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37. A particle of mass M moves in a spherically symmetric potential $V(r) = kr^2$, and is having angular momentum L, then a constant of motion is given by

(A) $\frac{1}{2}M\left(\frac{d\vec{r}}{dt}\right)^2 + kr^2 + \frac{L^2}{2Mr^2}$

(B) $\frac{1}{2}M\left(\frac{dr}{dt}\right)^2 + kr^2$

(C) $\frac{1}{2}M\left(\frac{d\vec{r}}{dt}\right)^2 + kr^2$

(D) $\frac{1}{2}M\left(\frac{dr}{dt}\right)^2 + kr^2 + \frac{L^2}{2Mr^2}$

38. A particle of mass m moves in a potential

$$V(r) = -V_o\left(\frac{3R}{r} + \frac{R^3}{r^3}\right) \quad , \quad V_o > 0$$

and has angular momentum $10\, m\, V_o R^2$. The radius of a stable circular orbit will be given by

(A) $R/3$
(B) $R/2$
(C) $2R$
(D) $3R$

39. The state of a quantum system is represented by $|\psi\rangle = 3|E_1\rangle + 4i|E_2\rangle$, where $|E_1\rangle$ and $|E_2\rangle$ are eigenvectors of the Hamiltonian with eigenvalues E_1 and E_2, respectively. The average value of energy is given by

(A) $3E_1 + 4E_2$
(B) $3E_1 + 4iE_2$
(C) $(9E_1 - 16E_2)/25$
(D) $(9E_1 + 16E_2)/25$

40. If the Hamiltonian of an oscillator in two-dimensions is

$$H = \frac{p_x^2}{2m} + \frac{p_y^2}{2m} + \frac{1}{2}(m\omega^2x^2 + 4m\omega^2y^2) \quad ,$$

the second excited state of this system

(A) has energy $2\hbar\omega$ and is non-degenerate
(B) has energy $2\hbar\omega$ and has degeneracy 2
(C) has energy $3\hbar\omega$ and has degeneracy 2
(D) has energy $3\hbar\omega$ and has degeneracy 3