PH202 Reading Guide

Chapter 11: Using Energy

In chapter 10 you learned about energy and the different types of energy. You also learned that energy in a system is conserved when no external work or heat is added to the system. This chapter we learn more about what we mean when we say we are "using energy". We talk about how, in an irreversible processes, some energy is transformed into useful energy and some into unusable energy, which is often related to a transformation of energy into heat. How much of the energy is transformed into a useful output depends on the efficiency of the system. We will talk about energy used in a human body, and energy flow in heat engines and heat pumps.

During the study of the material in chapter 11 we will learn about thermal energy. We have already mentioned the two ways to transfer energy into a system: doing work or transferring heat. We will learn that heat always moves from a hot object to a colder object. For many of us that does not seem to be a new discovery. Who has never touched a hot body and quickly felt how this heat transferred to our bodies. Did your hand cool further down, by giving even more heat to the hot object making it even hotter? We will introduce the new variable temperature.

We will particularly discuss two fundamental laws in physics: the first and second laws of thermodynamics and get a chance to discuss entropy. At the end of this chapter and the classes on these topics, the successful student will know more about conservation of energy and how it is used, as well as have some feel for what entropy is.

Student Learning Objectives

In covering the material of this chapter, students will learn to

- Use the concept of efficiency, and understand why some processes are less than 100%efficient.
- Calculate energy used by the body to perform different tasks.
- Reason about thermodynamic problems using the concepts of heat, temperature, and thermal energy.
- Understand the first law of thermodynamics and the different statements of the second law.
- Understand the concept of entropy and how it places a fundamental limit on efficiencies.

Physics Tools

- Laws of thermodynamics
- Heat flow diagrams (heat engine, heat pump)
- Energy Bar Charts

When reading the text

- Answer all "Stop To Think" questions (the answers are in the back of the chapter)
- Understand all examples
- Answer the following questions to ensure you understood the text

Some questions that successful students can answer after reading the text:

Section 11.1 (page 319-322):

What again was the work-energy equation?

What is an irreversible process?

What is the general definition of efficiency presented in our textbook?

Can the efficiency of a process be larger than 100%?

What is the typical efficiency of a human being climbing stairs?

What is the efficiency of a fluorescence light bulb?

What is the efficiency of an incandescent light bulb?

What causes energy losses in a system?

Section 11.2(page 322-327):

What is the difference between a Calorie (Cal) and a calorie (cal)? How do you convert each of them to SI units?

Does fat or carbohydrates store more energy?

How much energy is in a) one gram of fat, b) one gram of carbohydrates, c) one gram of gasoline?

How much energy is in a) a slice of pizza, b) an apple?

What is the total metabolic power used of a body at rest?

Why do you find resting power (in Watts) and not resting energy (in Joule) given in the book?

Is the metabolic power use of a body equal to the energy change resulting from a performed activity, or do you have to consider efficiency to calculate the actual useful power output?

What value do we generally use for the human body's efficiency? What factors would change this value?

How do you explain gaining weight from an energy point of view?

Why does walking at a constant speed use up energy?

Where on your body would you carry weight if you want to use very little energy for the transport? Where on your body would you carry weight if you want to lose weight and you do not want to carry the weight efficiently?

Section 11.3 (page 327-330):

How is the thermal energy of a gas related to the individual molecules in the gas?

What three main temperature scales are in use in the US? How are they related?

What is absolute zero? What temperature scale is 0 at absolute zero? What is absolute zero in the other two temperature scales? (you need to do a little calculation here)

Is there a difference between Heat and Thermal Energy? What is it?

How is heat transferred on a molecular/atomic scale?

What is thermal equilibrium?

Section 11.4 (page 330-332):

How do you expand the Work-Energy equation to include heat?

What is the first law of thermodynamics? How does it relate to the Work-Energy Equation?

What is an energy reservoir? What properties does it have?

What do the symbols Q_H and Q_C represent? Can they be negative? How are these different from T_H and T_C?

Sections 11.5-11.6 (page 332-337):

What are the three steps of a heat engine?

How do you calculate the efficiency of a heat engine?

What is the difference between a heat engine and a heat pump?

Sections 11.7-11.8(page 337-342):

What is the difference between a reversible and irreversible process? Give one example each.

What is entropy? What happens to entropy as two systems interact?

What is the second law of thermodynamics?

Why does the efficiency of a heat engine have a maximum?

What is an isolated system?

Why do we need to conserve energy in every day's life? Didn't we learn that energy is conserved?

Why is converting thermal energy into other forms of energy never 100% efficient? (Why is a heat engine never 100% efficient?)

Suggested Workbook Problems (best is answering all workbook questions)

Chapter 10 for review: 8, 9, 10, 12, 14, 15, 16, 20, 21, 22, 30, 31

Chapter 11: 1, 2, 3, 5, 6, 8, 9, 10, 11, 14, 15, 18, 22, 23