RANKERS JEE | NEET | FOUNDATION

JEE Main 2024
(Shift - 02 Physics Paper) 01.02.2024

PHYSICS | **TEST PAPER WITH SOLUTION**

SECTION-A

31. In an ammeter, 5% of the main current passes through the galvanometer. If resistance of the galvanometer is G, the resistance of ammeter will be :

(1) $\frac{G}{200}$

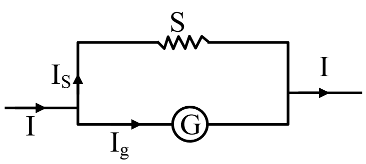
(2) $\frac{G}{199}$

(3) 199 G

(4) 200 G

Ans. (Bonus)

Sol.



$I_S S = I_g G$

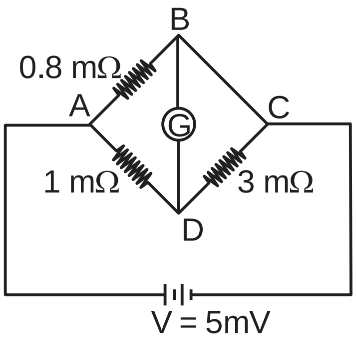
$\frac{95}{100} IS = \frac{5I}{100} G$

$S = \frac{G}{19}$

$R_A = \frac{SG}{S+G} = \frac{\frac{G^2}{19}}{\frac{20G}{19}}$

$R_A = \frac{G}{20}$

32. To measure the temperature coefficient of resistivity α of a semiconductor, an electrical arrangement shown in the figure is prepared. The arm BC is made up of the semiconductor. The experiment is being conducted at 25°C and resistance of the semiconductor arm is 3 mΩ. Arm BC is cooled at a constant rate of 2°C/s. If the galvanometer G shows no deflection after 10s, then α is :



(1) $-2 \times 10^{-2}\,°C^{-1}$

(2) $-1.5 \times 10^{-2}\,°C^{-1}$

(3) $-1 \times 10^{-2}\,°C^{-1}$

(4) $-2.5 \times 10^{-2}\,°C^{-1}$

Ans. (3)

Sol. For no deflection $\frac{0.8}{1} = \frac{R}{3}$

$\Rightarrow R = 2.4 m\Omega$

Temperature fall in 10s = 20°C

$\Delta R = R\,\alpha\,\Delta t$

$\alpha = \frac{\Delta R}{R\Delta t} = \frac{-0.6}{3 \times 20}$

$= -10^{-2} C^{-1}$

33. From the statements given below :

(A) The angular momentum of an electron in n^{th} orbit is an integral multiple of h.

(B) Nuclear forces do not obey inverse square law.

(C) Nuclear forces are spin dependent.

(D) Nuclear forces are central and charge independent.

(E) Stability of nucleus is inversely proportional to the value of packing fraction.

Choose the correct answer from the options given below :

(1) (A), (B), (C), (D) only
(2) (A), (C), (D), (E) only
(3) (A), (B), (C), (E) only
(4) (B), (C), (D), (E) only

Ans. **(3)**

Sol. Part of theory

34. A diatomic gas (γ = 1.4) does 200 J of work when it is expanded isobarically. The heat given to the gas in the process is :

(1) 850 J
(2) 800 J
(3) 600 J
(4) 700 J

Ans. **(4)**

Sol. $\gamma = 1 + \frac{2}{f} = 1.4 \Rightarrow \frac{2}{f} = 0.4$

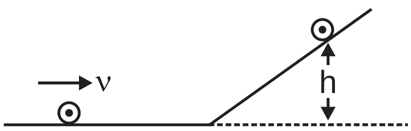
$\Rightarrow f = 5$

$W = n R \Delta T = 200J$

$Q = \left(\frac{f+2}{2}\right) nR\Delta T$

$= \frac{7}{2} \times 200 \quad = 700 \text{ J}$

35. A disc of radius R and mass M is rolling horizontally without slipping with speed v. It then moves up an inclined smooth surface as shown in figure. The maximum height that the disc can go up the incline is :



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

Ans. **(3)**

Sol. Only the translational kinetic energy of disc changes into gravitational potential energy. And rotational KE remains unchanged as there is no friction.

$\frac{1}{2}mv^2 = mgh$

$h = \frac{v^2}{2g}$

36. Conductivity of a photodiode starts changing only if the wavelength of incident light is less than 660 nm. The band gap of photodiode is found to be $\left(\frac{X}{8}\right)$eV . The value of X is :

(Given, $h = 6.6 \times 10^{-34}$ Js, $e = 1.6 \times 10^{-19}$C)

(1) 15
(2) 11
(3) 13
(4) 21

Ans. **(1)**

Sol. $E_g = \frac{hc}{\lambda} = \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{660 \times 10^{-9}} \text{ J}$

$= \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{660 \times 10^{-9} \times 1.6 \times 10^{-19}} \text{eV}$

$= \frac{15}{8} \text{eV}$

So x = 15

37. A big drop is formed by coalescing 1000 small droplets of water. The surface energy will become :

(1) 100 times
(2) 10 times
(3) $\frac{1}{100}$th
(4) $\frac{1}{10}$th

Ans. **(4)**

Sol. Lets say radius of small droplets is r and that of big drop is R

$\frac{4}{3}\pi R^3 = 1000 \frac{4}{3}\pi r^3$

$R = 10r$

$U_i = 1000\,(4\pi r^2 S)$

$U_f = 4\pi R^2 S$

$= 100\,(4\pi r^2 S)$

$U_f = \frac{1}{10} U_i$

38. If frequency of electromagnetic wave is 60 MHz and it travels in air along z direction then the corresponding electric and magnetic field vectors will be mutually perpendicular to each other and the wavelength of the wave (in m) is :

(1) 2.5 (2) 10

(3) 5 (4) 2

Ans. (3)

Sol. $\lambda = \frac{c}{f} = \frac{3\times10^8}{60\times10^6} = 5m$

39. A cricket player catches a ball of mass 120 g moving with 25 m/s speed. If the catching process is completed in 0.1 s then the magnitude of force exerted by the ball on the hand of player will be (in SI unit):

(1) 24 (2) 12

(3) 25 (4) 30

Ans. (4)

Sol. $F_{av} = \frac{\Delta p}{\Delta t}$

$= \frac{0.12\times25}{0.1} = 30N$

40. Monochromatic light of frequency 6×10^{14} Hz is produced by a laser. The power emitted is 2×10^{-3} W. How many photons per second on an average, are emitted by the source ?

(Given $h = 6.63 \times 10^{-34}$ Js)

(1) 9×10^{18} (2) 6×10^{15}

(3) 5×10^{15} (4) 7×10^{16}

Ans. (3)

Sol. $P = nh\nu$

$n = \frac{P}{h\nu} = \frac{2\times10^{-3}}{6.63\times10^{-34}\times6\times10^{14}}$

$= 5 \times 10^{15}$

41. A microwave of wavelength 2.0 cm falls normally on a slit of width 4.0 cm. The angular spread of the central maxima of the diffraction pattern obtained on a screen 1.5 m away from the slit, will be:

(1) 30° (2) 15°

(3) 60° (4) 45°

Ans. (3)

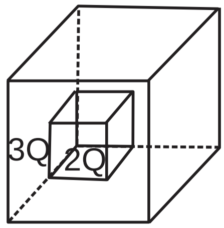
Sol. For first minima a $\sin\theta = \lambda$

$\sin\theta = \frac{\lambda}{a} = \frac{1}{2}$

$\theta = 30°$

Angular spread = 60°

42. C_1 and C_2 are two hollow concentric cubes enclosing charges 2Q and 3Q respectively as shown in figure. The ratio of electric flux passing through C_1 and C_2 is :



(1) 2 : 5 (2) 5 : 2

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

Ans. (1)

Sol. $\phi_{\text{smaller cube}} = \frac{2Q}{\epsilon_0}$

$\phi_{\text{bigger cube}} = \frac{5Q}{\epsilon_0}$

$\frac{\phi_{\text{smaller cube}}}{\phi_{\text{bigger cube}}} = \frac{2}{5}$

43. If the root mean square velocity of hydrogen molecule at a given temperature and pressure is 2 km/s, the root mean square velocity of oxygen at the same condition in km/s is :

(1) 2.0 (2) 0.5

(3) 1.5 (4) 1.0

Ans. (2)

Sol. $V_{rms} = \sqrt{\frac{3RT}{M}}$

$\frac{V_1}{V_2} = \sqrt{\frac{M_2}{M_1}} \Rightarrow \frac{2}{V_2} = \sqrt{\frac{32}{2}}$

$V_2 = 0.5$ km/s

44. Train A is moving along two parallel rail tracks towards north with speed 72 km/h and train B is moving towards south with speed 108 km/h. Velocity of train B with respect to A and velocity of ground with respect to B are (in ms^{-1}) :

(1) –30 and 50

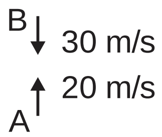
(2) –50 and –30

(3) –50 and 30

(4) 50 and –30

Ans. **(3)**

Sol.



$V_A = 20$ m/s

$V_B = -30$ m/s

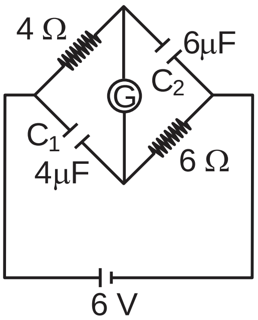
Velocity of B w.r.t. A

$V_{B/A} = -50$ m/s

Velocity of ground w.r.t. B

$V_{G/B} = 30$ m/s

45. A galvanometer (G) of 2Ω resistance is connected in the given circuit. The ratio of charge stored in C_1 and C_2 is :



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

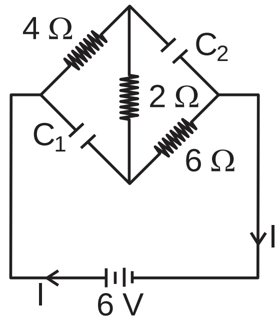
(2) $\frac{3}{2}$

(3) 1

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

Ans. **(4)**

Sol.



In steady state

Req = 12Ω

$$I = \frac{6}{12} = 0.5A$$

P.D across $C_1 = 3V$

P.D acoross $C_2 = 4V$

$q_1 = C_1V_1 = 12\ \mu C$

$q_2 = C_2V_2 = 24\ \mu C$

$$\frac{q_1}{q_2} = \frac{1}{2}$$

46. In a metre-bridge when a resistance in the left gap is 2Ω and unknown resistance in the right gap, the balance length is found to be 40 cm. On shunting the unknown resistance with 2Ω, the balance length changes by :

(1) 22.5 cm

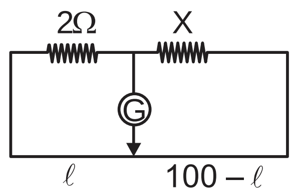
(2) 20 cm

(3) 62.5 cm

(4) 65 cm

Ans. **(1)**

Sol.



First case $\frac{2}{40} = \frac{X}{60} \Rightarrow X = 3\Omega$

In second case $X' = \frac{2\times 3}{2+3} = 1.2\Omega$

$$\frac{2}{\ell} = \frac{1.2}{100-\ell}$$

$200 - 2\ell = 1.2\ell$

$$\ell = \frac{200}{3.2} = 62.5\text{cm}$$

Balance length changes by 22.5 cm

47. Match List - I with List - II.

List - I (Number)	**List - II (Significant figure)**
(A) 1001	(I) 3
(B) 010.1	(II) 4
(C) 100.100	(III) 5
(D) 0.0010010	(IV) 6

Choose the correct answer from the options given below :

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

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

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

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

Ans. **(3)**

Sol. Theoretical

48. A transformer has an efficiency of 80% and works at 10 V and 4 kW. If the secondary voltage is 240 V, then the current in the secondary coil is :

(1) 1.59 A (2) 13.33 A

(3) 1.33 A (4) 15.1 A

Ans. **(2)**

Sol. Efficiency $= \frac{E_S I_S}{E_P I_P}$

$$0.8 = \frac{240 I_S}{4000}$$

$$I_S = \frac{3200}{240} = 13.33\text{A}$$

49. A light planet is revolving around a massive star in a circular orbit of radius R with a period of revolution T. If the force of attraction between planet and star is proportional to $R^{-3/2}$ then choose the correct option :

(1) $T^2 \propto R^{5/2}$ (2) $T^2 \propto R^{7/2}$

(3) $T^2 \propto R^{3/2}$ (4) $T^2 \propto R^3$

Ans. **(1)**

Sol. $F = \frac{GMm}{R^{3/2}} = m\omega^2 R$

$\omega^2 \propto \frac{1}{R^{5/2}} \quad \because T = \frac{2\pi}{\omega}$ so

$T^2 \propto R^{5/2}$

50. A body of mass 4 kg experiences two forces $\vec{F}_1 = 5\hat{i} + 8\hat{j} + 7\hat{k}$ and $\vec{F}_2 = 3\hat{i} - 4\hat{j} - 3\hat{k}$. The acceleration acting on the body is :

(1) $-2\hat{i} - \hat{j} - \hat{k}$

(2) $4\hat{i} + 2\hat{j} + 2\hat{k}$

(3) $2\hat{i} + \hat{j} + \hat{k}$

(4) $2\hat{i} + 3\hat{j} + 3\hat{k}$

Ans. **(3)**

Sol. Net force $= 8\hat{i} + 4\hat{j} + 4\hat{k}$

$$\vec{a} = \frac{\vec{F}}{m} = 2\hat{i} + \hat{j} + \hat{k}$$

SECTION-B

51. A mass m is suspended from a spring of negligible mass and the system oscillates with a frequency f_1. The frequency of oscillations if a mass 9 m is suspended from the same spring is f_2. The value of $\frac{f_1}{f_2}$ is ____.

Ans. **(3)**

Sol. $f_1 = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$

$$f_2 = \frac{1}{2\pi}\sqrt{\frac{k}{9m}}$$

$$\frac{f_1}{f_2} = \sqrt{\frac{9}{1}} = \frac{3}{1}$$

52. A particle initially at rest starts moving from reference point. x = 0 along x-axis, with velocity v that varies as $v = 4\sqrt{x}\,\text{m/s}$. The acceleration of the particle is ____ms^{-2}.

Ans. **(8)**

Sol. $V = 4\sqrt{x}$

$$a = V\frac{dv}{dx}$$

$$= 4\sqrt{x} \times 4 \times \frac{1}{2}x^{-1/2} = 8\text{ m/s}^2$$

53. A moving coil galvanometer has 100 turns and each turn has an area of 2.0 cm^2. The magnetic field produced by the magnet is 0.01 T and the deflection in the coil is 0.05 radian when a current of 10 mA is passed through it. The torsional constant of the suspension wire is $x \times 10^{-5}$ N-m/rad. The value of x is___.

Ans. **(4)**

Sol. $\tau = BINA\sin\phi$

$C\theta = BINA\sin 90°$

$$C = \frac{BINA}{\theta} = \frac{0.01 \times 10 \times 10^{-3} \times 100 \times 2 \times 10^{-4}}{0.05}$$

$= 4 \times 10^{-5}$ N-m/rad.

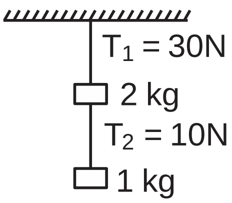
$x = 4$

54. One end of a metal wire is fixed to a ceiling and a load of 2 kg hangs from the other end. A similar wire is attached to the bottom of the load and another load of 1 kg hangs from this lower wire. Then the ratio of longitudinal strain of upper wire to that of the lower wire will be___.

[Area of cross section of wire = 0.005 cm^2, $Y = 2 \times 10^{11}$ Nm^{-2} and $g = 10$ ms^{-2}]

Ans. **(3)**

Sol.



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

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

$$\frac{\frac{\Delta L_1}{L_1}}{\frac{\Delta L_2}{L_2}} = \frac{F_1}{F_2} = \frac{30}{10} = 3$$

55. A particular hydrogen - like ion emits the radiation of frequency 3×10^{15} Hz when it makes transition from n = 2 to n = 1. The frequency of radiation emitted in transition from n = 3 to n = 1 is $\frac{x}{9} \times 10^{15}$ Hz, when x = ______.

Ans. **(32)**

Sol. $$E = -13.6z^2\left(\frac{1}{n_i^2} - \frac{1}{n_f^2}\right)$$

$$E = C\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

$$h\nu = C\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right]$$

$$\frac{\nu_1}{\nu_2} = \frac{\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right]_{2-1}}{\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right]_{3-1}}$$

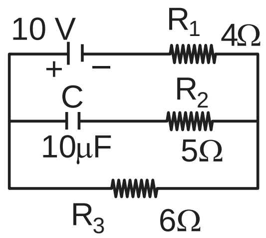
$$= \frac{\left[\frac{1}{1} - \frac{1}{4}\right]}{\left[\frac{1}{1} - \frac{1}{9}\right]} = \frac{3/4}{8/9}$$

$$= \frac{3}{4} \times \frac{9}{8}$$

$$\frac{\nu_1}{\nu_2} = \frac{27}{32}$$

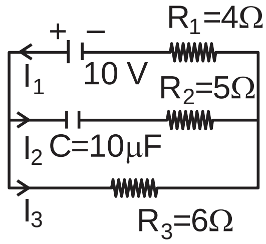
$$\nu_2 = \frac{32}{27}\nu_1 = \frac{32}{27} \times 3 \times 10^{15}\,\text{Hz} = \frac{32}{9} \times 10^{15}\,\text{Hz}$$

56. In an electrical circuit drawn below the amount of charge stored in the capacitor is ___μC.



Ans. **(60)**

Sol.



In steady state there will be no current in branch of capacitor, so no voltage drop across $R_2 = 5\Omega$

$I_2 = 0$

$$I_1 = I_3 = \frac{10}{4+6} = 1A$$

$V_{R_3} = V_c + V_{R_2}$ $\qquad$ $V_{R_2} = 0$

$I_3R_3 = V_c$

$V_c = 1 \times 6 = 6$ volt

$q_c = CV_c = 10 \times 6 = 60\ \mu C$

57. A coil of 200 turns and area 0.20 m^2 is rotated at half a revolution per second and is placed in uniform magnetic field of 0.01 T perpendicular to axis of rotation of the coil. The maximum voltage generated in the coil is $\frac{2\pi}{\beta}$ volt. The value of β is__.

Ans. **(5)**

Sol. $\phi = NAB\cos(\omega t)$

$$\varepsilon = -\frac{d\phi}{dt} = NAB\omega\sin(\omega t)$$

$\varepsilon_{max} = NAB\omega$

$= 200 \times 0.2 \times 0.01 \times \pi$

$$= \frac{4\pi}{10} = \frac{2\pi}{5} \text{volt}$$

58. In Young's double slit experiment, monochromatic light of wavelength 5000 Å is used. The slits are 1.0 mm apart and screen is placed at 1.0 m away from slits. The distance from the centre of the screen where intensity becomes half of the maximum intensity for the first time is___$\times 10^{-6}$ m.

Ans. **(125)**

Sol. Let intensity of light on screen due to each slit is I_0

So internity at centre of screen is $4I_0$

Intensity at distance y from centre-

$$I = I_0 + I_0 + 2\sqrt{I_0 I_0}\cos\phi$$

$I_{max} = 4I_0$

$$\frac{I_{max}}{2} = 2I_0 = 2I_0 + 2I_0\cos\phi$$

$\cos\phi = 0$

$$\phi = \frac{\pi}{2}$$

$$K\Delta x = \frac{\pi}{2}$$

$$\frac{2\pi}{\lambda} d\sin\theta = \frac{\pi}{2}$$

$$\frac{2}{\lambda} d \times \frac{y}{D} = \frac{1}{2}$$

$$y = \frac{\lambda D}{4d} = \frac{5\times10^{-7}\times1}{4\times10^{-3}}$$

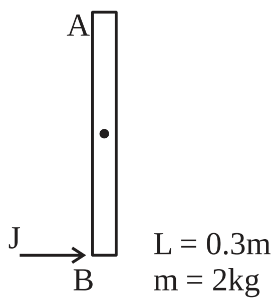
$= 125 \times 10^{-6}$

$= 125$

59. A uniform rod AB of mass 2 kg and Length 30 cm at rest on a smooth horizontal surface. An impulse of force 0.2 Ns is applied to end B. The time taken by the rod to turn through at right angles will be $\frac{\pi}{x}$ s, where x = ____.

Ans. **(4)**

Sol.



Impulse J = 0.2 N-S

$$J = \int F dt = 0.2 N - s$$

Angular impuls $(\vec{M})$

$$\vec{M}_c = \int \tau dt$$

$$= \int F \frac{L}{2} dt$$

$$= \frac{L}{2} \int F dt = \frac{L}{2} \times J$$

$$= \frac{0.3}{2} \times 0.2$$

= 0.03

$$I_{cm} = \frac{ML^2}{12} = \frac{2 \times (0.3)^2}{12} = \frac{0.09}{6}$$

$$M = I_{cm}(\omega_f - \omega_i)$$

$$0.03 = \frac{0.09}{6}(\omega_f)$$

$\omega_f = 2$ rad/s

$\theta = \omega t$

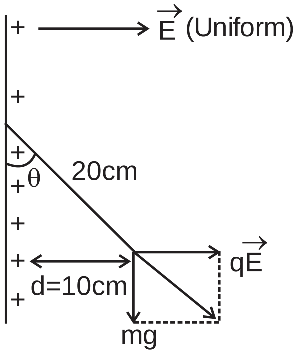
$$t = \frac{\theta}{\omega} = \frac{\pi}{2 \times 2} = \frac{\pi}{4} \text{sec}.$$

X = 4

60. Suppose a uniformly charged wall provides a uniform electric field of 2×10^4 N/C normally. A charged particle of mass 2 g being suspended through a silk thread of length 20 cm and remain stayed at a distance of 10 cm from the wall. Then the charge on the particle will be $\frac{1}{\sqrt{x}} \mu C$ where x =______. [use $g = 10 \text{ m/s}^2$]

Ans. **(3)**

Sol.



$$\sin\theta = \frac{10}{20} = \frac{1}{2}$$

$\theta = 30°$

$$\tan\theta = \frac{qE}{mg}$$

$$\tan 30° = \frac{q \times 2 \times 10^4}{1 \times 10^{-3} \times 10}$$

$$\frac{1}{\sqrt{3}} = q \times 10^6$$

$$q = \frac{1}{\sqrt{3}} \times 10^{-6} C$$

x = 3