Energy
on this world and elsewhere

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Course web site available at www.phys.virginia.edu,
click on classes and find Physics 1110.
or at http://people.virginia.edu/~gdc4k/phys111/fall11

November 15, 2011
Announcements

• **Midterm, Thursday, Nov. 17\(^{th}\), in class.**
  - Will cover everything through Chapter 7 of the class notes. (Lectures 1-21, but NO STUFF ON NUKES.)
  - Multiple choice, 20 questions.
  - 10 or less questions will require a calculation of some kind.
  - Calculator recommended.
  - Review sheet will be posted later today.

• **Office Hours:**
  - Tomorrow, Wednesday, from 4:00-5:30pm in Room 313 of the Physics Building
  - Tomorrow, Wednesday, from 6:30-8:00pm, also in Room 313 of the Physics Building
Unlike many physics classes, Physics 1110 puts less emphasis on actual problem solving, and more emphasis on learning a broad range of knowledge and concepts from multiple sources. You are expected to have completed **ALL** the reading.

- **Class Notes: Chapters 1-7**
- **Wolfson: Chapters 1-5.**
- **Feynman: Chapters 3 and 5.**
- **Asimov: The Last Question**
- **Richter: Chapters 1-10 and 13**
Quiz #2 Problem 2.

2. Judging from the information in Table 5.1 of the class notes, what is your best guess as to the length of time during which natural gas will remain relatively plentiful in the world? For the purposes of this question, assume that the world’s rate of consumption remains constant.

A. 20 years.
B. 57 years.
C. 100 years.
D. 1000 years.

In Table 5.1, using nothing but proved reserves, the world is estimated as having 57 years.

<table>
<thead>
<tr>
<th>World Fossil Fuel Reserves and time estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fossil Fuel</td>
</tr>
<tr>
<td>Oil (billions of barrels)</td>
</tr>
<tr>
<td>Natural gas (trillion cubic feet)</td>
</tr>
<tr>
<td>Coal (million short tons)</td>
</tr>
</tbody>
</table>

Table 5.1: Shown for each of the major fossil fuels is an estimate for the corresponding world-wide proved reserves. Non-conventional oil is not included in these estimates.
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<table>
<thead>
<tr>
<th>Fossil Fuel</th>
<th>Proved reserves</th>
<th>Consumption rate</th>
<th>Years remaining</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil (billions of barrels)</td>
<td>1340.0</td>
<td>26.37/year</td>
<td>50.8 years</td>
</tr>
<tr>
<td>natural gas (trillion cubic feet)</td>
<td>6261.3</td>
<td>109.79/year</td>
<td>57.0 years</td>
</tr>
<tr>
<td>coal (million short tons)</td>
<td>909,394</td>
<td>7,271/year</td>
<td>125.1 years</td>
</tr>
</tbody>
</table>

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Note that in Table 5.2, shown below, the number of years using resources is 133 years. It is NOT that you should have known about the numbers of Table 5.2. The key is that resources are always substantially more than reserves.

<table>
<thead>
<tr>
<th>Fossil Fuel</th>
<th>Resource base</th>
<th>Consumption rate</th>
<th>Years remaining</th>
</tr>
</thead>
<tbody>
<tr>
<td>oil (billion barrels)</td>
<td>1965.0</td>
<td>30.87/year</td>
<td>63.7 years</td>
</tr>
<tr>
<td>natural gas (trillion cubic feet)</td>
<td>14,049</td>
<td>105.4/year</td>
<td>133.3 years</td>
</tr>
<tr>
<td>coal (million short tons)</td>
<td>5,312,979</td>
<td>6,771/year</td>
<td>784.7 years</td>
</tr>
</tbody>
</table>
3. Which of the following statements best describes global temperatures over the past 1000 years?
   A. They have remained relatively constant.
   B. They declined for roughly 600 years and have been rising ever since.
   C. They have been relatively constant until the last 100 years at which point they began rising.
   D. They increased for roughly 600 years, declined for another 350 years, and have been rising for the last 150 years.
Quiz #2 Problem 11.

Mea Culpa !!!

Energy on this world and elsewhere
Quiz 2 - October 27, 2011
Page three of three pages. There are 12 questions on this quiz.

11. Consider the diagram at right illustrating heat flowing from a hot vessel (at temperature $T_H$) into a cold vessel (at temperature $T_C$). Once the heat $Q$ has flowed from one vessel to the other, which of the following statements is true? You may think of these two vessels as comprising a closed system.

A. The entropy of the closed system has increased.
B. The entropy of the closed system has decreased.
C. The entropy of the hot vessel has increased.
D. The entropy of the cold vessel has decreased.

This was my answer key to quiz #2. I kept checking it because I was surprised that so many people got question #2 wrong. The problem is, that I changed the order of the answers!! :-(

11. Consider the diagram at right illustrating heat flowing from a hot vessel (at temperature $T_H$) into a cold vessel (at temperature $T_C$). Once the heat $Q$ has flowed from one vessel to the other, which of the following statements is true? You may think of these two vessels as comprising a closed system.

A. The entropy of the hot vessel has increased.
B. The entropy of the cold vessel has decreased.
C. The entropy of the closed system has stayed the same or increased.
D. The entropy of the closed system has stayed the same or decreased.

Indeed, as most of you answered, the entropy of a close system MUST ALWAYS STAY THE SAME OR INCREASE.
Change in entropy during transfer of thermal energy

The change of entropy for a gas is defined as:

$$\Delta S = \frac{Q}{T}$$

Where $Q$ is the heat **ADDED** to the gas. Here we assume that during this addition of heat, the temperature doesn’t change much.

- So the entropy of the left-hand side has gone up.
- The entropy of the right-hand side has gone down.
- And if you work it out, the entropy of the entire system has gone up.
Practice Problems

• A car sold in Europe gets gas mileage of 13.6 km/liter. What is the gas mileage in miles per gallon?

Need: 1 km = 0.6214 miles

Need: 1 liter = 0.2642 gallons
Practice Problems

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Need: $1 \text{ km} = 0.6214 \text{ miles}$

Need: $1 \text{ liter} = 0.2642 \text{ gallons}$

Gas mileage $= 13.6 \frac{\text{km}}{\text{liter}} = 13.6 \frac{(0.6214 \text{ miles})}{(0.2642 \text{ gallons})} = 32.0 \text{ mpg}$
Practice Problems

- If the United States were to use only domestic proven reserves of coal for its coal needs, how many years would it take to exhaust those reserves?

Need: U.S. Domestic Reserves = 263.4 billion tons

Need: U.S. Consumption = 1,073 million tons per year
Practice Problems

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Need: U.S. Domestic Reserves = 263.4 billion tons

Need: U.S. Consumption = 1,073 million tons per year

Years remaining = \frac{(263.4 \times 10^9 \text{ tons})}{(1,073 \times 10^6 \text{ tons/year})} = 245.5 \text{ years}
Practice Problems

A Flex-Fuel car burns 8.5 liters of ethanol per hour. What is the rate at which thermal energy is being released by the fuel?

Need: 1 liter ethanol = 24.0 MJ

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\text{Power} = \frac{\text{Energy}}{\text{Time}} = \frac{8.5 \times 24.0 \times 10^6 \text{ J}}{3600 \text{ sec}} = 5.67 \times 10^4 \text{ J/s} = 56.7 \times 10^3 \text{ W} = 56.7 \text{ kW}
\]
During one cycle, a heat engine draws 825 Joules from its hot reservoir, and does 300 Joules of useful work.

a. How much energy is exhausted into its cold reservoir?
b. What is the efficiency of the heat engine?
c. Someone tells you that the hot reservoir is at a temperature of 600 K, and that the cold reservoir is at a temperature of 300 K. Is that possible? Yes or No.
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\[ 825 \text{ J} - 300 \text{ J} = 525 \text{ J} \]
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Efficiency = \( W/Q_H = (300 \text{ J})/(825 \text{ J}) = 0.364 \)
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\[ \text{efficiency} = \frac{W}{Q_H} = \frac{300 \text{ J}}{825 \text{ J}} = 0.364 \]

\[ \text{efficiency}_{\text{carnot}} = 1 - \frac{T_C}{T_H} = 1 - \frac{300 \text{K}}{600 \text{K}} \]

\[ = 1 - 0.5 = 0.5 \]

Since 0.5 > 0.364, yes, it is possible.