Physics 214 **Quiz 4-1 [20 points]**

The next two problems refer to the following situation:

A cesium atom at rest has two energy levels separated by 1.52 eV.

1) [5 points] What is the frequency of a photon that can excite the atom from the lower energy level to the upper?

   f = h/E = 3.68 *10^{14} Hertz

2) [5 points] If the atom emits such a photon, what will be the atom's recoil momentum be?

   momentum of atom = - momentum of photon = E/c = 8.12*10^(-28) kg m/s

The next two problems refer to the following situation:

We wish to accelerate an "optical sail" in a vacuum having a mass of 0.2 kg with an acceleration of 10 m/sec^2 using a laser. Assume that the laser is at normal incidence to the sail and that no gravitational fields act on the sail.

3) [6 points] What laser power (in watts) is required to achieve this acceleration if the sail **reflects** all of the laser energy incident on it.

   Change in momentum = 2 p of photon: Force = (2 p) * Rate of photons = (2 Power/c)
   Power = (c/2) (mass) a = 3*10^8 Watts

4) [4 points] Would the required laser power be larger or smaller if the sail absorbs all the light incident on it, as compared to the case where it is fully reflected? Explain your reasoning.

   Larger power since smaller momentum transfer per photon.