Reg. No.										

Manipal University, Manipal
First Semester M.Sc.(Physics)
End Semester Examination, December 2015
Subject: Quantum Mechanics I (PHY-605)
(Credit System)

Time: 3 hours **Marks: 50**

Answer any five full questions.

1. For the Gaussian wavepacket given by

$$\psi(x,0) = \frac{1}{(\pi\sigma_0^2)^{\frac{1}{4}}} exp\left(-\frac{x^2}{2\sigma_0^2} + \frac{i}{\hbar}p_0 x\right)$$

evaluate $< x >$, $< x^2 >$, $< p >$, $< p^2 >$, **and show that** $\triangle x \triangle p = \frac{1}{2}\hbar$. **[10]**

2. (i) Show that eigenfunctions of a Hermitian operator belonging to different eigenvalues are orthogonal. [5]

(ii) Briefly discuss about the Dirac's bra-ket notations. [5]

3. Show that for a finite deep square potential well only finite number of energy levels are possible. [10]

4. (i) The time-independent wave function of a particle of mass m **moving in a potential** $V(x) = \alpha^2 x^2$ **is**

$$\psi(x) = exp\left(-\sqrt{\frac{m\alpha^2}{2\hbar^2}}x^2\right)$$

where α **being a constant. Find the energy of the system. [5]**

(ii) A rigid rotator is constrained to rotate about a fixed axis. Find the eigenvalues and eigenfunctions. [5]

5. A particle of mass m **is confined to the interior of a hollow spherical cavity of radius** R **with impenetrable walls. Find the pressure exerted on the walls of the cavity by the particle in its ground state. [10]**

6. (i) Explain the meaning of:
(a) identical particle,
(b) distinguishable particles,
(c) indistinguishable particles. [5]

(ii) Write short notes on symmetric and anti-symmetric wave-functions. [5]

Useful formulae:

$$\int_0^\infty exp(-ax^2)\,dx = \frac{1}{2}\sqrt{\left(\frac{\pi}{a}\right)}$$

$$\int_0^\infty x^2 exp(-ax^2)\,dx = \frac{\sqrt{\pi}}{4}\frac{1}{a^{3/2}}$$

$$\int_0^\infty x^4 exp(-ax^2)\,dx = \frac{3\sqrt{\pi}}{8}\frac{1}{a^{5/2}}$$

$$\nabla^2 t = \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial t}{\partial r}\right) + \frac{1}{r^2 sin\theta}\frac{\partial}{\partial \theta}\left(sin\theta\frac{\partial t}{\partial \theta}\right) + \frac{1}{r^2 sin^2\theta}\frac{\partial^2 t}{\partial \phi^2}$$