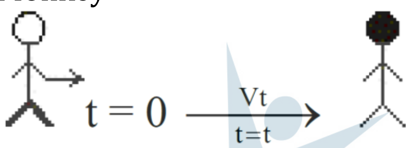
PHYSICS
JEE-MAIN (July-Attempt)
28 July (Shift-1) Paper Solution

SECTION - A

1. The dimensions of $\left(\frac{B^2}{\mu_0}\right)$ will be:
(if μ_0 : permeability of free space and B : magnetic field)
(A) $[M L^2 T^{-2}]$ (B) $[M L T^{-2}]$ (C) $[M L^{-1} T^{-2}]$ (D) $[M L^2 T^{-2} A^{-1}]$

Sol. **(C)**
$u = \frac{B^2}{2\mu_0}$
$u \rightarrow$ Energy per unit volume
$\left[\frac{B^2}{\mu_0}\right] = [u] = \frac{[ML^2T^{-2}]}{[L^3]} = [ML^{-1}T^{-2}]$

2. A NCC parade is going at a uniform speed of 9 km/h under a mango tree on which a monkey is sitting at height of 19.6 m. At any particular instant, the monkey drops a mango. A cadet will receive the mango whose distance from the tree at time of drop is :
(Given g = 9.8 m/s²)
(A) 5 m (B) 10 m (C) 19.8 m (D) 24.5 m

Sol. **(A)**
Monkey


Time taken by mango = $\sqrt{\frac{2h}{g}}$

$= \sqrt{\frac{2 \times 19.6}{9.8}} = 2$ second

Distance = vt
$= 9 \times \frac{5}{18} \times 2 = 5\text{m}$

3. In two different experiments, an objects of mass 5 kg moving with a speed of 25 ms^{-1} hits two different walls and comes to rest within (i) 3 second, (ii) 5 seconds, respectively. Choose the correct option out of the following:
(A) Impulse and average force acting on the object will be same for both the cases.
(B) Impulse will be same for both the cases but the average force will be different.
(C) Average force will be same for both the cases but the impulse will be different.
(D) Average force and impulse will be different for both the cases.

Sol. **(B)**
Impulse = change in momentum
$I = \Delta P$
$F_{aug} = \frac{\Delta P}{\Delta t}$
$\Delta t_1 = 3$ $\Delta t_2 = 5$
$\Delta P_1 = \Delta P_2$
$I_1 = I_2$
F_{avg} in case (i) is more than (ii)

4. A balloon has mass 10 g in air. The air escapes from the balloon at a uniform rate with velocity 4.5 cm/s. If the balloon shrinks in 5 s completely. Then, the average force acting on that balloon will be (in dyne).

(A) 3 (B) 9 (C) 12 (D) 18

Sol. **(B)**

$F = \frac{dm}{dt} v$

$= \frac{10g}{5s}\left(4.5 \frac{cm}{s}\right) = 9 \frac{gcm}{s^2} = 9$ dyne

5. If the radius of earth shrinks by 2% while its mass remains same. The acceleration due to gravity on the earth's surface will approximately:

(A) decrease by 2% (B) decrease by 4% (C) increase by 2% (D) increase by 4%

Sol. **(D)**

$g = \frac{GM}{R^2}$

M = constant $g < \frac{1}{R^2}$

$100 \frac{\Delta g}{g} = -2 \frac{\Delta R}{R} 100$

% change = – 2 (–2)

% change in g = 4%

increase by 4%

6. The force required to stretch a wire of cross-section 1 cm^2 to double its length will be :
(Given Yung's modulus of the wire = 2×10^{11} N/m^2)

(A) 1×10^7 N (B) 1.5×10^7 N (C) 2×10^7 N (D) 2.5×10^7 N

Sol. **(C)**

$F = \gamma A \frac{\Delta \ell}{\ell}$

$= 2 \times 10^{11} \times 10^{-4} \left(\frac{2\ell - \ell}{\ell}\right)$

$= 2 \times 10^7$ N

7. A Carnot engine has efficiency of 50%. If the temperature of sink is reduced by 40° C, its efficiency increases by 30%. The temperature of the source will be:

(A) 166.7 K (B) 255.1 K (C) 266.7 K (D) 367.7 K

Sol. **(C)**

$\eta = 1 - \frac{T_L}{T_H}$

$\frac{1}{2} = 1 - \frac{T_L}{T_H}$

$\frac{1}{2}(1 \cdot 3) = 1 - \left(\frac{T_L - 40}{T_H}\right)$

$\frac{1}{2}(1 \cdot 3) = \frac{1}{2} + \frac{40}{T_H}$ $T_H = 266.7$ K

8. Given below are two statements:

Statement I : The average momentum of a molecule in a sample of an ideal gas depends on temperature.

Statement II : The rms speed of oxygen molecules in a gas in ν. If the temperature is doubled and the oxygen molecules dissociate into oxygen atoms, the rms speed will become 2ν.

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

(A) Both Statement I and Statement II are true

(B) Both Statement I and Statement II are false

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

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

Sol. **(D)**

$[P_{avg} = 0]$ (due to random motion)

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

$T_{new} = 2T$

$M_{new} = \frac{M}{2}$

$\frac{v_{new}}{v} = \frac{\sqrt{\frac{2T}{M/2}}}{\sqrt{\frac{T}{M}}}$

$v_{new} = 2v$

9. In the wave equation

$y = 0.5 \sin \frac{2\pi}{\lambda}(400\,t - x)\text{m}$

The velocity of the wave will be:

(A) 200 m/s (B) $200\sqrt{2}$ m/s (C) 400 m/s (D) $400\sqrt{2}$ m/s

Sol. **(C)**

$y = 0.5 \sin\left(\frac{2\pi}{\lambda}400t - \frac{2\pi}{\lambda}x\right)$

$\omega = \frac{2\pi}{\lambda}400$

$K = \frac{2\pi}{\lambda}$

$v = \frac{\omega}{k}$ [v = 400 m/s]

10. Two capacitors, each having capacitance 40 μF are connected in series. The space between one of the capacitors is filled with dielectric material of dielectric constant K such that the equivalence capacitance of the system became 24 μF. The value of K will be :

(A)1.5 (B) 2.5 (C) 1.2 (D) 3

Sol. **(A)**

$C_{eq} = \frac{C(KC)}{C+KC} = \frac{KC}{K+1}$

$24 = \frac{K40}{K+1}$

[K = 1.5]

11. A wire of resistance R_1 is drawn out so that its length is increased by twice of its original length. The ratio of new resistance to original resistance is:

(A) 9 : 1 (B) 1 : 9 (C) 4 : 1 (D) 3 : 1

Sol. **(A)**

$R_1 = \rho\frac{L_1}{A_1}$

$R_2 = \rho\left(\frac{3L_1}{A_1/3}\right) = 9\rho\frac{L_1}{A_1}$

$\therefore \frac{R_2}{R_1} = 9$

12. The current sensitivity of a galvanometer can be increases by :

(A) Decreasing the number of turns

(B) Increasing the magnetic field

(C) Decreasing the area of the coil

(D) Decreasing the torsional constant of the spring

Choose the most appropriate answer from the options given below:

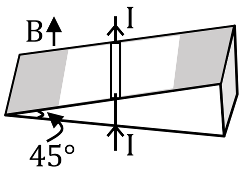
(A) (B) and (C) only (B) (C) and (D) only (C) (A) and (C) only (D) (B) and (D) only

Sol. **(D)**

$i = \left(\frac{K}{NAB}\right)\theta$

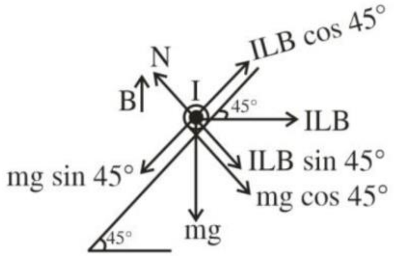
$\therefore \frac{d\theta}{di} = \frac{NAB}{K}$

13. As shown in the figure, a metallic rod of linear density 0.45 kg m^{-1} is lying horizontally on a smooth inclined plane which makes an angle of 45° with the horizontal. The minimum current flowing in the rod required to keep it stationary, when 0.15 T magnetic field is acting on it in the vertical upward direction, will be: {Use $g = 10\ m/s^2$}



(A) 30 A (B) 15 A (C) 10 A (D) 3 A

Sol. **(A)**



mg sin 45° = ILBcos 45°

$\therefore \ I = \left(\frac{m}{L}\right)\frac{g}{B}$

$= \frac{(0.45)(10)}{0.15} = 30 \text{ A}$

14. The equation of current in a purely inductive circuit is 5 sin (49 πt – 30°). If the inductance is 30 mH then the equation for the voltage across the inductor, will be :

$\left\{\text{Let } \pi = \frac{22}{7}\right\}$

(A) 1.47 sin(49 πt – 30°) (B) 1.47 sin(49 πt + 60°)

(C) 23.1 sin(49 πt – 30°) (D) 23.1 sin(49 πt + 60°)

Sol. **(D)**

$v = i_0 \, x_L = i_0 \, (wL)$

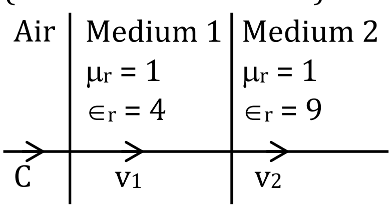
$= (5)(49\pi)(30 \times 10^{-3}) = 23.1$

Voltage will lead current by 90°.

$\therefore$ V = 23.1 sin (49 π t + 60°)

15. As shown in the figure, after passing through the medium 1. The speed of light v_2 in medium 2 will be :

(Given $c = 3 \times 10^8 \text{ ms}^{-1}$)



(A) $1.0 \times 10^8 \text{ ms}^{-1}$ (B) $0.5 \times 10^8 \text{ ms}^{-1}$ (C) $1.5 \times 10^8 \text{ ms}^{-1}$ (D) $3.0 \times 10^8 \text{ ms}^{-1}$

Sol. **(A)**

$\frac{\mu_2}{\mu_{air}} = \frac{C}{v_2}$

$\therefore \frac{\sqrt{\mu_{r_2}\varepsilon_{r_2}}}{(1)} = \frac{C}{v_2}$

$\therefore \sqrt{(1)(9)} = \frac{C}{v_2}$

$\therefore v_2 = \frac{C}{3}$

16. In normal adjustment, for a refracting telescope, the distance between objective and eye piece is 30 cm. The focal length of the objective, when the angular magnification of the telescope is 2, will be :

(A) 20 cm (B) 30 cm (C) 10 cm (D) 15 cm

Sol. **(A)**

$f_0 + f_e = 30$

$m = \frac{f_0}{f_e}$

$2 = \frac{f_0}{f_e} \Rightarrow f_0 = 2f_e$

So $f_0 + \frac{f_0}{2} = 30$

$f_0 = 32$ cm

17. The equation $\lambda = \frac{1.227}{x}$ nm can be used to find the de-Brogli wavelength of an electron. In this equation x stands for:

Where

m = mass of electron

P = momentum of electron

K = Kinetic energy of electron

V = Accelerating potential in volts for electron

(A) $\sqrt{mK}$ (B) $\sqrt{P}$ (C) $\sqrt{K}$ (D) $\sqrt{V}$

Sol. **(D)**

$\lambda = \frac{h}{mv}$ (de-Broglie's wavelength)

$\lambda \frac{h}{\sqrt{2m(K.E)}}$

$h = \frac{h}{\sqrt{2mqV}}$

Putting the values of m ; q

We get $\lambda = \frac{1.22}{\sqrt{V}}$ nm

18. The half life period of a radioactive substance is 60 days. The time taken for $\frac{7}{8}$th of its original mass to disintegrate will be:

(A) 120 days (B) 130 days (C) 180 days (D) 20 days

Sol. **(C)**

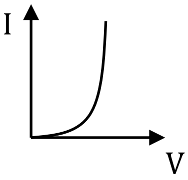
7/8 disintegrates means 1/8 remains

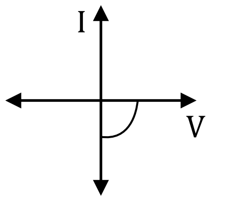
Or $\left(\frac{1}{2}\right)^3$

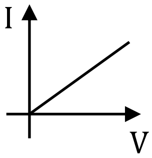
$\therefore$ 3 half lives

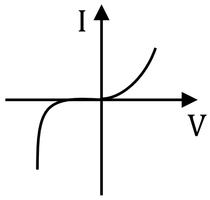
= 180 days

19. Identify the solar cell characteristics from the following options:

(A)


(B)


(C)


(D)


Sol. **(B)**

Conceptual / theory

20. In the case of amplitude modulation to avoid distortion the modulation index (μ) should be :

(A) $\mu \leq 1$ (B) $\mu \geq 1$ (C) $\mu = 2$ (D) $\mu = 0$

Sol. **(A)**

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

$\mu \leq 1$ to avoid distortion

because $\mu > 1$ will result in interference between

career frequency & message frequency.

SECTION - B

21. If the projection of $2\hat{i} + 4\hat{j} - 2\hat{k}$ on $\hat{i} + 2\hat{j} + \alpha\hat{k}$ is zero. Then, the value of α will be ________ .

Sol. **(5)**

$\vec{a} \cdot \vec{b} = 0$

$\therefore \vec{a} \cdot \vec{b} = 0$

$\therefore 2 \times 1 + 4 \times 2 - 2 \times \alpha = 0$

$\therefore \alpha = \boxed{5}$

22. A freshly prepared radioactive source of half life 2 hours 30 minutes emits radiation which is 64 times the permissible safe level. The minimum time, after which it would be possible to work safely with source, will be __________ hours.

Sol. **(15)**

$A = A_0 \times 2^{-t/T}$

$\frac{A_0}{64} = A_0 \times 2^{-t/T}$

$\therefore t = 6T = 6 \times 2.5 = \boxed{15}$ hours

23. In a Young's double slit experiment, a laser light of 560 nm produces an interference pattern with consecutive bright fringes' separation of 7.2 mm. Now another light is used to produce an interference pattern with consecutive bright fringes' separation of 8.1 mm. The wavelength of second light is __________ nm.

Sol. **(630)**

$\beta \propto \lambda$

$\lambda_2 = \frac{9}{8}\lambda_1$

$\therefore \beta_2 = \frac{9}{8}\beta_1 = \frac{9}{8} \times 500 = \boxed{630}$ nm

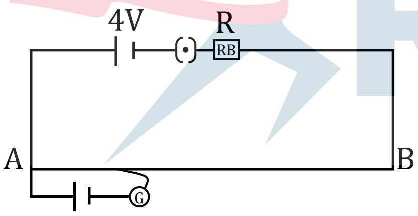
24. The frequencies at which the current amplitude in an LCR series circuit becomes $\frac{1}{\sqrt{2}}$ times its maximum value, are 212 rad s^{-1} and 232 rad s^{-1}. The value of resistance in the circuit is R = 5Ω. The self inductance in the circuit is ___________ mH.

Sol. **(250)**

Band width = 232 – 212 = $\frac{R}{L}$

$\therefore L = \frac{5}{20} = \boxed{250}$ mH

25. As shown in the figure, a potentiometer wire of resistance 20Ω and length 300 cm is connected with resistance box (R. B.) and a standard cell of emf 4 V. For a resistance 'R' of resistance box introduced into the circuit, the null point for a cell of 20 mV is found to be 60 cm. The value of 'R' is _____________Ω.



Sol. **(780)**

$E = \frac{AC}{AB}(V_A - V_B)$

$\therefore 20 \times 10^{-3} = \frac{60}{300} \times \frac{4\times20}{R+20}$

$\therefore$ R = $\boxed{780}$ Λ

26. The electric dipoles of dipole moments 1.2×10^{-30} Cm and 2.4×10^{-30} Cm are placed in two different uniform electric fields of strengths 5×10^4 NC^{-1} and 15×10^4 NC^{-1} respectively. The ratio of maximum torque experienced by the electric dipoles will be $\frac{1}{x}$. The value of x is ________.

Sol. **(6)**

$|\tau|_{max} = PE$

$\frac{\tau_1}{\tau_2} = \frac{P_1E_1}{P_2E_2} = \frac{1.2\times10^{-30}\times5\times10^4}{2.4\times10^{-30}\times15\times10^4} = \frac{1}{6}$

Hence x = 6

27. The frequency of echo will be ________ Hz if the train blowing a whistle of frequency 320 Hz is moving with a velocity of 36 km/h towards a hill from which an echo is heard by the train driver. Velocity of sound in air is 330 m/s.

Sol. **(340)**

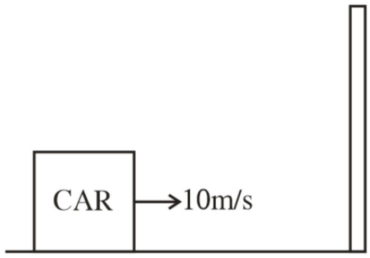
The hill will be a secondary source.

f_1 = frequency of the car w.r.t. the hill

$f_1 = \left(\frac{v}{v-v_s}\right) f = \left(\frac{330}{320}\right) \times 320 = 330\text{ Hz}$

f_2 = Frequency of the sound reflected by hill w.r.t. the car (echo)

$f_2 = \left(\frac{v+v_0}{v}\right) f_1 = \frac{(330+10)}{330} \times 330 = 340\text{ Hz}$



28. The diameter of an air bubble which was initially 2 mm, rises steadily through a solution of density 1750 kg m^{-3} at the rate of 0.35 cms^{-1}. The coefficient of viscosity of the solution is ________ poise (in nearest integer). (The density of air is negligible).

Sol. **(11)**

As the bubble is rising steadily the net force acting on it will be zero

(Because of density of air the value of mg can be neglected)

So $B = F \Rightarrow \frac{4\pi}{3} R^3 \rho g = 6\pi\eta R v$

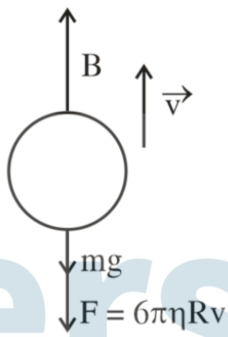
Putting $R = 1\text{mm} = 10^{-3}$ m

$\rho = 1.75 \times 10^3$ kg $/m^3$

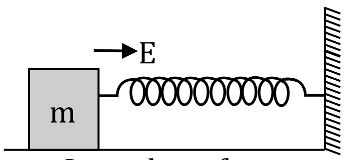
$g = 10\ m/s^2$

$v = 0.35 \times 10^{-2}$ m/s

$\eta = \frac{10}{9} \simeq 1.11$ SI unit = 11 poise (CGS)



29. A block of mass 'm' (as shown in figure) moving with kinetic energy E compresses a spring through a distance 25 cm when, its speed is halved. The value of spring constant of used spring will be nE Nm^{-1} for n = ________.



Smooth surface

Sol. **(24)**

Using work – energy theorem

$W_{net} = (K_f - K_i)$

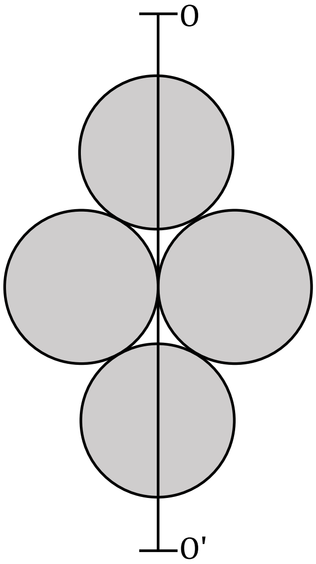
$\Rightarrow -\frac{1}{2}Kx^2 = \frac{1}{2}m\left(\frac{v}{2}\right)^2 - \frac{1}{2}mv^2 = \frac{E}{4} - E$

$\Rightarrow \frac{1}{2}Kx^2 = \frac{3E}{4} \Rightarrow K = \frac{3E}{2x^2}$

$\Rightarrow K = \frac{3E}{2\times\left(\frac{1}{4}\right)^2} = 24E$

n = 24

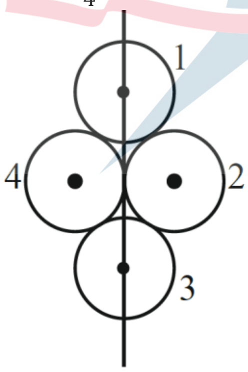
30. Four identical discs each of mass 'M' and diameter 'a' are arranged in a small plane as shown in figure. If the moment of inertia of the system about OO' is $\frac{x}{4}Ma^2$. Then, the value of x will be __________.



Sol. **(3)**

$I_1 = I_3 = \frac{MR^2}{4}$

$I_2 = \frac{MR^2}{4} + MR^2 = \frac{5}{4}MR^2 = I_4$



So $I = I_1 + I_2 + I_3 + I_4$

$= \frac{MR^2}{2} + \frac{5}{2}MR^2$

$= 3MR^2$, Putting $R = \frac{a}{2}$

$I = \frac{3Ma^2}{4}$, So x = 3