LULEÅ UNIVERSITY OF TECHNOLOGY
Division of Physics

Course code	MTF107
Examination date	2003-10-27
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: November 7, 2003 on the notice-board, building E
The grading may be scrutinised: after the results have been announced

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Allowed aids: Physics Handbook, *ANY* mathematical handbook (for example BETA), calculator

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Define notations and motivate assumptions and approximations. **You must 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. In a double-slit experiment with neutrons the wave function corresponding to a route through slit one is ψ_1, and through slit two it is ψ_2. Show *mathematically* and explain *physically* the difference in the probability distribution of N hits on the detector screen between:

   i) First only one slit open (N/2 hits) then only the other (N/2 hits).

   ii) Both slits open at the same time (N hits). (3p)

2. a) What is the physical meaning of eigenvalues (corresponding to Hermitian operators) in quantum physics?

   b) What is the physical meaning of an expectation value?

   c) If you have the wave function of a system and the eigenvalues and eigenstates of a specific observable (but not its explicit operator), write down an expression for calculating the corresponding expectation value. (3p)

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

$$\psi(\mathbf{r}) = N[4\psi_{100}(\mathbf{r}) + 3\psi_{211}(\mathbf{r}) - \psi_{310}(\mathbf{r}) + \sqrt{10}\psi_{410}(\mathbf{r})].$$

   a) What is the expectation value of the energy?

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

   c) What is the expectation value of L_z? (3p)

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4. A spin-1/2 particle is measured to be in the spin-up state in z-direction.

   a) Calculate the magnitude of the spin.

   b) A subsequent measurement is made of spin in y-direction. Calculate the probability for getting the result $+\hbar/2$. (Hint: Find normalized eigenstates of the operator S_y and express the spin-up state in z-direction in terms of these.) (3p)

5. A particle is known to be localized in the left half of an infinite square well with sides at $x = \pm a/2$, with wave function $\psi = \sqrt{2/a}$ for $-a/2 < x < 0$, and $\psi = 0$ for $0 < x < a/2$

   Calculate the probability that an energy measurement yields:

   a) The ground state energy.

   b) The energy of the first excited state. (3p)

GOOD LUCK !