PHYSICS-2

Elementary Physics of Energy

Homework 2

Due Date: APRIL 20, 2012 in class

1. *A typical clothes dryer uses 5 kW of power when it is running. If it takes about 1 hr to dry a load of clothes, and your house does about 15 loads each month, about how much does this cost on your PG&E bill if:*
a. it's an electric dryer?
b. it runs on natural gas?
Hint: current Santa Cruz energy charge rates can be found in the lecture notes, or on your PG&E bill. [10]

Solution:

The power usage is obtained by multiplying the power $5KW$ with the time of running, given to be 15 hours, thus we need the cost of $75KWh$. (Note that KWh is an em energy unit unlike KW, which is a *power* unit.). We now check the cost of energy by consulting the monthly bills. Calling the cost as r in \$/KWh, we get the required answer.
a) Electric cost rate per KWh is $r = \$.13/KWh$. Thus answer is $cost = r \times 75KWh = \$9.75$ per month.

b) Natural gas is sold at appxly \$ .9/therm. We can convert therm to KWh by the formula 1 Therm = 10^5 Btu, and 1 Btu = 2.93×10^{-4} KWh, and thus 1 Therm =29.3 KWH. Thus the rate r in units of \$/KWh is \$.031/KWh, and the final answer is $cost = r \times 75KWh = \$2.30$ per month. This is about 4 times cheaper than electricity.

2. *A person consumes 2000 Calories and this energy is equivalent to raising the temperature of an amount of water equal to their mass by 50 degrees F, what is the mass of this person in kg?* [10]

Solution

Let us recall that 1 $Calorie = 10^3$ $calories$, and the definition 1 *calorie* is the heat needed to raise the temperature of 1 gm of water by 1^0 C. Assume as in class the human body is essentially all water. Thus we can use the formula $\Delta Q = m\Delta T$, or inverting $m = \Delta Q/\Delta T$.

In this problem $\Delta Q = 2000 \times 10^3 = 2 \times 10^6$ *calories* and $\Delta T = 50^F = 27.8^0C$, and hence the answer $m = 2 \times 10^6/27.8 = 71942gms$. In terms of kilograms $m = 71.9kGs$.

Questions from Chapter 2 on page 59 of Ristinen and Kraushaar:

3. Problem 2. page 59 [10]
Solution: Fossil fuels are created by anerobic (i.e. without oxygen) decomposition of biolological matter consisting of animal and plant remains at high temp and pressures, over millions of years of sedimentation. Since this is such a slow process, our usage far exceeds the rate and hence we run out of these fuels pretty rapidly.

4. Problem 4. page 59 [10]
Solution: At the present rate of demand in the US of about $6bbl/year$ (bbl = billion barrels of oil) , taking the total resource as 30 *bbl*, we get about 5 years as the time required to use it up.

5. Problem 5. page 59 [10]
This is heavily dependent on the chosen values:

Table 2.2 estimates that 1146×10^9 bbl (billion barrels of oil) remains worldwide therefore per person we are left with $1146 \times 10^9\ bbl/6.84 \times 10^9 people = 167.5bbl/person$. (We estimated the world population at $6.84 \times 10^9 people$).
A similar calculation in the US uses resource of $113 \times 10^9 bbl$ and 311.6×10^6 people, so the ratio is 362 $bbl/person$.
A rather ambiguous ratio can also be formed by taking the world resource and dividing by the US population to give 3678 $bbl/person$.

6. Problem 7. page 59 [10]
Solution:

According to Example 2.1 on page 44, Natural gas costs $12.83/10^6 BTu$. If your furnace efficiency is only 60% then the amount of gas input that you pay for would be $10^6/0.6\ BTu = 1.67 \times 10^6\ BTu$. Taking the product we get the cost as 21.38$.

7. Problem 8. page 60 [10]
Solution: We could take one of the two values for the energy density of subbituminous coal (a) 10 750 BTu/lb (Table 2.6 page 51) or (b) 9,000 BTu/lb (page 51).

Taking the energy requirement as 1.67×10^6 BTu these two estimates of the energy density, we get 155.35 *lbs* or 185.56 *lbs*.

8. Problem 11. page 60 [10]
Solution:

This problem has two parts, the first is to calculate the work done against gravity in lifting the barrel of oil, and the second is to compute what fraction this is, of the energy content of the oil iteself.

To get the work done against gravity, we use the formula $W = F \times D$ where F is the force and $D = 2500$ft. In the FPS system, the weight of the object given in pounds is actually the force exerted by gravity. SInce 1 barrel contains 42 gallons, and each gallon weighs 7 lb, the weight of the barrel of oil is 294 lbs. Therefore $F = 294lb$ and hence $W = 294 \times 25,000 = 7.35 \times 10^6\ FootPounds$. We can write this in terms of BTu as $7.35 \times 10^6\ 1.29 \times 10^{-3} = 9.5 \times 10^3 BTu$.

The energy content of a barrel of oil is given in the table on cover page as 5.8×10^6 BTu, and hence the ratio of work done to energy content is .0016, a very small fraction indeed.

Multiple Choice Questions from Chapter 2:

1. Problem 2. [5]
Answer A, see table 1.1

2. Problem 4. [5]
Answer B, see Fig. 1.6

3. Problem 5. [5]
Answer A, see page 36

4. Problem 6. [5]
Answer D, see page 21

5. Problem 9. [5]
Answer A, see Figs 2.2,2.6, Table 2.7