

1) If \mathbf{A} and \mathbf{B} are constant vectors, then $\nabla(\mathbf{A} \cdot \mathbf{B} \times \mathbf{r})$ is

- a) $\mathbf{A} \cdot \mathbf{B}$ b) $\mathbf{A} \times \mathbf{B}$ c) \mathbf{r} d) Zero

2) $\Gamma(n + \frac{1}{2})$ is equal to [Given $\Gamma(n + 1) = n\Gamma(n)$ and $\Gamma(1/2) = \sqrt{\pi}$]

- a) $\frac{n!}{2^n} \sqrt{\pi}$ b) $\frac{2n!}{n!2^n} \sqrt{\pi}$ c) $\frac{2n!}{n!2^{2n}} \sqrt{\pi}$ d) $\frac{n!}{2^{2n}} \sqrt{\pi}$

3) The relativistic form of Newton's second law of motion is

- a) $F = \frac{mc}{\sqrt{c^2 - v^2}} \frac{dv}{dt}$ b) $F = \frac{m\sqrt{c^2 - v^2}}{c} \frac{dv}{dt}$ c) $F = \frac{mc^2}{c^2 - v^2} \frac{dv}{dt}$ d) $F = m \frac{c^2 - v^2}{c^2} \frac{dv}{dt}$

4) Consider a gas of atoms obeying Maxwell-Boltzmann statistics. The average value of $e^{i\mathbf{a} \cdot \mathbf{p}}$ over all the momenta \mathbf{p} of each of the particles (where \mathbf{a} is a constant vector and a is its magnitude, m is the mass of each atom, T is temperature and k is Boltzmann's constant) is,

- a) One b) Zero c) $e^{-\frac{1}{2}a^2mkT}$ d) $e^{-\frac{3}{2}a^2mkT}$

5) The electromagnetic form factor $F(q^2)$ of a nucleus is given by,

$$F(q^2) = \exp\left[-\frac{q^2}{2Q^2}\right]$$

where Q is a constant. Given that

$$F(q^2) = \frac{4\pi}{q} \int_0^\infty r dr \rho(r) \sin qr$$

$$\int d^3r \rho(r) = 1$$

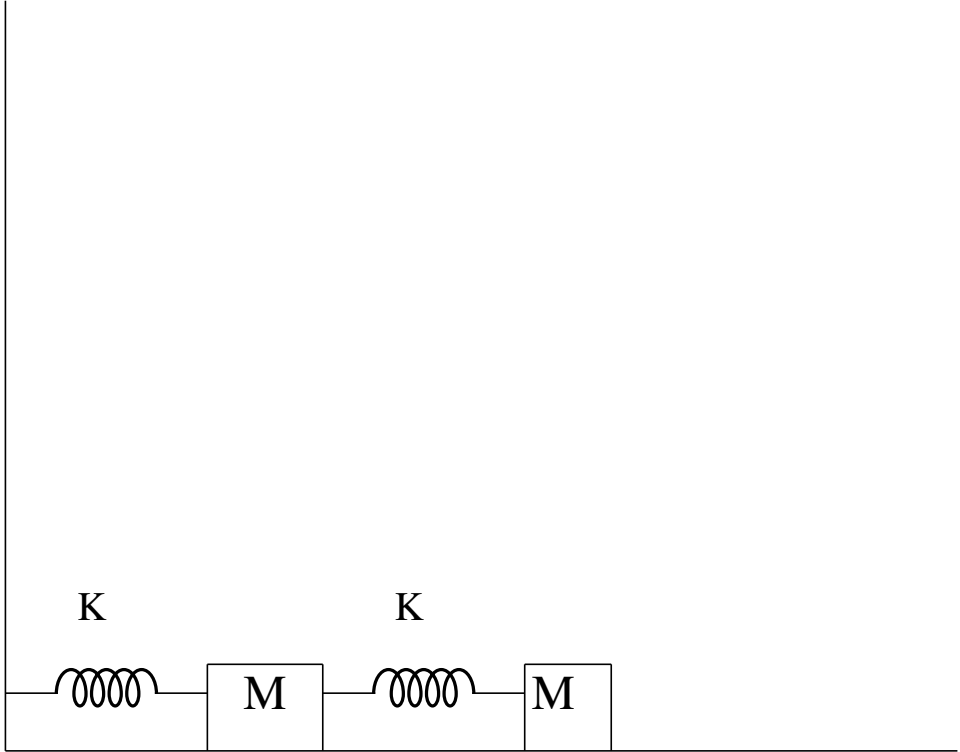
where $\rho(r)$ is the charge density, the root mean square radius of the nucleus is given by, Primeval

- a) $\frac{1}{Q}$ b) $\frac{\sqrt{2}}{Q}$ c) $\frac{\sqrt{3}}{Q}$ d) $\frac{\sqrt{6}}{Q}$

6) A uniform circular disk of radius R and mass M is rotating with angular speed ω about an axis, passing through its center and inclined at an angle 60 degrees with respect to its symmetry axis. The magnitude of the angular momentum of the disk is,

- a) $\frac{\sqrt{3}}{4}\omega MR^2$ b) $\frac{\sqrt{3}}{8}\omega MR^2$ c) $\frac{\sqrt{7}}{8}\omega MR^2$ d) $\frac{\sqrt{7}}{4}\omega MR^2$

- 7) Consider two small blocks, each of mass M , attached to two identical springs. One of the springs is attached to the wall, as shown in the figure. The spring constant of each spring is k . The masses slide along the surface and the friction is negligible. The frequency of one of the normal modes of the system is,



- a) $\sqrt{\frac{3+\sqrt{2}}{2}} \sqrt{\frac{k}{M}}$ b) $\sqrt{\frac{3+\sqrt{3}}{2}} \sqrt{\frac{k}{M}}$ c) $\sqrt{\frac{3+\sqrt{5}}{2}} \sqrt{\frac{k}{M}}$ d) $\sqrt{\frac{3+\sqrt{6}}{2}} \sqrt{\frac{k}{M}}$

- 8) A charge distribution has the charge density given by $\rho = Q\{\delta(x - x_0) - \delta(x + x_0)\}$. For this charge distribution the electric field at $(2x_0, 0, 0)$

- a) $\frac{2Q\hat{x}}{9\pi\epsilon_0 x_0^2}$ b) $\frac{Q\hat{x}}{4\pi\epsilon_0 x_0^3}$ c) $\frac{Q\hat{x}}{4\pi\epsilon_0 x_0^2}$ d) $\frac{Q\hat{x}}{16\pi\epsilon_0 x_0^2}$

- 9) A monochromatic plane wave at oblique incidence undergoes reflection at a dielectric interface. If \hat{k}_i , \hat{k}_r and \hat{n} are the unit vectors in the directions of incident wave, reflected wave and the normal to the surface respectively, which one of the following expressions is correct?

a) $(\hat{k}_i - \hat{k}_r) \times \hat{n} \neq 0$ b) $(\hat{k}_i - \hat{k}_r) \cdot \hat{n} = 0$ c) $(\hat{k}_i \times \hat{n}) \cdot \hat{k}_r = 0$ d) $(\hat{k}_i \times \hat{n}) \cdot \hat{k}_r \neq 0$

- 10) In a normal Zeeman effect experiment, spectral splitting of the line at the wavelength 643.8 nm corresponding to the transition $5^1D_2 \rightarrow 5^1P_1$ of cadmium atoms is to be observed. The spectrometer has a resolution of 0.01 nm. The minimum magnetic field needed to observe this is ($m_e = 9.1 \times 10^{-31}$ kg, $e = 1.6 \times 10^{-19}$ C, $c = 3 \times 10^8$ m/s.)

- a) 0.26 T
b) 0.52 T
c) 2.6 T
d) 5.2 T

- 11) The spacing between vibrational energy levels in CO molecule is found to be 8.44×10^{-2} eV. Given that the reduced mass of CO is 1.14×10^{-26} kg, Planck's constant is 6.626×10^{-34} Js and $1\text{eV} = 1.6 \times 10^{-19}$ J. The force constant of the bond in CO molecule is

- a) 1.87 N/m b) 18.7 N/m c) 187 N/m d) 1870 N/m

- 12) A lattice has the following primitive vectors (in Å): $\mathbf{a} = 2(\hat{j} + \hat{k})$, $\mathbf{b} = 2(\hat{k} + \hat{i})$, $\mathbf{c} = 2(\hat{i} + \hat{j})$. The reciprocal lattice corresponding to the above lattice is

- a) BCC lattice with cube edge of $(\frac{\pi}{2})\text{\AA}^{-1}$
b) BCC lattice with cube edge of $(2\pi)\text{\AA}^{-1}$
c) FCC lattice with cube edge of $(\frac{\pi}{2})\text{\AA}^{-1}$
d) FCC lattice with cube edge of $(2\pi)\text{\AA}^{-1}$