1. Give a clear and concise explanation for why we believe there is a tremendous amount of dark matter around galaxies and galaxy clusters that is not “normal” baryonic matter. Write this explanation as if you were trying to explain it to a friend who doesn’t know much science (even better, try it on a non-scientist friend of yours and see if they are convinced!).

2. Type 1A Supernovae (SN1a) have proven very important in recent cosmological studies because they are both bright and are good “standard candles”. What physical aspect of SN1a’s is primarily responsible for them being good standard candles?

3. Before it explodes as a SN1a, a white dwarf has a mass of 1.4M_{\odot}. During the explosion, all of the matter in the white dwarf is converted from helium to iron; this process converts mass to energy with an efficiency of approximately 0.1%. Calculate how much energy is released during this explosion. You will need to know that M_{\odot}=2\times10^{30} kg, and that c=3.0\times10^{8} m/s.

4. State and briefly explain two pieces of evidence that “dark energy” dominates the universe at the present time.

5. FMC Q12.12

6. FMC Q13.7

7. The “binding energy” of a galaxy is the energy required to completely disrupt the galaxy and disperse its constituent components. The binding energy of the Milky Way (including the Dark Matter) is approximately 1\times10^{52} Joules. At the center of the Milky Way is a M_{\bullet}=4\times10^{6} M_{\odot} black hole. In principal, was enough energy released in the formation of the central black hole to disrupt the galaxy? Assume that 10% of the rest mass energy of the black hole was released during its growth.