ASTR 1040
Problem Set #1

1. Gravity is the weakest of the four fundamental forces. Why does it dominate on large scales? (5pts.)

2. What does the exclusion principle say? (3 pts.)

3. The strength of degeneracy pressure in an object such as a neutron star depends on ___ (2pts)

4. Why is quantum tunneling important for life on earth? (5pts)

5. **Your quantum uncertainty (15 pts)**
   You are running to catch a squirrel at a speed of 20 +-1km/hr. Using your mass, you can calculate the uncertainty in your momentum. What is the corresponding quantum limit on the uncertainty in your position? Is this something the squirrel needs to account for in determining if it will get caught?

6. **How Long will the Sun Last? (50 pts.)**

   Let's do our own rough estimate on how long our Sun will last. The Sun's energy comes from fusing H into He. Ultimately, each set of four protons reacts so that 4H -> He, which yields 4.277×10^{-12} J of energy ($E = mc^2$). Eventually, the Sun will run out of protons to fuse.

   A. The mass of a proton is 1.67×10^{-27} kg. Look up the mass of the Sun. How many protons are in the Sun? For simplicity, assume that the Sun is entirely protons.

   B. Fusion can only occur in the Sun's core. About 10% of the mass of the Sun is in the core. How many protons are in the core?

   C. Look up the luminosity of the Sun (L_{Sun}). The 4H -> He nuclear reaction produces 4.277×10^{-12} J. How many protons must the Sun fuse every second to maintain its current luminosity?

   D. How long will it take for the Sun to burn all of its fuel in the **core**? Answer in billions of years.

   E. Does your estimate agree with that in the text?

7. **JWST vs. Spitzer (20 pts.)**
   Images from the new James Webb Space Telescope look way more awesome than the equivalent ones from the Spitzer Space Telescope. We will look here at two of the reasons why.
   A. In the infrared wavelengths shown in the image below (say 4.5 micron), how much better is the spatial resolution possible with JWST vs. Spitzer?

B. How much greater is the light collecting-area of JWST than Spitzer? What does that imply about the amount of observation time needed with each of these to collect the same number of photons?