JEE Main 2023 (1st Attempted)
(Shift - 02 Physics Paper) 01.02.2023

PHYSICS | **TEST PAPER WITH SOLUTION**

SECTION-A

1. A Carnot engine operating between two reservoirs has efficiency $\frac{1}{3}$. When the temperature of cold reservoir raised by x, its efficiency decreases to $\frac{1}{6}$. The value of x, if the temperature of hot reservoir is 99° C, will be:

(1) 16.5 K (2) 33 K

(3) 66 K (4) 62 K

Official Ans. by NTA (4)

Allen Ans. (4)

Sol. $T_H = 99°C = 99 + 273$

$= 372$ K.

$$1-\frac{T_C}{T_H}=\frac{1}{3}$$

$$\frac{T_C}{T_H}=\frac{2}{3} \text{ \_\_\_(1)} \Rightarrow T_C=\frac{2}{3}\times 372$$

$$= 2 \times 124 = 248 \text{ K}$$

$$1-\frac{T_C+X}{T_H}=\frac{1}{6}$$

$$\frac{5}{6}=\frac{T_C+X}{T_H}$$

$$\frac{5}{6}=\frac{248+X}{372}$$

$248 + X = 5 \times 62$

$X = 310 - 248 = 62K$

2. Given below are two statements : One is labelled as **Assertion A** and the other is labelled as **Reason R.**

Assertion A : Two metallic spheres are charged to the same potential. One of them is hollow and another is solid, and both have the same radii. Solid sphere will have lower charge than the hollow one.

Reason R : Capacitance of metallic spheres depend on the radii of spheres.

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

(1) **A** is false but **R** is true

(2) Both **A** and **R** are true and **R** is the correct explanation of **A**

(3) **A** is true but **R** is false

(4) Both **A** and **R** are true but **R** is not the correct explanation of **A**

Official Ans. by NTA (1)

Allen Ans. (1)

Sol. Potential of a conducting sphere is

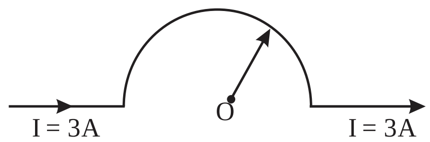
$V=\frac{KQ}{R}$ (Solid as well as hollow)

$V_1 = V_2$ and $R_1 = R_2$

$\therefore Q_1 = Q_2$

3. As shown in the figure, a long straight conductor with semicircular arc of radius $\frac{\pi}{10}$ m is carrying current I = 3A. The magnitude of the magnetic field. at the center O of the arc is:

(The permeability of the vacuum = $4\pi \times 10^{-7}$ NA^{-2})



(1) 6μT (2) 1μT

(3) 4μT (4) 3μT

Official Ans. by NTA (4)

Allen Ans. (4)

Sol. $B_C=\frac{\mu_0 I}{4\pi R}(\pi)$ (B at centre of circular arc)

$$=\frac{\mu_0 I}{4R}=\frac{4\pi\times10^{-7}\times3}{4\times\frac{\pi}{10}}$$

$= 3 \times 10^{-6}$ T = 3μT

4. A coil is placed in magnetic field such that plane of coil is perpendicular to the direction of magnetic field. The magnetic flux through a coil can be changed:

A. By changing the magnitude of the magnetic field within the coil.

B. By changing the area of coil within the magnetic field.

C. By changing the angle between the direction of magnetic field and the plane of the coil.

D. By reversing the magnetic field direction abruptly without changing its magnitude.

Choose the most appropriate answer from the options given below:

(1) **A** and **B** only (2) **A**, **B** and **C** only

(3) **A**, **B** and **D** only (4) **A** and **C** only

Official Ans. by NTA (2)

Allen Ans. (2)

Sol. $\phi = \vec{B}.\vec{A}$

$= BA\cos\theta$

Most suitable ans is 2 [Otherwise ABCD]

5. In an amplitude modulation, a modulating signal having amplitude of X V is superimposed with a carrier signal of amplitude Y V in first case. Then, in second case, the same modulating signal is superimposed with different carrier signal of amplitude 2Y V. The ratio of modulation index in the two case respectively will be:

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

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

Official Ans. by NTA (3)

Allen Ans. (3)

Sol. Modulating Index

$$\mu = \frac{A_m}{A_c}$$

$$\mu_1 = \frac{X}{Y}$$

$$\mu_2 = \frac{X}{2Y}$$

$$\frac{\mu_1}{\mu_2} = \frac{2}{1}$$

6. For a body projected at an angle with the horizontal from the ground, choose the correct statement.

(1) Gravitational potential energy is maximum at the highest point.

(2) The horizontal component of velocity is zero at highest point.

(3) The vertical component of momentum is maximum at the highest point.

(4) The kinetic energy (K.E.) is zero at the highest point of projectile motion.

Official Ans. by NTA (1)

Allen Ans. (1)

Sol. At highest point

$V_y = 0$

$V_x = u_x = u\cos\theta$

$U_g = mgh$, it is maximum at H_{max}.

7. Two objects A and B are placed at 15 cm and 25 cm from the pole in front of a concave mirror having radius of curvature 40 cm. The distance between images formed by the mirror is:

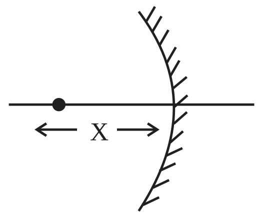
(1) 40 cm (2) 60 cm

(3) 160 cm (4) 100 cm

Official Ans. by NTA (3)

Allen Ans. (3)

Sol.



by mirror formula

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$$

$$\frac{1}{v_1} + \frac{1}{-15} = \frac{1}{(-20)}$$

$$\frac{1}{v_1} = -\frac{1}{20} + \frac{1}{15}$$

$$= \frac{-3+4}{60}$$

$v_1 = 60$ cm

$$\frac{1}{v_2} + \frac{1}{(-25)} = \frac{1}{(-20)}$$

$$\frac{1}{v_2} = \frac{-1}{20} + \frac{1}{25}$$

$$= \frac{-5+4}{100} = \frac{-1}{100}$$

$v_2 = -100$ cm

d = 60 + 100 = 160 cm

8. The Young's modulus of a steel wire of length 6 m and cross-sectional area 3 mm^2, is 2×11^{11} N/m^2. The wire is suspended from its support on a given planet. A block of mass 4 kg is attached to the free end of the wire. The acceleration due to gravity on the planet is $\frac{1}{4}$ of its value on the earth. The elongation of wire is (Take g on the earth = 10 m/s^2):

(1) 1 cm (2) 1 mm

(3) 0.1 mm (4) 0.1 cm

Official Ans. by NTA (3)

Allen Ans. (3)

Sol. Tension (F) = mg

$$= 4 \times \frac{10}{4} = 10\text{N}$$

$$\Delta L = \frac{FL}{AY}$$

$$= \frac{10 \times 6}{3 \times 10^{-6} \times 2 \times 10^{11}}$$

$= 10^{-4}$ m = 0.1 mm

9. Equivalent resistance between the adjacent corners of a regular n-sided polygon of uniform wire of resistance R would be:

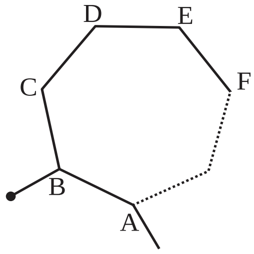
(1) $\frac{(n-1)R}{n^2}$ (2) $\frac{(n-1)R}{(2n-1)}$

(3) $\frac{n^2R}{n-1}$ (4) $\frac{(n-1)R}{n}$

Official Ans. by NTA (1)

Allen Ans. (1)

Sol.



Suppose resistance of each arm is r, then r = R/n

$$R_{eq(AB)} = \frac{R_1R_2}{R_1 + R_2}$$

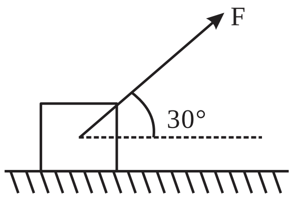
$$\frac{r(n-1)r}{r+(n-1)r}$$

$$= \frac{r(n-1)r}{nr}$$

$$= \frac{n-1}{n}r$$

$$= \frac{(n-1)R}{n^2}$$

10. As shown in the figure a block of mass 10 kg lying on a horizontal surface is pulled by a force F acting at an angle 30°, with horizontal. For $\mu_s = 0.25$, the block will just start to move for the value of F: [Given g = 10 ms^{-2}]



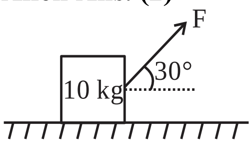
(1) 33.3 N (2) 25.2 N

(3) 20 N (4) 35.7 N

Official Ans. by NTA (2)

Allen Ans. (2)

Sol.



N = Mg – F Sin 30°

$$= mg - \frac{F}{2} = 100 - \frac{F}{2} = \frac{200-F}{2}$$

F Cos 30° = μN

$$\sqrt{3}\frac{F}{2} = 0.25 \times \left(\frac{200-F}{2}\right)$$

$$4\sqrt{3}F = 200 - F$$

$$F = \frac{200}{4\sqrt{3}+1} = 25.22$$

11. Given below are two statements : One is labelled as **Assertion A** and the other is labelled as **Reason R**.

Assertion A : For measuring the potential difference across a resistance of 600 Ω, the voltmeter with resistance 1000 Ω will be preferred over voltmeter with resistance 4000 Ω.

Reason R : Voltmeter with higher resistance will draw smaller current than voltmeter with lower resistance.

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

(1) **A** is not correct but **R** is correct

(2) Both **A** and **R** are correct and **R** is the correct explanation of **A**

(3) Both **A** and **R** are correct but **R** is not the correct explanation of **A**

(4) **A** is correct but **R** is not correct

Official Ans. by NTA (1)

Allen Ans. (1)

Sol. Error of voltmeter decreases with increase in its resistance.

12. Choose the correct statement about Zener diode:

(1) It works as a voltage regulator in reverse bias and behaves like simple pn junction diode in forward bias.

(2) It works as a voltage regulator in both forward and reverse bias.

(3) It works a voltage regulator only in forward bias.

(4) It works as a voltage regulator in forward bias and behaves like simple pn junction diode in reverse bias.

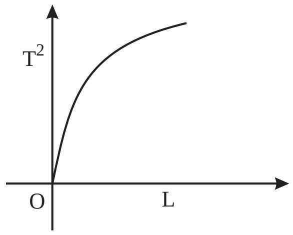
Official Ans. by NTA (1)

Allen Ans. (1)

Sol. Woks as voltage regulator in reverse bias and as simple P-n junction in forward bias.

13. Choose the correct length (L) versus square of time period (T^2) graph for a simple pendulum executing simple harmonic motion.

(1)



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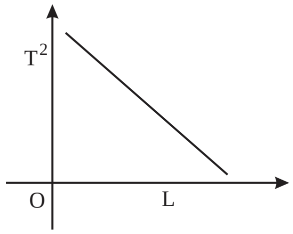
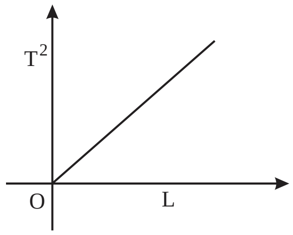
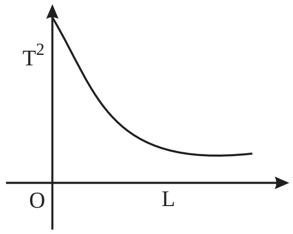


(3)



(4)



Official Ans. by NTA (3)

Allen Ans. (3)

Sol. $T = 2\pi\sqrt{\frac{\ell}{g}}$

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

$T^2 \; \alpha \; \ell$

14. The escape velocities of two planets A and B are in the ratio 1 : 2. If the ratio of their radii respectively is 1 : 3, then the ratio of acceleration due to gravity of planet A to the acceleration of gravity of planet B will be:

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

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

Official Ans. by NTA (4)

Allen Ans. (4)

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Sol. $V_e = \sqrt{\frac{2GM}{R}} = \sqrt{\frac{2G\rho\frac{4}{3}\pi R^3}{R}} = C\sqrt{\rho}.R$

$\frac{V_{e_1}}{V_{e_2}} = \frac{R_1}{R_2}\sqrt{\frac{\rho_1}{\rho_2}} = \frac{1}{2}$

$\frac{R_1^2}{R_2^2} \times \frac{\rho_1}{\rho_2} = \frac{1}{4}$

$\frac{R_1}{R_2} = \frac{1}{3}$

$g = \frac{GM}{R^2} = \frac{G\frac{4}{3}\pi R^3 \times \rho}{R^2} C.\rho R$

$\frac{g_1}{g_2} = \frac{\rho_1 R_1}{\rho_2 R_2} = \frac{1}{4}\frac{R_2^2}{R_1^2} \times \frac{R_1}{R_2}$

$= \frac{1}{4} \times \frac{R_2}{R_1} = \frac{3}{4}$

15. An electron of a hydrogen like atom, having Z = 4, jumps from 4[th] energy state to 2[nd] energy state, The energy released in this process, will be:

(Given Rch = 13.6 eV)

Where R = Rydberg constant

c = Speed of light in vacuum

h = Planck's constant

(1) 13.6 eV

(2) 10.5 eV

(3) 3.4 eV

(4) 40.8 eV

Official Ans. by NTA (4)

Allen Ans. (4)

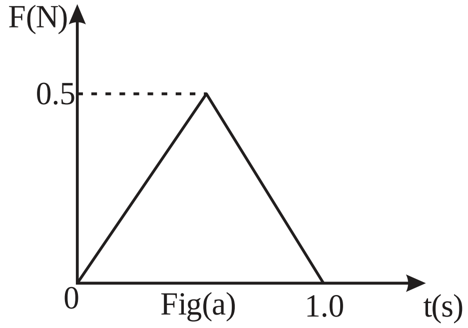
Sol. $\Delta E = 13.6Z^2\left[\frac{1}{2^2} - \frac{1}{4^2}\right]eV$

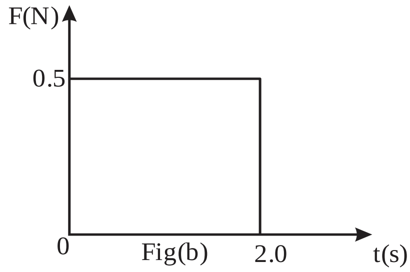
$= 13.6 \times (4)^2\left(\frac{1}{4} - \frac{1}{16}\right)eV.$

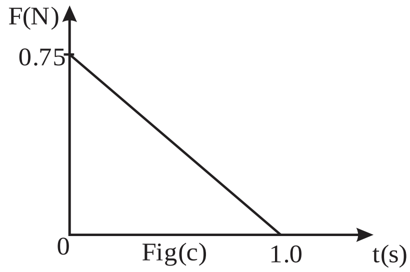
$= 13.6[4-1]eV$

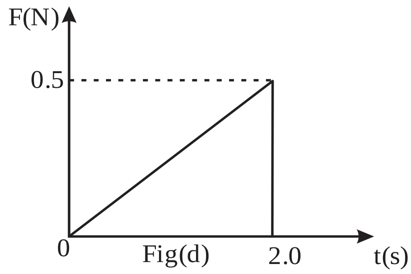
= 13.6 × 3 = 40.8 eV

16. Figures (a), (b), (c) and (d) show variation of force with time.









The impulse is highest in figure.

(1) Fig (c) (2) Fig (b)

(3) Fig (a) (4) Fig (d)

Official Ans. by NTA (2)

Allen Ans. (2)

Sol. Impulse = Area under F = t curve

(a) $\frac{1}{2} \times 1 \times 0.5 = \frac{1}{4}$N.s

(b) 0.5 × 2 = 1 N.s (maximum)

(c) $\frac{1}{2} \times 1 \times 0.75 = \frac{3}{8}$N.s

(d) $\frac{1}{2} \times 2 \times 0.5 = \frac{1}{2}$ N.s

17. If the velocity of light c, universal gravitational constant G and planck's constant h are chosen as fundamental quantities. The dimensions of mass in the new system is:

(1) $\left[h^{\frac{1}{2}}c^{-\frac{1}{2}}G^{1}\right]$ (2) $\left[h^{1}c^{1}G^{-1}\right]$

(3) $\left[h^{-\frac{1}{2}}c^{\frac{1}{2}}G^{\frac{1}{2}}\right]$ (4) $\left[h^{\frac{1}{2}}c^{\frac{1}{2}}G^{-\frac{1}{2}}\right]$

Official Ans. by NTA (4)

Allen Ans. (4)

Sol. Say dimensional formale of mass is $H^x C^y G^z$

$M^1 = (ML^2T^{-1})^x (LT^{-1}) (M^{-1}L^3T^{-2})^Z$

$M^1L^0T^0 = M^{x-z} L^{2x+y+3z} T^{-x-y-2z}$

on comparing both side

$x - z = 1$

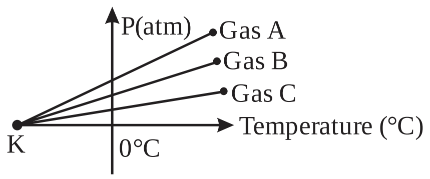
$2x + y + 3z = 0$

$-x - y - 2z = 0$

On solving above equations we get

$x = \frac{1}{2} \quad y = \frac{1}{2} \quad z = \frac{-1}{2}$

18. For three low density gases A, B, C pressure versus temperature graphs are plotted while keeping them at constant volume, as shown in the figure.



The temperature corresponding to the point 'K' is:

(1) –273°C (2) –100°C

(3) –373°C (4) –40°C

Official Ans. by NTA (1)

Allen Ans. (1)

Sol. For isochoric process

$\frac{P}{T} = n\frac{R}{V} = \text{constant}$

$P = \frac{nR}{V}(t + 273)$

If $P = 0 \Rightarrow t = -273°C$

19. The ratio of average electric energy density and total average energy density of electromagnetic wave is:

(1) 2 (2) 1

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

Official Ans. by NTA (4)

Allen Ans. (4)

Sol. $< u_E > = < u_B > = \frac{1}{2} < u_{total} >$

So $\frac{\langle u_E \rangle}{\langle u_{total} \rangle} = \frac{1}{2}$

20. The threshold frequency of metal is f_0. When the light of frequency $2f_0$ is incident on the metal plate, the maximum velocity of photoelectron is v_1. When the frequency of incident radiation is increased to $5f_0$. the maximum velocity of photoelectrons emitted is v_2. The ratio of v_1 to v_2 is:

(1) $\frac{v_1}{v_2} = \frac{1}{2}$ (2) $\frac{v_1}{v_2} = \frac{1}{8}$

(3) $\frac{v_1}{v_2} = \frac{1}{16}$ (4) $\frac{v_1}{v_2} = \frac{1}{4}$

Official Ans. by NTA (1)

Allen Ans. (1)

Sol. $K_{max} = hf - hf_0$

For $f = 2f_0$

$\frac{1}{2} m V_1^2 = 2hf_0 - hf_0 = hf_0$

For $f = 5f_0$

$\frac{1}{2} m V_2^2 = 5hf_0 - hf_0 = 4hf_0$

$\frac{V_1}{V_2} = \frac{1}{2}$

SECTION-B

21. For a train engine moving with speed of 20 ms^{-1}, the driver must apply brakes at a distance of 500 m before the station for the train to come to rest at the station. If the brakes were applied at half of this distance, the train engine would cross the station with speed $\sqrt{x}$ ms^{-1}. The value of x is ______ (Assuming same retardation is produced by brakes)

Official Ans. by NTA (200)

Allen Ans. (200)

Sol. u = 20 m/s, S_1 = 500 m, v = 0

By third equation of mation

$0 = (20)^2 - 2a.\ 500 \Rightarrow a = \frac{4}{10} m/s^2$

u = 20 m/s, S_2 = 250 m, v = ?

$v^2 = (20)^2 - 2a.\ 250$

$= v = \sqrt{200} m/s$

x = 200

22. A force F = (5 + $3y^2$) acts on a particle in the y-direction, where F is newton and y is in meter. The work done by the force during a displacement from y = 2m to y = 5m is ______j.

Official Ans. by NTA (132)

Allen Ans. (132)

Sol. $F = 5 + 3y^2$

$W = \int_2^5 (5 + 3y^2) dy$

$= \left[5y + \frac{3y^3}{3}\right]_2^5$

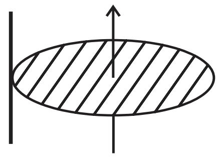
= 132 J

23. Moment of inertia of a dise of mass M and radius 'R' about any of its diameter is $\frac{MR^2}{4}$. The moment of inertia of this disc about an axis normal to the disc and passing through a point on its edge will be, $\frac{x}{2}$ MR^2. The value of x is _____.

Official Ans. by NTA (3)

Allen Ans. (3)

Sol.



$I = I_{cm} + Md^2$

$= \frac{MR^2}{2} + MR^2$

$= \frac{3}{2} MR^2$

x = 3

24. Nucleus a having Z = 17 and equal number of protons and neutrons has 1.2 MeV binding energy per nucleon.

Another nucleus B of Z = 12 has total 26 nucleons and 1.8 MeV binding energy per nucleons.

The difference of binding energy of B and A will be ____MeV.

Official Ans. by NTA (6)

Allen Ans. (6)

Sol. For A mass number = 34

Total binding energy = 1.2 × 34 = 40.8 MeV

For B mass number = 26

total binding energy = 1.8 × 26 MeV

= 46.8 MeV

Difference of BE = 6 MeV

25. A square shaped coil of area 70 cm^2 having 600 turns rotates in a magnetic field of 0.4 wbm^{-2}, about an axis which is parallel to one of the side of the coil and perpendicular to the direction of field. If the coil completes 500 revolution in a minute, the instantaneous emf when the plane of the coil is inclined at 60° with the field, will be ____ V. (Take $\pi = \frac{22}{7}$)

Official Ans. by NTA (44)

Allen Ans. (44)

Sol. N = 600, A = 70 × 10^{-4} m^2, B = 0.4T

$\omega = \frac{500 \times 2\pi}{60} = \frac{100\pi}{6} rad/s$

E= NABω sinωt   ωt is angle b/w $\vec{A}$ & $\vec{B}$

$= 600 \times 70 \times 10^{-4} \times 0.4 \times \frac{100\pi}{6} \times \frac{1}{2}$

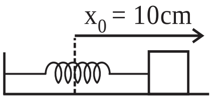
= 44 V

26. A block is fastened to a horizontal spring. The block is pulled to a distance x = 10 cm from its equilibrium position (at x = 0) on a frictionless surface from rest. The energy of the block at x = 5 cm is 0.25 J. The spring constant of the spring is ____Nm^{-1}.

Official Ans. by NTA (50)

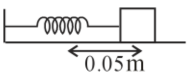
Allen Ans. (67)

Sol.



$$U_i = \frac{1}{2}kx_0^2$$

$K_i = 0$



$$U_f = \frac{1}{2}k\left(\frac{x_0}{2}\right)^2$$

$K_f = 0.25$ J

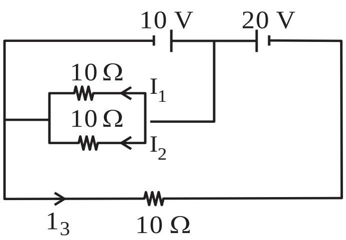
$$\frac{1}{2}kx_0^2 + 0 = \frac{1}{2}k\frac{x_0^2}{4} + 0.25$$

$$\frac{1}{2}kx_0^2\frac{3}{4} = \frac{1}{4}$$

$$\frac{1}{2}k\frac{3}{100} = 1 \Rightarrow k = \frac{200}{3}\,N/m$$

= 67 N/m

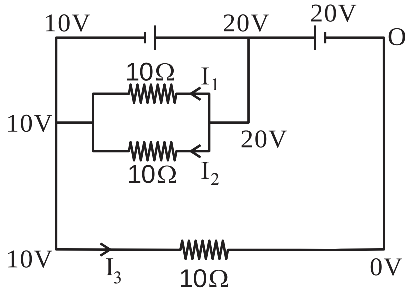
27. In the given circuit the value of $\left|\frac{I_1 + I_3}{I_2}\right|$ is:



Official Ans. by NTA (2)

Allen Ans. (2)

Sol.

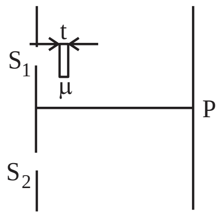


$$I_1 = I_2 = \frac{20-10}{10} = 1A$$

$I_3 = 1A$

$$\left|\frac{I_1 + I_3}{I_2}\right| = 2$$

28. As shown in the figure, in Young's double slit experiment, a thin plate of thickness t = 10 μm and refractive index μ = 1.2 is inserted infront of slit S_1. The experiment is conducted in air (μ = 1) and uses a monochromatic light of wavelength λ = 500 nm. Due to the insertion of the plate, central maxima is shifted by a distance of $x\beta_0$. β_0 is the fringe-width before the insertion of the plate. The value of the x is_____.



Official Ans. by NTA (4)

Allen Ans. (4)

Sol. Fringe shift = $\frac{t(\mu-1)}{\lambda}B$

$$= \frac{10\times10^{-6}(1.2-1)}{5\times10^{-7}}B$$

$$= \frac{10^{-5}\times0.2}{5\times10^{-7}} = 4$$

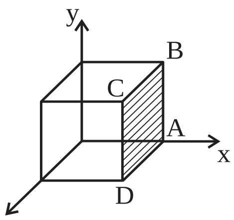
29. A cubical volume is bounded by the surfaces $x = 0, x = a, y = 0, y = a, z = 0, z = a$. The electric field in the region is given by $\vec{E} = E_0 x\hat{i}$. Where $E_0 = 4 \times 10^4$ NC^{-1} m^{-1}. If a = 2 cm, the charge contained in the cubical volume is $Q \times 10^{-14}$C. The value of Q is____.

Take $\in_0 = 9 \times 10^{-12}$ C^2/Nm^2)

Official Ans. by NTA (288)

Allen Ans. (288)

Sol.



$\vec{E} = E_0 x\hat{i}$

$\phi_{net} = \phi_{ABCD} = E_0 a.a^2$

$\frac{q_{en}}{\in_0} = E_0 a^3$

$q_{en} = E_0 \in_0 a^3$

$= 4 \times 10^4 \times 9 \times 10^{-12} \times 8 \times 10^{-6}$

$= 288 \times 10^{-14}$ C

Q = 288

Ans. 288

30. The surface of water in a water tank of cross section area 750 cm^2 on the top of a house is *h* m. above the tap level. The speed of water coming out through the tap of cross section area 500 mm^2 is 30 cm/s. At that instant, $\frac{dh}{dt}$ is $x \times 10^{-3}$ m/s. The value of x will be_____.

Official Ans. by NTA (2)

Allen Ans. (2)

Sol. $A_1V_1 = A_2 V_2$

$750 \times 10^{-4} V_1 = 500 \times 10^{-6} \times 0.3$

$V_1 = \frac{500 \times 3 \times 10^{-3}}{750}$ m / s

$= 2 \times 10^{-3}$ m/s

$\frac{dh}{dt} = -2 \times 10^{-3}$ m / s