Assigned:	9/7/2021
Due:	9/16/2021 on Canvas > Assignments > Problem Set 1 **NOTE: for hand-written work, converting to a PDF file is preferred, but you may use the Canvas Student app or a scanner to submit images
Covering:	Energy Units & Conversions, Sac State emissions, Global Energy Use
Total Points:	100

A guide to doing problems:

- Read through the problem it its entirety before you try to start solving. Sometimes useful information or links may be given later in the problem description.
- Clearly state any assumptions (e.g., average commuting distances).
- Cite all of your data sources (unless they are conversion factors provided in class or the reference sheet).
- Show all your work so that you can get partial credit where applicable.
- Mark your answers by circling/boxing them.
- See the PS Reference Sheet for useful Energy Conversions.
- Use scientific notation (10^x) when writing very small or very large numbers.
- Use the correct number of significant figures (as a reference, see Lecture 2).
- Your name must appear at the top of each sheet you turn in (and all must be stapled).
- Late assignments will be penalized 10% if turned in late, up to the first 24 hours, then 10% for each additional 24 hours. No assignments will be accepted after the solution set is posted (usually 1 week after due date).
- You will get the most out of the problem sets if you make an initial effort to work through all of the problems on your own. After attempting to solve the problems on your own, you may then work with other students to discuss different approaches. Even then, you should work out each problem yourself. It is a violation of the Code of Student Conduct to copy answers.

1. SAC STATE BUILDING ENERGY USE *(30 points total)*

According to Sac State's Sustainability Tracking, Assessment & Rating System (STARS®) Report,[1] total baseline energy consumption during the 2013-2014 (12-month) Academic Year was 257,086 MBTU (million British Thermal Units). For the problems below, assume that 100% of the energy available in the following sources can be converted to provide for this amount of energy.

a. How many joules is this equivalent to? Express your answer in GJ. *(2 points)*
b. How many kilowatt-hours is this? *(2 points)*
c. How many barrels of oil contain this much energy? *(3 points)*
d. How many metric tons of wood? *(3 points)*
e. How many metric tons of coal? *(3 points)*

[1] www.csus.edu/experience/innovation-creativity/sustainability/_internal/_documents/stars-report-final.pdf

f. How many cubic feet of natural gas? *(3 points)*
g. How many kilograms of nuclear fuel? *(4 points)*
h. How many square meters of solar panels (assume that the panels receive an annual average solar radiation of 5 kWh/m^2/day)? *(5 points)*
i. How many Baja Fresh Burrito Ultimos from the Dining Commons? *(4 points)*?
j. Which of these fuels is the most dense energy source? *(1 point)*

BONUS: How many gallons of water that fall the height of Folsom Dam? *(4 points)*

2. SAC STATE COMMUTER ENERGY AND EMISSIONS *(40 points total)*

The STARS Report from Problem 1 includes energy-related greenhouse gas emissions for "Scope 1" activities (direct emissions on campus, e.g. Central Plant) and "Scope 2" activities (indirect emissions from purchased energy, e.g. electricity from SMUD). "Scope 3" activities would include emissions from commuting and business travel, purchased goods and services, and waste. Let's just look at the commuting piece and please think about a normal, non-pandemic school year. You should use the following baseline assumptions, but you will need to make or look up others:

- 30,000 students, 6% of which live on campus
- 10,000 student parking spaces on campus

a. How much gasoline is used on a weekly basis by Sac State's student commuters? Build 2 or more models for different transport modes (single occupancy vehicles, carpoolers, etc.) then add them together. *(10 points, plus up to 6 bonus points for additional transport modes, 2 points each)*
b. How many joules is this equivalent to? Express your answer in GJ and as a percentage of (weekly) campus energy use from Problem 1. *(5 points)*
c. How many metric tons of Carbon (mtC) are emitted on a weekly basis from student commuting as part of Sac State's Scope 3 emissions? *(5 points)*
d. Assuming all building energy use in Problem 1 is from natural gas, calculate the expected yearly Carbon emissions (mtC) included in Sac State's Scope 1 and Scope 2. What percent of this amount do Scope 3 emissions from commuting (part c) represent? *(5 points)*
e. On a per-student basis, what is the total average carbon footprint of Sac State, including Scope 1, 2 and 3(commuting only) activities? *(5 points)*
f. What about solutions? State one intervention in each of these (Scope 1, 2, and 3) categories to reduce emissions. Based on your assessment above, which category do you think Sac State should focus on to reduce its per-student carbon footprint? Is this based on the size of related emissions or the feasibility of implementation? Pick one intervention and demonstrate, numerically, its potential to reduce carbon emissions. Indicate the expected reduction as a percentage of overall emissions. *(10 points)*

3. INTERNATIONAL ENERGY COMPARISONS *(30 points total)*

For this problem, please refer to the Energy Information Administration website for all energy data (http://www.eia.gov/). You may wish to use MS Excel for this problem.

a. Of total global primary energy consumption in 2017, what percent did the U.S. consume? *(3 points)*

b. What is the average per-capita energy consumption (also known as "energy intensity") in MMBTU/person for the U.S. for that year? For the world? Choose six other countries from different parts of the world and from what you think of as different stages of development. *(4 points)*

c. Looking at the per capita energy use of the countries you researched, what is the ratio between the country with the largest and the country with the smallest level of per-capita consumption? What are those countries? *(3 points)*

d. For three of these countries, compare energy use per capita in 2017 with another year at least 20 years earlier. How do these trajectories differ? What might explain this? Be sure to indicate the countries and years that you are comparing *(10 points)*

e. For the countries listed in part b, examine the relationship between per capita energy consumption and per capita Gross Domestic Product (GDP). For 2017 find population and GDP data on the EIA website to calculate GDP per capita (or find GDP per capita from another source for). Plot a graph that compares per-capita energy consumption with per-capita GDP. What can you suggest about the correlation between those two statistics? For this graph, should energy consumption per capita be put on the x-axis or on the y-axis? Why? *(10 points)*