Instructor’s Manual
to accompany

ENERGY
Its Use and the Environment
Fourth Edition

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INTRODUCTION TO THE USE OF THIS MANUAL AND THE TEXT

This Instructor’s Manual was prepared to supplement Energy: Its Use and the Environment, fourth edition. This Manual provides the instructor with the following aids:

1. **Instructor’s Notes.** Each chapter has a short introduction to help the instructor integrate the chapter into the text. Notes are provided on which chapters can be modified without losing important concepts. Questions are also provided that might be used to bring about greater class participation. The topics of energy and the environment can be made much more relevant to the student if it is tied into everyday events and practical applications. The instructor might wish to have students bring in newspaper or magazine articles on these topics to share.

2. **Answers to Questions and Problems.** Answers are given for most of the exercises at the end of each chapter. Because many of these questions are open ended, the instructor may wish to elaborate on these.

3. **Demonstrations.** A few demonstrations are given for almost every chapter. For a class that might have a majority of non-science majors, it is important to stimulate them with at least one demonstration per class period. Research shows that this is one of the things that they will retain longest about that topic. Don’t forget that many of the activities at the end of each chapter can be used as in–class projects/demonstrations for groups of 3–4 students.

4. **Multiple Choice Question Bank.** A bank of multiple choice test questions is given at the end of this manual. For most classes it is important to provide a chance for students to express themselves on longer questions as well, dealing with an idea or concept that was discussed. Such “essay”-type exam questions are not given here but might be built upon the questions at the end of each chapter in the text.

5. **Labs and Activities.** These labs and activities are relatively simple to organize for a class but some require special equipment. All labs and activities have been successfully used during in-service workshops for technology and secondary school teachers.

Updates/additions to relevant material for instructors can be found on the website to accompany the text located at: http://physics.brookscole.com/hinrichs4e.

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Multiple Choice Question Bank............................. 25

Labs and Activities

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CHAPTER 1: INTRODUCTION

INSTRUCTOR’S NOTES
This chapter is an important one in that it provides current background (as of late-2004) on energy use and energy resources, worldwide. It also sets the stage for the theme of energy conservation. It seems important to help students realize the important role of energy resources in their economy as well as their environment. Can they list renewable resources and non-renewable ones? How many know what fuel is used for their domestic hot water? How have high gasoline prices affected their lives? Many students do not understand patterns of energy use, especially Americans as compared to the majority of people in the world. A homework assignment on energy use in developing countries might be appropriate. Activity 3 at the end of Chapter 3 on developing countries might be good at this stage. Many of the questions at the end of the chapter can be used as good motivators for class discussion. For example, why do we use more energy today per person than was used two generations ago?

ANSWERS TO QUESTIONS
2. In the last 50 years, petroleum has grown the fastest due to its low cost, adaptability to many uses, and relatively low pollution. Recently, natural gas is seeing the fastest growth.
3. From Table 1.1, oil will last
   \[1213 \times 10^6 \text{ bbl} / 78 \times 10^6 \text{ bbl/day} = 15.6 \times 10^3 \text{ days} = 43 \text{ years}.\]
4. b. DT = 70/2 = 35 years, so about 400 plants of this size would be needed.
5. DT = 70/1.3 = 54 years, so in 2040 the world’s population will be 10 billion.
6. Increased: travel, move to single family homes from apartments, leisure time, appliances, higher per capita income, electrification, etc.
8. Energy use depends upon the energy required for the particular activity and its frequency.
11. \(5100(1.08)^n = 39000. \ n = 26 \text{ years.}\)
21. Per capita consumption for India (App E) is 13 MBtu and US is 333 MBtu/year. Therefore /Indian consumes about 4% that of an American, or 1/4 gal per day.
22. Much of the economic growth is in developing countries, which have a low energy use per capita. Also increased efficiency in the use of energy, especially in the industrialized world.

DEMONSTRATIONS
A variety of models can be used to spark student interest in energy. Solar cells, electrical generators, energy efficient lights, wind turbines are just some. One can simulate the problem of resource depletion and demand by passing around a bag of candy and asking students to take as many pieces as they wish. Make sure the number of pieces is less than the class size.

A “What-If” activity during the first weeks of the course can be used to help students see the interplay between energy, economics, and the environment. This starts with a statement of a proposed action (for example: car efficiency standards are doubled or suppose all coal fired power plants are taken off line) and then one examines the consequences of that action. For the examples mentioned, automobile manufacturers will need to overhaul their models, new technology will have to be implemented, poor people might not be able to afford the newer cars, less oil imports will cause..., etc. This activity is best done in teams, with each team later reporting out their solutions to the entire class.
CHAPTER 2: ENERGY MECHANICS

INSTRUCTOR’S NOTES
This is one of the foundational chapters of the text. The emphasis is on energy and not forces, although the laws of motion are covered in the special topic section at the end of the chapter and might be good review for those students who are rusty in this area. Important concepts are forms of energy, conversions between different energy forms, and power. If the text is used for a course with more emphasis on conceptual physics, then the special topic on Newton’s Laws should be covered. With high gasoline prices, the dominance of oil in the transportation sector is especially relevant. A class discussion on transportation and energy use might be begun by asking: “What if corporate average fuel efficiency (CAFE) standards of 40 mpg were mandated for new cars (including sport utility vehicles) beginning in 5 years? What are the implications?” Try to bring out the use of energy in other countries by referring to Figures 2.6 and 2.7. Be sure to discuss the “How Would You Choose” question on energy conversions, especially since this is the first such question in the text. Adding to the examples of energy conversions in Table 2.2 is a good class discussion activity.

ANSWERS TO QUESTIONS
1. See Tables 2.1 and 2.2 for examples.
2. a) match: chemical to thermal + light
   b) kinetic (wind) to kinetic (shaft rotation)
   c) PE to (KE + TE) to PE to (KE + TE) etc.
   d) sound to electrical
   e) chemical to electrical to light
3. a) bicycle: chemical to mechanical energy
   b) windmill: solar (or wind) to mechanical energy
4. Hydropower: PE to KE to electrical energy
5. KE of car transformed into PE + TE
6. Decrease mass, increase aerodynamics and engine performance, drive slower
8. Acceleration is a constant; velocity increases (or decreases)
9. Yes; if a ball is thrown vertically upward, acceleration is always –9.8 m/s/s, but velocity at top of path = 0
10. \( F_{\text{net}} = F_{\text{engine}} - F_{\text{air resis}} - F_{\text{rolling resis}} = ma \)
   If \( v = \text{constant} \), \( F_{\text{net}} = 0 \).
11. If there is a net force on the object, then work goes to KE + TE. If net force is zero, then work goes to TE only.
12. Work done = force × distance; power expended = work done/time
13. Work: Btu, J, kWh, ft-lbs, cal; Power: watts, ft-lb/min
14. Head height, flow rate (gal/min), turbine efficiency

ANSWERS TO PROBLEMS
1. 0.24 m/s/s
2. 12.5 m/s/s
3. PE = mgh = 1372 J
4. 32 ft-lbs = 43 J
5. \( W = F \times d = 540 \text{ ft/lbs} \)
6. KE = 0.5 (3000/32)(60 mph = 88 ft/s)2 = 363,000 ft-lbs
7. 0.46 m
8. KE = 200 J \( v = 4.47 \text{ m/s} \)
9. \( PE = mgh = 280 \times 106 \text{ ft}^2 \times 40 \text{ ft} \times 62 \text{ lb/ft}^3 \times 580 \text{ ft} = 402 \times 1012 \text{ ft-lbs} = 518 \times 109 \text{ Btu} \) (assuming average water height of 580 ft)
10. U.S. annual per capita residential use = $3.6 \times 10^{11} \times 0.20$ (Fig. 1-8) = $72 \times 10^9$ J/yr. therefore Bangladesh per capita use is 10% of U.S.

11. 400 W = 0.54 hp
12. 15 ft-lbs = 20 J
13. $1395/3.25$ h = 492 mph. 492 mph $\times 0.447$ m/s/mph = 220 m/s
14. $0.1$ kW $\times 2$ d $\times 24$ h/d $\times 50$ cents/kwh = 58 cents
15. $P = \frac{mgh}{t} = (8l \times 1$ kg/l)(9.8)(1.5m)/1 s = 117 W
16. 1000 homes
17. $W = 300 \times 24 = 7200$ ft-lbs. Table inside back cover gives 1 ft-lb = $3.77 \times 10^{-7}$ kwh. So money earned = $7200 \times 3.77 \times 10^{-7} \times 14$ cents/kWh = $3.8 \times 10^{-4}$ cents!

ANSWERS TO SPECIAL TOPIC PROBLEMS
1. 1.5 min
2. 330 m
3. $1.25 \times 10^{-8}$ sec
4. 2880 km
5. 29 m
6. 24 m/s
7. 30 m/s
8. 390,000 J, 24.5 m/s time = 2.74 s
9. 392 W
10. 62.5 mph
11. 60 mph $\times (0.447$ m/s/mph) = 26.8 m/s;
12. 5.1 m
13. 5.58 m/s/s
14. Total length = 10 + 1.5 = 11.5 ft

DEMONSTRATIONS
Some of the figures in this chapter reflect demonstrations the author uses regularly in class. One is the example with dishes and inertia (Fig. 2-10). Toys provide great examples of energy mechanics. I enjoy spring-loaded ones and a toy that has penguins which slide down a slide and then are transported back to the top by a set of (battery run) moving stairs. This is a great illustration of PE to KE, then work done to give the figures PE again.

A great class participation activity is the egg drop (Fig. 2-8). Students might design and construct as homework their own device to hold a raw egg which is dropped from about 5-10 meters. However, I enjoy doing this in class with all students provided with the same material as itemized in Activity 6. This activity can be done in one period. Using one towel as a parachute (held by toothpicks, since no tape or string is allowed) usually is part of a successful design. But let the students figure this out.

Power can be demonstrated by timing students as they run to the top of a flight of stairs. They can each calculate their own power output. Activity 8 succeeds by getting students to work together and calculate the cost of leaving lights on over a weekend in the bathrooms.
CHAPTER 3: CONSERVATION OF ENERGY

INSTRUCTOR’S NOTES
This chapter was part of Chapter 2 in the first edition, but was split apart so that students would not have such a large amount of information to digest in one chapter. The emphasis here is on the conservation of energy. Care should be taken here to distinguish between the conservation of energy (the first law of thermodynamics) and energy conservation—conserving fuel and using increased conversion efficiencies. A difficult point for students is that energy is conserved even though the efficiency of an energy conversion process (such as in an automobile or in a power plant) is much less than 100%. Section D on efficiency is important for future work. The use of Section F on energy equivalences will depend upon how quantitative you wish to be, but the table in that section (repeated in Appendix B) is helpful for many problems throughout the text. Some of the conversions in that table give students a better idea of the amount of energy involved in a variety of everyday activities. This chapter has some illustrations of energy use in developing countries, a theme which could be emphasized by having the students do some internet work with Activity 3. (World Bank and United Nations publications are good references for information on developing countries.)

ANSWERS TO QUESTIONS
1. Car slows as KE goes into TE due to road and air friction.
2. Electrical energy of element goes into thermal energy stored in water and kettle plus heat transferred out to air and steam.
3. KE = PE when bob is half way up, with the PE defined as 0 at the low point of the pendulum’s trajectory
4. Engine efficiency = mechanical energy transmitted to the drive shaft divided by the chemical energy of the fuel.
5. 97%
6. Overall efficiency: ICE: 10%; EV: 18%.
7. About 6,200 Btu (38% efficiency)
8. Bulb efficiency = light out / electrical energy in
9. From Table 3–4, we find that 50 MT/yr of coal = 25 × 10^6 Btu/ton × 50 × 10^6 tons/yr = 1.25 × 10^{15} Btu/yr
   Now, 0.6 MBPD = (2.12 × 10^{12} Btu/yr/l000 Bbl/day) × 0.6 × 1000 Bbl = 1.27 × 10^{15} Btu/yr. So, energy of both quantities is about the same.

ANSWERS TO PROBLEMS
1. ½ mv^2 = mgh, so h = 1.28 m
2. 9.9 m/s
3. gasoline energy = 20 gal × 1.24 × 10^5 Btu/gal; coal has 1.25 × 10^6 Btu/lb; dividing these yields 198 lbs.
4. 29.3 kW
5. Coal plant: efficiency = 6000 kWh/2 tons coal = 3.61 × 10^6 J/kWh × 6000 kWh/(2 tons coal × 25 × 10^6 Btu/ton × 1055 J/Btu) = 0.41
6. $2,880,000
7. 0.6 × 0.01 = 0.006 Oil consumed per year for buses (Appendix G) = 0.006 × 6.74 × 10^9 Bbl/yr = 0.040 × 10^9 Bbl/yr = 0.11 MBPD
8. Electricity used = 72 kWh/mo. Chemical energy = (72/0.3) × 3.61 × 10^6 J/kWh = 8.66 × 10^8 J wasted, or about 144 meals.
9. 518E9 Btu/5.8E6 Btu/bbl = 89E3 bbl
DEMONSTRATIONS
A good demonstration of your faith in the conservation of energy is the “nosecracker” (Fig. 3-1), which is more exciting if a bowling ball is used. A thought-provoking toy for a discussion of the conservation of energy and perpetual motion machines is one in which the motion of some object (a miniature wheel or barbell) is aided by the use of a (hidden) electromagnet. The object will continue to move until the enclosed battery runs down. (Gift shops usually carry items like this.)

Activity 3.1 can be done in class. (The ruler needs to have a groove in it.) Recall that for the conservation of mechanical energy (assuming no heat loss) the PE change = mgh = KE change = 1/2 mv^2. The graph gives a pretty straight line. Further Activity 2 deals with the conversion of KE into work and is easy to do after Activity 3.1. The steelie is the hardest item to procure.
CHAPTER 4: HEAT AND WORK

INSTRUCTOR’S NOTES
This chapter provides the necessary background on the laws of thermodynamics and heat transfer that are foundational to the rest of the text. Chapter 6 on solar energy builds on some of this treatment. Illustrations of heat transfer control are in the next chapter. This chapter contains important concepts relative to energy efficiency (notably the Carnot efficiency) which can be skipped on a first reading. Understanding what is a heat engine is important since so many of our engines convert heat into work. The Second Law of Thermodynamics is tough to understand, but it is presented in several different ways in layman’s terms; these sections can be skipped on a first reading.

ANSWERS TO QUESTIONS
1. Heat is energy transferred to/from a system due to a temperature difference.
2. a) Heat added to gas contained in a rigid container is equal to the increase in total energy of the gas.  
   b) The work done to compress gas in an insulated cylinder is equal to the increase in TE of the gas.
3. Total energy = sum of object’s KE, PE, TE, chemical energy, electrical.
4. Condensation of steam
5. Yes – do work via compression of gas
6. See Fig. 4-18  
8. Efficiency = mechanical energy out of turbine divided by heat energy into kettle.
9. Condenser will increase efficiency of steam engine by providing a low temperature sink for condensation of steam, as well as being a low pressure region.
11. Use concentrating solar collector to heat a fluid. The fluid can be passed through a heat exchanger to produce steam for running the engine.
12. Quality of fluid is low since it has a low temperature
13. Second law says that some heat energy must be expelled to a low temperature sink. We need a ΔT for there to be a flow of heat.
14. Engine will be more efficient as ΔT is larger
15. Condenser increases the efficiency for the steam turbine, and provides water for reinjection back into the ground.
17. The entropy (disorder) of a system can decrease (i.e., order increase) by the addition of work. This system is not isolated.
19. Entropy decreases as heat leaves a container. Entropy of the surroundings will increase, by more than it decreased in the container.
20. No. The kitchen will warm up as energy is added to the room by the work of the compressor.

ANSWERS TO PROBLEMS
1. 80°F.
2. 12 gal × 8.3 lb/gal × 80° = 7997 Btu required; 7997 Btu/3413 Btu/kWh = 2.34 kWh; cost = 18.7 c.
3. $Q = 40 \text{ gal} \times 8.3 \text{ lbs/gal} \times 0.454 \text{ kg/lb} \times 4186 \text{ J/kg/C} \times 30 \text{ C} = 18.9E6 \text{ J} \times 1 \text{ kWh/3.61E6 J} = 5.24 \text{ kWh}$
4. 4.88 kWh required; 0.24 h
5. Need 80(4184) = 334.7 kJ/kg to boil in 5 min. 2260 kJ/kg required for vaporization.  
   Time = 2260/335 × 5 min = 34 min
6. Need 335 kJ/kg for heat of fusion or 5025 kJ total; 34 km.
7. 2.5 m
8. 500 m
9. 20%
10. (1-283/303) = 0.064 = 6.6%
11. Carnot efficiency = (1-293/823) = 0.64, so this is 59% of Carnot efficiency

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12. 27%
13. No. Carnot efficiency = (1-300/600) = 0.5, so can only do 12,500 J of work ideally.

DEMONSTRATIONS
There are many demonstrations dealing with types of heat transfer. Temperature measurements of hot water in different colored but similar containers can be done in class during a regular lecture. Vernier's “Temperature Plotter” is a good one to use with a Mac or PC.

Boiling water in a paper cup illustrates heat transfer, while a thermos bottle shows all three methods of heat transfer. On a sunny day, one can put three glass milk bottles outside—one clear, one painted flat black, and one clear container filled with black water. Monitor the temperature over time. The results might surprise some. This chapter allows one to introduce solar energy devices as well. A window box heater (See Fig. 4.13) illustrates convection and radiation.

To illustrate a heat engine, one could use a bicycle pump and emerge it first in hot water then in cold water to illustrate heat into work. Entropy can be illustrated with the diffusion of a drop of black ink in water, or breaking up an arrangement of billiard balls with the cue ball.
CHAPTER 5: HOME ENERGY CONSERVATION AND HEAT-TRANSFER CONTROL

INSTRUCTOR’S NOTES
This chapter gives a treatment of heat transfer control in a way that can be very practical to students and homeowners. One might discuss the payback on installing plastic storm windows, since many students must pay their own utility bills. The heating budget calculations could be skipped, but they provide practical information for the future. Appendix C provides a successful tested home heating analysis (audit) that the authors use in our Energy Institute for secondary school science and technology teachers. It certainly brings out the marriage of math and science. A good video that emphasizes energy conservation in the home is “How to Keep the Heat in Your House”, by BullFrog Films. Be sure to draw attention to the table on Retrofitting, which is based on years of practical experience.

Two discussion questions for class are:
- What steps would you take if you had to cut back your use of residential energy by 25%?
- What would you do if you had but 4 hours to prepare for the loss of commercial energy to your home (in a hot summer, in a cold winter)?

ANSWERS TO QUESTIONS
1. See Fig. 4-12
3. Weatherstripping and caulking doors and windows, exterior wall electrical plates
4. Weatherstrip, draw insulating drape, use window shade, install clear plastic sheet over windows.
5. Undershirt contains air trapped in small holes in the shirt
6. Rubber soled shoes are good insulators.
7. silver cup
8. white shingles best
11. the evaporator

ANSWERS TO PROBLEMS
1. Adding R-values from Table 5.2 – R = 12.78. \( Q_c = 1 \times 50/12.78 = 3.9 \text{ Btu/hr/ft}^2 \)
2. \( R_{\text{window}} = 1.72; \ R_{\text{covered window with polyboard}} = 9.72 \)
   Savings of 82%.
3. \( R_{\text{walls}} = 3.08; \ R_{\text{roof}} = 12.8; \ R_{\text{floor}} = 1.66; \ R_{\text{window}} = 0.88 \)
   \( Q_{\text{walls}} = (28 \times 10 \times 2 + 40 \times 10 \times 2) \times 0.75 \times 40/3.08 = 13,247 \text{ Btu/hr} \)
   \( Q_{\text{roof}} = (28 \times 40) \times 40/12.8 = 3500 \text{ Btu/hr} \)
   \( Q_{\text{floor}} = (28 \times 40) \times 40/1.66 = 26,988 \text{ Btu/hr} \)
   \( Q_{\text{windows}} = (28 \times 10 \times 2 + 40 \times 10 \times 2) \times 0.25 \times 40/0.88 = 15,455 \text{ Btu/hr} \)
   \( Q_{\text{total}} = 59,187 \text{ Btu/hr} \).
   a) Now \( Q_{\text{roof}} = 2144 \); New \( Q_{\text{total}} = 57,833 \); Savings of 2.3%
   b) Now \( Q_{\text{walls}} = 2918 \); New \( Q_{\text{total}} = 48,861 \); Savings of 17%
   c) Now \( R_{\text{window}} = 1.72 \); New \( Q_{\text{total}} = 51,642 \); Savings of 13%
4. a) \( R_{\text{total}} = 2.3 \)
   b) \( R_{\text{total}} = 21.3 \); Savings of 89%
   c) \( Q = (1 \text{ ft}^2)(24)(6500)/2.3 = 67,826 \text{ Btu/ft}^2/\text{season} \)
   d) \( Q_{\text{new total}} = (1 \text{ ft}^2)(24)(6500)/21.3 = 7324 \); Savings of 60,502 Btu/ft^2/season. Will save 60¢ per season per ft^2. Therefore payback is less than one season, since fiberglass costs 40c/sq.ft.
5. a) \( Q_{\text{infill}} = 0.018(28 \times 40 \times 10)(40)(2) = 16,128 \text{ Btu/hr} \)
   b) 21%.
7. No. \( Q_c = (4 \times 60 \text{ ft}^2 + 100 \text{ ft}^2) \times 25^\circ/1.25 = 6800 \text{ Btu/hr} \) (and no infiltration included)
DEMONSTRATIONS
One should show different types of insulation; a model of a wall with studs and the installation of fiberglass can be important visual aid. Show a caulking gun and a variety of types of weatherstripping.
CHAPTER 6: SOLAR ENERGY:
CHARACTERISTICS AND HEATING

INSTRUCTOR’S NOTES
This chapter is put early in the text because of students’ interests in this topic. One needs to temper the enthusiasm with some economic calculations. Material on heat transfer from Chapter 4 is important. There are numerous demonstrations and experiments that can be done both inside and outside to illustrate principles of solar energy. A choice few are laid out at the end of the chapter.

While space heating using active solar processes has significantly declined due to the economics, DHW is still very important, especially while electricity and natural gas prices continue to rise. This might be an appropriate time to point to the chapters ahead on environmental pollution from the use of non-renewable fuels.

ANSWERS TO QUESTIONS
1. Use reflectors, lens > 1 ft in diameter, adjust tilt angle.
2. Horizontal
3. winter
5. Fundamentals: insulation, south facing windows, thermal storage. Types: direct gain, thermal storage wall, attached greenhouse.
12. All methods of heat transfer from FPC increase as \( \Delta T \). Wish water flow rate to be fast enough so temperature of absorber plate doesn’t rise too much. If too fast, pump will be too big.
14. 30°, 40°
16. Heat transfer in pebbles is by conduction—a slower process than convection. See Activity 2 in Chapter 4.

ANSWERS TO PROBLEMS
2. 5 kW \times 1 \text{ hr} \times 30 \text{d/mo} \times $0.09 = $13.50/\text{month}
3. \( 850(0.2)A = 240 \text{ W.} \ A = 1.41 \text{ m}^2 \)
4. Will need 80 gal \times 8.3 \text{ lbs/gal} \times 1 \text{ Btu/lb/°F} \times 70° = 46,480 \text{ Btu/day.} \text{ Will collect 2060 Btu/day ft}^2 \times 0.40 \times \text{Area. Find Area} = 56 \text{ ft}^2 
5. \( 800(A)(0.40) = 30,000 \times 24 \text{ hrs.} \ A = 2250 \text{ ft}^2 
6. \( 620 \text{ Btu/°F} = (0.2 \text{ Btu/°F/lb} \times 170 \text{ lbs/ft}^3 ) \times V, \ V = 18 \text{ ft}^3 
7. Will collect 700 \text{ ft}^2 \times 0.5 \times 1410 \text{ Btu/ft}^2/\text{day} = 493,500 \text{ Btu/day.} 
\text{ Need 40,000 Btu/hr \times 24 hrs = 960,000 Btu/day. So 51% met by FPC.}

DEMONSTRATIONS
Characteristics of solar energy can be illustrated with a fresnel lens, but be careful. (I’ve burned a hole in my pants before!) Such lenses are available from American Science & Surplus (Chicago) or Edmund Scientific for about $4.00 each. Models of solar ovens and flat plate absorbers will help illustrate the material in the chapter. A Styrofoam™ ice chest or shoe box with a plastic window and thermal mass inside (like activity 3) can illustrate a passive solar house. This is a great homework activity with temperature measurements taken during class – both heating up and cooling down. Using only recyclable materials provides a good emphasis on the environment.
CHAPTER 7: ENERGY FROM FOSSIL FUELS

INSTRUCTOR’S NOTES
This chapter provides some important background on resource terminology and updated information on fossil fuel supply and demand. The following chapters on air pollution and global warming need the overall perspective of this chapter. The “Special Topic” on Oil and Gas Exploration allows more physics to be introduced into this area. But it could be skipped.

ANSWERS TO QUESTIONS
1. U.S. crude oil production has been decreasing as U.S. addition of new reserves has been declining and production costs have been increasing. Opening of the Arctic National Wildlife Refuge (ANWR) might change this.
2. Growth in oil consumption is greater in Southeast Asia.
6. Strip mining has a smaller cost per ton of coal; it also extracts coal of low sulfur content. Restoration will need adequate water for revegetation.
8. Constraints on coal demand will come from stricter air pollution standards, smaller demand for electricity, and lower cost of other fuels.
9. Soda is forced up straw by pressure exerted by the atmosphere.
10. Secondary recovery injects water in the ground to increase pressure on oil while tertiary recovery injects steam, gas, or organic solvent into the ground to enhance recovery.

ANSWERS TO PROBLEMS
1. 10%, so about 30¢/gal.
2. Reserves in Arctic National Wildlife Refuge = 5 billion bbl. Total U.S. use = 19 MBPD or 19 × 365 d/yr = 6.9 billion bbl per year required. Therefore, Refuge would provide for only 0.72 years.
3. Energy used = 2 × 1000 MW × 10^3 kW × 365 d/y × 24 h/d = 17.5 × 10^9 kWh × 3413 Btu/kWh = 60 × 10^12 Btu.
   Gas used = Energy used × 1 scf/1000 Btu = 60 × 10^9 SCF/yr.
4. Today, 3.5 trillion kWh electrical energy used in US. Electricity provided by plants with total power output of about 800,000 MWe. If consumption continues to grow at 2%/year, then in 10 years we will need (1.02)^10 = 1.219, or about 22% more plant capacity. This is equivalent to 0.22(800) = 176 1000 MWe plants; multiplying this by 0.060 tcf per 1000 MWe plant—problem 3—yields about 10 tcf more natural gas needed per year; this is about 50% of our current gas consumption.
5. Coal energy input: 26,000 tons × 2000 lbs/ton × 8700 Btu/lb = 4.52 × 10^{11} Btu. Gas energy output = 250,000,000 ft^3 × 950 Btu/ft^3 = 2.37 × 10^{11} Btu. Therefore, Eff = 0.52

ANSWERS TO SPECIAL TOPIC QUESTIONS
1. Density of iron ore is about 3 times that of petroleum reservoir rocks such as sandstone or shale. Earth’s average density = 5500 kg/m^3.
2. Weight is inversely proportional to your distance squared from earth’s center. Your mass is a constant.
3. Both waves obey the relationship \( v = \lambda f \), but their velocities are quite different. Light can travel in a vacuum, sound cannot.
4. 60 m
5. Object appears shallower and closer to you while under water.
6. Seismic waves will refract (bend) differently at each rock interface and so arrive at different times at the detectors.
CHAPTER 8: AIR POLLUTION AND ENERGY USE

INSTRUCTOR’S NOTES
This chapter begins with some basic physics concepts on pressure and buoyant force, as related to air pollution. Air pollutants are introduced next, and then air pollution control devices for both the automobile and power plants are discussed. One can encourage class discussion with a question such as: “If coal-fired power plant emissions of sulfur dioxide were mandated to be reduced by a factor of 2, what would be the consequences?”

ANSWERS TO QUESTIONS
1. Reduce the area by placing book on its side.
2. Equal heights in all containers since pressure = \( \rho g h \).
3. Need to increase pressure upon the oil at bottom of well by injecting a fluid.
4. BF = weight of displaced liquid, so 2-tons for both water and alcohol. Ball floats if its \( \rho < \rho \) liquid.
5. Blimp will rise until its density = density of surrounding air. Larger blimp will rise higher.
6. Moist air is less dense. Low pressure regions usually indicate that the air in that region has greater moisture content.
7. Pressure increases as water depth increases.
8. Pressure decreases due to decrease in air’s density.
9. Decrease in temperature of ambient air as height goes up (assuming no temperature inversion) will allow less-dense pollutants to rise and disperse.
10. Emissions are expressed in terms of lbs/MBtu of thermal output. Local concentrations are expressed in \( \mu g/m^3 \), or ppm in air.
11. Smog is due primarily to NOx and VOC and sunlight. Pittsburgh has more industrial emissions of particulates and SO2.
12. More massive particles, with more inertia, will collide with the cyclone’s walls as they undergo circular motion.
13. Precipitators are only used for solids and are not very effective in removing very small sized particles.
14. Exhaust gases have been cooled by addition of water and must be reheated to increase buoyancy. Power plant efficiency is lowered.

ANSWERS TO PROBLEMS
1. \( p = \frac{F}{A} = 15 \text{ lbs/}(0.25 \text{ in.} \times 0.25 \text{ in.}) = 240 \text{ psi} \)
2. \( p = 62 \text{ lbs/ft}^2 \times 1 \text{ ft (depth)} = 62 \text{ lbs/ft}^2 = 0.43 \text{ psi} \)
3. \( p = 13,600 \text{ lbs/ft}^3 \times 9.8 \times 0.15 = 20,000 \text{ N/m}^2 = 20,000 \text{ Pa (1 Atm=101,000 kPa.)} \)
4. \( 140 \times 1000 \text{ kg/m}^3 \times 9.8 = 1,372,000 \text{ N = 390,000 lbs.} \)
5. 1000 MWe plant: uses 9000 tons of coal/day \( \times 0.03 \times 64/32 \) (for O2) = 540 tons SO2/day emitted.
6. 1000 MWe plant: 9000 tons of coal/day \( \times 0.02 \) (ash) \( \times 0.05 \times 1 \text{ day/24 hrs} \times 2000 \text{ lbs/ton} \times \text{1kg/2.2 lbs} \)
   \( = 340 \text{ kg/hr of ash (assuming all ash volatilized)} \)
   \( \text{Hg emitted} = 340 \text{ kg/hr} \times 10^{-6} \times 24 \text{ hrs/d} \times 365 \text{ d/yr} \times 1 \text{ tonne/1000 kg} = 2986 \times 10^{-6} \text{ tonnes/yr} = 3.0 \times 10^{-3} \text{ tonnes/yr} = 3 \text{ kg/yr} \)
7. Standards for CO = 3.4 g/mile. Traveling 20,000 miles/year = 68,000 grams/year \( \times \frac{1 \text{ kg/1000 grams}}{} = 68 \text{ kg/year.} \)
DEMONSTRATIONS

There are a number of demonstrations on air pressure and on Archimedes principle that can be used here. I like to use a laser beam to illuminate chalk dust to illustrate particulates and their settling time. A bell jar (with a vacuum pump) containing marshmallows and a balloon are great illustrations of air pressure. An electrostatic precipitator as illustrated in Fig. 8-26 is a good model to build using incense; one needs a source of high voltage, as a Tesla coil.
CHAPTER 9: GLOBAL WARMING, OZONE DEPLETION, AND WASTE HEAT

INSTRUCTOR’S NOTES
This chapter is structured in such a way that it is easy to cover only those sections that are of interest. Global warming and ozone depletion are two topics that are usually of strong interest. You’ll need to rely on some material from Chapter 4. Note that these are two different things. Distinguish between impact of ozone in the stratosphere and ground level. Understanding of human contributions to global warming continues to grow. How should we adapt to upcoming climate change? Was Hurricane Katrina in any way related to these effects? Students should be encouraged to bring to class relevant science and economics and political articles on this.

ANSWERS TO QUESTIONS
1. Deforestation removes CO₂ sinks and adds CO₂ in the burning process.
2. There is an apparent positive correlation between earth’s temperature and carbon dioxide concentration, but still debatable.
3. There will be a warming trend, due to decreased reflectivity and release of carbon from permafrost.
4. At the publication of this 4th edition, new evidence on melting of the ice caps has been brought forth.
5. The low temperature water doesn’t have many uses. Raising the temperature of the cooling water would decrease plant efficiency.
6. Ozone is a benefit in the stratosphere as an uv shield. Near ground level, it is an air pollutant.
7. About 26°C or 79°F
8. Evaporation and dilution.
11. Thermal pollution alters growth patterns in the food chain, causes increased chemical reactions, and brings about eutrophication.

ANSWERS TO PROBLEMS
1. Driving 100 miles (with 20 mpg) adds 100 lbs of CO₂. Running an electric clothes dryer @5000 W for 30 minutes consumes 2.5 kWh and adds about 5 lbs of CO₂ per load. 5 hours of a 100 W TV adds 1 lb of CO₂.
2. To rise to 5670 billions tons/yr of CO₂ from 3070, at 5% per year growth rate, will take 12.5 years, as 5670 = 3070(1.05)x
4. Waste heat discharged per unit output is 4 for geothermal and 1.5 for fossil-fueled plant, or 267% more.
6. Carnot eff. = 1 – (293/773) = 0.62 for first case. For second case, Carnot eff. = 1 – (303/773) = 0.61, so a decrease of 1%.
CHAPTER 10: ELECTRICITY: CIRCUITS AND SUPERCONDUCTORS

INSTRUCTOR'S NOTES
This chapter is basic to an understanding of electrical energy. Electrostatics in the Special Topics section at the end of the chapter can be covered in a more conceptual physics course. One needs to understand the pricing of electricity. You should know whether time of day metering is used in your area, the cost per kWh of electricity (for both generation and distribution), and the percent contributions of resources used by your local utility.

ANSWERS TO QUESTIONS
1. To ground charges that were picked up by moving car
2. Discharge from body over a large area reduces shock.
3. Shoes will provide a higher resistance between the hand and ground and so there will be less current.
4. Depends upon current through body (function of body resistance) and pathway taken (through heart, torso, etc.)
5. Large diameter wire has less resistance, so less heating occurs.
6. 220 V allows larger current to be used for heating purposes
7. They protect circuit from overheating when current is large
8. In parallel. Limit placed by circuit breaker or fuse
9. Larger resistance of small diameter wire leads to a greater voltage drop in extension cord and so less voltage available for the appliance. Also the larger resistance will lead to a greater heat loss in the wire and so the possibility of a fire!
10. Need a potential difference and closed circuit for current.
11. ON

ANSWERS TO PROBLEMS
1. 60 ohms, 240 W.
2. 1.5 kW × 0.5 h × $0.12/kwh = $0.09
3. 0.5 A, 6 W.
4. 8.33 A.
5. 1.2 kW × 1/60 h = 0.02 kWh. Cost = 0.16¢.
6. a) $14.40 b) $1.20 c) 5.8¢.
7. 720 W-hrs × 3413 Btu/kWh = 2457 Btu = 0.02 × 125,000 Btu
8. 38 W × 40 × 10⁶ × 365 × 24 = 13315 × 10⁶ kWh/yr.
9. 13.3 W-hr/lb. If used once, price of $40/0.06 kWh = $67/kWh. However is always recharged.
10. In series, 3 A. In parallel, 4 A.
11. 10¢ per kWh in 1925.

DEMONSTRATIONS
A board of energy efficient lights, and the payback time on these, is a good introduction to this chapter. Parallel and series circuits are still important to demonstrate. Elementary circuits is always a tough topic. Let your class experiment with bulbs and batteries and the activities spelled out in the chapter. If liquid nitrogen is available, demonstration superconductors are available at pretty good prices. Balloons and pith balls and small Van de Graaff generators are important for coverage of electrostatics.

Activity 10.1 has always been a popular in-class activity. Another statics experiment uses pieces of scotch tape placed down on the table. Two pieces pulled up will repel each other, one tape placed on top of another and then the unit pulled up from the table, and the two then pulled part, will show attraction. I’ve
recently had good success demonstrating the inverse squared dependence of Coulombs Law by using a pith ball and a charged straw. One charges the pith ball and then measures the angle of deviation of the pith ball from the vertical as a function of distance from the straw. Works best if done quickly and in dry conditions.
CHAPTER 11: ELECTROMAGNETISM AND
THE GENERATION OF ELECTRICITY

INSTRUCTOR’S NOTES
After an introduction to electromagnetism, this chapter provides some up-to-date coverage of transmission lines and the generation of electricity, including co-generation. You might wish to review the steam cycle of Chapters 2 and 4 at this point. Published material and studies on biological effects of EMF continues to grow, so keep and eye out for such information.

ANSWERS TO QUESTIONS
1. None. Particle will be deflected to the right or left depending on its charge.
2. Turn the shaft. Motor must have permanent magnets inside.
3. Yes, briefly. A magnetic field is associated with the electric current.
5. To reduce heating losses in transmission lines.
8. Less expensive to install. Fuel availability, convenient to use.
11. No, unless the question is between using or not using the process steam, depending upon its temperature.

ANSWERS TO PROBLEMS
1. \(10^6 \text{ kW} \times 24 \text{ hrs/day} \times 0.08/\text{kWh} = 1,920,000/\text{day}\)
2. 5 A
3. a) \(130/10 = 13:1\)
   b) \(10 \text{ MW} = 130,000 \times I, I = 77 \text{ A.}\)
   c) \(I^2R = (77)^2(4) = 23692 \text{ W}; 0.24\%\)
4. 56%. Pumped storage helps to smooth out hourly electricity production curves.

DEMONSTRATIONS
One can begin this chapter with demonstrations with simple magnets: what material will shield you from a magnet? Small, inexpensive circular magnets from stores such as Radio Shack are great for this. Try putting the small, circular magnets inside a (black, plastic) film canister and examine their interaction. You can relate this to EMF’s from transmission lines later. Observing the deflection of a compass by a current-carrying wire or the pattern of iron filings around an electromagnet is a good introduction to the chapter as well. Show the deflection of a current-carrying wire in a magnetic field. Also illustrate the bending of a beam of electrons with a magnet. Move a bar magnet through a coil of wire and observe the induced current using a microammeter. Holding a key to a Tesla coil while you hold a fluorescent light bulb in the other hand will be illuminating to students.
CHAPTER 12: ELECTRICITY FROM SOLAR, WIND, AND HYDRO

INSTRUCTOR’S NOTES
This chapter could be skipped at this point and returned to later, but the topics are of strong interest to students, especially solar cells and wind turbines. One needs to emphasize the economics as well as the advantages of solar cells, especially in light of finite resources and the environment. It might not be hard to locate a wind turbine in your area to videotape. Some material on hydropower was previously covered in Chapter 2.

ANSWERS TO QUESTIONS
1. Ratio of electricity out to insolation upon the cell is 15%
2. No. For silicon, only those wavelengths below 1000 nm provide enough energy for electron emission. A filter would only block out, not intensify, certain wavelengths.
3. Need to energize a normally closed relay to an open position when light is incident upon cells. One might have to use several cells in parallel to obtain enough current to energize the relay, or use a transistor as a switch. See diagram.
4. Wire 3 or 4 cells (0.5 V output) in series (One might need more current, so more cells might need to be wired in parallel.)
5. Higher temperature fluids needed to achieve higher efficiencies in heat engine. See sketch of Luz facility (Fig. 12-23)
6. Need direct rays for concentrating collectors. Also insolation is highest there.
7. About 5000 kW/km².
15. In 2005, world’s largest hydroelectric plant is Itaipu in Brazil/Paraguay at 12,600 MW.

ANSWERS TO PROBLEMS
1. $30,000/kW output.
2. 500 W/m² (0.10) × Area = 10⁹ W;
   Area = 2 × 10⁷ m² = 2000 hectares = 4940 acres for 1000 MWe plant.
3. Each unit produces 0.3 W. Therefore we need 40/0.3 = 133 units.
   Each unit is 40 cm², so we need a total of 5330 cm² = 0.533 m² = 1 m × 0.53 m. (Comparable to commercial panels available today.)
4. \( P = 2.36 \times 10^{-4}(20)^2(15)^3 = 3.2 \text{ kW} \)
5. \( P = PE/t = 12 \text{ kg/s} \times 9.8 \text{ m/s/s} \times 4 = 470 \text{ W} \)
6. \( P = 1000 \text{ W/m}^2 \times 0.1 \times A; A = 10 \text{ m}^2 \text{ per person at } 10\% \text{ efficiency.} \)
   Total Area = 6 × 10⁹ × 10 m²/person = 6 × 10¹⁰ m² = 60,000 km² (size of MA and NH combined).
   Volume of silicon = 6 × 10¹⁰ m² × 200 × 10⁻⁶ m = 1200 × 10⁴ m³.
   Silicon mass = density × vol = 2330 kg/m³ × 1.2 × 10⁻⁷ m³ = 2.8 × 10¹⁰ kg.
7. Presently, wind provides 0.5% of U.S. electricity. 0.5(1.20)ⁿ = 5, so n = 13 years.
8. Max output \( E = P \times t = (10,500 \text{ kW})(365 \text{ days/yr})(24 \text{ h/d}) = 92 \times 10^6 \text{ kWh} \)
   Capacity factor = 28 × 10⁶ kWh/yr/(92 × 10⁶ kWh/yr) = 30%.

DEMONSTRATIONS
Solar cell powered toys, although common, are still attractive to students at this point. You might try powering a toy car with an array of cells (e.g., see www.Kelvin.com for kits). “Grab Bags” of amorphous silicon solar cells are available from science stores (including Edmund Scientific) and can be built into an array by soldering wires to the cells. See Photovoltaic Array Construction in Labs and Activities at end of this manual. PV units (encased in plastic) can be purchased at reasonable prices—see text’s web site. 0.5 V DC motors from American Science and Surplus can be powered by a single cell. The solarimeter (Chapter 6 Activities) could also be built while studying this chapter. The ping-pong ball wind speed indicator could be used with a 3-speed fan to discuss the velocity cube dependence of wind power.
CHAPTER 13: THE BUILDING BLOCKS OF MATTER: THE ATOM AND ITS NUCLEUS

INSTRUCTOR’S NOTES
For a shortened version of a course, one might want to skip the familiar material on the atom and proceed to section D on nuclear structure, which allows one to lead into Chapter 14.

ANSWERS TO QUESTIONS
1. Number of protons.
2. Zn mass = 65; S mass = 32; Zn fraction = 0.67
3. Oxygen isotopes with masses 15, 16, 17, 18. Last 3 are stable.
4. Electrical (light), light (fluorescence), uv, x-rays, energetic nuclear particles, chemical reactions, etc.
7. Due to presence of isotopes.
8. 7/8 will have decayed.
9. $^{38}\text{Ar}$ (Z = 18)
10. $^{60}\text{Ni}$
11. $^{92}\text{U}^{235} \rightarrow ^{90}\text{Th}^{231} \rightarrow ^{91}\text{Pa}^{231} \rightarrow ^{89}\text{Ac}^{227}$
13. 50, 130 (Sn)

DEMONSTRATIONS
Gas discharge tubes can help to illustrate the quantized energy levels in the atom. Diffraction gratings should be passed out to the class. A Rutherford-type experiment to show a localized nucleus (or possibly the quark nature of the proton) uses a toy table tennis ball gun. You can shoot it at metal balls hanging in a box. Some ping pong balls will hit the massive balls and bounce backwards.

Exponential decay can be shown by using small blocks with one side painted red (see Half-Life Calculation Activity in the Labs and Activities section of this book). Roll the blocks on the table and take out the ones with the red side up. The number left decreases with a “half-life” of 3.8 rolls.

A G–M counter and some radioactive sources can help illustrate shielding and the inverse square law. Orange Fiesta-ware dishes and older Coleman lantern mantles also are radioactive (with U and Th, respectively).
CHAPTER 14: NUCLEAR POWER: FISSION

INSTRUCTOR’S NOTES
This chapter might be a little long but covers a multitude of topics dealing with nuclear power. Objectivity is important. At least at this point in the course one should begin to compare different resources and their environmental and economic impacts. Questions about what is an acceptable risk, and what is a voluntary and involuntary risk, should be addressed through class discussions. The awarding of the 2005 Nobel Peace prize to the International Atomic Energy Agency might serve as a spring board for the discussion of links between peaceful and weapons uses of nuclear energy.

ANSWERED TO QUESTIONS
1. $^{235}\text{U}$ percentage is too small.
2. Neutron moderator and heat transfer fluid.
3. Due to direct radiation from reactor core and turbine, and emissions of fission fragment gases.
5. Assuming environmental temperature is $20^\circ \text{C} = 293\text{K}$, maximum efficiency $= 1-T_C/T_H = 1-293/588 = 0.50$.
6. The output will decrease since the density of water in the core decreases. Less moderation of neutrons occurs and so probability of fission decreases.
7. Enrichment of $^{235}\text{U}$ is only 3%, not 90% as in a bomb.
8. “Decay heat” is present as long as waste material continues to be radioactive, which is the case for much of the material due to the long half-lives.
9. Passive reactor safety system has gravity feed for the coolant water. If a LOCA occurs, heat dissipation is by natural means.
10. This gives other nations capability to extract $^{235}\text{U}$ and $^{239}\text{Pu}$ from spent fuel rods.
11. HLRW are associated with the nuclear fuel cycle and have high levels or radioactivity and long half lives.
15. Emergency Core Cooling System, plus back-up pumps.

DEMONSTRATIONS
Chain reactions can be illustrated by the use of dominoes, or table tennis balls placed on top of a set of mouse traps. Many utilities have videos available that show the workings of a nuclear reactor.
CHAPTER 15: EFFECTS AND USES OF RADIATION

INSTRUCTOR’S NOTES
In a shortened course, this chapter could be added later if time permits. Topics on radiation dose and radiation protection could be integrated into the chapter on nuclear power or section on radioactivity in Chapter 13.

ANSWERS TO QUESTIONS
1. Gamma rays
2. Activity = disintegration per second of a source
   dose = total energy deposited in a person
   dose rate = rate that energy is deposited in tissue
3. If energy of radiation is too low, then no ionization will occur.
4. Greater energy will be deposited near the end of the range, and so damage can be localized.
5. Alphas. They have a quality factor of 10-20, compared to 1 for x-rays.
6. Type of radiation emitted, biological half-life of material swallowed. Amount swallowed
7. Water and paraffin are good shields for neutrons.
8. X-rays will scatter from bone in mouth
9. 200 \times 10^{-6} \text{ deaths/rem/year} \times 5 \times 10^{-3} \text{ rem} \times 275 \times 10^6 \text{ people} = 275 \text{ extra deaths per year}
10. Reduce radiation by 9 times, so go to 3 m
11. Max. time = 3000 \text{ mrem}/150 \text{ mrem/h} = 20 \text{ hours}
12. 5 \text{ rem}/0.33 \text{ hour} = 15 \text{ rem/h}. Probably gammas, as they can penetrate soil. Leave promptly!
13. Inject different radioisotopes into each liquid that goes into the water system. Identification of each effluent can be made by analyzing the energy of the gamma rays.

DEMONSTRATIONS
One could use the Geiger counter from Chapter 13 again. Old film badges are useful to show. A carbon canister for radon detection is good to show and can be found at most hardware stores. You might wish to check out your state’s requirements on radon surveys required for selling a house. The “Personal Radiation Dose” form at the end of the chapter always brings about good discussions.
CHAPTER 16: FUTURE ENERGY
ALTERNATIVES: FUSION

INSTRUCTOR’S NOTES
This chapter has quite a few details but is a good way to apply some of the material on electromagnetism and nuclear physics of previous chapters. Students should be aware of this alternative, even though its prospect for the foreseeable future is dim.

ANSWERS TO QUESTIONS
1. Energy comes from loss of mass of products.
2. Fusion’s requirements of both high temperatures and large densities for extended time periods are difficult to achieve. Sun has extreme gravitational force and high temperatures.
3. One needs high densities for extended time periods to produce enough energy for fusion reactions to break even.
4. Swimming pool 50m × 2m × 10 m = 1000 m³. D₂O is 0.015%, so amount of D₂O in pool is 1000 m³ × 1000 kg/m³ × 0.00015 = 150 kg, or 4/20 × 150 = 30 kg D. Fusion of 1 g D = 2400 gal gasoline 1 gal = 11 kWh generated; 30,000 g × 2400 gal/g × 11 kWh/gal = 80 × 10⁷ kWh. Appendix B gives 5.3 × 10⁹ kWh used for 1 million people. So about 150,000 people could be served with this pool water.
5. Magnetic bottle confines plasma to specified volume without using walls
6. One could use resistive heating through plasma and/or injection of energetic ions into plasma, or could use lasers
7. Interaction of powerful lasers with fuel heats plasma and implosion brings about increased density.
8. Scientific breakeven means as much energy is released in fusion as is put into the means to achieve it (magnetic fields, lasers, etc.).
9. 10¹³ W

DEMONSTRATIONS
If you have not already used it, the demonstration of the effect of magnetic fields upon a beam of electrons should be shown here as magnetic bottles are discussed. Using a laser and a beam splitter and mirrors to produce two or more beams of light can illustrate the layout of laser-induced fusion.
CHAPTER 17: BIOMASS: FROM PLANTS TO GARBAGE

INSTRUCTOR’S NOTES
Chapter 17 has been significantly updated and modified for this fourth edition. Biomass, especially ethanol from corn, has become a prominent part of national energy scenarios. The dependency of the transportation sector upon imported expensive oil is a growing concern. This chapter could even be put earlier in the text, as prerequisite material occurs in early chapters. This chapter also ties such current topics as municipal solid waste and wood combustion into the energy and environment picture. You should be aware of the status of your community/state in regards to dealing with the first item. A question for class discussion would be “What if all landfills in your state were to be closed at the end of the year; what are the consequences?” Food vs. energy as a topic could certainly be expanded beyond the coverage of this chapter according to your interests.

ANSWERS TO QUESTIONS
2. Incineration can lead to emissions of particulate and organic contaminants. It also has an ash high in metal concentrations that must be disposed. Incineration might also discourage recycling.
3. See Fig. 17.8
4. Secondary combustion completes the burning of combustion gases and so increases stove efficiency. Too much air (as with a fireplace) reduces overall stove efficiency.
5. A fireplace has a low efficiency due to excess air being drawn up the hot chimney, and radiant heat emitted to more than the room.

ANSWERS TO PROBLEMS
2. Recycling Al cans saves 95% of the energy used to make the can, or about 3 hours of TV. At 100 W for each TV, this is 0.3 kWh, or 1025 Btu. A Bangladeshi uses (Fig. 2-7) about 4 MBtu/year or 11,000 Btu/day.
3. Two cows yield 0.75 m³/day. 50 ft³ = 1.42 m³. So we need manure from 4 cows.
4. Hardwood at $120/cord is equivalent to electricity at 3.5¢/kWh.
7. Direct and indirect fuels can contribute. For the former, ethanol (from corn), rapeseed, used vegetable oil, and compressed natural gas are possibilities, although the middle two are in limited supply. Indirectly, hydrogen via natural gas or from electrolysis, await fuel cell improvements.
CHAPTER 18: TAPPING THE EARTH’S HEAT: GEOTHERMAL ENERGY

INSTRUCTOR’S NOTES
This is a short chapter but can be used according to your interest in this area. There have been some recent breakthroughs in geothermal energy, notably hot dry rocks.

ANSWERS TO QUESTIONS
1. Hydrothermal, geopressured, and hot dry rock systems
2. Thermal energy of the earth’s crust is at too low a temperature.
3. Water heated at bottom of coffeepot is under greater pressure. It rises up the stem, begins to boil as the pressure decreases and “percolates”
4. At junctions of tectonic plates, magma can push to the surface.
5. Emissions of toxic gases from wells, and minerals from steam and hot water, subsidence.
6. Eff. of geothermal = 1/3 (1 - 300/423) = 0.10
   Eff. of fossil fuel plant = 2/3 (1 - 300/823) = 0.42
   So therefore 0.90/0.58 = 1.6 times more heat added to environment from geothermal plant.

DEMONSTRATIONS
A model of a geyser, or a coffee percolator, is appropriate here.
MULTIPLE CHOICE QUESTION BANK

CHAPTER 1: INTRODUCTION

1. Which of the following statements is true (only one):
   a. The growth rate of energy consumption has kept pace with GNP growth.
   b. Oil use has expanded more than any other fuel since 1940.
   c. We reached the point last year where we imported no oil.
   d. Electricity use has actually fallen since 1975.

   Answer: b

2. Which of the following is a non-renewable resource?
   a. uranium b. water c. wind d. biomass e. radiant solar

   Answer: a

3. Today, the U.S. imports about what percentage of the oil it uses?
   a. 10% b. 25% c. 40% d. 60% e. 80%

   Answer: d

4. One of the primary motivating forces behind our per capita reduction in energy use in the 1980’s was _____________.
   a. a smaller population growth
   b. higher oil prices
   c. increased nuclear power costs
   d. increased domestic oil discoveries

   Answer: b

5. The most significant aspect of world consumption of energy over the last 40 years has been the _________.
   a. growth of nuclear power
   b. expanding use of oil
   c. increased use of coal
   d. emphasis on energy conservation
   e. increase in our fossil fuel reserves

   Answer: b

6. If you started with $100 in the bank and you had $200 after letting it sit there for 5 years, what would be the annual interest rate you received?
   a. 2% b. 5% c. 10% d. 14% e. 22%

   Answer: d
7. Continued use of the fuels most relied upon in developing countries will eventually lead to _______.
   a. depletion of soil nutrients
   b. severe thermal pollution of water
   c. increased oil prices
   d. depletion of coal reserves in those countries

   Answer: a

8. If the growth rate of the number of solar collectors is 7% per year, then 1000 units in use in 2010 will grow to _______ units by the year 2040.
   a. 1200    b. 2000    c. 4000    d. 8000    e. 20,000

   Answer: d

9. The Hubbert curve for an energy resource displays what quantity on the y-axis?
   a. time    b. total production    c. yearly production    d. amount of fuel left

   Answer: c

CHAPTERS 2 AND 3: ENERGY MECHANICS

10. A net force of 30 newtons is applied to a block of mass 10 kg. The force that must be applied to a block of mass 5 kg to give it equal acceleration is _______.
    a. 5    b. 10    c. 15    d. 20    e. 30 N

    Answer: c

11. If a constant non-zero force is applied to an object, its velocity will certainly _______.
    a. change    b. stop    c. be zero    d. be constant    e. equal acceleration

    Answer: a

12. Which of the following is a unit of energy:
    a. watt    b. ft—lb/sec    c. newton/sec.    d. horsepower    e. joule

    Answer: e

13. Our nose cracker moved back and forth as shown. The kinetic energy will be greatest at point:

   a. A    b. B    c. C

    Answer: b
14. For a fossil fueled electrical generating plant, 10,000 Btu of chemical energy into the plant will result in about how many Btu’s of waste heat dumped into the environment:

   a. 0   b. 1000   c. 4000   d. 6000   e. 10,000 Btu’s

   **Answer:** d

15. If a net force of 30 newtons is applied to a cart of mass 3 kg at rest, the velocity of the cart at the end of 5 meters will be ____ m/s.

   a. 5   b. 10   c. 12   d. 25   e. 30

   **Answer:** b

16. The cost of running a set of eight 100 watt light bulbs for 6 hours, with the cost of electricity at 9¢ per kWh, is approximately:

   a. 5¢   b. 24¢   c. 43¢   d. 54¢   e. 72¢

   **Answer:** c

17. A 100 lb sack of potatoes falls from an airplane. As the velocity of fall increases, the air resistance also increases. When air resistance equals 100 lb, the acceleration of the sack will be ____ m/sec/sec.

   a. 0   b. 16   c. 32   d. 9.8   e. 24

   **Answer:** a

18. Pumped storage facilities ________.

   a. increase the overall efficiency of a power plant
   b. make use of the output of electricity from photovoltaic cells
   c. are used to produce electricity mainly at night
   d. have an increase in their potential energy mainly at night
   e. cannot be used with a nuclear plant

   **Answer:** d

19. If the energy conversion efficiencies in a 3 step process are 30% for the first step, 40% for the second, and 20% for the third, the overall efficiency (step one to end) is about:

   a. 2%   b. 10%   c. 20%   d. 50%   e. 90%

   **Answer:** a

20. What is the minimum work that a motor must do to lift a 70 lb object from the floor to a height of 14 feet?

   a. 5   b. 70   c. 700   d. 980   e. 2010 ft-lbs

   **Answer:** d

21. If the push that you give to a bike is the action force, then the reaction force is ________.

   a. the force of the bike upon you
   b. the weight of the bike
   c. the friction force on the tires
   d. the acceleration of the bike
   e. air resistance on the bike

   **Answer:** a
22. If the height of water behind a dam is increased by a factor of two, then the maximum kinetic energy of the water at the bottom of the dam will increase by a factor of _____.
   a. one  b. two  c. four  d. zero

   Answer: b

23. The net force required to move a body at a constant velocity in outer space is ________.
   a. zero  
   b. its weight  
   c. the force of gravity  
   d. its mass times its velocity  
   e. the force of friction

   Answer: a

24. A force applied to an object will always cause the object to
   a. speed up  
   b. accelerate  
   c. change its momentum  
   d. all of the above  
   e. none of the above

   Answer: e

25. If you shout across a canyon and the echo returns in four seconds, how far away is the other side?
   (Velocity of sound in air is 300 m/s).
   a. 150  b. 300  c. 600  d. 1200  e. 2400 meters

   Answer: c

26. Power is defined as ________.
   a. the energy used times the time  
   b. the work done times the distance of motion  
   c. the energy used divided by the work  
   d. the rate of converting energy  
   e. the ability to do work

   Answer: d

27. If a 60 kg person is observed to accelerate at a rate of 4 m/sec/sec, the net force responsible for this is:
   a. 600 N  b. 240 N  c. 30 N  d. the force of gravity  e. 480 N

   Answer: b

28. The “efficiency” of a light bulb is the ratio of the:
   a. heat plus electricity produced to the electrical input  
   b. voltage output of the bulb to the power input  
   c. energy into the bulb to the energy out of the bulb  
   d. light output to the electrical energy input

   Answer: d
29. A ball rolls back and forth on the track shown. The kinetic energy at position A will be ________ than that at position B.

a. greater  
b. smaller  
c. the same as  

![Diagram of a ball on a track with positions A and B]

Answer: b

30. The reason that you would use a ramp to carry a weight to the top of a platform, rather than lifting it up a ladder, is because the

a. force exerted would be less  
b. work done would be less  
c. power expended would be less  
d. gain in potential energy would be more  

Answer: a

31. How much work is required to increase the velocity of a 4 kg car from rest to 5 m/sec?

a. 10  
b. 20  
c. 50  
d. 100  
e. 200 Joules  

Answer: c

32. When a car is braked to a stop, its kinetic energy is transformed into

a. stopping energy  
b. potential energy  
c. heat energy  
d. energy of motion  

Answer: c

33. If the same force is applied to a 2 kg object as to a 1 kg one, ________.

a. the velocity of the 2 kg object will be greater after 2 sec.  
b. the distance traveled in the same time will be more for the 1 kg object  
c. the acceleration of the larger object will be more  
d. the acceleration of the 1 kg object will be 4 times more  

Answer: b
34. A sheet of paper can be withdrawn from under a bottle of milk without toppling the bottle if the paper is jerked out quickly. This is an example of ________.
   a. inertia
   b. action-reaction
   c. potential energy
   d. friction forces

   **Answer: a**

35. Which of the following is a unit of power?
   a. Btu
   b. kilowatt
   c. kilowatt-hour
   d. joule
   e. horsepower per hour

   **Answer: b**

**CHAPTERS 4 AND 5: HEAT**

36. Heat is ________.
   a. a measure of the average kinetic energy of molecules in an object
   b. a property of an object
   c. the energy transferred between bodies due to a temperature difference
   d. the specific heat of an object

   **Answer: c**

37. Heat energy will spontaneously always flow in the direction of ________.
   a. a higher temperature
   b. a lower temperature
   c. up, since heat rises
   d. a smaller heat capacity

   **Answer: b**

38. What color would you select for a container that will hold ice cubes such that the ice is preserved the longest?
   a. white
   b. black
   c. green
   d. color doesn’t matter

   **Answer: a**

39. Your feet feel warmer on a rug than on a tile floor because the rug
   a. is usually warmer than the tile
   b. is a better insulator than tile
   c. has more internal energy than tile for the same mass
   d. all of these

   **Answer: b**
40. At a restaurant you are served coffee before you are ready to drink it. In order that the coffee be the hottest when you are ready for it, when would it be best to add cream (at room temperature) to it?
   a. when you are ready to drink it
   b. right when you are served the coffee
   c. it doesn’t matter, as the final temperature will be the same

   Answer: b

41. If the R-value of a wall is 10 ft²•°F-hr/Btu, then the rate of heat transfer through a 2 ft × 3 ft section of wall, with \( \Delta T = 50^\circ F \), will be:
   a. 10
   b. 30
   c. 500
   d. 3000
   e. 10,000 Btu/hr

   Answer: b

42. Running a clothes dryer for 90 minutes at 800 Watts will cost about ______ cents if the cost of electricity is 7 cents per kWh:
   a. 4
   b. 10
   c. 24
   d. 50
   e. 120

   Answer: b

43. An object with a high specific heat will ________.
   a. lose its heat very fast
   b. decrease in temperature quite fast if removed from the heat source
   c. take considerably more heat to raise its temperature
   d. always be water

   Answer: c

44. When ice crystals form in the clouds, ________.
   a. heat energy is released
   b. the atmosphere becomes colder
   c. phase change from solid to liquid occurs
   d. the thermal mass of the atmosphere increases

   Answer: a

45. The “R-value” of material is not related to its ________.
   a. composition
   b. area
   c. thickness
   d. resistance to heat flow

   Answer: b

46. The temperature on an Oswego, New York “warm” spring day has a maximum of 64°F and a minimum of 30°F. What is the number of heating degree days?
   a. 18
   b. 30
   c. 34
   d. 47
   e. 64

   Answer: a
47. Infiltration in a house will ________.
   a. increase on windy days
   b. raise the heating load by about 10%
   c. reduce the number of air changes
   d. be increased by caulkling around windows

   **Answer: a**

48. The predominant method of heat transfer to a cold drink held in an evacuated bottle (a thermos) is by ________.
   a. conduction  b. convection  c. radiation

   **Answer: c**

49. A heat pump will have an efficiency (heat out to electrical in) of about ________.
   a. 35%  b. 50%  c. 75%  d. 100%  e. 200%

   **Answer: e**

50. Since the rate of heat transfer by conduction is proportional to the $\Delta T$, what percent savings in your heating bill would you expect if you turned the thermostat down from 75° to 65° F, and the outside temperature is 25°F?
   a. 10%  b. 20%  c. 30%  d. 40%  e. 50%

   **Answer: b**

51. The R-value of a piece of material goes up if the material is
   a. thicker
   b. a better conductor
   c. covering a larger area
   d. thinner

   **Answer: a**

52. Materials A, B, and C have R values of 1, 4, and 8 ft$^2$-$^\circ$F-hr/Btu, respectively. If the rate of heat transfer through material A alone is 20 Btu/hr, then the rate of heat transfer through the combination of A, B and C is _____.
   a. 1.5  b. 2.5  c. 4.0  d. 7.0  e. 80 Btu/hr

   **Answer: a**

53. For a furnace to provide 50,000 Btu/hr of thermal energy to a living space, what should the rate of heat supplied by the fuel if the furnace efficiency is 75%?
   a. 25,000  b. 37,000  c. 50,000  d. 67,000  e. 125,000 Btu/hr

   **Answer: d**
54. The cooling effect in a refrigerator is produced by _____.
   a. the electric motor which essentially converts electricity into heat
   b. compression of the refrigeration gas into a liquid
   c. liquefying the refrigeration gas
   d. vaporization of the refrigeration liquid
   e. proper insulation

   Answer: d

55. Which of the following situations would be allowed by the second law of thermodynamics?
   a. running of a heat engine using temperature differences in the oceans
   b. converting 100 joules of heat energy into 100 joules of work
   c. passage of heat from the freezer into the refrigerator section
   d. the reduction of waste heat from a power plant to zero with better technology

   Answer: a

56. A heat engine ________.
   a. converts work into heat energy
   b. needs a temperature difference to be able to work
   c. can be 100% efficient in the absence of friction
   d. needs electricity to be able to run

   Answer: b

57. Coffee will cool faster when put into a saucer due to
   a. conduction  b. evaporation  c. condensation  d. a and b  e. b and c

   Answer: d

58. As a liquid changes into a vapor ________.
   a. heat energy is absorbed
   b. heat energy is given off
   c. the temperature of the liquid rises substantially
   d. the specific heat maintains the temperature

   Answer: a

59. The maximum efficiency of a heat engine operating between 2°C and 200°C will be about ________.
   a. 10%  b. 40%  c. 60%  d. 90%  e. 100%

   Answer: b

60. Hot water in a ________ can will cool off faster than hot water in any other color can.
   a. white  b. red  c. black  d. silver

   Answer: c
61. The primary method by which the water in a pot is heated is by ________.
   a. conduction  b. convection  c. radiation  d. evaporation  e. condensation

   Answer: b

62. The most cost effective way to reduce heat loss from a window is ________.
   a. add a storm window
   b. install a triple pane window
   c. weatherstrip around the outside perimeter of the window
   d. install a thermal drape

   Answer: c

63. The greatest source of heat loss in a new home is from the ________.
   a. roof  b. walls  c. floor  d. windows  e. infiltration

   Answer: d

64. Infiltration can be reduced primarily by ________.
   a. insulation
   b. double pane windows
   c. weatherstripping
   d. lowering the thermostat
   e. furnace maintenance

   Answer: c

65. How much heat does it take to increase the temperature of 5 lbs of water by 20°F?
   a. 4  b. 25  c. 100  d. 800 Btu.

   Answer: c

66. The greatest percentage of heat loss from an average house with 6-inches of fiberglass in the walls, 4-inches in the floor, 9-inches in the roof, and double pane windows, comes from the ________.
   a. roof  b. walls  c. floor  d. windows

   Answer: d

67. For a cube-shaped room, 10 ft on a side, what will be the rate of heat loss if the R-value is 4 ft²°F·hr/Btu for each side and the ΔT is 50°F?
   a. 800  b. 1200  c. 5000  d. 7500  e. 12,000 Btu/hr

   Answer: d

68. The flow of heat in a cold soft drink will be from ________.
   a. the drink to the ice cubes
   b. the drink to the outside air
   c. the drink to the glass
   d. the ice cubes to the drink

   Answer: a
CHAPTER 6: SOLAR ENERGY

69. The measure of the position of the sun from the horizontal is called the ________.
   a. altitude    b. azimuth    c. declination    d. insolation
   Answer: a

70. If the insolation upon a flat plate collector is 800 Btu/ft²/day, how large must the collector be to provide 30,000 Btu/hr of thermal energy for an entire day? Take the efficiency of the collector to be 50%.
   a. 150         b. 750         c. 1800         d. 4000         e. 7200 ft²
   Answer: c

71. The optimum angle of tilt (from the horizontal) for a flat plate collector at 35° N latitude for the purpose of space heating is ________.
   a. 0°           b. 25°           c. 35°           d. 45°           e. 75°
   Answer: d

72. A Trombe wall in a house uses a large window and _____.
   a. R-19 insulation in the walls
   b. a vertical thermal mass across the room from the window
   c. a vertical thermal mass close to the window
   d. a slate floor by the window
   e. a vertical flat plate collector using water
   Answer: c

73. The use of thermal mass on a direct gain passive solar system ________.
   a. reduces temperature fluctuations during the day.
   b. provides foundation support for the collector superstructure
   c. increases the insolation on the south-facing windows
   d. increases temperature fluctuations during the night
   Answer: a

74. During which season will more insolation be delivered to a vertical south-facing window on a clear day?
   a. winter       b. fall       c. spring       d. summer       e. depends upon the R-value
   Answer: a

75. One advantage of using air as the working fluid in a solar collector is ________.
   a. that freezing will not be a problem
   b. that water heats up faster than air
   c. a smaller storage facility can be used
   d. that one needs hot water for showers
   Answer: a
76. Commonly used units for solar energy input are
   a. watts  b. watts/day  c. watts/day/m²  d. Btu  e. Btu/ft²/day

   **Answer: e**

77. Water circulates in a thermosiphon, hot water system because ________.
   a. a pump is used
   b. gravity causes water to flow from the top of the collector to the bottom
   c. hot water is less dense than cold water
   d. solar energy is used to run the circulating pump

   **Answer: c**

78. One can increase the insolation upon a one ft² horizontal plate by ________.
   a. using a fresnel lens of one ft²
   b. using two 1 ft² fresnel lenses, one on top of the other
   c. adding reflectors around the plate
   d. increasing the temperature of the plate
   e. increasing the absorption of the plate

   **Answer: c**

79. Solar energy is quite compatible for a major part of the U.S. because our major energy needs are
   for ________ energy.
   a. electrical  b. thermal  c. kinetic  d. potential  e. mechanical

   **Answer: b**

80. An effective way to passively cool a house is to ________.
   a. open all the windows
   b. use a light colored roofing material
   c. use concentrating collectors to provide air conditioning
   d. add more insulation on the south side of the house
   e. use thermal storage mass

   **Answer: b**

**CHAPTERS 7, 8, AND 9: AIR POLLUTION, GLOBAL WARMING, AND FOSSIL FUELS**

81. Which of the following air pollutants is emitted in about equal amounts by stationary and mobile
    sources?
    a. particulates  b. carbon monoxide  c. sulfur dioxides  d. hydrocarbons  e. nitrogen oxides

   **Answer: e**
82. Which of the following air pollutants is emitted mainly by the automobile?
   a. particulates
   b. carbon monoxide
   c. sulfur dioxides
   d. hydrocarbons
   e. nitrogen oxides

   **Answer: b**

83. Increases in the temperature of the earth due to the greenhouse effect over the last 50 years is least due to ________.
   a. burning of oil by industry and utilities
   b. flatulence by cows
   c. addition of hot water to lakes by utilities
   d. clearing land for farming
   e. use of freons

   **Answer: c**

84. The emissions of particulates due to the burning of coal can be reduced by the use of ________.
   a. electrostatic precipitators
   b. scrubbers
   c. coal from strip mines of the Western US
   d. limestone
   e. catalytic converters

   **Answer: a**

85. A balloon is buoyed up with a force equal to the
   a. density of the surrounding air
   b. atmospheric pressure
   c. weight of the balloon and its contents
   d. weight of the air it displaces

   **Answer: d**

86. If the volume of an object were to be halved with the same mass, its density would
   a. halve      b. double      c. stay the same

   **Answer: b**

87. CFC’s in the stratosphere ________.
   a. provide protection from incoming solar radiation
   b. dissipate within days
   c. combine with NOX to produce smog
   d. adsorb ultraviolet light from the sun
   e. contribute to ozone destruction

   **Answer: e**
88. Ozone production via automobile emissions _______.
   a. is usually associated with photochemical smog
   b. can help restore the ozone being depleted in the outer atmosphere
   c. is eliminated by appropriate use of catalytic converters
   d. will provide overall worldwide reduction in skin cancer

   Answer: a

89. Your largest personal contribution to global warming in a year comes from _______.
   a. use of freon propellants
   b. use of air conditioners in your home
   c. driving your car
   d. cutting down trees
   e. burning natural gas for home heating.

   Answer: c

90. One of the major economic problems in less developed countries is _______.
   a. deforestation
   b. neglected use of solar energy
   c. dependence upon imported oil
   d. increased emission of greenhouse gases.

   Answer: c

91. One of the changes experienced by a body of water when waste heat is added from a power plant is _______.
   a. an increase in water’s capacity to hold oxygen
   b. an increased spawning success for fish
   c. an increased biological growing season
   d. decreased eutrophication

   Answer: c

CHAPTERS 10, 11, AND 12: ELECTRICITY

92. One of the fundamentals of static electricity is that the force between two charges of like charge
   a. is attractive
   b. is repulsive
   c. is neutralized
   d. is zero

   Answer: b

93. How much current is drawn by a 1500 W appliance operating at 120V?
   a. 2  b. 8  c. 12  d. 15  e. 24 amps

   Answer: c
94. What quantity is the same for three resistors in a parallel circuit?
   a. power    b. resistance    c. voltage across them    d. current

   Answer: c

95. A 100 ohm and a 150 ohm resistor are connected in parallel to a 120 V source. What is the current through the 150 ohm resistor?
   a. 0.5    b. 0.8    c. 1.2    d. 1.8    e. 2.0 amps

   Answer: b

96. Cosmic rays impinging upon the earth will generally _____.
   a. be deflected by the earth’s gravitational field
   b. not be affected if they are electrically neutral
   c. be weaker in intensity at the earth’s poles
   d. lead to lightning discharges in the atmosphere

   Answer: b

97. Pumped storage generally will enable a utility to _______.
   a. increase the efficiency of their electrical generating system
   b. store energy until the demand is high enough
   c. raise electrons to higher energy states
   d. increase their electrical potential energy

   Answer: b

98. Alternating current has an advantage over direct current because _______.
   a. one can step up the voltage that one can use
   b. batteries can be displaced in most circuits
   c. electrical generators can be made to function
   d. incandescent lights will only work with AC

   Answer: a

99. The largest share of renewable energy in the U.S. comes from
   a. wind    b. natural gas    c. hydro    d. petroleum    e. radiant solar

   Answer: c

100. Superconductors have a primary advantage in that they will _______.
    a. reduce heating losses in transmission lines
    b. provide large magnetic fields for levitation
    c. be able to conduct more current
    d. allow electric motors to run almost forever

   Answer: a
101. Revenue from a 10 MWe electrical power plant over 24 hours when electricity is sold at 7¢/kwh will be about:
   a. $1,700    b. $17,000    c. $34,000    d. $340,000    e. $700,000

   Answer: b

102. The fuel that provides most of the electricity in the U.S. is ________.
   a. oil       b. natural gas  c. coal       d. uranium    e. solar

   Answer: c

103. Static charge can build up quickly on an object ________.
   a. during days when the conditions are not humid
   b. when the object is in good electrical contact with the ground
   c. only when it is in contact with a good conductor
   d. only when the object is moving

   Answer: a

104. Electricity is transmitted from power plants at ________.
   a. high voltages
   b. high currents
   c. low resistances
   d. low power

   Answer: a

105. If a 20 and a 40 ohm resistor are wired in parallel to a 20V source, what will be the current in the 40 ohm resistor?
   a. 0.33      b. 0.5       c. 1.0       d. 2.0       e. 3.0 amps

   Answer: b

106. If a 20 and a 40 ohm resistor are wired in series to the same source, the current through the 40 ohm resistor will be:
   a. 0.33      b. 0.5       c. 1.0       d. 2.0       e. 3.0 amps

   Answer: a

107. How much current will be drawn by a 1200 watt hair dryer operating at 120 volts?
   a. 0.1      b. 1.0       c. 1.44       d. 10       e. 20 amps

   Answer: d

108. What will be the approximate cost of running a 2 watt clock for one week when electricity costs 8¢ per kWh?
   a. 0.1¢      b. 3¢        c. 11¢       d. 16¢       e. 115¢

   Answer: b
109. The electrical force between two particles of unlike charge will be _______.
   a. repulsive  b. attractive  c. zero

   **Answer: b**

110. A bird sitting on a bare high voltage wire is not electrocuted because
   a. of the high resistance of its body
   b. there is no electrical potential difference across its body
   c. its body is at a low electrical potential compared to the wire
   d. the high voltage across its feet produced a small current

   **Answer: b**

111. The magnetic field of a bar magnet is similar to that produced by _______.
   a. a current carrying wire shaped like a coil
   b. a horseshoe magnet
   c. a straight current carrying wire

   **Answer: a**

112. One of the possible dangers of EMF’s are _______.
   a. radio system interference
   b. their potential to produce a shock
   c. biological effect of small magnetic fields
   d. electrocution

   **Answer: c**

113. A device which transforms electrical energy into mechanical energy is a _______.
   a. magnet  b. transformer  c. generator  d. motor

   **Answer: d**

114. A transformer can only operate if _______.
   a. the power in equals the power out
   b. the potential difference is large enough
   c. a.c. is used
   d. we step up the voltage

   **Answer: c**

115. If the current through a 5 ohm and a 10 ohm resistor in series is 4 amps, then the total voltage drop across both of these resistors will be
   a. 15  b. 20  c. 60  d. 120 volts

   **Answer: c**
116. For light bulbs of different wattages connected in a series circuit, the _______ will be the same for each when ON.
   a. current  b. voltage  c. power  d. resistance

   Answer: a

117. How much money does it cost to leave on 10 60 watt lights for 15 hours, if the cost of electricity is 8 cents per kWh?
   a. 15¢  b. 32¢  c. 72¢  d. 120¢  e. 480¢

   Answer: c

118. EMF’s from electrical lines ________.
   a. drop off with the distance squared from the line
   b. are only an influence for high voltages
   c. have been positively shown to cause cancer in children
   d. are not important inside houses.

   Answer: a

119. The overall efficiency of a power plant can be increased by “co-generation”, that is, by ________.
   a. recycling the waste heat from a power plant back to the boiler
   b. raising the temperature of the steam by the use of two boilers
   c. combining two types of steam engines to generate electricity
   d. generating electricity and using some of the waste heat to provide process steam

   Answer: d

120. For photovoltaic cells, the potential difference for two silicon cells in series will at most be ________.
   a. 0.1  b. 0.5  c. 1.0  d. 2.0  e. 5.0 volts.

   Answer: c

121. Co-generation has the advantage that ________.
   a. more energy is generated than is put into the system
   b. the overall efficiency of the energy conversion process increases
   c. more waste heat is generated
   d. solar energy can be utilized to a greater extent

   Answer: b

122. What is not a life-cycle cost associated with a power plant?
   a. capital cost
   b. maintenance
   c. cost of electricity sold
   d. fuel cost
   e. staffing

   Answer: c
123. The efficiency of a solar cell is the ratio (numerator to denominator) of the _____.
   a. heat plus electricity produced to the solar input
   b. light output to the electrical energy input
   c. electricity output to the heat output
   d. electricity output to the solar input
   e. heat input to the electricity output

   Answer: d

124. The site location for a wind turbine is especially important. If the power output goes as the cube of
the wind velocity, then which of the following average velocities will give approximately twice as much output as a 10 mph wind?
   a. 13  b. 20  c. 30  d. 60  e. 80 mph

   Answer: a

125. If the average wind speed for 24 hours is 15 mph at one site, but 10 mph for 12 hours and then
20 mph for 12 hours at another site, how much output can be expected from the same turbine situated
at the first site compared to the second site?
   a. three-quarters
   b. half
   c. one quarter
   d. one eighth
   e. same, since the average wind speeds are the same

   Answer: a

CHAPITERS 13, 14, 15 AND 16 NUCLEAR

126. The majority of the radiation emitted to the general public in the normal operation of a nuclear plant
comes from the ________.
   a. cooling water discharged to a lake or a river.
   b. reactor core directly.
   c. spent fuel rods stored on site.
   d. fission fragment gases vented to the atmosphere.
   e. low level wastes shipped from the plant

   Answer: d

127. The average radiation dose received from radon in the home is ________.
   a. less than a dental x-ray dose.
   b. comparable to that from a nuclear plant
   c. very dependent upon local geology
   d. larger in older homes

   Answer: c

128. At 9 a.m. on Monday a radioactive sample contained four million nuclei. At 9 a.m. on Friday three
million of these nuclei had decayed. The half-life of this sample is:
   a. 5 days  b. 4 days  c. 3 days  d. 2 days  e. 1 day

   Answer: d
129. For the same energy, the most penetrating type of radiations in human tissue are ________.
   a. alpha particles
   b. beta particles
   c. gamma rays

   Answer: c

130. In the following fission reaction, the atomic number and mass of nucleus Y are:

   \[ n + ^{235}_{92}U \rightarrow ^{135}_{53}I + ^{A}_{Z}Y + 2n \]

   a. 37,100     b. 37, 102     c. 38,102     d. 39,99     e. 39,100

   Answer: d

131. The reason a nuclear reactor will not explode like a bomb is because ________.
   a. the uranium-235 enrichment is too low.
   b. there is not enough uranium-238 present.
   c. the cooling water will always take away the heat
   d. there are control rods present
   e. …nonsense! It can explode like a bomb in the event of a loss of coolant accident

   Answer: a

132. The future disposal of high level radioactive waste will probably be done in the US in ________.
   a. volcanic rock
   b. deep seabed sediments
   c. transmutation processes
   d. concrete building, as proposed for West Valley, NY
   e. containers at present nuclear power plant sites

   Answer: a

133. The two purposes of water in a reactor core are ________.
   a. neutron absorber and heat transfer liquid
   b. neutron moderator and heat transfer liquid
   c. neutron moderator and neutron absorber
   d. neutron absorber and lubricant
   e. neutron moderator and radiation shield

   Answer: b

134. The Emergency Core Cooling System is used in the event of an accident to ________.
   a. stop the fission reactions
   b. reduce fuel rod temperatures
   c. provide backup power to control rods
   d. change the decay heat of the fuel pellets

   Answer: b
135. Fission and fusion reactions have in common _______.
a. absorption of energy in the nuclear reaction  
b. high temperature requirements  
c. liberation of neutrons  
d. loss of mass of products over reactants  
e. gain in mass of products over reactants.

**Answer:** d

136. The best way to reduce your radiation dose from a Co-60 gamma emitting source is to _______.
a. reduce the temperature of the source  
b. move twice as far away  
c. spend half the time near the source  
d. double the thickness of wood between you and the source  
e. nonsense! You cannot change the potential dose

**Answer:** b

137. If a light-weight stable nucleus has 12 neutrons, the atomic mass is expected to be about:
   a. .6 b. 12 c. 18 d. 24 e. 36 amu.

**Answer:** d

138. Exceedingly high temperatures are needed in a fusion reactor because _______.
a. electrostatic barriers must be overcome  
b. the fuel must be ionized  
c. combustion needs heat to occur  
d. water must be boiled and pressurized.

**Answer:** a

139. The largest component of ionizing radiation the average American receives is from:
a. radon  
b. cosmic rays  
c. TV  
d. medical x-rays  
e. terrestrial sources

**Answer:** a

**CHAPTER 17: BIOMASS**

140. The largest component of municipal solid waste in the U.S. is
   a. glass b. plastics c. paper d. yard waste e. metals

**Answer:** c
141. One of the larger problems in municipal recycling programs is
   a. public awareness
   b. finding markets for materials
   c. net energy used in recycled material preparation
   d. declining number of landfills

   **Answer:** b

142. One of the least environmental concerns with incineration of waste is
   a. emission of dioxins
   b. particulate emissions
   c. heat addition to rivers
   d. metal concentrations in ash

   **Answer:** c

143. A primary resource used for the production of alternate fuel for vehicles is
   a. biogas  b. corn  c. municipal solid waste  d. wood products

   **Answer:** b

144. Anerobic digestion for biomass production takes place under conditions of
   a. no oxygen
   b. high temperatures
   c. strong acidity for dissolving waste

   **Answer:** a

145. Energy used for production of ethanol from corn is _____ than the energy output.
   a. more  b. less  c. the same

   **Answer:** b

146. An efficient wood-burning stove has an advantage over an open fireplace primarily because
   a. combustion air intake is limited
   b. higher temperatures are reached
   c. creosote buildup is reduced
   d. most heat transfer occurs by radiation

   **Answer:** a
Name ____________________________

**Energy in Developing Countries**

**Purpose:** To identify and explore the use of energy in another country and its effect upon the economic and political situation.

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<thead>
<tr>
<th>Country:</th>
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<tbody>
<tr>
<td>Capital:</td>
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<td>Unemployment:</td>
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<td>Principle exports:</td>
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**Principle imports**

**Primary energy fuels used (breakdown into residential/industrial):**

<table>
<thead>
<tr>
<th>Natural energy resources:</th>
<th></th>
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</table>

**Potential fuels for meeting future energy needs:**

On this and the next page describe this country’s economic and food situations. Discuss how energy resources play a role in these issues. Mention environmental problems that are particularly troublesome. What changes in the use of energy and economic situation has there been in the last 10-20 years?
Name ____________________________

Energy Conversion Lab
Institute in Energy Education

Objective: This lab should help you to see how energy can be converted from one form to another. You will observe the loss in useful energy as a result of such a conversion and measure the efficiency for such conversions.

Materials: D.C. Motor; Set of weights; timer; Photovoltaic array; D.C. voltmeter; D.C. millimeter; meter stick; 1.5V battery; cork and washer set; string; track sneakers.

Introduction: Energy is required to lift an object into the air. The potential energy gained by that object (and subsequently the minimum energy required to lift it to that height) is measured in joules and is found by multiplying mass (kg), acceleration due to gravity (10 m/s/s), and the height (m) the object has been raised. This potential energy can be released if the object is dropped. If the object is lifted to that height using an electric motor then the energy put into the motor while it is lifting the mass can also be determined. The amount of electrical energy is measured in joules and is found by multiplying the electrical voltage (V), current (amps), and the time (sec) the electricity was being used. In this way the electrical energy used and the mechanical energy used are compared. The ratio of energy gained by the lifted object to electrical energy put into the operation equals the efficiency for the system.

Procedure:

A. Chemical to Mechanical Conversion

1. Determine your weight in units of Newtons.
   a. your weight in pounds: ____________ (lb)
   b. divide your weight by 2.2 to convert to mass: ____________ (kg)
   c. multiply your mass (kg) by acceleration due to gravity (10 m/s/s)
      to find weight in Newtons: ____________ (N)

2. Find an elevation that you will lift your body to. Measure the height above starting level. ____________ (m)

3. Multiply the weight (N) by the height (m) to determine work done. ____________ (j)

4. Power is the rate that work is done. To determine the power required to lift your body to the height in question you must time yourself from start to finish. Units of power will be watts.
   a. Total work done (from #3) ____________ (j)
   b. Time required ____________ (s)
   c. Power is work divided by time ____________ (W)

In this problem what is a disadvantage of not having much weight?
Procedure: B. Electrical to Mechanical Conversions

1. Attach string to cork
2. Attach cork to shaft of motor.
3. Secure the motor to a ringstand so that the string can fall off the end of the work table.
4. Wire one end of the motor to a milliammeter and the other end of the motor to the battery. Wire the other end of the milliammeter to the other end of the battery. Wire a voltmeter across the two ends of the battery. See schematic.

5. When you connect the motor and battery the motor will turn. As the mass is lifted into the air, record the voltage and the current indicated on the meters, and the time required. Repeat for the different masses indicated.

<table>
<thead>
<tr>
<th>Mass</th>
<th>Time</th>
<th>Voltage</th>
<th>Current</th>
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</table>

6. Replace battery with the solar array placed flat on the table. Repeat step #5. Keep in mind that not all the masses will be lifted.

<table>
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<tr>
<th>Mass</th>
<th>Time</th>
<th>Voltage</th>
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7. To determine the efficiency of the solar cell itself you must know how much solar energy is striking the ground. This is done with an insolation meter provided by the instructor. Record that data here.

Insolation (watts/meter²) ___________
Analysis of data.

1. The efficiency of a system ($\eta$) is found by dividing the useful energy or work gotten out of a system by the energy put into the system.

2. Electrical energy can be found by multiplying volts $\times$ current $\times$ time

3. Mechanical energy can be found by multiplying mass $\times$ acceleration of gravity $\times$ height.

4. Both units of electrical and mechanical energy are ‘joules.’

I. Efficiency of electrical (battery) to mechanical. Use data for the 20g mass.

Calculate electrical energy input from data table A1. ________ j

Calculate mechanical energy out. $0.02 \text{ kg} \times 10 \text{ m/s/s} \times \text{height}$ ________ j

Calculate efficiency of battery system (this is a ratio and has no units)

$$\eta = \frac{\text{output}}{\text{input}}$$

II. Efficiency of solar cell electrical to mechanical. Use data for the 20g mass.

Calculate electrical energy input from data Table A2. ________ j

Calculate mechanical energy out. $0.02 \text{ kg} \times 10 \text{ m/s/s} \times \text{height}$. ________ j

Calculate efficiency of solar cell system

________
Questions
a. How does the value of $\eta$ vary with the different systems? What applications can be seen?

b. A major form of energy is not even mentioned in this lab but it adds to the amount of energy lost. Think about the idea of total energy conservation and see if you can determine where a large part of the energy is going (besides friction).

c. The efficiency of the photovoltaic array itself can be determined. It is \((\text{voltage} \times \text{current})\) divided by \((\text{insolation} \times \text{surface areas of cells})\).

Measure the surface area of the cells that you used. 
Calculate the efficiency of the photovoltaic array. 

Volts \(\times\) current will give units of Watts. Insolation (watts/m\(^2\)) \(\times\) area (m\(^2\)) will also provide units of Watts. The ratio of the two will equal the efficiency. Determine the efficiency of your system and comment on solar cells in general for electrical production.

Variations for future use:
1. try homemade batteries (fruit cells).
2. vary solar cell positions to increase work output.
3. How large a mass can the motor lift using the solar cell? Try 2 cells in parallel (more current) or in series (more voltage).
4. PV powered cars. Races? Climb an incline?
Photovoltaic Array Construction  
Institute in Energy Education

Objective: This activity will allow participants to practice soldering techniques and wiring theory. They will also learn practical solar cell applications.

Materials: 2 photovoltaic cells; light gauge wire, mounting board; sheet of Plexiglas; mounting ‘glue’; soldering pen; solder.

Photovoltaic cells are very fragile. The pieces are still useful even if they do break.

Procedure: Solder a wire from the top of one cell to the bottom of the next cell. This is a series circuit and causes the voltages of the cells to add together. Connect a lead to the bottom of first cell and another lead to the top of the second cell.

Secure the cells flat to the mounting board with glue.

Secure the leads so that they extend beyond the edge of the mounting board. It is to your advantage to insure that they extend over the same side.

Place the Plexiglas carefully over the solar cells and glue it, making sure not to press too hard.

Conclusion: This PV array can be connected in series to a battery charger (which is simply a germanium diode (voltage drop 0.2v) and a battery holder).
Solar Home Contest
Institute in Energy Education

Contest Objective: To attain the highest possible temperature inside the structure during the heating time allotted and to retain the highest possible temperature after removal from the sunlight until the termination of the contest.

Materials: Thermometer; whatever... You are encouraged to recycle materials...

Enabling Objectives:
1. An understanding of basic concepts in energy efficient home construction.
2. A practical application of home construction.

Introduction: This activity will allow participants to experiment with and see the results of different methods of solar home technology. You can put a lot of work into this and have a working model that you can use for years.

Procedure:
1. Design and construct a solar home with a minimum of 2,000 cm$^3$ of living space (about a shoe box size).
2. You can use any materials that you are willing to commit to this project.
3. You must limit yourself to direct solar gain.

Requirements: You will be expected to complete a temperature vs. time graph of the heating and cooling of your solar house. The data can be collected on the data table provided. Collecting heating data may not be as often as cooling data.

The Contest:
1. On the day of the contest you will be asked to place your home outside. This will be left during lunch, and for a time afterwards.
2. On command the internal temperatures will be recorded and the houses moved inside.
3. Every 10 minutes the internal temperature will be checked and recorded. During that time the participants will be reporting on the theory behind their constructions.
4. Highest temperature, most heat held, and most realistic will all win prizes.
## Data Table

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Name __________________________

**Water Heating Contest**  
**Institute in Energy Education**

**Contest Objective:** To heat a given quantity of water to the highest possible temperature in the shortest amount of time during the contest time allotted using only direct, radiant solar energy as the energy source.

**Materials:** 300 ml of cold water  
Other materials required in designing and constructing a solar water heater device are to be provided by the participants or purchased or borrowed (not stolen) from laboratory stock.

**Enabling objectives:**
1. Research and translate solar energy concepts.
2. Apply these concepts successfully to a laboratory problem solving activity.
3. Construct a heating device using direct, radiant solar energy as the sole energy source.
4. Observe and compare the ability of other participants to apply their knowledge in a learning environment.
5. Collect, record, and compare quantitative data.
6. Relate this activity to full-scale practical applications in society.
7. Experience both formal and informal methods of evaluation.

**Introduction:** The ability of persons to understand and apply the principles of solar energy can have a substantial effect upon the financial well-being of persons, their families, the environment, and the nation. Near-future generations will be facing a serious energy crisis as fuels, which have taken millions of years to form, are depleted. Utilization of renewable energy sources will conserve these valuable fossil fuel reserves which are essential feedstocks for the medical, agricultural, polymer, and other sectors of society.

This activity is intended to provide participants with an enjoyable, valuable learning experience while capitalizing on the competitive nature of individuals and groups.

**Procedure:**
1. Establish a group of participants to include no more than 4 people.
2. Review resource materials.
3. Design and construct a solar water heating device. Sketches are encouraged.
4. No indirect solar energy resources to help in heating are permitted.

5. Bring your device to the contest site on time.

**The Contest:** On the day of the contest you will place your device at the contest site. Each group will be given 300 ml of fresh cold water. At a given signal all groups will place the water in their devices. When you have attained maximum temperature, or the contest time has expired, return the water to the judge to be measured for temperature and volume. (length of contest will be determined in part by weather conditions)

**Conclusion:** Total score is calculated by the following formula:

\[
\text{Score} = \Delta \text{temp} \times \frac{\text{amount of water returned}}{\text{total time}}
\]

Prizes will be awarded to the contestants with the highest score.
Half-Life Calculation Activity

Introduction: This activity simulates radioactive decay (exponential decay).

Procedure: Prepare 80 to 120 small cubic blocks with one side painted red. Roll them and take out the ones with the red side up. Enter the data on the following table and plot the number of blocks remaining vs. the number of throws. The “half-life” for this experiment is by determining the number of rolls it takes until the number of blocks remaining is one-half of the original number. (You should find that the number left decreases with a “half-life” of 3.8 rolls.)

An alternate version of this activity can also be performed using pennies. In this variant, each participant has a penny. A leader is determined and all flip their coins. The results of the leader’s flip determines who has “decayed.” Everyone whose penny matches the leader’s flip has “decayed,” while those whose penny is different are still “radioactive.” Those who have “decayed” are removed from the activity and another flip is performed. Plot the number radioactive pennies vs. the flip number and determine the half-life. Is the number of people out each turn always one half the number of pennies flipped?

Results: Initial number of blocks: _____

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<thead>
<tr>
<th>Throw</th>
<th>Remaining blocks</th>
<th>Throw</th>
<th>Remaining blocks</th>
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