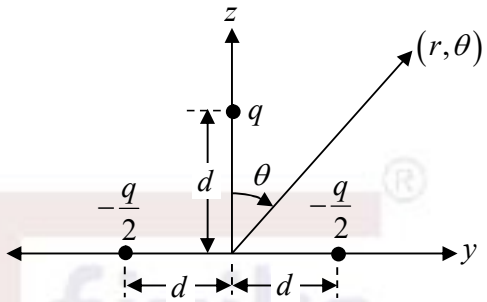
# Test Your fiziks concepts!

## Topic: Electromagnetic Theory

### (For CSIR NET-JRF, GATE, JEST and TIFR Aspirants)

**Q.** Consider a system of three charges as shown in the figure below:




For $r = 10\ m; \theta = 60$ degrees; $q = 10^{-6}$ Coulomb, and $d = 10^{-3}\ m$, the electric dipole potential in volts at a point $(r,\theta)$ is: [Use: $\frac{1}{4\pi \in_0} = 9\times10^9 \frac{Nm^2}{C^2}$]

(a) 0.025 (b) 0.035 (c) 0.045 (d) 0.055

**Ans.: (c)**

**Solution.:** Monopole moment $= -\frac{q}{2} - \frac{q}{2} + q = 0$

$$\vec{p} = -\frac{q}{2}\times(-d\hat{y}) - \frac{q}{2}(d\hat{y}) + q(d\hat{z}) \Rightarrow \vec{p} = qd\hat{z}$$

$$V(r,\theta) = \frac{1}{4\pi \in_0}\frac{\vec{p}\cdot\hat{r}}{r^2} = \frac{1}{4\pi \in_0}\frac{qd\cos\theta}{r^2}$$

$$V(r,\theta) = 9\times10^9 \times \frac{10^{-6}\times10^{-3}\times\cos 60^0}{(10)^2} = 9\times10^9 \times \frac{10^{-9}}{2\times100} = 0.045 \text{ Volts}$$



**Note:**

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# Test Your fiziks concepts!

## Topic: Solid State Physics

### (For IIT-JAM, JEST, TIFR and CUET Aspirants)

**Q.** Fermi energy of a certain metal $M_1$ is $5eV$. A second metal $M_2$ has an electron which is $6\%$ higher than that of $M_1$. Assuming that the free electron theory is valid for both the metals, the Fermi energy of $M_2$ is closet to

(a) $5.6eV$ (b) $5.2eV$ (c) $4.8eV$ (d) $4.4eV$

**Ans.: (b)**

**Solution.:** The expression of Fermi energy is $E_F = \frac{\hbar^2}{2m}\left(3\pi^2 n\right)^{2/3}$

Let us consider that $n_1, \mathrm{E}_{F_1}$ are the concentration of electron and Fermi energy in metal $M_1$ and $n_2, \mathrm{E}_{F_2}$ is in metal $M_2$.

Given, $n_2 = n_1 + 0.06n_1 = 1.06n_1$

$$\frac{E_{F_2}}{E_{F_1}} = \frac{\left(\frac{\hbar^2}{2m}\left(3\pi^2 n_2\right)^{2/3}\right)}{\left(\frac{\hbar^2}{2m}\left(3\pi^2 n_1\right)^{2/3}\right)} = \frac{\left(n_2\right)^{2/3}}{\left(n_1\right)^{2/3}} = \frac{\left(1.06n_1\right)^{2/3}}{\left(n_1\right)^{2/3}} = \left(1.06\right)^{2/3} = 1.0396$$

$$E_{F_2} = 1.0396 \times E_{F_1} = 1.0396 \times 5eV = 5.2eV$$

**Note:**

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# Test Your fiziks concepts!

## Topic: Mechanics

### (For PGT: KVS, NVS, DSSSB, State Education Boards, etc.)

**Q.** A trapped air bubble of volume $V_0$ is released from a depth $h$ measured from the water surface in a large water tank. The volume of the bubble grows to $2V_0$ as it reaches just below the surface. The temperature of the water and the pressure above the surface of water $(10^5 N/m^2)$ remain constant throughout the process. If the density of water is $1000 kg/m^3$ and the acceleration due to gravity is $10 m/s^2$, then the depth $h$ is

(a) $1m$ (b) $10m$ (c) $50m$ (d) $100m$

**Ans.: (b)**

**Solution.:** At depth $h$ pressure $P_1 = P_0 + \rho gh$ and volume $V_1 = V_0$

At surface pressure $P_2 = P_0$ and volume $V_2 = 2V_0$

Then, $P_1V_1 = P_2V_2$

$$(P_0 + \rho gh)V_0 = P_0 2V_0 \Rightarrow h = \frac{P_0V_0}{\rho gV_0} = \frac{P_0}{\rho g} = \frac{1\times10^5}{10\times10^3} = 10\ m$$

$$P_0 = 10^5 N/m^2, g = 10m/s^2,\ \rho = 1000kg/m^3 \Rightarrow h = 10m$$

**Note:**

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# Test Your fiziks concepts!

## Topic: Electromagnetic Theory

### (For CSIR NET-JRF, GATE, JEST and TIFR Aspirants)

**Q.** An insulating sphere of radius *a* carries a charge density

$$\rho\left(\vec{r}\right)=\rho_0\left(a^2-r^2\right)\cos\theta;\quad r<a\,.$$

The leading order term for the electric field at a distance *d*, far away from the charge distribution, is proportional to

(a) $d^{-1}$ (b) $d^{-2}$ (c) $d^{-3}$ (d) $d^{-4}$

**Ans.: (c)**

**Solution.:** $V(r)=\left[\frac{1}{r}\int_V \rho d\tau+\frac{1}{r^2}\int \rho\cos\theta d\tau+\cdots\right]$,

I$^{st}$ term, $\int \rho d\tau=\int_0^a\int_0^\pi\int_0^{2\pi}\rho_0\left(a^2-r^2\right)\cos\theta\times r^2\sin\theta dr d\theta d\phi=0$

II$^{nd}$ term, $\int \rho\cos\theta d\tau=\int_0^a\int_0^\pi\int_0^{2\pi}\rho_0\left(a^2-r^2\right)\cos^2\theta\times r^2\sin\theta dr d\theta d\phi\neq 0\,.$

$\Rightarrow \mathrm{V}\propto\frac{1}{\mathrm{r}^2}\Rightarrow E\propto\frac{1}{\mathrm{r}^3}$

**Note:**

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# Test Your fiziks concepts!

## Topic: Solid State Physics

### (For IIT-JAM, JEST, TIFR and CUET Aspirants)

**Q.** The total number of Na and Cl ions per unit cell of the NaCl crystal is:

(a) 2 (b) 4

(c) 8 (d) 16

**Ans.: (c)**

**Solution.:** In a NaCl crystal:

- The structure is face-centered cubic (FCC) with $Na^+$ and $Cl^-$ ions arranged alternately.

In one-unit cell:

- The $Na^+$ ions contribute 4 ions (from 8 corner atoms contributing 1/8 each and 6 face atoms contributing 1/2 each).

- The $Cl^-$ ions also contribute 4 ions in the same arrangement.

Thus, the total number of ions ($Na^+ + Cl^-$) per unit cell is: $4 + 4 = 8$

Thus, correct answer is option (c).

**Note:**

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# Test Your fiziks concepts!

## Topic: Mechanics

### (For PGT: KVS, NVS, DSSSB, State Education Boards, etc.)

**Q.** The general form of a central force is represented by $\vec{F} = \frac{C}{r^n}\hat{r}$ (C = constant) known as Inverse Power law.

A. The force represented by above equation will be attractive if $C < 0$.

B. The force represented by above equation will repulsive if $C < 0$.

C. The force represented by above equation will be repulsive if $C > 0$.

D. The force represented by above equation will be attractive if $C > 0$.

Choose the correct answer from the options given below.

(a) A and B only (b) B and C only (c) A and C only (d) A and D only

**Ans.: (c)**

**Solution.:** $\because \vec{F} = \frac{c}{r^n}\hat{r} \Rightarrow V = -\int_{\infty}^{r} \vec{F}\cdot dr = -c\int_{\infty}^{r} \frac{dr}{r^n} = -\left.\frac{cr^{-n+1}}{-n+1}\right|_{\infty}^{r} \Rightarrow V(r) = \frac{c}{(n-1)r^{n-1}}$

**Note:**

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