ASTR340 (Fall 2018) Homework 3

More relativity

(Due at the start of class on the 4th October 2018)

1. FMC Q7.10

2. FMC Q7.11

3. [Based upon FMC Q8.10] Describe in your own words what a gravitational wave is? At what speed do gravitational waves propagate? How does the speed of a gravitational wave depend upon the observer's frame of reference?

4. Imagine a situation in which two gamma-rays of equal energy experience a head on "collision" and produce an electron/anti-electron pair.
    a. What is the energy associated with the rest-mass of the final pair of particles? Express your answer in Joules. [Hint: you'll need to look up the mass of an electron.]
    b. This process cannot occur unless the gamma-rays have at least a certain minimum energy. What is the value of that critical energy?
    c. If the gamma-rays have more than the minimum energy, where will that "excess" energy go?

5. Suppose you had a mass of fuel m, and you were able to extract 1% of its rest mass energy $E = mc^2$ for practical use (this is similar to the efficiency of energy extraction in fusion). How much fuel (in kg) you would need each year to power 10 million light bulbs of 100 watt (total of 1000 Mwatt) using this energy? Remember that 1watt = 1 Joule/sec, where 1 Joule = $1kgm^2/sec^2$; also make sure to use the correct units for the speed of light.

6. A rocket of mass M needs an energy $E = GM_{earth}M/R_{earth}$ to escape earth's gravitational potential, where $M_{earth} = 6\times10^{24}$ kg is the mass of the earth and M = 5000 Kg. Using a fuel with the same efficiency of 1% as in question 5), how many grams of fuel are need to leave earth? Remember that $G = 6.67 \times 10^{-11}$ joule m kg^{-2} and R_{earth} = 6378 km. Remember to convert all numbers to the appropriate units.