FINAL JEE–MAIN EXAMINATION – APRIL, 2023

(Held On Saturday 15th April, 2023) **TIME : 9 : 00 AM to 12 : 00 NOON**

PHYSICS

TEST PAPER WITH SOLUTION

SECTION-A

31. The electric field due to a short electric dipole at a large distance (r) from center of dipole on the equatorial plane varies with distance as :

(1) r (2) $\frac{1}{r}$

(3) $\frac{1}{r^3}$ (4) $\frac{1}{r^2}$

Official Ans. by NTA (3)

Allen Ans. (3)

Sol. Electric field due to a dipole at point on its axis

$$E = \frac{2kp}{r^3}$$

32. In a linear simple harmonic motion (SHM)

(A) Restoring force is directly proportional to the displacement.

(B) The acceleration and displacement are opposite in direction.

(C) The velocity is maximum at mean position.

(D) The acceleration is minimum at extreme points.

Choose the correct answer from the options given below :

(1) (A), (B) and (C) only

(2) (C) and (D) only

(3) (A), (B) and (D) only

(4) (A), (C) and (D) only

Official Ans. by NTA (1)

Allen Ans. (1)

Sol. $F = -kx$ A true

$a = -\omega^2 x$ B true

Velocity is maximum at mean position C true

Acceleration is maximum at extreme points D false

33. Two identical particles each of mass 'm' go round a circle of radius *a* under the action of their mutual gravitational attraction. The angular speed of each particle will be :

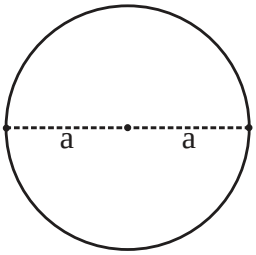
(1) $\sqrt{\frac{Gm}{2a^3}}$ (2) $\sqrt{\frac{Gm}{8a^3}}$

(3) $\sqrt{\frac{Gm}{4a^3}}$ (4) $\sqrt{\frac{Gm}{a^3}}$

Official Ans. by NTA (3)

Allen Ans. (3)

Sol.



$F = m\omega^2 r$

$$\Rightarrow \frac{Gmm}{(2a)^2} = m\omega^2 a$$

$$\Rightarrow \omega = \sqrt{\frac{Gm}{4a^3}}$$

34. The height of transmitting antenna is 180 m and the height of the receiving antenna is 245 m. The maximum distance between them for satisfactory communication in line of sight will be :

(given R = 6400 km)

(1) 48 km (2) 56 km

(3) 96 km (4) 104 km

Official Ans. by NTA (4)

Allen Ans. (4)

Sol. $d_{max} = \sqrt{2Rh_t} + \sqrt{2Rh_r}$

$$= \sqrt{2\times64\times10^5\times180} + \sqrt{2\times64\times10^5\times245}$$

$$= \{(8\times6\times10^3) + (8\times7\times10^3)\}\ m$$

$$= (48 + 56)\ km$$

$$= 104\ km$$

35. The half-life of a radioactive nucleus is 5 years, The fraction of the original sample that would decay in 15 years is :

(1) $\frac{1}{8}$ (2) $\frac{1}{4}$

(3) $\frac{7}{8}$ (4) $\frac{3}{4}$

Official Ans. by NTA (3)

Allen Ans. (3)

Sol. 15 year = 3 half lives

Number of active nuclei = $\frac{N_0}{8}$

Number of decay = $\frac{7N_0}{8}$

36. The de Broglie wavelength of an electron having kinetic energy E is λ. If the kinetic energy of electron becomes $\frac{E}{4}$, then its de-Broglie wavelength will be :

(1) $\frac{\lambda}{\sqrt{2}}$ (2) $\frac{\lambda}{2}$

(3) 2λ (4) $\sqrt{2}\lambda$

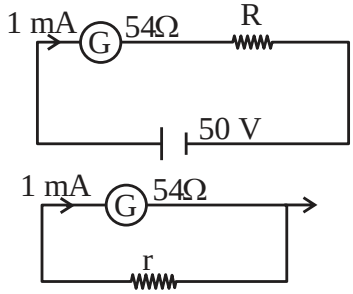
Official Ans. by NTA (3)

Allen Ans. (3)

Sol. $\lambda = \frac{h}{\sqrt{2mE}}$

$\lambda' = \frac{h}{\sqrt{2m\left(\frac{E}{4}\right)}} = \frac{2h}{\sqrt{2mE}} = 2\lambda$

37. For designing a voltmeter of range 50 V and an ammeter of range 10 mA using a galvanometer which has a coil of resistance 54 Ω showing a full scale deflection for 1 mA as in figure.



(A) for voltmeter R ≈ 50 kΩ

(B) for ammeter r ≈ 0.2 Ω

(C) for ammeter r ≈ 6 Ω

(D) for voltmeter R ≈ 5 kΩ

(E) for voltmeter R ≈ 500 Ω

Choose the correct answer from the options given below :

(1) (C) and (E) (2) (C) and (D)

(3) (A) and (C) (4) (A) and (B)

Official Ans. by NTA (3)

Allen Ans. (3)

Sol. For voltmeter

$R = \frac{V}{I_g} - G$

$= \frac{50}{10^{-3}} - 54 \approx 50k\Omega$ (A)

For ammeter

$S = \frac{I_g G}{I - I_g} = \frac{10^{-3} \times 54}{(10-1)\times 10^{-3}} = 6\Omega$ (C)

38. (A flask contains Hydrogen and Argon in the ratio 2:1 by mass. The temperature of the mixture is 30°C. The ratio of average kinetic energy per molecule of the two gases (K argon/K hydrogen) is: (Given: Atomic Weight of Ar = 39.9)

(1) 1 (2) 2

(3) $\frac{39.9}{2}$ (4) 39.9

Official Ans. by NTA (1)

Allen Ans. (1)

Sol. Average KE per molecule = $\frac{3}{2}kT$

$\frac{K_{Ar}}{K_H} = \frac{1}{1}$

39. Given below are two statements:

Statement I : The equivalent resistance of resistors in a series combination is smaller than least resistance used in the combination.

Statement II : The resistivity of the material is independent of temperature.

In the light of the above statements, choose the correct answer from the options given below :

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

(2) Both Statement I and Statement II are false

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

(4) Both Statement I and Statement II are true

Official Ans. by NTA (2)

Allen Ans. (2)

Sol. $R_{eq} = R_1 + R_2 + R_3$ So St–1 False

Resistivity depends on temperature. St–2 False

40. A body is released from a height equal to the radius (R) of the earth. The velocity of the body when it strikes the surface of the earth will be :

(Given g = acceleration due to gravity on the earth.)

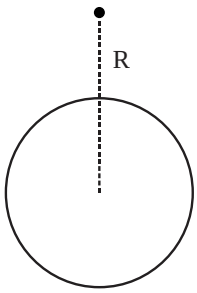
(1) $\sqrt{gR}$ (2) $\sqrt{4gR}$

(3) $\sqrt{2gR}$ (4) $\sqrt{\frac{gR}{2}}$

Official Ans. by NTA (1)

Allen Ans. (1)

Sol.



By conservation of mechanical energy

$U_i + K_i = U_f + K_i$

$$-\frac{GMm}{2R} + 0 = -\frac{GMm}{R} + \frac{1}{2}mv^2$$

$$\frac{GMm}{2R} = \frac{1}{2}mv^2$$

$$v = \sqrt{\frac{GM}{R}} = \sqrt{gR}$$

41. A 12 V battery connected to a coil of resistance 6 Ω through a switch, drives a constant current in the circuit. The switch is opened in 1 ms. The emf induced across the coil is 20 V. The inductance of the coil is :

(1) 5 mH (2) 12 mH

(3) 8 mH (4) 10 mH

Official Ans. by NTA (D)

Allen Ans. (D)

Sol. Induced emf $= -L\frac{dI}{dt}$

$$\Rightarrow 20 = -L\frac{(0-2)}{10^{-3}}$$

$\Rightarrow L = 10$ mH

42. A wire of length 'L' and radius 'r' is clamped rigidly at one end. When the other end of the wire is pulled by a force f, its length increases by 'ℓ'.

Another wire of same material of length '2L' and radius '2r' is pulled by a force '2f'. Then the increase in its length will be :

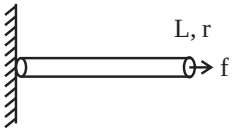
(1) 2ℓ (2) ℓ

(3) 4ℓ (4) $\ell/2$

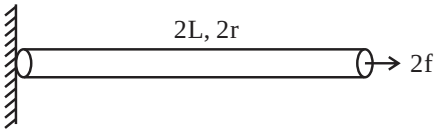
Official Ans. by NTA (2)

Allen Ans. (2)

Sol.



$$\frac{f}{\pi r^2} = Y\frac{\ell}{L}$$



$$\frac{2f}{\pi(2r)^2} = Y\frac{\ell'}{2L}$$

$$\Rightarrow \frac{2}{1} = \frac{2\ell'}{\ell} \Rightarrow \ell' = \ell$$

43. The position of a particle related to time is given by $x = (5t^2 - 4t + 5)$m. The magnitude of velocity of the particle at t = 2s will be :

(1) 10 ms^{-1} (2) 14 ms^{-1}

(3) 16 ms^{-1} (4) 06 ms^{-1}

Official Ans. by NTA (3)

Allen Ans. (3)

Sol. $x = 5t^2 - 4t + 5$

$v = 10t - 4$

At t = 2s v = 16m/s

44. The position vector of a particle related to time t is given by

$$\vec{r} = \left(10t\hat{i} + 15t^2\hat{j} + 7\hat{k}\right)m$$

The direction of net force experienced by the particle is :

(1) Positive y-axis (2) Positive x-axis

(3) Positive z-axis (4) In x-y plane

Official Ans. by NTA (1)

Allen Ans. (1)

Sol. $\vec{r} = 10t\hat{i} + 15t^2\hat{j} + 7\hat{k}$

$\vec{v} = 10\hat{i} + 30t\,\hat{j}$

$\vec{a} = 30\hat{j}$

So Net force is along +y direction

45. Match List I with List II of Electromagnetic waves with corresponding wavelength range :

List I	**List II**
(A) Microwave	(I) 400 nm to 1 nm
(B) Ultraviolet	(II) 1 nm to 10^{-3} nm
(C) X-Ray	(III) 1 mn to 700 nm
(D) Infra-red	(IV) 0.1 m to 1mm

Choose the correct answer from the options given below :

(1) (A)-(I), (B)-(IV), (C)-(II), (D)-(III)

(2) (A)-(IV), (B)-(I), (C)-(II), (D)-(III)

(3) (A)-(IV), (B)-(II), (C)-(I), (D)-(III)

(4) (A)-(IV), (B)-(I), (C)-(III), (D)-(II)

Official Ans. by NTA (2)

Allen Ans. (2)

Sol. Increasing order of wave length

X-ray	1 nm to 10^{-3} nm
Ultra Violet	400 nm to 1 nm
Intra red	1 mm to 700 nm
Micro wave	0.1 m to 1mm

46. A vector in x-y plane makes an angle of 30° with y-axis The magnitude of y-component of vector is $2\sqrt{3}$. The magnitude of x-component of the vector will be :

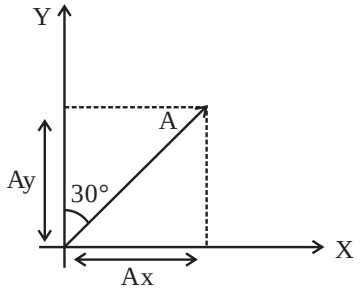
(1) $\frac{1}{\sqrt{3}}$ (2) 6

(3) $\sqrt{3}$ (4) 2

Official Ans. by NTA (4)

Allen Ans. (4)

Sol.



$A_y = A\cos 30° = 2\sqrt{3}$

$\Rightarrow A\frac{\sqrt{3}}{2} = 2\sqrt{3}$

$\Rightarrow A = 4$

Now $A_x = A\sin 30° = 4 \times \frac{1}{2} = 2$

47. The speed of a wave produced in water is given by $\upsilon = \lambda^a g^b \rho^c$. Where λ, g and ρ are wavelength of wave, acceleration due to gravity and density of water respectively. The values of a, b and c respectively, are :

(1) $\frac{1}{2}, \frac{1}{2}, 0$ (2) 1, 1, 0

(3) 1, –1, 0 (4) $\frac{1}{2}, 0, \frac{1}{2}$

Official Ans. by NTA (1)

Allen Ans. (1)

Sol. $\nu = \lambda^a g^b \rho^c$

using dimension formula

$\Rightarrow [M^0L^1T^{-1}] = [L^1]^a [L^1T^{-2}]^b [M^1L^{-3}]^c$

$\Rightarrow [M^0L^1T^{-1}] = [M^c L^{a+b-3c} T^{-2b}]$

$\therefore c = 0, a + b - 3c = 1, -2b = -1 \Rightarrow b = \frac{1}{2}$

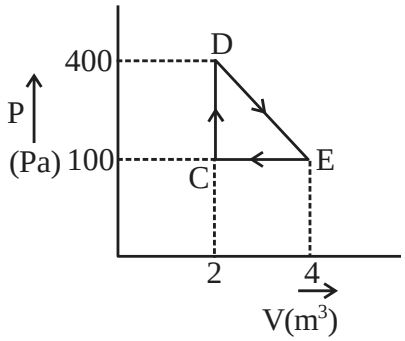
Now $a + b - 3c = 1$

$\Rightarrow a + \frac{1}{2} - 0 = 1$

$\Rightarrow a = \frac{1}{2}$

$\therefore a = \frac{1}{2}, b = \frac{1}{2}, c = 0$

48. A thermodynamic system is taken through cyclic process. The total work done in the process is :



(1) 100 J (2) 300 J

(3) Zero (4) 200 J

Official Ans. by NTA (2)

Allen Ans. (2)

Sol. On P–V scale area of loop = work done

$\Rightarrow W = +\frac{1}{2}(2) \times 300$

$W = 300J$

49. A single slit of width a is illuminated by a monochromatic light of wavelength 600 nm. The value of 'a' for which first minimum appears at $\theta = 30°$ on the screen will be :

(1) 0.6 μ m (2) 1.2 μ m

(3) 1.8 μ m (4) 3 μ m

Official Ans. by NTA (2)

Allen Ans. (2)

Sol. As for first minima

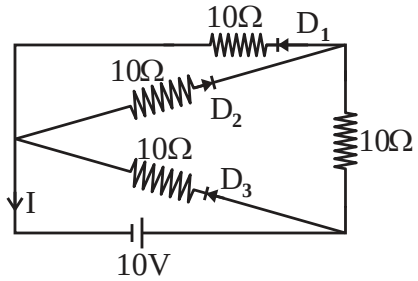
$a \sin\theta = \lambda$

$\Rightarrow a \sin 30° = 600 \times 10^{-9}$

$\Rightarrow a = 1200 \times 10^{-9}$ m

$\Rightarrow a = 1.2\ \mu m$

50. In the given circuit, the current (I) through the battery will be :



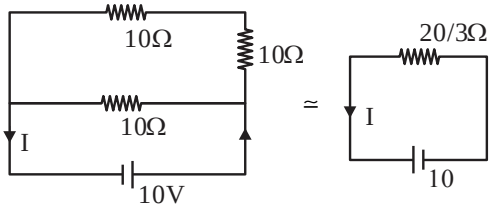
(1) 1.5 A (2) 1 A

(3) 2.5 A (4) 2 A

Official Ans. by NTA (1)

Allen Ans. (1)

Sol. In the circuit D_1 and D_3 are forward biased and D_2 is reverse biased.



$\therefore I = \frac{10}{20/3} = \frac{3}{2} A = 1.5A$

SECTION-B

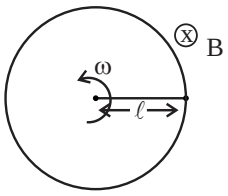
51. A 20 cm long metallic rod is rotated with 210 rpm about an axis normal to the rod passing through its one end. The order end of the rod is in contact with a circular metallic ring. A constant and uniform magnetic field 0.2T parallel to the axis exists everywhere. The emf developed between the centre and the ring is _____ mV.

Take $\pi = \frac{22}{7}$

Official Ans. by NTA (88)

Allen Ans. (88)

Sol.



Here $\omega = 210$ rpm

$= 210 \times \frac{2\pi}{60}$ rad/s

$\Rightarrow \omega = 7\pi$ rad/s

& $\ell = 0.2$m

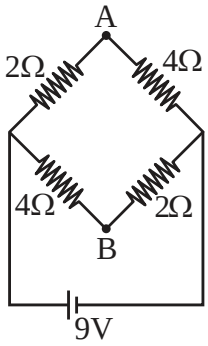
& B = 0.2T

emf developed across rod is $= \frac{1}{2} B\omega\ell^2$

$\frac{1}{2} \times 0.2 \times 7\pi \times (0.2)^2$

= 88 mV

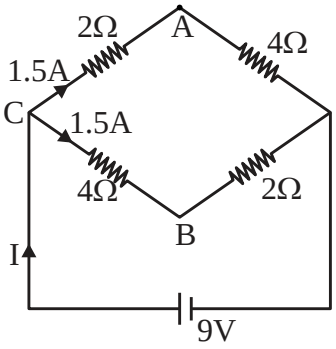
52. A network of four resistances is connected to 9V battery, as shown in figure. The magnitude of voltage difference between the points A and B is _____V.



Official Ans. by NTA (3)

Allen Ans. (3)

Sol.



In the circuit $I = \frac{9}{3} = 3A$

$V_C - V_A = 2 \times 1.5 = 3$ .....(I)

$V_C - V_B = 4 \times 1.5 = 6$ .....(I)

Eq^n (II) – Eq^n (I)

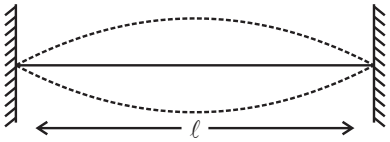
$V_A - V_B = 6 - 3 = 3$ Volt

53. The fundamental frequency of vibration of a string stretched between two rigid support is 50 Hz. The mass of the string is 18 g and its linear mass density is 20 g/m. The speed of the transverse waves so produced in the string is_____ ms^{-1}.

Official Ans. by NTA (90)

Allen Ans. (90)

Sol.



Fundamental frequency = 50 Hz

mass/length = 20g/m

mass = 18g

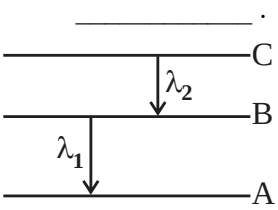
length of string = $\frac{18}{20}m = \frac{9}{10}m$

from diagram $\frac{\lambda}{2} = \ell$

$\Rightarrow \lambda = 2\ell = \frac{9}{5}m$

again speed $v = f\lambda = 50 \times \frac{9}{5} = 90$ m/s

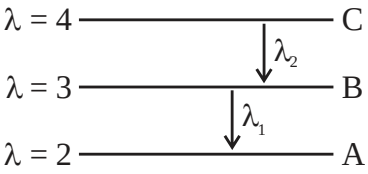
54. As per given figure A, B and C are the first, second and third excited energy level of hydrogen atom respectively. If the ratio of the two wavelengths $\left(\text{i.e.}\frac{\lambda_1}{\lambda_2}\right)$ is $\frac{7}{4n}$, then the value of n will be _____.



Official Ans. by NTA (5)

Allen Ans. (5)

Sol.



As $\frac{1}{\lambda} = RZ^2\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

$\frac{1}{\lambda_1} = R(1)^2\left[\frac{1}{(2)^2} - \frac{1}{(3)^2}\right] = R\left(\frac{5}{36}\right)$ (i)

& $\frac{1}{\lambda_2} = R(1)^2\left[\frac{1}{(3)^2} - \frac{1}{(4)^2}\right] = R\left(\frac{7}{144}\right)$ (ii)

(ii) ÷ (i) gives

$\frac{\lambda_1}{\lambda_2} = \frac{7/144}{5/36} = \frac{7}{20} = \frac{7}{4\times5}$

$\therefore n = 5$

55. A solid sphere and a solid cylinder of same mass and radius are rolling on a horizontal surface without slipping. The ratio of their radius of gyrations respectively (k_{sph} : k_{cyl}) is $2:\sqrt{x}$, then value of x is _____ .

Official Ans. by NTA (5)

Allen Ans. (5)

Sol. For solid sphere $\frac{2}{5}mR^2 = mk_{sph}^2$

$$k_{sph} = \sqrt{\frac{2}{5}}R$$

For solid cylinder $\frac{mR^2}{2} = mk_{cyl}^2$

$$\Rightarrow k_{cyl} = \frac{R}{\sqrt{2}}$$

$$\frac{k_{sph}}{k_{cyl}} = \frac{\sqrt{\frac{2}{5}}}{\frac{1}{\sqrt{2}}} = \frac{2}{\sqrt{5}} = \frac{2}{\sqrt{x}}$$

$\therefore x = 5$

56. The refractive index of a transparent liquid filled in an equilateral hollow prism is $\sqrt{2}$. The angle of minimum deviation for the liquid will be _____°.

Official Ans. by NTA (30)

Allen Ans. (30)

Sol. As $\mu = \frac{\sin\left(\frac{D_{min}+A}{2}\right)}{\sin\left(\frac{A}{2}\right)}$

$$\sqrt{2} = \frac{\sin\left(\frac{D_{min}+60}{2}\right)}{\sin\left(\frac{60}{2}\right)}$$

$$\Rightarrow \frac{1}{\sqrt{2}} = \sin\left(\frac{D_{min}+60}{2}\right)$$

$$\Rightarrow \frac{D_{min}+60}{2} = 45$$

$\Rightarrow D_{min} = 30$

57. An electron in a hydrogen atom revolves around its nucleus with a speed of 6.76×10^6 ms^{-1} in an orbit of radius 0.52 A°. The magnetic field produced at the nucleus of the hydrogen atom is _____T.

Official Ans. by NTA (40)

Allen Ans. (40)

Sol. Magnetic field due to moving charge

$$B = \frac{\mu_0}{4\pi}\frac{q\,v\sin\theta}{r^2}$$

$$B = \frac{\mu_0}{4\pi}\frac{ev\sin(\pi/2)}{r^2}$$

$$B = \frac{10^{-7}\times1.6\times10^{-19}\times6.76\times10^{6}}{0.52\times0.52\times10^{-20}}$$

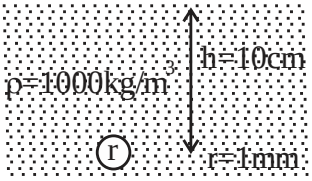
$B = 40$ T

58. There is an air bubble of radius 1.0 mm in a liquid of surface tension 0.075 Nm^{-1} and density 1000 kg m^{-3} at a depth of 10 cm below the free surface. The amount by which the pressure inside the bubble is greater than the atmospheric pressure is_____ Pa ($g = 10\ ms^{-2}$)

Official Ans. by NTA (1150)

Allen Ans. (1150)

Sol.



Pressure inside the bubble

$$P = P_0 + h\rho g + \frac{2T}{r}$$

$$P - P_0 = h\rho g + \frac{2T}{r}$$

$$= 0.1\times1000\times10 + \frac{2\times.075}{10^{-3}}$$

$= 1000 + (0.15)\ (1000)$

$= 1150$ Pa

59. A block of mass 10 kg is moving along x-axis under the action of force F = 5x N. The work done by the force in moving the block from x = 2m to 4m will be _____J.

Official Ans. by NTA (30)

Allen Ans. (30)

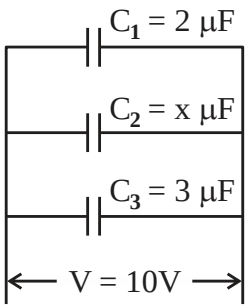
Sol. Work done = $\int F dx$

$$\int_2^4 5x dx = 5\left[\frac{x^2}{2}\right]_2^4$$

$$= \frac{5}{2}[16-4]$$

= 30 J

60. In the given figure the total charge stored in the combination of capacitors is 100 μC. The value of 'x' is_____ .



Official Ans. by NTA (5)

Allen Ans. (5)

Sol. Charge on C_1 is $Q_1 = 2 \times 10 = 20\mu C$ (i)

Charge on C_2 is $Q_2 = x \times 10 = 10x\mu C$ (ii)

Charge on C_3 is $Q_3 = 3 \times 10 = 30\mu C$ (iii)

Total charge $20 + 10x + 30 = 100$

$\Rightarrow x = 5$