance 2 F is charged to a potential V. The energy stored in the capacitor is E_1. The capacitor is now connected to another uncharged identical capacitor in parallel combination. The energy stored in the combination is E_2. The ratio E_2/E_1 is :

(1) 2 : 1 (2) 1 : 2

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

Official Ans. by NTA (2)

Ans. (2)

Sol. Initially

$Q_1 = CV = (2)\ V$

$E_1 = 1/2\ CV^2 = 1/2\ (2)V^2 = V^2$

Finally

Charge on each capacitor, $Q_2 = \frac{Q_1}{2} = \frac{2V}{2} = V$

$$E_2 = 2\left(\frac{1}{2}\frac{Q_2^2}{C}\right) = \frac{V^2}{2}$$

$$\therefore \frac{E_2}{E_1} = \frac{1}{2}$$

37. Two identical heater filaments are connected first in parallel and then in series. At the same applied voltage, the ratio of heat produced in same time for parallel to series will be:

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

Official Ans. by NTA (1)

Ans. (1)

Sol. Parallel combination

$$H_p = \left[\frac{V^2}{\quad}\right]t = \frac{2V^2t}{\quad}$$

Series combination

$$H_s = \left(\frac{V^2}{2R}\right)t$$

$$\therefore \frac{H_p}{H_s} = 4$$

38. A transmitting antenna is kept on the surface of the earth. The minimum height of receiving antenna required to receive the signal in line of sight at 4 km distance from it is $x \times 10^{-2}$ m. The value of x is (Let. radius of earth R = 6400 km)

(1) 125 (2) 12.5 (3) 1.25 (4) 1250

Official Ans. by NTA (1)

Ans. (1)

Sol. $d_r = \sqrt{2h_rR}$

$$\therefore h_r = \frac{d_r^2}{2R}$$

$$= \frac{(4\text{km})^2}{2(6400\ \text{km})}$$

$$= 1.25\ \text{m}$$

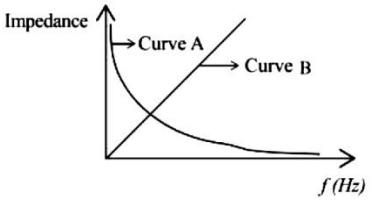
39. As per the given graph choose the correct representation for curve A and curve B.

{Where X_C = reactance of pure capacitive circuit connected with A.C. source

XL = reactance of pure inductive circuit connected with A.C. source

R = impedance of pure resistive circuit connected with A.C. source

Z = Impedance of the LCR series circuit}



(1) $A = X_C, B = R$ (2) $A = X_L, B = Z$

(3) $A = X_C, B = X_L$ (4) $A = X_L, B = R$

Official Ans. by NTA (3)

Ans. (3)

Sol. $X_C = \frac{1}{\omega C} = \frac{1}{(2\pi f)C}$

$\therefore X_C \propto \frac{1}{f}$

$\therefore$ Curve A

$X_L = \omega L = (2\pi f)L$

$\therefore X_L \propto f$

$\therefore$ Curve B

40. 1 kg of water at 100°C is converted into steam at 100°C by boiling at atmospheric pressure. The volume of water changes from 1.00×10^{-3} m^3 as a liquid to 1 671 m^3 as steam. The change in internal energy of the system during the process will be
(Given latent heat of vaporisaiton = 2257 kJ/kg. Atmospheric pressure = 1×10^5 Pa)

(1) + 2090 kJ (2) – 2090 kJ

(3) – 2426 kJ (4) + 2476 kJ

Official Ans. by NTA (1)

Ans. (1)

Sol. $\Delta Q = \Delta U + \Delta W$

$\therefore \Delta U = \Delta Q - \Delta W$

$= mL_V - P\Delta V$

$= (1Kg)(2257 \times 10^3 J/kg) - (1 \times 10^5 Pa)(1.671 m^3 - 1 \times 10^{-3} m^3)$

$= 2257 \times 10^3 J - 167 \times 10^3 J$

$= 2090$ KJ

41. The critical angle for a denser-rarer interface is 45°. The speed of light in rarer medium is 3×10^8 ms. The speed of light in the denser medium is:

(1) 5×10^7 m/s (2) 2.12×10^8 m/s

(3) 3.12×10^7 m/s (4)

Official Ans. by NTA (2)

Ans. (2)

42. A metallic surface is illuminated with radiation of wavelength λ, the stopping potential is V_o. If the same surface is illuminated with radiation of wavelength 2λ, the stopping potential becomes $\frac{V_o}{4}$. The threshold wavelength for this metallic surface will be -

(1) $\frac{\lambda}{4}$ (2) 4λ

(3) $\frac{3}{2}\lambda$ (4) 3λ

Official Ans. by NTA (4)

Ans. (4)

43. The free space inside a current carrying toroid is filled with a material of susceptibility 2×10^{-2}. The percentage increase in the value of magnetic field inside the toroid will be

(1) 2% (2) 0.2%

(3) 0.1% (4) 1%

Official Ans. by NTA (1)

Ans. (1)

44. The current sensitivity of moving coil galvanometer is increased by 25%. This increase is achieved only by changing in the number of turns of coils and area of cross section of the wire while keeping the resistance of galvanometer coil constant. The percentage change in the voltage sensitivity will be:

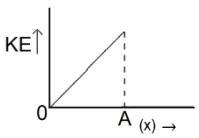
(1) +25% (2) – 50%

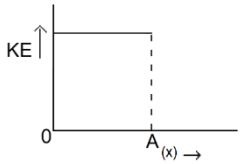
(3) Zero (4) – 25%

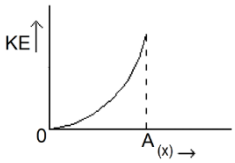
Official Ans. by NTA (1)

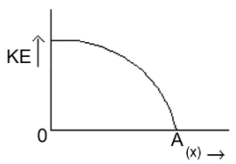
Ans. (1)

45. The variation of kinetic energy (KE) of a particle executing simple harmonic motion with the displacement (x) starting from mean position to extreme position (A) is given by

(1) 

(2) 

(3) 

(4) 

Official Ans. by NTA (4)

Ans. (4),a.

46. On a temperature scale 'X'. The boiling point of water is 65° X and the freezing point is –15°X. Assume that the X scale is linear. The equivalent temperature corresponding to –95° X on the Farenheit scale would be:

(1) –63°F (2) –112°F

(3) –48°F (4) –148°F

Official Ans. by NTA (4)

Ans. (4)

47. Given below are two statements :

Statements I : Astronomical unit (Au). Parsec (Pc) and Light year (ly) are units for measuring astronomical distances.

Statements II: Au < Parsec (Pc) < ly

In the light of the above statements. choose the most appropriate answer from the options given below:

(1) Both Statements I and Statements II are correct.

(2) Statements I is correct but Statements II is incorrect.

(3) Both Statements I and Statements II are incorrect.

(4) Statements I is incorrect but statements II is correct.

Official Ans. by NTA (2)

Ans. (2)

48. Three vessels of equal volume contain gases at the same temperature and pressure. The first vessel contains neon (monoatomic). the second contains chlorine (diatomic) and third contains uranium hexafloride polyatomic). Arrange these on the basis of their root mean square speed (v_{rms}) and choose the correct answer from the options given below:

(1) $v_{rms}(\text{mono}) = v_{rms}(\text{dia}) = v_{rms}(\text{poly})$

(2) $v_{rms}(\text{mono}) > v_{rms}(\text{dia}) > v_{rms}(\text{poly})$

(3) $v_{rms}($ $_{rms}(\text{poly}) < v_{rms}(\text{mono})$

(4) $v_{rms}(\text{mono}) < v_{rms}(\text{dia}) < v_{rms}(\text{poly})$

Official Ans. by NTA (2)

Ans. (2)

49. An average force of 125 N is applied on a machine gun firing bullets each of mass 10 g at the speed of 250 m/s to keep it in position. The number of bullets fired per second by the machine gun is :

(1) 5 (2) 50

(3) 100 (4) 25

Official Ans. by NTA (2)

Ans. (2)

50. Two radioactive elements A and B initially have same number of atoms. The half life of A is same as the average life of B. If and B are decay constants of A and B respectively, then choose the correct relation from the given options.

(1) $\lambda_A = \lambda_B$ (2) $\lambda_A = 2\lambda_B$

(3) $\lambda_A = \lambda_B \ln 2$ (4) $\lambda_A \ln 2 = \lambda_B$

Official Ans. by NTA (3)

Ans. (3)

SECTION-B

51. A monochromatic light is incident on a hydrogen sample in ground state. Hydrogen atoms absorb a fraction of light and subsequently emit radiation of six different wavelengths. The frequency of incident light is x × 10^{15}) Hz. The value of x is _____. (Given h = 4.25 × 10^{-15} eVs)

Official Ans. by NTA ( )

Ans. (3)

Sol. $6 = {}^4C_2 \quad \Rightarrow n_2 = 4$

$h\nu = E_4 - E_1$

$\therefore \nu = 13.6\left(\frac{1}{1^2} - \frac{1}{4^2}\right) \times \frac{1}{4.25 \times 10^{-15}}$

$= 3 \times 10^{15}\,\text{Hz}$

52. The radius of curvature of each surface of a convex lens having refractive index 1.8 is 20 cm. The lens is now immersed in a liquid of refractive index 1.5. The ratio of power of lens in air to its power in the liquid will be x : 1. The value of x is _____.

Official Ans. by NTA ( )

Ans. (4)

Sol. $P=(1.8-1)\left(\frac{1}{20}+\frac{1}{20}\right)$ by lens maker's formula

$$P'=\left(\frac{1.8}{1.5}-1\right)\left(\frac{1}{20}+\frac{1}{20}\right)$$

Dividing $\frac{P}{P'}=\frac{0.8}{1.2-1}=4$

53. The equation of wave is given by

$$Y=10^{-2}\sin 2\pi\left(160t-0.5x+\frac{\pi}{4}\right)$$

Where x and Y are in m and t is s. The speed of the wave is ____ km h^{-1}

Official Ans. by NTA ( )

Ans. (1152)

Sol. $V=\frac{\omega}{k}=\frac{2\pi\times 60}{2\pi\times 0.5}=\frac{160}{0.5}\text{m/s}$

$=\frac{160}{0.5}\times\frac{18}{5}\text{km/h}$

$=1152\text{ km}$

54. A force $\vec{F}=(2+3x)\hat{i}$ acts on a particle in the x direction where F is in newton and x is in meter. The work done by this force during a displacement from x = 0 to x = 4 m, is ____J.

Official Ans. by NTA ( )

Ans. (32)

Sol. $W=\int_0^4(2+3x)dx$

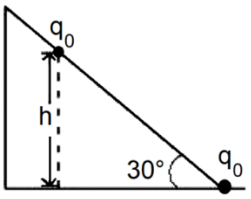
$=\left[2x+\frac{3x^2}{2}\right]_0^4$

$=8+3\times 8$

$=32\text{ J}$

55. As shown in the figure. a configuration of two equal point charges (q_0 = –2μ C) is placed on an inclined plane. Mass of each point charge is 20 g. Assume that there is no friction between charge and plane. For the system of two point charges to be in equilibrium (at rest) flic height h = x × 10^{-3} m The value of x is ____.

(Take $\frac{1}{4\pi\varepsilon_0}=9\times10^9\text{ N m}^2\text{C}^{-2}, g=10\text{ ms}^{-1}$)



Official Ans. by NTA ( )

Ans. (300)

Sol. For equilibrium along the plane

$$mg\sin\theta=\frac{1}{4\pi\in_0}\times\frac{q_0^2}{(h\text{ cosec }30°)^2}$$

$$\therefore h^2=\frac{1}{4\pi\in_o}\times\frac{q_0^2}{mg\text{ cosec }30°}$$

$$=9\times10^9\times\frac{(2\times10^{-6})^2}{0.02\times10\times2}$$

$$\therefore h=3\times10^4\times\frac{2\times10^{-6}}{0.2}$$

$=0.3\text{ m}$

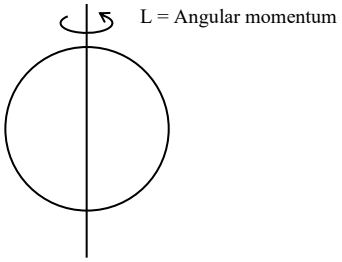
$=300\text{ mm}$

56. A solid sphere of mass 500 g and radius 5 cm is rotated about one of its diameter with angular speed of 10 rad s^{-1}. If the moment of inertia of the sphere about its tangent is x × 10^{-2} times its angular momentum about the diameter. Then the value of x will be _____.

Official Ans. by NTA ( )

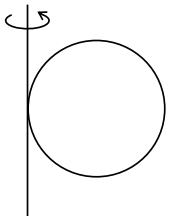
Ans. (35)

Sol.



m = 500 g = 0.5 kg
R = 5cm
ω = 10 rad/sec

moment of inertia about tangent = I_T



$I_t = x \times 10^{-2} L$

$\frac{7}{5} mR^2 = x \times 10^{-2} \frac{2}{5} mR^2 \omega$

$\frac{7}{2\omega} = x \times 10^{-2} = \frac{7}{2 \times 10}$

57. The length of wire becomes l_1 and l_2 when 100N and 120 N tensions are applied respectively. If 10 l2 = 11 l_1, the natural length of wire will be $\frac{1}{x} l_1$. Here the value of x is ____.

Official Ans. by NTA ( )

Ans. (2)

Sol. Let the original length be 'ℓ_0'

When T_1 = 100 N, Extension = $\ell_1 - \ell_0$

When T_2 = 120 N, Extension = $\ell_2 - \ell_0$

Then $100 = K(\ell_1 - \ell_0)$ ...(1)

And $120 = K(\ell_2 - \ell_0)$ ...(2)

$\frac{1}{2} \Rightarrow \frac{5}{6} = \frac{\ell_1 - \ell_0}{\ell_2 - \ell_0}$

$5\ell_2 - 5\ell_0 = 6\ell_1 - 6\ell_0$

$\ell_0 = 6\ell_1 - 5\ell_2$

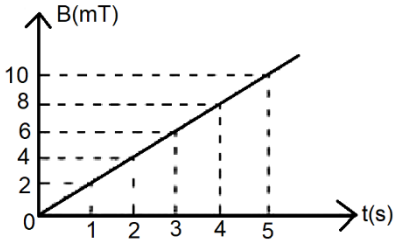
$\ell_0 = 6\ell_1 - 5\left(\frac{11\ell_1}{10}\right)$

$\ell_0 = 6\ell_1 - \frac{11\ell_1}{2}$

$\ell_0 = \frac{\ell_1}{2}$

$\therefore x = 2$

58. The magnetic field B crossing normally a square metallic plate of area 4 m^2 is changing with time as shown in figure. The magnitude of induced emf in the plate during t = 2s to t = 4s, is _____ mV



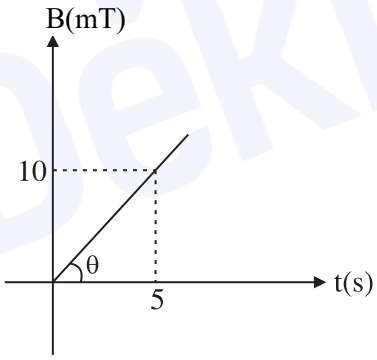
Official Ans. by NTA ( )

Ans. (8)

Sol. $m = \tan\theta = \frac{10}{5} = 2$

$B = mt$

$B = 2t$



$\varepsilon = \left|\frac{d\phi}{dt}\right| = \frac{d(BA)}{dt} = \frac{AdB}{dt}$

$\varepsilon = \frac{4d(2t)}{dt} = 4 \times 2 = 8 \text{ mVolt}$

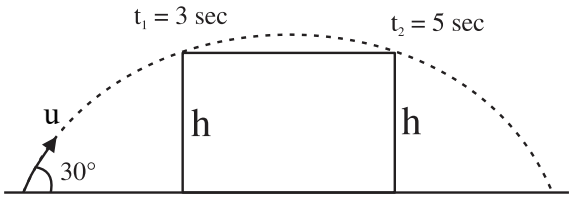
59. A projectile fired at 30° to the ground is observed to be at same height at time 3s and S after projection, during its flight. The speed of projection of the projectile is _____ ms^{-1}

(Given g = 10 m s^{-2})

Official Ans. by NTA ( )

Ans. (80)

Sol. Time of flight $t_1 + t_2 = 3 + 5 = 8\,\text{sec}$

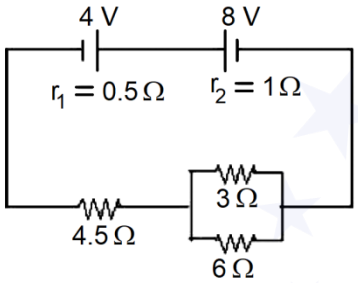


$$T = \frac{2u\sin 30°}{g}$$

$$8 = \frac{2u\sin(30°)}{10}$$

$$u = 80\ \text{m/s}$$

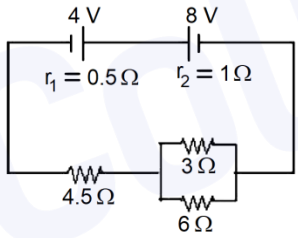
60. In the circuit diagram shown in figure given below, the current flowing through resistance $3\,\Omega$ is $\frac{x}{3}$A. The value of x is ____.



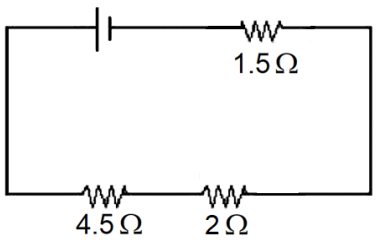
Official Ans. by NTA ( )

Ans. (1)

Sol.

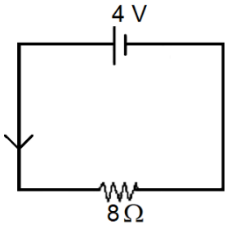


$$E_2 - E_1 = 8 - 4 = 4\text{V}$$

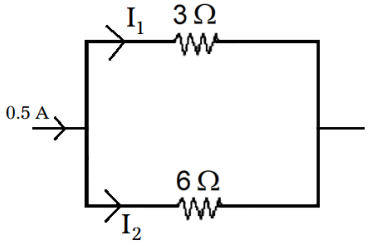


$$\frac{1}{3} + \frac{1}{6} = \frac{1}{2} = \frac{1}{R}$$

$$R = 2\,\Omega$$



$$I = \frac{4}{8} = 0.5\text{A}$$



$$I_1 = \left(\frac{6}{3+6}\right) \times 0.5$$

$$I_1 = \frac{2}{3} \times 0.5 = \frac{1}{3}\text{A}$$

$$I_1 = \frac{x}{3} = \frac{1}{3} \therefore x = 1$$