Reminder: we will have an hour exam on Friday, 17 February 2006, covering chapters 1–4 in Townsend.

Problem 1 – Townsend 4.3 Use (4.16) to verify that the expectation value of an observable $A$ does not change with time if the system is in an energy eigenstate (a stationary state) and $\hat{A}$ does not depend explicitly on time.

Problem 2 – Townsend 4.7 Use the data given in Fig. 4.3 to determine the $g$ factor of the muon.

Problem 3 – Townsend 4.8 A spin-$\frac{1}{2}$ particle, initially in a state with $S_n = h/2$ with 
$$n = \sin \theta \mathbf{i} + \cos \theta \mathbf{k},$$
is in a constant magnetic field $B_0$ in the $z$ direction. Determine the state of the particle at time $t$ and determine how $\langle S_x \rangle$, $\langle S_y \rangle$, and $\langle S_z \rangle$ vary with time.

Problem 4 – Townsend 4.9 Derive Rabi’s formula (4.45).

Problem 5 – Townsend 4.12 A particle with intrinsic spin one is placed in a constant external magnetic field $B_0$, in the $x$ direction. The initial spin state of the particle is $|\psi(0)\rangle = |1, 1\rangle$, that is, a state with $S_z = h$. Take the spin Hamiltonian to be
$$\hat{H} = \omega_0 \hat{S}_x$$
and determine the probability that the particle is in the state $|1, -1\rangle$ at time $t$. Suggestion: If you haven’t already done so, you should first work out Problem 3.15 to determine the eigenstates of $\hat{S}_x$ for a spin-1 particle in terms of the eigenstates of $\hat{S}_z$. 