PHYS 4021 DAY 1: NAME:______________________________________

1. What physics courses did you take last year (or most recently) and will you take this year?

2. AT WHITEBOARDS in groups of ~3:

(a) Write down what comes to mind when you hear or think “quantum mechanics.”

(b) What do you think you’re going to learn in this course?

For Tuesday: Read thru sec. 1.2 in Townsend.

For class discussion:

What's weird about the units in this book?

A thin circular disk has electric charge spread evenly on its top surface. The disk spins about an axis perpendicular to the disk thru its center. How do you find the magnetic dipole moment?

What are the four SG experiments described in the reading?

How or when is the spin state of a particle (e.g. a silver atom like SG used) measured in these experiments?

For Wednesday: Read thru 1.4 in Townsend

For class discussion:

What is the quantum state vector? What's a ket?

What does the ket | **+z** > represent?

For Friday: Read thru 1.5 in Townsend. NO! Save this til Tuesday.

For hand-in: End-of-chapter problems 1.1 and 1.2.

Week 2 PHYS 4021:

For Tuesday, read 1.5.

For discussion: what, in words does $|\langle +y|+x\rangle|^2$ represent?

For Wednesday, read 1.6.
For discussion: What do “orthonormal” and “complete” mean? Are $\hat{i}, \hat{j}, \hat{k}$ orthonormal and complete if I’m writing down, say, traditional vectors like electric field vectors?

For Thursday, read thru 2.2.
For discussion: Bras, kets, column vectors, row vectors, which is which? What does $\hat{R}(\frac{\pi}{2}\hat{j})$ mean?

For Friday: Hand-in end-of-chapter problems 1.3, 1.5, 1.8, 1.11 +

?? =

The Helmholtz system in MWAH 395 has four relevant controls for this exercise: (1) Power switch on the back side (duh!) , the field direction switch (UP/DOWN), the field gradient switch (ON/OFF) and the current control knob. Leave the strobe and air-bearing switches OFF.
With the field gradient switch OFF the coils produce a very uniform magnetic field in the center, with current circulating in the same sense in each of the two coils. With the gradient switch ON, the magnetic field in the center passes through zero, so there is a gradient. To do this, the direction of the current through one of the coils has been reversed.
The permanent magnet should be sitting in the middle of the coils, hanging on a spring as during the class demo, unless someone has tampered with the set-up.

1) With the magnetic field UP (and gradient OFF), what must be the sense of current flow through the coils - clockwise or counter-clockwise as viewed from above? Adjust the current to make sure the permanent magnet’s dipole moment points up, then return the current to zero.
2) Next, with the field switch UP still and the gradient ON, start from zero current and observe the behavior of the magnet. What is the direction of the magnetic force on the magnet? What, therefore, is the direction of (i.e. sign of $\partial B_z/\partial z$) the gradient in the field (up or down). Explain your reasoning.
3) Based on your observations, has the current in the upper or lower coil been reversed when the gradient is ON? Again explain your reasoning.

As always, supporting pictures and diagrams are most desirable.

Week 3 PHYS 4021:

For Monday Re-read thru 2.2
For discussion: Bras, kets, column vectors, row vectors, which is which? What's an operator? What does $\hat{R}(\frac{\pi}{2}\hat{j})$ mean or do? What would it do to $\hat{j}$ or to $\hat{i}$ if it "operated" on them? What's an adjoint operator? A unitary operator?? A hermitian operator???

For Tuesday, read 2.3.
For discussion: What does the identity operator do? A projection operator?

For Wednesday, read 2.4.
How do you find the matrix representation of an operator?

For Friday read thru 2.5.
Hand-in end-of-chapter problems 2.1, 2.2, 2.3.

Week 4 PHYS 4021:

For Monday Read 2.6-7
What is the new prescription for calculating expectation values?
What re the |x>, |y>, |R> and |L> states for photons?

For Tuesday, read 2.8
What can be said about the eigenvalues of a hermitian operator? What's special about an operator's eigenvectors or eigenstates?
When is the matrix representing an operator diagonal?

For Wednesday, read thru 3.2.
What's meant by the commutator of two operators?
If two operators commute, what can be said about their eigenstates?
What's degeneracy mean?

For Friday read thru 3.3
Hand-in end-of-chapter problems 2.8, 2.9, 2.10, 2.16

Week 5 PHYS 4021:

For Monday Re-read 3.3
How are the raising and lowering operators constructed? What do the raising and lowering operators do?

For Tuesday, read 3.4
What do the quantum numbers j and m tell us? For a given j what is the range of m?

For Wednesday, read thru 3.6
What are the Pauli spin matrices? What's the distinction being made in notation when using quantum numbers j,m compared to s,m?

For Friday read thru 3.7
Hand-in end-of-chapter problems 3.1c, 3.14, 3.17.

Week 6 PHYS 4021:

For Monday read 3.8.
(Maybe finish quantum mouse tutorial.)

For Tuesday, read 4.1-2;
What does the Hamiltonian operator do? What equation describes the time evolution of a quantum state vector $|\psi(t)\rangle$? What's a stationary state?

For Wednesday, read thru 4.3.
Classically what should happen to a magnetic moment in a magnetic field? (Remember the magnetic moment and angular momentum are proportional, and a magnetic moment is subject to a torque of $\vec{\mu} \times \vec{B}$.)

For Friday: TEST #1, through chapter 3.

Week 7 PHYS 4021:

For Monday read 4.3-4.
Classically what does a magnetic moment do in a constant magnetic field? In magnetic resonance what's the role of the time-dependent B field.

For Tuesday, read 4.5-6;
What's the significance of off-diagonal elements in a Hamiltonian? What does the energy-time "uncertainty" relation really tell us?

For Wednesday, read thru 4.7

For Friday, read 5.1-2.
Hand in end-of-chapter problems 4.1, 4.4, 4.7, 4.11

Week 8 PHYS 4021:

For Monday read thru 5.2.
The hyperfine interaction in hydrogen is the interaction between what two spins? Why is this a small effect?

For Tuesday, read 5.3;
What are singlet and triplet states?

For Wednesday, read 5.4

For Friday, read 6.1-2
Hand in end-of-chapter problems 4.13, 4.15, 5.1, 5.2, 5.6

Week 9 PHYS 4021:

For Monday read thru 6.3.

For Tuesday, read 6.4-5

For Wednesday, read 6.6-7

(No class Friday.)

Week 10 - PHYS 4021:

For Monday read thru 6.8.

For Tuesday, read 6.9

For Wednesday, read 6.10

For Friday, read 7.1-3
Hand in end-of-chapter problems 6.3, 6.9, 6.13, 6.15

Week 11 - PHYS 4021 (revised)

For Tuesday read thru 7.3

For Wednesday, read 7.4, 7.9

For Friday, read 7.5-7
Hand in end-of-chapter problems 6.17, 6.18.

Monday, November 11: Test #2 through chapter 6.

Week 12 - PHYS 4021

(Monday: Test #2)

Tuesday: Harmonic oscillator wrap-up

For Wednesday, read 9.1-4.
Focus on center-of-mass and relative motion.

For Friday, read thru 9.7
Focus on orbital angular momentum operators.
Hand-in: end-of-chapter problems: 7.7, 7.12

Week 13 - PHYS 4021

Tuesday: Read 9.8-10

For Wednesday, read 10.1

For Friday, read thru 10.2

Hand-in:

(1) Use the position-momentum commutators $[x, p_x] = i\hbar$, etc and the classical expression of angular momentum $\overrightarrow{L} = \vec{r} \times \overrightarrow{p}$ to work out in detail the commutator $[L_x, L_y] = i\hbar L_z$.

(2) Using the results above (and the appropriate extensions to the other components of angular momentum) to find $[L^2, L_x]$. ($L^2 = L_x^2 + L_y^2 + L_z^2$). Some of the commutator identities from problem 3.1 might be useful.

(3) Some spherical harmonics ($Y_{l,m}(\theta . \phi)$) are tabulated on page 334, with some graphical representations of $|Y_{l,m}(\theta, \phi)|^2$ on p. 335. Construct and simplify the combinations $Y_{1,1} \pm Y_{1,-1}$ and try to sketch/describe what these look like, akin to the figures on p. 335.

Week 14 - PHYS 4021

Monday: Read 10.2

Tuesday: Read 10.3-4

For Wednesday, read 10.5

Hand-in: end-of-chapter problems 9.12, 9.19, 9.20 a&b (skip parts c and d)
(In “rigid rotators” the relative distance r is a constant and hence all the $\partial/\partial r$ pieces in the spherical coordinate version of ∇^2 are 0. And there is no potential energy to worry about.)

Week 15 - PHYS 4021

Monday: Snow day

Tuesday: Read 12.1, 12.2 lightly

Wednesday: —

Friday: —
Suggested practice: 10.2, 10.4, 10.5.