PHYSICS
JEE-MAIN (July-Attempt)
29 July (Shift-2) Paper Solution

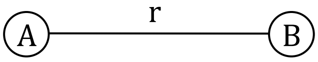
SECTION - A

1. Two identical metallic spheres A and B when placed at certain distance in air repel each other with a force of F. Another identical uncharged sphere C is first placed in contact with A and then in contact with B and finally placed at midpoint between spheres A and B. The force experienced by sphere C will be :

(A) 3F/2 (B) 3F/4 (C) F (D) 2F

Sol. **B**

Let $q_A = q_B = q$

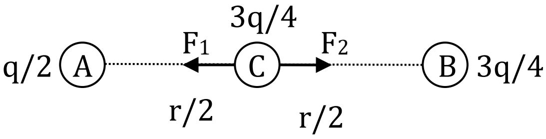


$F = \frac{Kq^2}{r^2}$

When C is placed in contact with A, charge on A and C will be = q/2

Now, C is placed in contact with B, charge on B and C will be = $\frac{q+\frac{q}{2}}{2} = \frac{3q}{4}$

Now,



$F' = F_2 - F_1 = \frac{\left(K\frac{3q}{4} - K\frac{q}{2}\right)}{\frac{r^2}{4}} \cdot \frac{3q}{4} = \frac{3Kq^2}{4r^2} = \frac{3F}{4}$

2. Match List – I with List – II

	List-I		**list- II**
A.	Torque	I.	Nms^{-1}
B.	Stress	II.	Jkg^{-1}
C.	Latent Heat	III.	Nm
D.	Power	IV.	Nm^{-2}

Choose the correct answer from the options given below:

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

Sol. **B**

Torque = $F \times r_\perp$ Nm

Stress = $\frac{\text{Force}}{\text{Area}}$ N/m^2

Latent Heat = $\frac{\text{Energy}}{\text{Mass}}$ JKg^{-1}

Power = $\frac{\text{Work}}{\text{Time}}$ Nms^{-1}

3. Two identical thin metal plates has charge q_1 and q_2 respectively such that $q_1 > q_2$. The plates were brought close to each other to form a parallel plate capacitor of capacitance C. The potential difference between them is :

(A) $\frac{(q_1+q_2)}{C}$ (B) $\frac{(q_1-q_2)}{C}$ (C) $\frac{(q_1-q_2)}{2C}$ (D) $\frac{2(q_1-q_2)}{C}$

Sol. **C**

Electric field between plates E = $\frac{q_1-q_2}{2A\epsilon_0}$

V = Ed = $\frac{q_1-q_2}{2A\epsilon_0}d$

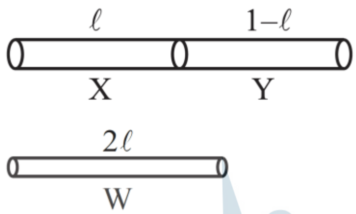
V = $\frac{q_1-q_2}{2C}$

4. Given below are two statement : One is labelled as Assertion (A) and other is labelled as Reason (R).
Assertion (A) : Alloys such as constantan and manganin are used in making standard resistance coils.
Reason (R): Constantan and manganin have very small value of temperature coefficient of resistance.
In the light of the above statements, choose the correct answer from the options given below.
(A) Both (A) and (R) are true and (R) is the 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) true

Sol. **A**
Theory based

5. A 1m long wire is broken into two unequal parts X and Y. The X part of the wire is stretched into another wire W. Length of W is twice the length of X and the resistance of W is twice that of Y. Find the ratio of length of X and Y.
(A) 1 : 4 (B) 1 : 2 (C) 4 : 1 (D) 2 : 1

Sol. **B**



$\frac{R_X}{R_Y} = \frac{\ell_X}{\ell_Y}$

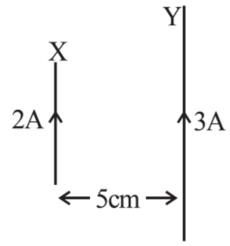
When wire is stretched to double of its length, then resistance becomes 4 times

$R_W = 4R_X = 2R_Y$

$\frac{R_X}{R_Y} = \frac{1}{2}$

So, $\frac{\ell_X}{\ell_Y} = \frac{1}{2}$

6. A wire X of length 50 cm carrying a current of 2 A is placed parallel to a long wire Y of length 5 m. The wire Y carries a current of 3 A. The distance between two wire is 5 cm and currents flow in the same direction. The force acting on the wire Y is



(A) 1.2×10^{-5} N directed toward wire. X
(B) 1.2×10^{-4} N directed away from wire X
(C) 1.2×10^{-4} N directed toward wire X
(D) 2.4×10^{-5} N directed toward wire X.

Sol. **A**

Force of interaction = $I_1 \ell_1 B_{12}$

$= \frac{\mu_0 I_1 I_2}{2\pi r} \ell_1$

$= \frac{4\pi \times 10^{-7} \times 6 \times 0.5}{2\pi \times 5 \times 10^{-2}}$

$= 1.2 \times 10^{-5}$ towards X

7. A juggler throws balls vertically upwards with same initial velocity in air. When the first ball reaches its highest position, he throws the next ball. Assuming the juggler throws n balls per second, the maximum height the ball can reach is.

(A) g/2n (B) g/n (C) 2gn (D) $\frac{g}{2n^2}$

Sol. **D**

Time taken by ball to reach highest point = $\frac{u}{g}$

Frequency of throw = $\frac{g}{u}$ = n

$\Rightarrow u = \frac{g}{n}$

$H_{max} = \frac{u^2}{2g} = \frac{\left(\frac{g}{n}\right)^2}{2g}$

$\frac{g}{2n^2}$

8. A circuit element X when connected to an a.c. supply of peak voltage 100 V gives a peak current of 5A which is in phase with the voltage. A second element Y when connected to the same a.c. supply also gives the same value of peak current which lags behind the voltage by $\frac{\pi}{2}$. If X and Y are connected in series to the same supply, what will be the rms value of the current in ampere ?

(A) $\frac{10}{\sqrt{2}}$ (B) $\frac{5}{\sqrt{2}}$ (C) $5\sqrt{2}$ (D) $\frac{5}{2}$

Sol. **D**

Elemeent X should be resistive with R = 20 Ω

Element Y should be inductive with X_L = 20 Ω

When X and Y are connector in series

$Z = \sqrt{X_L^2 + R^2} = 20\sqrt{2}$

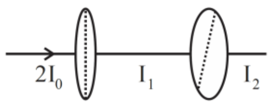
$I_0 = \frac{E_0}{Z} = \frac{100}{20\sqrt{2}} = \frac{5}{\sqrt{2}}A$

$I_{rms} = \frac{I_0}{\sqrt{2}} = \frac{5}{2}A$

9. An unpolarised light beam of intensity $2I_0$ is passed through a polaroid P and then through another polaroid Q which is oriented in such a way that its passing axis makes an angle of 30° relative to that of P. The intensity of the emergent light is

(A) $\frac{I_0}{4}$ (B) $\frac{I_0}{2}$ (C) $\frac{3I_0}{4}$ (D) $\frac{3I_0}{2}$

Sol. **C**



$I_1 = \frac{1}{2} = (2I_0) = I_0$

$I_2 = I_1 \cos^2 30°$

$= I_0 . \frac{3}{4} = \frac{3I_0}{4}$

10. An a particle and a proton are accelerated from rest through the same potential difference. The ratio of linear momenta acquired by above two particals will be:

(A) $\sqrt{2} : 1$ (B) $2\sqrt{2} : 1$ (C) $4\sqrt{2} : 1$ (D) 8 : 1

Sol. **B**

$p = \sqrt{2mE} = \sqrt{2mqV}$

$\frac{p_0}{p_p} = \sqrt{\frac{m_\alpha q_\alpha}{m_P q_P}} = \sqrt{\frac{4}{1} \times \frac{2}{1}}$

$= \frac{2\sqrt{2}}{1}$

11. Read the following statements :

(A) Volume of the nucleus is directly proportional to the mass number

(B) Volume of the nucleus is independent of mass number

(C) Density of the nucleus is directly proportional to the mass number

(D) Density of the nucleus is directly proportional to the cube root of the mass number.

(E) Density of the nucleus is independent of the mass number.

Choose the correct option from the following options

(A) (A) and (D) only (B) (A) and (E) only

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

Sol. **B**

$R \propto A^{1/3}$

$V = \frac{4}{3}\pi R^3 \propto A$

Mass $\propto$ A

So density is independent of A

12. An object of mass 1 kg is taken to a height from the surface of earth which is equal to three times the radius of earth. The gain in potential energy of the object will be

[If. $g = 10ms^{-2}$ and radius of earth = 6400 km]

(A) 48 MJ (B) 24 MJ (C) 36 MJ (D) 12 MJ

Sol. **A**

$U_i = \frac{-GMm}{R}$

$U_f = -\frac{GMm}{4R}$

$\Delta U = U_f - U_i = \frac{3GMm}{4R}$

$= \frac{3}{4}mgR$

$= \frac{3}{4} \times 1 \times 10 \times 64 \times 10^5$

= 48 MJ

13. A ball is released from a height h. If t_1 and t_2 be the time required to complete first half and second half of the distance respectively. Then choose the correct relation between t_1 and t_2

(A) $t_1 = (\sqrt{2})t_2$ (B) $t_1 = (\sqrt{2} - 1)t_2$

(C) $t_2 = (\sqrt{2} + 1)t_1$ (D) $t_2 = (\sqrt{2} - 1)t_1$

Sol. **D**

For first $\frac{h}{2}$

$\frac{h}{2} = \frac{1}{2} g t_1^2$

For total height h

$h = \frac{1}{2} g (t_1 + t_2)^2$

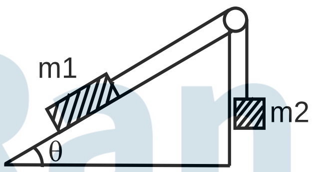
$\frac{1}{\sqrt{2}} = \frac{t_1}{t_1+t_2}$

$1 + \frac{t_2}{t_1} = \sqrt{2}$

$\frac{t_1}{t_2} = \frac{1}{\sqrt{2}-1}$

$t_2 = (\sqrt{2} - 1)t_1$

14. Two bodies of masses $m_1 = 5\text{kg}$ and $m_2 = 3\text{kg}$ are connected by a light string going over a smooth light pulley on a smooth inclined plane as shown in the figure. The system is at rest. The force exerted by the inclined plane on the body of mass m_1 will be : [Take $g = 10\text{ms}^{-2}$]



(A) 30N (B) 40 N (C) 50 N (D) 60 N

Sol. **B**

For equilibrium $m_2 g = m_1 g \sin\theta$

$\sin\theta = \frac{m_2}{m_1} = \frac{3}{5}$

$\cos\theta = \frac{4}{5}$

Normal force on $m_1 = 5g\cos\theta$

$= 5 \times 10 \times \frac{4}{5} = 40$ N

15. If momentum of a body is increased by 20%, then its kinetic energy increases by

(A) 36% (B) 40% (C) 44% (D) 48%

Sol. **C**

$P' = P + \frac{20}{100} P = 1.2 P$

% change in KE $= \frac{k'-k}{K} \times 100$

$= \left(\frac{\frac{P'^2}{2m} - \frac{P^2}{2m}}{\frac{P^2}{2m}}\right) \times 100$

$= [(1.2)^2 - 1] \times 100 = 44\%$

16. The torque of a force $5\hat{i} + 3\hat{j} - 7\hat{k}$ about the origin is τ. If the force acts on a particle whose position vector is $2\hat{i} + 2\hat{j} + \hat{k}$, then the value of τ will be

(A) $11\hat{i} + 19\hat{j} - 4\hat{k}$ (B) $-11\hat{i} + 9\hat{j} - 16\hat{k}$ (C) $-17\hat{i} + 19\hat{j} - 4\hat{k}$ (D) $17\hat{i} + 9\hat{j} + 16\hat{k}$

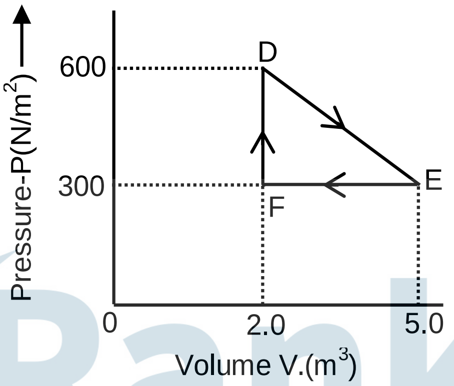
Sol. C

$$\vec{\tau} = \vec{r} \times \vec{F} = \begin{vmatrix} i & j & k \\ 2 & 2 & 1 \\ 5 & 3 & -7 \end{vmatrix}$$

$= \hat{i}(-14 - 3) - \hat{j}(-14 - 5) + \hat{k}(6 - 10)$

$= -17\hat{i} + 19\hat{j} - 4\hat{k}$

17. A thermodynamic system is taken from an original state D to an intermediate state E by the linear process shown in the figure. Its volume is then reduced to the original volume from E to F by an isobaric process. The total work done by the gas from D to E to F will be



(A) −450 J (B) 450 J (C) 900 J (D) 1350 J

Sol. **B**

$W_{DE} = \frac{1}{2}(600 + 300)\ 3J$

$=1350$ J

$W_{EF} = -300 \times 3 = -900$ J

$W_{DEF} = 450$ J

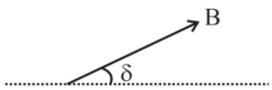
18. The vertical component of the earth's magnetic field is 6×10^{-5} T at any place where the angle of dip is 37°. The earth's resultant magnetic field at that place will be (Given tan 37°= $\frac{3}{4}$)

(A) 8×10^{-5}T (B) 6×10^{-5}T (C) 5×10^{-4}T (D) 1×10^{-4}T

Sol. **D**

$(\delta = 37°)$

$B_V = B \sin \delta$



$6 \times 10^{-5} = B\frac{3}{5}$

$B = 10 \times 10^{-5}$ T

$= 10^{-4}$ T

19. The root mean square speed of smoke particles of mass 5×10^{-17} kg in their Brownian motion in air at NTP is approximately. [Given k = 1.38×10^{-23} JK^{-1}]

(A) 60 mm s^{-1} (B) 12 mm s^{-1} (C) 15 mm s^{-1} (D) 36 mm s^{-1}

Sol. **C**

$v_{rms} = \sqrt{\frac{3kT}{m}} = \sqrt{\frac{3\times1.38\times10^{-23}\times293}{5\times10^{-17}}}$

≈ 15 mm/s

20. Light enters from air into a given medium at an angle of 45° with interface of the air-medium surface. After refraction, the light ray is deviated through an angle of 15° from its original direction. The refractive index of the medium is :

(A) 1.732 (B) 1.333 (C) 1.414 (D) 2.732

Sol. **C**

$i = 45°$

$D = i - r$

$15° = 45 - r \Rightarrow r = 30°$

$n_1 \sin i = n_2 \sin r$

$1 \sin 45° = \mu \sin 30°$

$\frac{1}{\sqrt{2}} = \mu \frac{1}{2}$

$\mu = \sqrt{2} = 1.414$

SECTION - B

21. A tube of length 50 cm is filled completely with an incompressible liquid of mass 250g and closed at both ends. The tube is then rotated in horizontal plane about one of its ends with a uniform angular velocity $x\sqrt{F}$ rad s^{-1}. If F be the force exerted by the liquid at the other end then the value of x will be ___________.

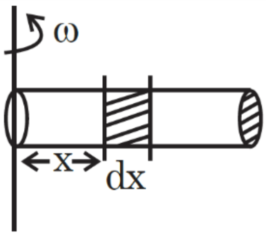
Sol. **4**

$F = \int (dm)\omega^2 x$

$= \int_0^L \left(\frac{m}{L}dx\right)\omega^2 x$

$= \frac{m}{L}\omega^2\frac{L^2}{2}$

$= \frac{m\omega^2 L}{2}$



$\omega = \sqrt{\frac{2}{mL}}\sqrt{F}$

$= \sqrt{\frac{2}{0.25\times0.5}}\sqrt{F}$

$= \sqrt{16}\sqrt{F}$

$= 4\sqrt{F}$

22. Nearly 10% of the power of a 110 W light bulb is converted to visible radiation. The change in average intensities of visible radiation, at a distance of 1m from the bulb to a distance of 5m is $a \times 10^{-2}$ W/m^2. The value of 'a' will be ___________

Sol. **84**

P' = 10% of 110 W

$= \frac{10}{100} \times 110$ W

= 11 W

$I_1 - I_2 = \frac{P'}{4\pi r_1^2} - \frac{P'}{4\pi r_2^2}$

$= \frac{11}{4\pi}\left[\frac{1}{1} - \frac{1}{25}\right]$

$= \frac{11}{4\pi} \times \frac{24}{25}$

$= \frac{264}{\pi} \times 10^{-2} = 84 \times 10^{-2} W/m^2$

23. A metal wire of length 0.5 m and cross-sectional area $10^{-4} m^2$ has breaking stress $5 \times 10^8 Nm^{-2}$. A block of 10 kg is attached at one end of the string and is rotating in a horizontal circle. The maximum linear velocity of block will be _________ ms^{-1}

Sol. **50**

$T = \frac{mv^2}{\ell} = \frac{10 \times v^2}{0.5} = 20v^2$

T_{max} = Breaking stress × Area

$= 5 \times 10^8 \times 10^{-14} = 5 \times 10^4$

$20V^2 = 5 \times 10^4$

$V = \sqrt{\frac{1}{4}10^4} = 50$ m/s

24. The velocity of a small ball of mass 0.3 g and density 8 g/cc when dropped in a container filled with glycerine becomes constant after sometime. If the density of glycerine is 1.3 g/cc. then the value of viscous force acting on the ball will be $x \times 10^{-4}$N. The value of x is ________.
(use $g = 10 m/s^2$)

Sol. **25**

$F_V + F_B = mg$ (v = constant)

$F_V = mg - F_B$

$= \rho_B Vg - \rho_L Vg$

$= (\rho_B - \rho_L)Vg$

$= (8 - 1.3) \times 10^{+3} \times \frac{0.3 \times 10^{-3}}{8 \times 10^3} \times 10$

$= \frac{6.7 \times 0.3}{8} \times 10^{-2}$ (g = 10)

$= \frac{67 \times 3}{8} \times 10^{-4} = 25.125 \times 10^{-4}$

Ans. 25.125

25. A modulating signal $2\sin(6.28 \times 10^6)t$ is added to the carrier signal $4\sin(12.56 \times 10^9)t$ for amplitude modulation. The combined signal is passed through a non-linear square law device. The output is then passed through a band pass filter. The bandwidth of the output signal of band pass filter will be ___________ MHz.

Sol. **2**

Frequencies present in output of square law device

$2f_c$, $f_c + f_m$, f_c, $f_c - f_m$, $2f_m$, f_m

After passing through band bass filte.

$f_c + f_m$, f_c, $f_c - f_m$

Band width = $2f_m$

$= \frac{2\omega_m}{2\pi} = \frac{6.28\times10^6}{3.14} = 2$ MHz

26. The speed of a transverse wave passing through a string of length 50 cm and mass 10 g is 60 ms^{-1}. The area of cross-section of the wire is 2.0 mm^2 and its Young's modulus is 1.2×10^{11} Nm^{-2}. The extension of the wire over its natural length due to its tension will be $x \times 10^{-5}$m. The value of x is

Sol. **15**

$V_w = \sqrt{\frac{T}{\mu}}$

$60 = \sqrt{\frac{T}{10\times10^{-3}} \times 0.5}$

$T = \frac{(60)^2\times10^{-2}}{0.5} = 72$ N

$\Delta\ell = \frac{F\ell}{AY} = \frac{72\times0.5}{2\times10^{-6}\times1.2\times10^{11}}$

$= \frac{72\times5}{24} \times 10^{-5} = 15 \times 10^{-5}$

27. The metallic bob of simple pendulum has the relative density 5. The time period of this pendulum is 10 s. If the metallic bob is immersed in water, then the new time period becomes $5\sqrt{x}$ s. Then value of x will be ________.

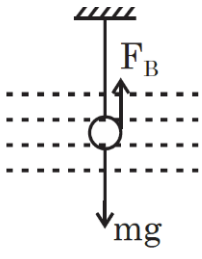
Sol. **5**

$mg' = mg - F_B$

$g' = \frac{mg-F_B}{m}$

$= \frac{\rho_B Vg-\rho_w Vg}{\rho_B V}$

$= \left(\frac{\rho_B-\rho_w}{\rho_B}\right) g$ $T = 2\pi\sqrt{\frac{\ell}{g}}$



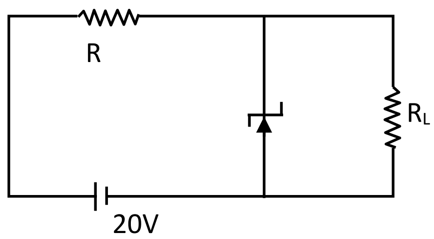
$= \frac{5-1}{5} \times g = \frac{4}{5} g$

$\frac{T'}{T} = \sqrt{\frac{g}{g'}} = \sqrt{\frac{g}{\frac{4}{5}g}} = \sqrt{\frac{5}{4}}$

$T' = T\sqrt{\frac{5}{4}} = \frac{10}{2}\sqrt{5}$

$T' = 5\sqrt{5}$

28. A 8 V Zener diode along with a series resistance R is connected across a 20 V supply (as shown in the figure). If the maximum Zener current is 25 mA, then the minimum value of R will be __________ Ω.



Sol. **(480)**

$\varepsilon - IR - V_Z = 0$

$20 - IR - 6 = 0$

$IR = 12$

$25 \times 10^{-3}\, R = 12$

$R = \frac{12}{25\times10^{-3}} = 480\Omega$

29. Two radioactive materials A and B have decay constant 25λ and 16 λ respectively. If initially they have same number of nuclei, then the ratio of the number of nuclei of B to that of A will be "e" after a time $\frac{1}{\alpha\lambda}$. The value of a is ______________.

Sol. **(9)**

$N = N_0 e^{-\lambda t}$

$\frac{N_B}{N_A} = \frac{e^{-\lambda_2 t}}{e^{-\lambda_1 t}} = e^{-\lambda_2 t}.e^{-\lambda_1 t}$

$e^1 = e^{(\lambda_1 - \lambda_1)t}$

$(\lambda_1 - \lambda_2)t = 1$

$t = \frac{1}{\lambda_1 - \lambda_2} = \frac{1}{25\lambda - 16\lambda} = \frac{1}{9\lambda}$

30. A capacitor of capacitance 500 μF is charged completely using a dc supply of 100 V. It is now connected to an inductor of inductance 50 mH to form and LC circuit. The maximum current in LC circuit be _______________ A.

Sol. **(10)**

Energy stored in capacitor

$= \frac{1}{2}CV^2 = \frac{1}{2}500 \times 10^{-6} \times 10^4 = \frac{5}{2}J$

Current will be maximum when whole energy of capacitor becomes energy of inductor.

$\frac{1}{2}LI^2 = \frac{5}{2}$

$I = \sqrt{\frac{5}{L}} = \sqrt{\frac{5}{50\times10^{-3}}} = 10\,A$