Quantum Physics, Preparation for Tuesday, Feb. 6

Study the First Half of Q6 from *Six Ideas*

An electron has:

* a position, usually given by three coordinates, x, y, and z
* a momentum, usually given by three components, p_x, p_y, and p_z.
* in Q6, you learn that it also has a spin, usually given by three components, S_x, S_y, and S_z.

By focusing only on the electron's spin, and ignoring its position and momentum, a lot about quantum mechanics can be discussed. This is because spin is quantized! For the electron, S_x only has two values, ditto for S_y, and ditto for S_z. Contrast this with position or momentum. Each component has an infinity of values. Quantization of spin into just two values makes the tricky aspects of quantum mechanics far more manageable.

Study only Q6.1, Q6.2, and Q6.3. Come armed with questions. We need to have a serious review of angular momentum and torque, and we also need to know the basics of magnetism in order to understand spin.

Study the Beginning of Churchill, Brown, and Verhey

The laws of quantum mechanics are written terms of complex variables (also known as imaginary numbers). *Complex Variables and Applications* by Churchill, Brown, and Verhey is the classic, self-contained introduction to complex variables used by huge numbers of scientists and engineers for decades. More advanced introductions are typically used by mathematicians, and I think most of them would have been better served by using this one instead.

There is a beauty in starting a new mathematical subject. Mathematicians scrutinize their own thinking to identify axioms (assumptions), and they lay out their definitions (carefully, like lawyers). Then they start proving theorems, that are often surprising, useful, or both. The subject of complex variables is a perfect example of this.

I have photocopied Sections 1-4 of Churchill, Brown, and Verhey for you.

For Problem Set 6

Complex variables, basic algebra

1. Problem 1 on p. 5 of Churchill, Brown, and Verhey
2. Problem 2 on p. 5
3. Problem 3 on p. 5
4. Problem 4 on p. 5

Complex variables, graphical representation

5. Problem 1 on p. 10 of Churchill, Brown, and Verhey
6. Problem 2 on p. 10 (you are meant to show it graphically)
7. Problem 3 on p. 10
8. (a) Take $\cos\theta + i \sin\theta$ and cube it. There are 8 terms, but a bunch are the same. (b) A trig identity you probably don't know is $\cos 3\theta = \cos^3\theta - 3\sin^2\theta \cos\theta$. Another is $\sin 3\theta = 3\sin\theta\cos^2\theta - \sin^3\theta$. Use these identities to dramatically simplify and summarize what you found in (a).