LULEÅ UNIVERSITY OF TECHNOLOGY
Division of Physics

Course code	MTF067
Examination date	2002-04-24
Time	09.00 - 14.00

Examination in: QUANTUM PHYSICS
Total number of problems: 5
Teacher on duty: Johan Hansson — Tel: 491072, Room E102a
Examiner: Johan Hansson — Tel: 491072, Room E102a
The results are announced: May 2, 2002 — on the notice-board, building E
The grading may be scrutinised: after the results have been announced

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Allowed aids: FYSIKALIA, BETA, calculator, COLLECTION OF FORMULAE

Define notations and motivate assumptions and approximations. Present the solutions so that they are easy to follow. The maximum number of points is 15 p. 7 points is required to pass the examination (grade 3), 10.5 points for grade 4, 13 points for grade 5.

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1. Derive the stationary Schrödinger equation from the more general time-dependent one. State the assumptions you make in each step of the derivation. (3p)

2. Calculate the expectation values $\langle x \rangle$ and $\langle x^2 \rangle$ for:

   a) The ground state

   b) The first excited state

   of a one-dimensional (quantum mechanical) harmonic oscillator. (3p)

3. An electron in a hydrogen atom is in the state described by the wave function

$$\psi(\mathbf{r}) = \frac{1}{6}[4\psi_{100}(\mathbf{r}) + 3\psi_{211}(\mathbf{r}) - \psi_{210}(\mathbf{r}) + \sqrt{10}\psi_{21-1}(\mathbf{r})].$$

   a) What is the expectation value of the energy? (1p)

   b) What is the expectation value of $\mathbf{L}^2$? (1p)

   c) What is the expectation value of L_z? (1p)

4. The spin-part of a spin-1/2 quantum mechanical system is given by

$$\chi = N(2|\uparrow\rangle + i|\downarrow\rangle).$$

   a) Calculate the normalization constant N. (1p)

   b) What are the possible eigenvalues of $\mathbf{S}^2$ and S_z?

   Are they simultaneously measurable? (1p)

   c) Calculate the probabilities for obtaining these eigenvalues. (1p)

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5. The Hamiltonian for an axially symmetric rotator is

$$H = \frac{L_x^2 + L_y^2}{2I_1} + \frac{L_z^2}{2I_2},$$

where I_1 and I_2 are constants. What are the possible energy eigenvalues? (3p)

GOOD LUCK !