FINAL JEE–MAIN EXAMINATION – JUNE, 2022

(Held On Wednesday 29th June, 2022) **TIME : 3 : 00 PM to 06 : 00 PM**

PHYSICS — TEST PAPER WITH SOLUTION

SECTION-A

1. A small toy starts moving from the position of rest under a constant acceleration. If it travels a distance of 10m in t s,. the distance travelled by the toy in the next t s will be :

(A) 10m (B) 20m

(C) 30m (D) 40m

Official Ans. by NTA (C)

Allen Ans. (C)

Sol. u = 0, Say acceleration is a

For t s $10 = \frac{1}{2}at^2$

For 2t s $10 + x = \frac{1}{2}a(2t)^2$

$\frac{10+x}{10} = \frac{4}{1}$

x = 30 m

2. At what temperature a gold ring of diameter 6.230 cm be heated so that it can be fitted on a wooden bangle of diameter 6.241 cm? Both the diameters have been measured at room temperature (27ºC). (Given: coefficient of linear thermal expansion of gold $\alpha_L = 1.4 \times 10^{-5}\ K^{-1}$)

(A) 125.7ºC (B) 91.7ºC

(C) 425.7º (D) 152.7ºC

Official Ans. by NTA (D)

Allen Ans. (D)

Sol. $\Delta\ell = 6.241 - 6.230 = 0.011$ cm

$\Delta\ell = \ell\,\alpha\,\Delta\theta$

$0.011 = 6.230 \times 1.4 \times 10^{-5}(\theta - 27)$

$\theta - 27 = \frac{0.011\times10^5}{6.230\times1.4}$

$\theta \approx 153.11$ nearest is 152.7°C.

3. Two point charges Q each are placed at a distance d apart. A third point charge q is placed at a distance x from mid-point on the perpendicular bisector. The value of x at which charge q will experience the maximum Coulomb's force is :

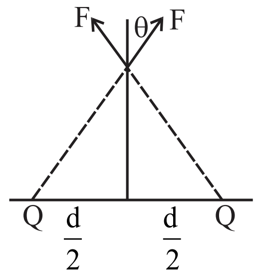
(A) x = d (B) $x = \frac{d}{2}$

(C) $x = \frac{d}{\sqrt{2}}$ (D) $x = \frac{d}{2\sqrt{2}}$

Official Ans. by NTA (D)

Allen Ans. (D)

Sol.



$F = \frac{KQq}{\left(x^2 + \frac{d^2}{4}\right)}$

Net force on g = 2 F cosθ

$F_{net} = \frac{2KQqx}{\left(x^2 + \frac{d^2}{4}\right)^{3/2}}$

For maximum F_{net}

$\frac{d\,F_{net}}{dx} = 0$

we get $x = \frac{d}{2\sqrt{2}}$

4. The speed of light in media 'A' and 'B' are 2.0 × 10^{10} cm/s and 1.5 × 10^{10} chm/s respectively. A ray of light enters from the medium B to A at an incident angle 'θ'. If the ray suffers total internal reflection, then

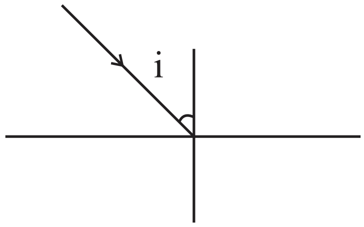
(A) $\theta = \sin^{-1}\left(\frac{3}{4}\right)$ (B) $\theta > \sin^{-1}\left(\frac{2}{3}\right)$

(C) $\theta < \sin^{-1}\left(\frac{3}{4}\right)$ (D) $\theta > \sin^{-1}\left(\frac{3}{4}\right)$

Official Ans. by NTA (D)

Allen Ans. (D)

Sol. $\sin i_c = \frac{n_r}{n_d} = \frac{C_d}{C_r} = \frac{1.5\times10^{10}}{2\times10^{10}}$



$\sin i_c = \frac{3}{4}$

$i_c = \sin^{-1}\left(\frac{3}{4}\right)$

for T I R $\quad \theta > i_c$

$\theta > \sin^{-1}\left(\frac{3}{4}\right)$

5. In the following nuclear rection,

$$D \xrightarrow{\alpha} D_1 \xrightarrow{\beta^-} D_2 \xrightarrow{\alpha} D_3 \xrightarrow{\gamma} D_4$$

Mass number of D is 182 and atomic number is 74. Mass number and atomic number of D_4 respectively will be___.

(A) 174 and 71 (B) 174 and 69

(C) 172 and 69 (D) 172 and 71

Official Ans. by NTA (A)

Allen Ans. (A)

Sol. Say for D_4 Atomic No = Z

Mass Number = A

$A = 182 - 4 - 4 = 174$

$Z = 74 - 2 + 1 - 2 = 71$

6. The electric field at the point associated with a light wave is given by

$E = 200\,[\sin(6 \times 10^{15})\,t + \sin(9 \times 10^{15})\,t]\ Vm^{-1}$

Given : $h = 4.14 \times 10^{-15}$ eVs

If this light falls on a metal surface having a work function of 2.50 eV, the maximum kinetic energy of the photoelectrons will be :

(A) 1.90 eV (B) 3.27 eV

(C) 3.60 eV (D) 3.42 eV

Official Ans. by NTA (D)

Allen Ans. (D)

Sol. For maximum KE we will take

higher frequency $\left(f = \frac{9\times10^{15}}{2\pi}\text{Hz}\right)$

$K_{max} = hf - \phi$

$= \frac{9\times10^{15}\times4.14\times10^{-15}}{2\pi} - 2.50$

3.43 eV nearest is 3.42 eV

7. A capacitor is discharging through a resistor R. Consider in time t_1, the energy stored in the capacitor reduces to half of its initial value and in time t_2, the charge stored reduces to one eighth of its initial value. The ratio t_1/t_2 will be :

(A) 1/2 (B) 1/3

(C) 1/4 (D) 1/6

Official Ans. by NTA (D)

Allen Ans. (D)

Sol. In t_1 time energy becomes half so charge will become $\frac{1}{\sqrt{2}}$ time

$q = Q_0\, e^{-\frac{t_1}{RC}} = \frac{Q_0}{\sqrt{2}}$

and $q = Q_0\, e^{-\frac{t_1}{RC}} = \frac{Q_0}{8} = \left(\frac{Q_0}{\sqrt{2}}\right)^6$

$t_2 = 6t_1$

$\frac{t_1}{t_2} = \frac{1}{6}$

8. Starting with the same initial conditions, an ideal gas expands from volume V_1 to V_2 in three different ways. The work done by the gas is W_1 if the process is purely isothermal. W_2. if the process is purely adiabatic and W_3 if the process is purely isobaric. Then, choose the coned option

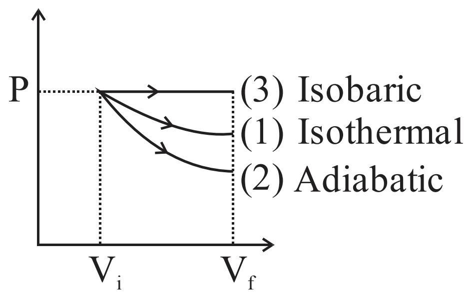
(A) $W_1 < W_2 < W_3$ (B) $W_2 < W_3 < W_1$

(C) $W_3 < W_1 < W_2$ (D) $W_2 < W_1 < W_3$

Official Ans. by NTA (D)

Allen Ans. (D)

Sol.



Area under curve is work

$W_2 < W_1 < W_3$

9. Two long current carrying conductors are placed parallel to each other at a distance of 8 cm between them. The magnitude of magnetic field produced at mid-point between the two conductors due to current flowing in them is 300 μT. The equal current flowing in the two conductors is :

(A) 30A in the same direction.

(B) 30A in the opposite direction.

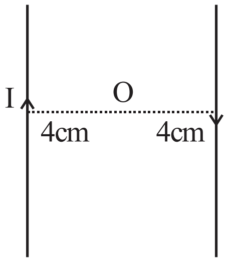
(C) 60A in the opposite direction.

(D) 300A in the opposite direction.

Official Ans. by NTA (B)

Allen Ans. (B)

Sol.



$$B \text{ at } O = 2\frac{\mu_0 I}{2\pi r}$$

$$\frac{2\times 4\pi\times 10^{-7} I}{2\pi\ 4\times 10^{-2}} = 3\times 10^{-4} T$$

I = 30A in opp. direction

10. The time period of a satellite revolving around earth in a given orbit is 7 hours. If the radius of orbit is increased to three times its previous value, then approximate new time period of the satellite will be :

(A) 40 hours (B) 36 hours

(C) 30 hours (D) 25 hours

Official Ans. by NTA (B)

Allen Ans. (B)

Sol. $T = \frac{2\pi}{\sqrt{GM}} r^{3/2}$

$$\frac{T_1}{T_2} = \left(\frac{r_1}{r_2}\right)^{3/2} = \left(\frac{1}{3}\right)^{3/2}$$

$T_2 = T_1\ 3\sqrt{3} = 21\ \sqrt{3}$ hours

≈ 36 hours

11. The TV transmission tower at a particular station has a height of 125 m. For dubling the coverage of its range, the height of the tower should be increased by :

(A) 125 m (B) 250 m

(C) 375 (D) 500 m

Official Ans. by NTA (C)

Allen Ans. (C)

Sol. Range $d = \sqrt{2Rh}$

$d_2 = 2d_1$

$\sqrt{2Rh_2} = 2\sqrt{2Rh_1}$

$h_2 = 4h_1 = 500$ m

$\Delta h = 500$ m – 125 m = 375 m

12. The motion of a simple pendulum excuting S.H.M. is represented by following equation.

$Y = A \sin(\pi t + \phi)$, where time is measured in second.

The length of pendulum is :

(A) 97.23 cm (B) 25.3 cm

(C) 99.4 cm (D) 406.1 cm

Official Ans. by NTA (C)

Allen Ans. (C)

Sol. $\omega = \sqrt{\frac{g}{\ell}} = \pi$

$$\frac{g}{\ell} = \pi^2 \Rightarrow \ell = \frac{g}{\pi^2}$$

$$\ell = \frac{980}{\pi^2} \approx 99.4\,\text{cm}$$

13. A vessel contains 16g of hydrogen and 128 g of oxygen at standard temperature and pressure. The volume of the vessel in cm^3 is :

(A) 72×10^5 (B) 32×10^5

(C) 27×10^4 (D) 54×10^4

Official Ans. by NTA (C)

Allen Ans. (C)

Sol. No of moles of H_2 = 8 moles

No of moles of O_2 = 4 moles

Total moles = 12 moles

At STP 1 mole occupy = $22.4\ell = 22.4 \times 10^3\ cm^3$

12 moles will occupy = $12 \times 22.4 \times 10^3\ cm^3$

$\approx 26.8 \times 10^4\ cm^3$

14. Given below are two statements :

Statement I: The electric force changes the speed of the charged particle and hence changes its kinetic energy: whereas the magnetic force does not change the kinetic energy of the charged particle.

Statement II: The electric force accelerates the positively charged particle perpendicular to the direction of electric field. The magnetic force accelerates the moving charged particle along the direction of magnetic field. In the light of the above statements, choose the most appropriate answer from the options given below:

(A) Both Statement I and Statement II are correct.

(B) Both Statement I and Statement II are incorrect.

(C) Statement I is correct but Statement II is incorrect.

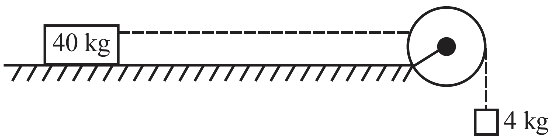
(D) Statement I is incorrect but Statement II is correct.

Official Ans. by NTA (C)

Allen Ans. (C)

Sol. Electric field can change speed and kinetic energy but magnetic field can not change speed Δ KE. Because magnetic force is always ⊥ to velocity.

15. A block of mass 40 kg slides over a surface, when a mass of 4 kg is suspended through an inextensible massless string passing over frictionless pulley as shown below. The coefficient of kinetic friction between the surface and block is 0.02. The acceleration of block is. (Given g = 10 ms^{-2}.)



(A) 1 ms^{-2} (B) 1/5 ms^{-2}

(C) 4/5 ms^{-2} (D) 8/11 ms^{-2}

Official Ans. by NTA (D)

Allen Ans. (D)

Sol. For 4 kg block

$4g - T = 4a$

For 40 kg block

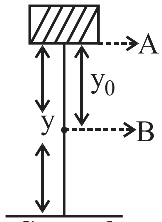
$T - 40g \times 0.02 = 40\ a$

Adding both eq.

$40 - 8 = 44a$

$a = \frac{32}{44} = \frac{8}{11} m/s^2$

16. In the given figure, the block of mass m is dropped from the point 'A'. The expression for kinetic energy of block when it reaches point 'B' is :



(A) $\frac{1}{2}mg y_0^2$ (B) $\frac{1}{2}mg y^2$

(C) $mg(y - y_0)$ (D) mgy_0

Official Ans. by NTA (D)

Allen Ans. (D)

Sol. Work done by gravity = $K_B - K_A$

$mgy_0 = K_B - 0$

$K_B = mgy_0$

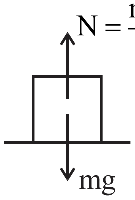
17. A block of mass M placed inside a box descends vertically with acceleration 'a'. The block exerts a force equal to one-fourth of its weight on the floor of the box. The value of 'a' will be :

(A) $\frac{g}{4}$ (B) $\frac{g}{2}$ (C) $\frac{3g}{4}$ (D) g

Official Ans. by NTA (C)

Allen Ans. (C)

Sol.



$mg - N = ma$

$a = g - \frac{g}{4}$

$a = \frac{3g}{4}$

18. If the electric potential at any point (x, y, z)m in space is given by $V = 3x^2$ volt. The electric field at the point (1, 0, 3) m will be :

(A) 3 Vm^{-1}, directed along positive x-axis.

(B) 3 Vm^{-1}, directed along negative x-axis.

(C) 6 Vm^{-1}, directed along positive x-axis.

(D) 6 Vm^{-1}, directed along negative x-axis.

Official Ans. by NTA (D)

Allen Ans. (D)

Sol. $E_x = -\frac{\partial V}{\partial x} = -6x$

At (1, 0, 3)

$\vec{E} = -6V/m\ \hat{i}$

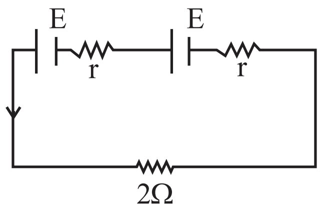
19. The combination of two identical cells, whether connected in series or parallel combination provides the same current through an external resistance of 2Ω. The value of internal resistance of each cell is :

(A) 2Ω (B) 4Ω (C) 6Ω (D) 8Ω

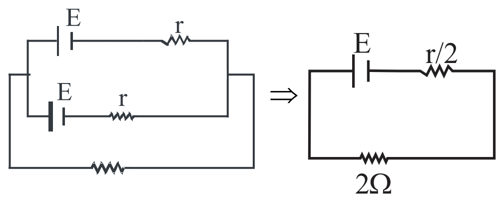
Official Ans. by NTA (A)

Allen Ans. (A)

Sol.



$I_1 = \frac{2E}{2r+2}$



$I_2 = \frac{E}{\frac{r}{2}+2} = \frac{2E}{r+4}$

$I_1 = I_2$

$2r + 2 = r + 4$

$2r - r = 2\Omega \Rightarrow r = 2\Omega$

20. A person can throw a ball upto a maximum range of 100 m. How high above the ground he can throw the same ball?

(A) 25 m (B) 50 m

(C) 100 m (D) 200 m

Official Ans. by NTA (B)

Allen Ans. (B)

Sol. **R =** $\frac{u^2 \sin 2\theta}{g}$ $R_{max} = \frac{u^2}{g} = 100$

$H_{max} = \frac{u^2}{2g} = \frac{100}{2} = 50m$

SECTION-B

1. The vernier constant of Vernier callipers is 0.1 mm and it has zero error of (–0.05) cm. While measuring diameter of a sphere, the main scale reading is 1.7 cm and coinciding vernier division is 5. The corrected diameter will be_____ $\times 10^{-2}$ cm.

Official Ans. by NTA (180)

Allen Ans. (180)

Sol. Measured diameter = MSR + VSR × VC

= 1.7 + 0.01 × 5

= 1.75

Corrected = Measured – Error

= 1.75 – (–0.05)

= 1.80 cm

= 180×10^{-2} cm

180

2. A small spherical ball of radius 0.1 mm and density 10^4 kg m^{-3} falls freely under gravity through a a distance h before entering a tank of water. If after entering the water the velocity of ball does not change and it continue to fall with same constant velocity inside water, then the value of h wil be_____m.

(Given g = 10 ms^{-2}, viscosity of water = 1.0×10^{-5} N-sm^{-2}).

Official Ans. by NTA (20)

Allen Ans. (20)

Sol. Speed after falling through height h

Should be equal to terminal velocity

$$\sqrt{2gh} = \frac{2}{9}\frac{r^2(d-\rho)g}{\eta}$$

$$\sqrt{2gh} = \frac{2}{9}\frac{10^{-8}(10000-1000)\times 10}{10^{-5}}$$

$$= \frac{2}{9}\times 10^{-8}\frac{9\times 10^4}{10^{-5}} = 20$$

$2 \times 10 \times h = 400$

$h = 20$ m

3. In an experiment to determine the velocity of sound in air at room temperature using a resonance is observed when the air column has a length of 20.0 cm for a tuning fork of frequency 400 Hz is used. The velocity of the sound at room temperature is 336 ms^{-1}. The third resonance is observed when the air column has a length of ____cm.

Official Ans. by NTA (104)

Allen Ans. (104)

Sol. For first resonance

$$\ell_1 + e = \frac{\lambda}{4}$$

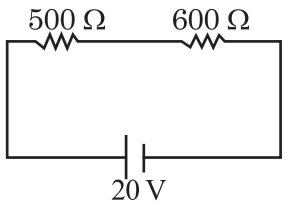
$$\lambda = \frac{336}{400}\times 100 \text{ cm} = 84 \text{ cm} \Rightarrow \frac{\lambda}{4} = 21 \text{ cm}$$

$e = 21 - 20 = 1$ cm

For third resonance

$$\ell_3 + e = \frac{5\lambda}{4} = 105 \text{ cm} \Rightarrow \ell_3 = 104 \text{ cm}$$

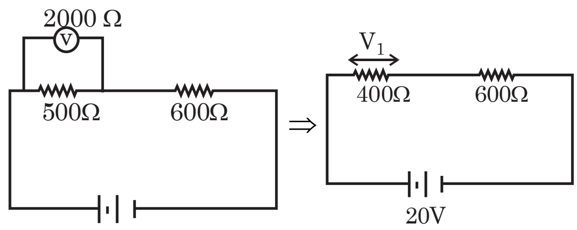
4. Two resistors are connected in series across a battery as shown in figure. If a voltmeter of resistance 2000 Ω is used to measure the potential difference across 500 Ω resister, the reading of the voltmeter will be____V.



Official Ans. by NTA (8)

Allen Ans. (8)

Sol.



$$I = \frac{20}{1000}A$$

$$V_1 = I \times 400 = \frac{20}{1000}\times 400$$

$= 8$ V

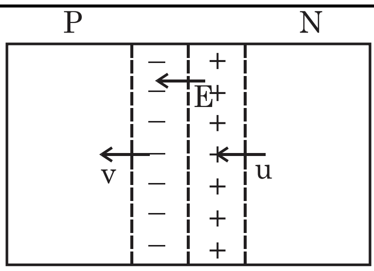
5. A potential barrier of 0.4 V exists across a p-n junction. An electron enters the junction from the n-side with a speed of 6.0×10^5 ms^{-1}. The speed with which electron enters the p side will be $\frac{x}{3}\times 10^5 \, ms^{-1}$ the value of x is _______.

(Given mass of electron = 9×10^{-31} kg, charge on electron = 1.6×10^{-19}C.)

Official Ans. by NTA (14)

Allen Ans. (14)

Sol.



Work done by Electric field = $K_f - K_i$

$$\frac{1}{2}mv^2 - \frac{1}{2}mu^2 = -1.6 - 10^{-19} \times 0.4$$

$$\frac{1}{2}9\times10^{-31}(v^2 - u^2) = -0.64\times10^{-19}$$

$$u^2 - v^2 = \frac{2\times0.64\times10^{12}}{9}$$

$$v^2 = \left(36 - \frac{128}{9}\right)\times10^{10}$$

$$v = \frac{14}{3}\times10^5 m/s$$

x =14

6. The displacement current of 4.425 μA is developed in the space between the plates of parallel plate capacitor when voltage is changing at a rate of 10^6 Vs^{-1}. The area of each plate of the capacitor is 40 cm^2. The distance between each plate of the capacitor is x × 10^{-3}m. The value of x is,

(Permittivity of free space, $E_0 = 8.85 \times 10^{-12}\ C^2\ N^{-1}\ m^{-2}$)

Official Ans. by NTA (8)

Allen Ans. (8)

Sol. Displacement Current = Conduction Current

$$= \frac{dq}{dt}$$

$$I_d = \frac{\epsilon_0 A}{d}\frac{dV}{dt}$$

$$d = \frac{8.85\times10^{-12}\times4\times10^{-3}\times10^6}{4.425\times10^{-6}}$$

= 8 mm

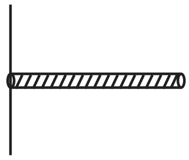
X = 8

7. The moment of inertia of a uniform thin rod about a perpendicular axis passing through one end is I_1. The same rod is bent into a ring and its moment of inertia about a diameter is I_2. If $\frac{I_1}{I_2}$ is $\frac{x\pi^2}{3}$, then the value of x will be_______.

Official Ans. by NTA (8)

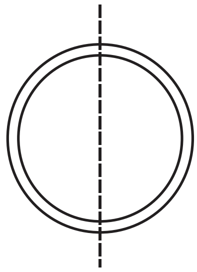
Allen Ans. (8)

Sol.



$$I_1 = \frac{ml^2}{3}$$

$$\ell = 2\pi r \Rightarrow \frac{\ell}{r} = 2\pi$$



$$I_1 = \frac{mr^2}{2}$$

$$\frac{I_1}{I_2} = \frac{2}{3}\left(\frac{\ell}{r}\right)^2$$

$$= \frac{2}{3}\times4\pi^2 = \frac{8\pi^2}{3}$$

x = 8

8. The half life of a radioactive substance is 5 years. After x years a given sample of the radioactive substance gest reduced to 6.25% of its initial value of x is _______.

Official Ans. by NTA (20)

Allen Ans. (20)

Sol. **T1/2 = 5 year**

$$N = N_0\left(\frac{1}{2}\right)^{\text{No of half lives}}$$

$$\frac{N}{N_0} = \frac{1}{16} = \left(\frac{1}{2}\right)^4$$

Time = 4 half lives = 20 years

9. In a double slit experiment with monochromatic light, fringes are obtained on a screen placed at some distance from the plane of slits. If the screen is moved by 5×10^{-2} m towards the slits, the change in fringe width is 3×10^{-3} cm. If the distance between the slits is 1 mm, then the wavelength of the light will be ______nm.

Official Ans. by NTA (600)

Allen Ans. (600)

Sol. $\beta = \frac{\lambda D}{d}$

$\Delta\beta = \frac{\lambda}{d}\Delta D$

$\lambda = \frac{\Delta\beta . d}{\Delta D}$

$= \frac{3\times10^{-5}\times1\times10^{-3}}{5\times10^{-2}}$

$= 60\times10^{-8} = 600 \times 10^{-9}$m

= 600nm

10. An inductor of 0.5 mH, a capacitor of 200 μF and a resistor of 2 Ω are connected in series with a 220 V ac source. If the current is in phase with the emf, the frequency of ac source will be___$\times 10^2$ Hz.

Official Ans. by NTA (5)

Allen Ans. (5)

Sol. If Current is in phase with emf then the frequency of source $= \frac{1}{2\pi\sqrt{LC}}$ (Resonant frequency)

$$\frac{1}{2\pi\sqrt{\frac{1}{2}\times10^{-3}\times2\times10^{-4}}}$$

$= \frac{1}{2\pi}\times\sqrt{10}\times1000 = 500$ Hz