Joules to Dollars Midterm Exam 2015

Rules for the Exam: 1) The exam must be your own work. 2) You may only use your own notes and non-human resources from the internet to answer the questions. 3) **Write you exam answers on the sheets of paper provided and show your calculations.** 4) Place a copy of all spreadsheet calculations in your private Google Drive course folder labeled *<initials>*-E1-2015.

Honor Statement – your exam will not be graded if you do not complete this section

I agree to complete this exam within 3 hours *without help from anyone* through direct or indirect conversation in person, on the phone, via electronic communications (e.g., email, Twitter, etc.), and/or social media interactions (e.g., Facebook, blog posts, etc.). I understand that the consequences of violating this honor statement will constitute academic dishonesty with the possible consequences including failing this course.

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(signature – handwritten or typed) (date)

1. Colby Power and Light produces steam at 417 ^{o}F and a pressure of 300 PSI in the boilers. After the steam passes through the electric turbine the steam is 280 ^{o}F and the pressure is 50 PSI.
    a. What is the maximum efficiency of generating electricity at Colby?
    b. Why is this a good deal for Colby?

2. Suppose the price elasticity of demand for electricity in Ohio is inelastic while the price elasticity of demand in Maine is relatively elastic. In which state will a 1% increase in electricity prices have a bigger effect on demand? Explain your answer carefully in words and with a supporting graph.

3. Converting Dollars to Joules. Consider the following data for a hypothetical college professor living in Central Maine:
    - In 2014 this professor paid a total of $1,627.93 for electricity at an average price of 16.57 cents per kWh
    - This same professor paid $1,837.59 for propane at an average price of $2.185 per gallon.

    a. How many **TOTAL** Joules of energy did this professor consume for his home in 2014?
    b. Which energy source delivered more useful heat or work? Explain.
    c. Before heat pumps became popular, simple electric heaters with 100% efficiency were common in new construction. Why are these older heating systems seldom used in Maine?

4. The New England Regional Greenhouse Gas Initiative (RGGI) trades carbon dioxide emission credits between the New England States. The current price of carbon emission is $4/ton of CO_2. Compared to an old oil burner, does the Efficiency Maine rebate of $5000 on pellet

boilers make sense from a RGGI carbon dioxide abatement standpoint alone? Please justify your answer with appropriate calculations.

Answer Question 5 OR 6. Do not answer BOTH!

5. The solar panels cannot meet the entire electrical demand of Flagstaff hut so a propane generator is used to supply additional power. The generator uses about 1400 gallons of propane a year.

   A few basics on propane generators:
   - It requires 2 horsepower to produce 1000 watts of electrical power under load.
   - Under load, each horsepower consumes 10,000 BTU per hour.
   - Propane contains 92,000 BTU per gallon.
   - Propane costs $3.00 per gallon.

   A. If the annual electrical energy produced by the solar system was 5500 kWh and the generator supplies the rest of the load, how does the fuel-only cost of these systems compare to residential electricity costs of 0.14 $/kWh?
   B. If an installed propane generator costs $5000 and last five years and the hut's solar system costs $35,000 and is warranted for 25 years, what is best 25 year investment for power production at Flagstaff? Hint: Make a model of annual expenses to help answer this question.
   C. Why might they choose not to make the "best" investment?

6. Consider an electricity generation market with 3 types of firms:
   - Type 1 firms generate electricity with natural gas and have fixed costs of emissions (abatement costs) of $50 per ton and variable abatement costs equal to Q_1^2, where Q_1 is the quantity of CO_2 pollutants emitted in tons.
   - Type 2 firms generate electricity with coal and have fixed abatement costs of $100 per ton and variable abatement costs equal to $0.3Q_2^2$, where Q_2 is quantity of CO_2 pollutants emitted by type 2 firms in tons.
   - Type 3 firms generate electricity with fuel oil and have fixed abatement costs of $66 per ton and abatement costs equal to $0.1Q_3^3$, where Q_3 is the quantity of CO_2 emitted by type 3 firms.

Suppose that in an effort to reduce total $C0_2$ emissions a cap is imposed by a government regulatory agency on the amount of allowable emissions by these firms accompanied by tradeable 'pollution rights' thus ensuring an efficient market outcome with respect to abatement costs for all firms.

At the end of trading, the marginal cost for Type 3 firms is $30 per ton.

Calculate the **average total cost of abatement** for Type 1, Type 2, and Type 3 firms after trading has been completed.