# Sample Questions JEST 2011

The JEST screening test for entrance to the PhD programme in Physics focusses on the following broad areas:

- Classical Mechanics
- Electromagnetic Theory and Optics
- Quantum Mechanics
- Thermodynamics and Statistical Mechanics
- Mathematical Methods
- Electronics and Experimental Methods
- Advanced topics (like Atomic, Molecular and Nuclear Physics and very elementary Solid State Physics)

In each of these areas, familiarity with the basics (including the necessary mathematics) is assumed.

The test will contain only multiple choice questions. Half the questions would carry ONE POINT and the candidate may have to do a short calculation to get the answer. The rest would be THREE POINT QUESTIONS which will require more detailed problem solving. A sample questionnaire is attached.

Some textbooks which may help the candidate prepare for the test are listed below. It is not essential to read every chapter of all the books. There is no specified syllabus for the test, rather the objective is to check whether the student understands the basic principles of physics and is able to apply them in solving problems.

- *Classical Mechanics* by H. Goldstein
- *An Introduction to Mechanics* by Daniel Kleppner & Robert J. Kolenkow
- *Introduction to Electrodynamics* by David J. Griffiths
- *Principles of Quantum Mechanics* by R. Shankar
- *Introduction to Quantum Mechanics* by David J. Griffiths
- *Fundamentals of Statistical and Thermal Physics* by Frederick Reif
- *Heat and Thermodynamics* by M. W. Zemansky & Richard H. Dittman
- *Mathematical Methods for Physicists* by George B. Arfken & Hans J. Weber
- *Concepts of Modern Physics* by Arthur Beiser

## THREE POINT QUESTIONS

1. In quantum mechanics, one may picture a wave function in either momentum space or configuration space. If the wave function in momentum space is $\phi(p) = N/(p^2 + \alpha^2)$, then calculate the wave function in configuration space (aside from a multiplicative constant).

   (a) $\exp\left(-\alpha^2 x^2/\hbar^2\right)$
   (b) $\exp\left(-\alpha|x|/\hbar\right)$
   (c) $\sin\left(px/\hbar\right)$
   (d) $\cos\left(px/\hbar\right)$

2. Consider the two-body decay of a particle $X$ which is at rest in the laboratory and of mass $M$ in its rest-frame into a particle $A$ of mass $m_A$ and another particle which is massless. The energy of the particle $A$ in the laboratory frame is ($c = 1$):

   (a) $M/2$
   (b) $(M^2 + m_A^2)/(2M)$
   (c) $(M^2 - m_A^2)/(2M)$
   (d) $(M^2 - 4m_A^2)/(2M)$

3. The electric potential of a grounded conducting sphere of radius $a$ in an uniform electric field is given as $\phi(r, \theta) = -E_0 r \left[1 - (a/r)^3\right] \cos\theta$. Find the surface charge distribution on the sphere.

   (a) $\epsilon_0 E_0 \sin\theta$
   (b) $\epsilon_0 E_0 \cos\theta$
   (c) $3\epsilon_0 E_0 \cos\theta$
   (d) $2\epsilon_0 E_0 \sin\theta$

4. Compute

$$\lim_{z\to 0} \frac{\mathrm{Re}(z^2) + \mathrm{Im}(z^2)}{z^2}$$

   (a) the limit does not exist.
   (b) 1
   (c) $-i$
   (d) $-1$

5. Consider a two state system with an observable represented by

$$\hat{A} = \begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix}$$

   For any physical state of the system the expectation value $\langle \hat{A} \rangle$ is best described by

   (a) $0 \le \langle \hat{A} \rangle < \infty$
   (b) $0 \le \langle \hat{A} \rangle < 1$
   (c) $0 \le \langle \hat{A} \rangle \le 2$
   (d) $\langle \hat{A} \rangle \ge 1$

## ONE POINT QUESTIONS

1. The states $|n\rangle, n = 0, 1, 2$ form a complete orthonormal set of states in Fock space. Annihilation operator $\hat{a}$ is defined by

$$\hat{a}|n\rangle = \sqrt{n}\ |n-1\rangle, \quad \hat{a}|0\rangle = 0$$

The matrix elements of hermitian adjoint $\hat{a}^\dagger$ are given by $\langle n|\hat{a}^\dagger|n'\rangle =$

   (a) $\sqrt{n}\ \delta_{nn'}$
   (b) $\sqrt{n}\ \delta_{n\ n'+1}$
   (c) $\sqrt{n}\ \delta_{n+1\ n'}$
   (d) $\sqrt{n}\ n'$

2. A hard ball dropped from a height of 1 m in earth's gravitational field bounces to a height of 95 cm. What will be the total distance traversed by the ball?

   (a) 2000 cm
   (b) 1010 cm
   (c) 1810 cm
   (d) 3900 cm

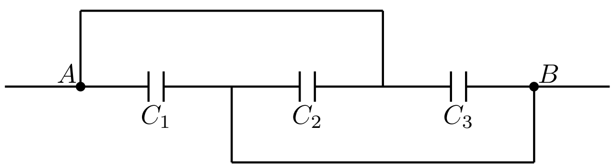
3. The force experienced by a mirror when it reflects all the light from a laser with a power of 10 mW is about

   (a) $6.7 \times 10^{-11}$ N
   (b) $0.7 \times 10^{-13}$ N
   (c) $3.33 \times 10^{-11}$ N
   (d) $7.0 \times 10^{-13}$ N

4. The coordinate transformation $x' = 0.8x + 0.6y, \quad y' = 0.6x - 0.8y$ represents

   (a) a translation.
   (b) a rotation in the $x - y$ plane.
   (c) a reflection in the $x - y$ plane.
   (d) none of the above

5. The equivalent capacitance of a system of capacitors shown in the adjacent figure between points $A$ & $B$ is




   (a)

$$\left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}\right)^{-1}$$

   (b)

$$C_1 - C_2 + C_3$$

   (c)

$$\frac{C_1 C_2}{C_1 + C_2} + C_3$$

   (d)

$$C_1 + C_2 + C_3$$