1. **Energy efficiency.** Read the following article [https://en.wikipedia.org/wiki/Fossil-fuel_power_station](https://en.wikipedia.org/wiki/Fossil-fuel_power_station) and answer the following questions:

   (a) A solar cell can be considered to be a thermodynamic system operating between $T_H = 5800 \, K$ and $T_C = 25 \, ^\circ C$ (note different units). What is the maximum theoretical efficiency that the solar cell can ever achieve? Units should be converted to Kelvin. (No knowledge of solar cell is needed; you can replace “solar cell” with “shaftaloo” [name of a fruit] and get the same answer.)

   (b) What are the efforts done to filter and control the emissions the flue gas in a coal-fired power plant?

   (c) In a steam plant (Rankine cycle), assume the cold temperature is $T_C = 10 \, ^\circ C$. Assume the turbine is only 90% efficient and the fuel, due to impurities, is burned with an efficiency of 95%. There is also 2% of stray losses. What should $T_H$ be to have an efficiency of at least 32%. Is this the minimum value of $T_H$ or its maximum?

2. **Carbon Footprint.** Carbon footprint is the amount of greenhouse gasses produced by a process (see [https://en.wikipedia.org/wiki/Carbon_footprint](https://en.wikipedia.org/wiki/Carbon_footprint) for a more accurate definition). Calculate the carbon footprint for two average US families (2.54 persons per household is the average, but use 3 in your calculations), one living in Pullman, WA, and the other living in New York City, NY. Assume the following for these two families:

   - The Pullman family lives in a 4,000 sq ft three-bedroom house and the New York family (not being able to afford a similarly sized house in NYC), lives in a 900 sq ft loft.
   - The Pullman family owns a sedan (30 mpg) and a minivan (15 mpg) and travels 30 mi with each per day. The NYC family lives in in SoHo and can only dream of having a car (and paying for its parking space).
   - The Pullman family takes two trips per year, both by air; one a 5000 mi round trip to NYC and another a 12,500 mi round trip to Europe. The New York family rents a car and drives to Jersey Shore (120 mi round trip) twice a year.

   Use an online carbon footprint calculator (e.g., [http://www3.epa.gov/carbon-footprint-calculator/](http://www3.epa.gov/carbon-footprint-calculator/) or [http://www.terrapass.com/carbon-footprint-calculator/](http://www.terrapass.com/carbon-footprint-calculator/) to calculate the annual footprint for each family. Present the results in a table. Note any assumptions you make (and some calculators need lots of other data; make reasonable assumptions).

3. **WA.** In State of Washington, (search online!)
• What sources of energy are categorized as renewable energy?
• Does WA have a renewable portfolio standard or a renewable portfolio goal? What is the difference?
• What is the target of the standard/goal above?
• How many utilities qualify (or are required) to participate?
• What is the name of the entity that owns most of the transmission system in WA? What are their functions?

5. Masters 1.6.