PHYSICS

JEE–MAIN EXAMINATION – JUNE, 2022

28 June S - 01 Paper Solution

SECTION-A

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

Assertion A : Product of Pressure (P) and time (t) has the same dimension as that of coefficient of viscosity.

Reason R:

$$\text{Coefficient of viscosity} = \frac{\text{Force}}{\text{Velocity gradient}}$$

Question: Choose the correct answer from the options given below :

(A) Both A and R true, and R is correct explanation of A.

(B) Both A and R are true but R is NOT the correct explanation of A.

(C) A is true but R is false.

(D) A is false but R is true.

Ans. (C)

Sol. Pressure and time

$$P : \frac{N}{m^2}, \text{Time} : \text{Sec}$$

$$Pt = \frac{N\,sec}{m^2}$$

$$\eta = \frac{F}{6\pi rv} : \frac{N}{m.m/sec} : \frac{N\,sec}{m^2}$$

2. A particle of mass m is moving in a circular path of constant radius r such that its centripetal acceleration (a) is varying with time t as $a = k^2rt^2$. where k is a constant. The power delivered to the particle by the force acting on it is given as

(A) zero

(B) $mk^2r^2t^2$

(C) mk^2r^2t

(D) mk^2rt

Ans. (C)

Sol. $a = k^2rt^2 = \frac{V^2}{r}$

$V = krt$

$a_t = \frac{dv}{dt} = kr$

$F_t = ma_t = mkr$

$P = \vec{F}.\vec{V}$

$= F\cos\theta V = F_tV = mkr(krt)$

$P = mk^2r^2t$

3. Motion of a particle in x-y plane is described by a set of following equations $x = 4\sin\left(\frac{\pi}{2} - \omega t\right)$ m and $y = 4\sin(\omega t)$ m. The path of particle will be –

(A) circular

(B) helical

(C) parabolic

(D) elliptical

Ans. (A)

Sol. $x = 4\sin\left(\frac{\pi}{2} - \omega t\right)$ $\quad y = 4\cos(\omega t)$

$x = 4\cos(\omega t) \qquad y = 4\sin(\omega t)$

Eliminate 't' to find relation between x and y

$x^2 + y^2 = y^2\cos^2\omega t + y^2\sin^2\omega t = 4^2$

$x^2 + y^2 = 4^2$

4. Match List-I with List-II

	List-I		List-II
A	Moment of inertia of solid sphere of radius R about any tangent	I	$\frac{5}{3}MR^2$
B	Moment of inertia of hollow sphere of radius (R) about any tangent	II	$\frac{7}{5}MR^2$
C	Moment of inertia of circular ring of radius (R) about its diameter.	III	$\frac{1}{4}MR^2$
D	Moment of inertia of circular disc of radius (R) about any diameter.	IV	$\frac{1}{2}MR^2$

Question: Choose the correct answer from the options given below

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

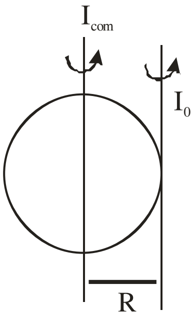
(B) A-I, B-II, C-IV, D-III

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

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

Ans. (A)

Sol. Solid sphere

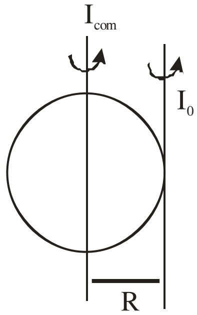


$I_0 = I_{com} + MR^2$ (Parallel Axis theorem)

$I_0 = \frac{2}{5}MR^2 + MR^2$

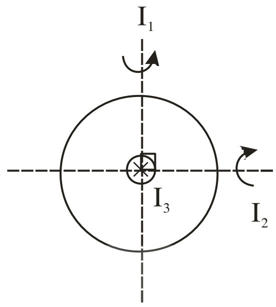
$I_0 = \frac{7}{5}MR^2$

Hollow sphere



$I_0 = I_{com} + MR^2$

$= \frac{2}{3}MR^2 + MR^2 = \frac{5}{3}MR^2$



$I_1 + I_2 + I_3$ (Perpendicular axis theorem)

By symmetry MOI

About 1” and 2” Axis are same i.e.

$I_1 = I_2$

$\therefore\ 2I_1 = I_3 = MR^2 \ \left(I_{com} = MR^2\right)$

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

Similarly in disc

$2I_1 = \frac{MR^2}{2} \left\{ I_{com} = \frac{MR^2}{2} \right\}$

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

5. Two planets A and B of equal mass are having their period of revolutions T_A and T_B such that $T_A = 2T_B$. These planets are revolving in the circular orbits of radii r_A and r_B respectively. Which out of the following would be the correct relationship of their orbits?

(A) $2r_A^2 = r_B^2$

(B) $r_A^3 = 2r_B^3$

(C) $r_A^3 = 3r_B^3$

(D) $T_A^2 - T_B^2 = \frac{\pi^2}{GM}\left(r_B^3 - 4r_A^3\right)$

Ans. (C)

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

$T^2 \propto r^3$

$\left(\frac{T_A}{T_B}\right)^2 = \left(\frac{r_A}{r_B}\right)^3$

$\Rightarrow \left(\frac{2}{1}\right)^2 = \left(\frac{r_A}{r_B}\right)^3 \Rightarrow r_A^3 = 4r_B^3$

6. A water drop of diameter cm is broken into 64 equal droplets. The surface tension of water is 0.075 N/m. In this process the gain in surface energy will be :

(A) 2.8×10^{-4} J (B) 1.5×10^{-3} J

(C) 1.9×10^{-4} J (D) 9.4×10^{-5} J

Ans. (A)

Sol. d = 2cm; r = 1 cm; T = 0.075

$\Delta SE = T\,\Delta A$

$= 0.075\left(A_f - A_1\right)$

$A_i = 4\pi r^2$

$A_f = 4\pi r_0^2 \times 64$

By volume conservation

$\frac{4}{3}\pi r^3 = 64\cdot\frac{4}{3}\pi r_0^3$

$r_0 = \frac{r}{4}$

$A_f = 4\pi\left(\frac{r}{4}\right)^2\cdot 64 = 16\pi r^2$

$\Delta SE = 0.075\left(16\pi r^2 - 4\pi r^2\right)$

$= 0.075\left(12\pi(0.01)^2\right)$

$= 2.8\times10^{-4}$ J

7. Given below are two statement :

Statement – I : What μ amount of an ideal gas undergoes adiabatic change from state (P_1, V_1, T_1) to state (P_2, V_2, T_2), the work done is $W = \frac{1R(T_2 - T_1)}{1-\gamma}$, where $\gamma = \frac{C_P}{C_V}$ and R = universal gas constant,

Statement — II: In the above case. when work is done on the gas. the temperature of the gas would rise.

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.

Ans. (A)

Sol. $W_{adiabatic} = \dfrac{NR(T_f - T_i)}{1-\gamma} \rightarrow$ statment 1

$Q = W + \Delta U$

$0 = W + \Delta U$

$\Delta U = -W$

If work is done on the gas, i.e. work is negative $\therefore \Delta U$ is positive.

$\therefore$ Temperature will increase.

8. Given below are two statements :

Statement-I : A point charge is brought in an electric field. The value of electric field at a point near to the charge may increase if the charge is positive.

Statement-II : An electric dipole is placed in a non-uniform electric field. The net electric force on the dipole will not be zero.

Choose the correct answer from the options given below :

(A) Both statement-I and statement-II are true.

(B) Both statement-I and statement-I are false.

(C) Statement-I is true but statement-II is false.

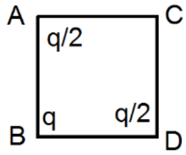
(D) Statement-I is false but statement-II is true.

Ans. (C)

Sol. If the electric field is in the positive direction and the positive charge is to the left of that point then the electric field will increase. But to the left of the positive charge the electric field would decrease.

If the dipole is kept at the point where the electric field is maximum then the force on it will be zero.

9. The three charges q/2, q and q/2 are placed at the corners A, B and C of a square of side 'a' as shown in figure. The magnitude of electric field (E) at the comer D of the square, is :



(A) $\dfrac{q}{4\pi \epsilon_0 a^2}\left(\dfrac{1}{\sqrt{2}} + \dfrac{1}{2}\right)$

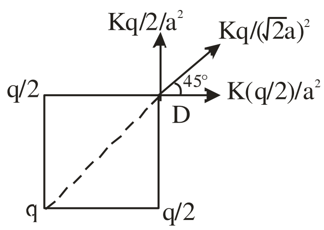
(B) $\dfrac{q}{4\pi \epsilon_0 a^2}\left(1 + \dfrac{1}{\sqrt{2}}\right)$

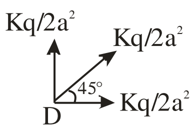
(C) $\dfrac{q}{4\pi \epsilon_0 a^2}\left(1 - \dfrac{1}{\sqrt{2}}\right)$

(D) $\dfrac{q}{4\pi \epsilon_0 a^2}\left(\dfrac{1}{\sqrt{2}} - \dfrac{1}{2}\right)$

Ans. (A)

Sol.



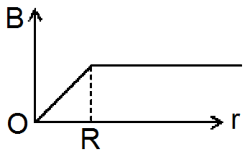


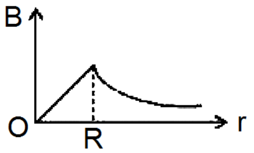
$(E_{net})_D = \dfrac{kq}{2a^2} + \dfrac{\sqrt{2}kq}{2a^2}$

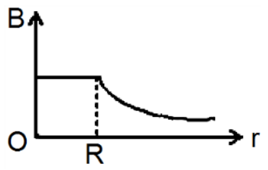
$(E_{net})_D = \dfrac{kq}{a^2}\left(\dfrac{1}{2} + \dfrac{1}{\sqrt{2}}\right)$

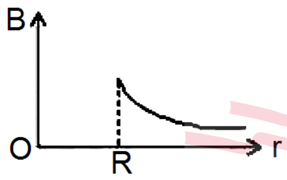
$(E_{net})_D = \dfrac{q}{4\pi \epsilon_0 a^2}\left(\dfrac{1}{2} + \dfrac{1}{\sqrt{2}}\right)$

10. An infinitely long hollow conducting cylinder with radius R carries a uniform current along its surface. Choose the correct representation of magnetic field (B) as a function of radial distance (r) from the axis of cylinder.

(A) 

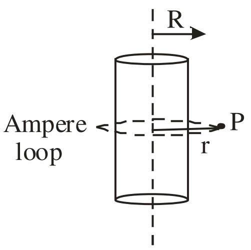
(B) 

(C) 

(D) 

Ans. (D)

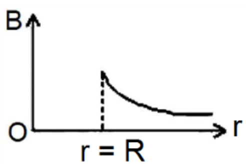
Sol.



1) $r < R, B_p = 0$

2) $r \geq R, B_p = \dfrac{\mu_0 I}{2\pi r}$

$B_p \propto \dfrac{1}{r}$



11. A radar sends an electromagnetic signal of electric field (E_0) = 2.25 V/m and magnetic field (B_0) = 1.5 x 10^{-8} T which strikes a target on line of sight at a distance of 3 km in a medium. After that, a pail of signal (echo) reflects back towards the radar vit1i same velocity and by same path. If the signal was transmitted at time t_0 from radar. then after how much time echo will reach to the radar?

(A) 2.0×10^{-5}s

(B) 4.0×10^{-5}s

(C) 1.0×10^{-5}s

(D) 8.0×10^{-5}s

Ans. (B)

Sol. $C = \dfrac{E_0}{B_0} = \dfrac{2.25}{1.5\times10^{-8}} = 1.5\times10^{8}\,ms^{-1}$

$t = \dfrac{6\times10^{3}}{1.5\times10^{8}} = 4\times10^{-5}\,s$

12. The refracting angle of a prism is A and refractive index of the material of the prism is cot (A/2). Then the angle of minimum deviation will be -

(A) 180 – 2A (B) 90 – A

(C) 180 + 2A (D) 180 – 3A

Ans. (A)

Sol. $\mu = \dfrac{\sin\left(\dfrac{A+\delta_m}{2}\right)}{\sin\dfrac{A}{2}}$

$\mu = \cot\dfrac{A}{2}$

$\Rightarrow \quad \sin\left(\dfrac{A+\delta_m}{2}\right) = \cos\dfrac{A}{2}$

$\delta_m = 180 - 2A$

13. The aperture of the objective is 24.4 cm. The resolving power of this telescope. If a light of wavelength 2440 Å is used to see the object will be

(A) 8.1×10^{6} (B) 10.0×10^{7}

(C) 8.2×10^{5} (D) 1.0×10^{-8}

Ans. (C)

Sol. $R.P=\dfrac{d}{1.22\lambda}=\dfrac{24.4\times10^{-2}}{1.22\times2440\times10^{-10}}=8.2\times10^{5}$

14. The de Brogue wavelengths for an electron and a photon are λ_e and λ_p respectively. For the same kinetic energy of electron and photon. which of the following presents the correct relation between the de Brogue wavelengths of two ?

(A) $\lambda_p\propto\lambda_e^2$ (B) $\lambda_p\propto\lambda_e$

(C) $\lambda_p\propto\sqrt{\lambda_e}$ (D) $\lambda_p\propto\sqrt{\dfrac{1}{\lambda_e}}$

Ans. (A)

Sol. $\lambda_e=\dfrac{h}{\sqrt{2mk}}$

Also for photon $k=\dfrac{hc}{\lambda_p}$

$\lambda_e=\dfrac{h\sqrt{\lambda_p}}{\sqrt{2m\,hc}}$

$\lambda_p\propto\lambda e^2$

15. The Q-value of a nuclear reaction and kinetic energy of the projectile particle, K_p are related as :

(A) $Q = K_p$ (B) $(K_p + Q) < O$

(C) $Q < K_p$ (D) $(K_p + Q) > 0$

Ans. (D)

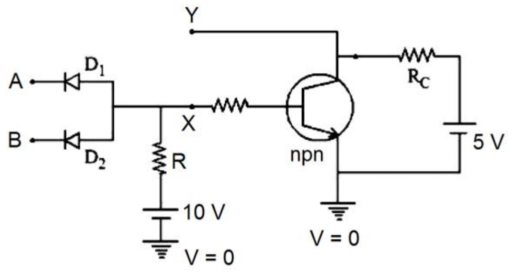
Sol. $x + p\,\gamma \rightarrow + b$

$Q = k_\gamma + k_b - k_p$

$Q + k_p = k_\gamma + k_b$

$Q + k_p > 0$

16. In the following circuit, the correct relation between output (Y) and inputs A and B will be :



(A) $Y=AB$ (B) $Y=A+B$

(C) $Y=\overline{AB}$ (D) $Y=\overline{A+B}$

Ans. (C)

Sol. This is NAND gate

A	B	Y
0	0	1
1	0	1
0	1	1
1	1	0

17. For using a multimeter to identify diode from electrical components. choose the correct statement out of the following about the diode :

(A) It is two terminal device which conducts current in both directions.

(B) It is two terminal device which conducts current in one direction only

(C) It does not conduct current gives an initial deflection which decays to zero.

(D) It is three terminal device which conducts current in ne direction only between central terminal and either of the remaining two terminals

Ans. (B)

Sol. In forward bias diode conducts

In revers bias it does not conducts.

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

Assertion A : n-p-n transistor permits more current than a p-n-p transistor.

Reason R : Electrons have greater mobility as a charge carrier.

Choose the correct answer from the options given below :

(A) Both A and R true. and R is correct explanation of A.

(B) Both A and R are true but R is NOT the correct explanation of A.

(C) A is true but R is false.

(D) A is false but R is true.

Ans. (A)

Sol. Theory

19. Match List-I with List-II

	List-I		List-II
A	Television signal	I	03 KHz
B	Radio signal	II	20 KHz
C	High Quality Music	III	02 MHz
D	Human speech	IV	06 MHz

Choose the correct answer from the options given below :

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

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

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

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

Ans. (C)

Sol. Theory

20. The velocity of sound in a gas. in which two wavelengths 4.08m and 4.16m produce 40 beats in 12s, will be :

(A)2.82.8 ms^{-1} (B) 175.5 ms^{-1}

(C) 353.6 ms^{-1} (D) 707.2 ms^{-1}

Ans. (D)

Sol. $f_b = f_1 - f_2$

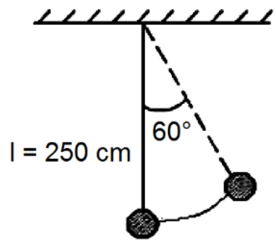
$$\frac{v}{4.08} - \frac{v}{4.16} = \frac{40}{12}$$

$$\Rightarrow v = 707.2$$

SECTION - B

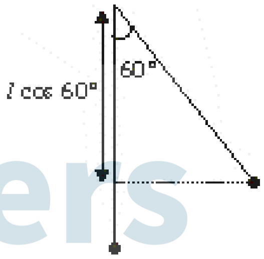
1. A pendulum is suspended by a string of length 250 cm. The mass of the bob of the pendulum is 200 g. The bob is pulled aside until the string is at 60° with vertical as shown in the figure. After releasing the bob. the maximum velocity attained by the bob will be ____________ ms^{-1}.

(if g = 10 m/s^2)



Ans. (5)

Sol. $V_{max} = \sqrt{2gh}$

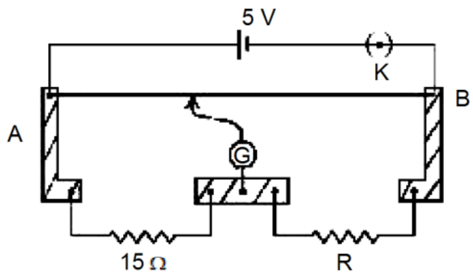


The speed will be highest at the lowest position.

$$h = (\ell - \ell\cos 60°) = \frac{\ell}{2}$$

$$V_{max} = \sqrt{2 \times g \times \frac{\ell}{2}} = \sqrt{10 \times 2.5} = 5\,m/s$$

2. A meter bridge setup is shown in the figure. It is used to determine an unknown resistance R using a given resistor of 1 5 Ω. The galvanometer (G) shows null deflection when tapping key is at 43 cm mark from end A. If the end correction for end A is 2 cm. then the determined value of R will be _______ Ω.



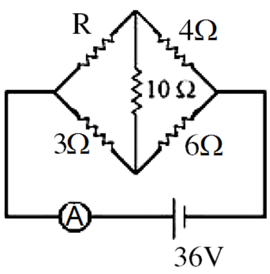
Ans. (19)

Sol. Using the conditions of a balanced wheat stone bridge and adding the end correction.

$$\frac{15}{(43+2)}=\frac{R}{(102-45)}\Rightarrow R=\frac{57}{45}\times 15$$

$R=19\Omega$

3. Current measured by the ammeter Ⓐ in the reported circuit when no current flows through $10\ \Omega$ resistance. will be _________ A.



Ans. (10)

Sol. Using the condition of a balanced wheat stone bridge,

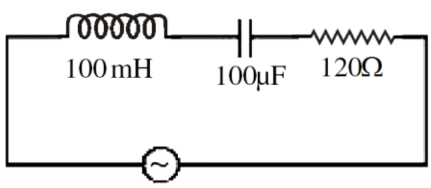
$$\Rightarrow \frac{R}{3}=\frac{4}{6}\Rightarrow R=2\Omega$$

So the effective resistance of the circuit is

$$R_{eq}=\frac{6\times 9}{6+9}=\frac{18}{5}\Omega$$

$$i=\frac{36}{R_{eq}}=10A$$

4. An AC source is connected to an inductance of 100 mH, a capacitance of 100 μ F and a resistance of $120\ \Omega$ as shown in figure. The time in which the resistance having a thermal capacity 2 J°/C will get heated by 16°C is _______s.



Ans. (15)

Sol. $|(X_L-X_C)|=|10-10^2|=90\Omega$

Z = Impendance

$$=\sqrt{(X_L-X_C)^2+R^2}=\sqrt{(90)^2+(20)^2}=150\Omega$$

$$i_{rms}=\frac{V_{rms}}{z}=\left(\frac{2}{15}\right)A$$

Now $i_{rms}^2 R\Delta t=ms(\Delta T)$

$\Rightarrow\ \Delta t=15\sec$

5. The position vector of 1 kg object is $\vec{r}=(3\hat{i}-\hat{j})m$ and its velocity $\vec{v}=(3\hat{j}+k)ms^{-1}$. The magnitude of its angular momentum is $\sqrt{x}$ Nm where x is ______ .

Ans. (91)

Sol. Using $\vec{L}=\vec{r}\times\vec{p}=\vec{r}\times m\vec{v}, m=1kg$

$$\vec{L}=(3\hat{i}-\hat{j})\times(3\hat{j}+\hat{k})=(9\hat{k}-3\hat{j}-\hat{i})N-s$$

$$\Rightarrow|\vec{L}|=\sqrt{91}\,N-s$$

6. A man of 60 kg is running on the road and suddenly jumps into a stationary trolly car of mass 120 kg. Then. the trolly car starts moving with velocity 2 ms^{-1}. The velocity of the running man was _______________ ms^{-1}. when he jumps into the car.

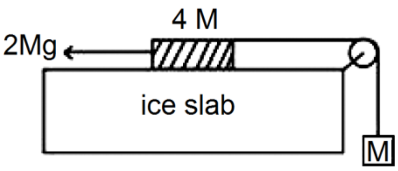
Ans. (6)

Sol. Taking the system as man and trolley and using conservation of linear momentum.

60 × v = (60 + 120) × 2

$\Rightarrow$ v = 6 m/s

7. A hanging mass M is connected to a four times bigger mass by using a string-pulley arrangement. as shown in the figure. The bigger mass is placed on a horizontal ice-slab and being pulled by 2 Mg force. In this situation. tension in the string is $\frac{x}{5}$ Mg for x = _________. Neglect mass of the string and friction of the block (bigger mass) with ice slab. (Given g = acceleration due to gravity)



Ans. (6)

Sol. Using $\vec{F}_{net} = \mu\vec{a}$,

$$2Mg - T = 4Ma$$
$$T - Mg = Ma$$
$$\Rightarrow a = \frac{g}{5}$$

$$T = Mg + Ma = Mg + \frac{Mg}{5} = \frac{6}{5}Mg$$

8. The total internal energy of two mole monoatomic ideal gas at temperature T = 300 K will be J. (Given R = 8.31 J/mol.K)

Ans. (7479)

Sol. $U = nC_vT$

$$= 2 \times \frac{3}{2} R \times 300$$

$$= 900\,R = 900 \times 8\cdot31 = 7479 \text{ J}$$

9. A sing1y ionized magnesium atom (A24) ion is accelerated to kinetic energy 5 keV and is projected perpendicularly into a magnetic field B of the magnitude 0.5 T. The radius of path formed will be _____________ cm.

Ans. (10)

Sol. $R = \frac{mv}{qB} = \frac{\sqrt{2mK}}{qB}$

10. A telegraph line of length loo km has a capacity of 0.01 μF/km and it carries an alternating current at 0.5 kilo cycle per second. If minimum impedance is required, then the value of the inductance that needs to be introduced in series is ________ mH.

$\left(\text{if } \pi = \sqrt{10}\right)$

Ans. (100)

Sol. For minimum impedance

$$X_L = X_C$$

$$\Rightarrow \omega L = \frac{1}{\omega C} \Rightarrow L = \frac{1}{\omega^2 C} = 10^{-1} H = 100\,mH$$