RLP-PSB · RLP Physical Science B — Forces, Energy and Waves

Unit 3: Energy Conservation and Transformation

Practice Workbook. The same problems, in the same order, as the Practice sections of the online lessons.

Name _____ Period _____

Lesson 3.1 — Storing Sunshine by Pumping Water Uphill

FLUENCY

1. Find the kinetic energy of a 1000 kg object moving at 20 m/s.

2. Find the kinetic energy of a 60 kg object moving at 20 m/s.

3. Find the gravitational potential energy gained when a 2 kg object is lifted 3 m ($g = 9.8\ m/s^2$).

4. Find the gravitational potential energy gained when a 55 kg object is lifted 25 m ($g = 9.8\ m/s^2$).

5. A ball is released from rest 45 m above the ground. Use conservation of energy (ignore air resistance) to find its speed just before impact.

6. A ball is released from rest 20 m above the ground. Use conservation of energy (ignore air resistance) to find its speed just before impact.

APPLICATION

7. A 1,200 kg car's speed doubles from 15 m/s to 30 m/s. Find its kinetic energy at each speed and the factor by which it increases.

8. At Taum Sauk, 1,000 kg of water (1 m^3) is pumped up the plant's 262 m maximum head. How much energy is stored, in joules and kWh? Using Ameren's pump-back efficiency of 0.714, how much electrical energy comes back?

9. A roller-coaster car starts from rest at the top of a 40 m drop. Ignoring friction, how fast is it moving at the bottom? Does the answer depend on the car's mass?

CHALLENGE

10. Explain why the chemical energy in gasoline and the thermal energy in hot water can both be described as kinetic energy or energy stored in fields when you look at the particle scale.

REVIEW

11. A 0.5 kg object moving at 0.6 m/s collides and sticks to a 1.0 kg object moving at −0.3 m/s (same line; positive is the first object's direction). Find the total momentum and the velocity just after the collision.

12. If the distance between two charges triples, by what factor does the electric force change?

Lesson 3.2 — Mixing Hot and Cold Water

FLUENCY

1. How much energy does it take to warm 250 g of water from 18 °C to 33 °C?

2. Predict the final temperature when 80 g of water at 44 °C is mixed with 120 g at 14 °C.

3. Predict the final temperature when 300 g at 42 °C is mixed with 200 g at 12 °C.

4. In which direction does thermal energy flow between a cold drink and warm air? When does it stop?

5. Which has more thermal energy: a bathtub of water at 40 °C or a cup of water at 90 °C? Which has the higher temperature?

APPLICATION

6. 100 g of water at 45 °C is mixed with 100 g at 15 °C in a thin plastic cup, and the measured final temperature is 28.5 °C. Calculate the energy lost by the hot water and gained by the cold water, and account for the difference.

7. A 100 g steel washer stack at 40.0 °C is dropped into 100 g of water at 20.0 °C; the final temperature is 21.9 °C (illustrative data). Assuming no losses, find the specific heat of the steel and compare it with water's.

8. Explain why Missouri, in the middle of the continent, has larger swings between summer and winter temperatures than cities on an ocean coast, using specific heat.

CHALLENGE

9. Mixed 30 °C water never separates on its own into 45 °C and 15 °C layers, even though that would conserve energy. Explain what principle this illustrates and why a refrigerator needs a power supply.

REVIEW

10. A 10 kg box is pushed with 85 N to the right against 6 N of friction. Find the net force and the acceleration.

11. Convert 100 m/s to km/h.

Lesson 3.3 — Where Did the Energy Go? Modeling Bouncing Balls

FLUENCY

1. A device takes in 2000 J and delivers 1030 J of useful energy. What is its efficiency, and where did the rest go?

2. A device takes in 1200 J and delivers 395 J of useful energy. What is its efficiency, and where did the rest go?

3. A device takes in 1200 J and delivers 453 J of useful energy. What is its efficiency, and where did the rest go?

4. A ball dropped from 1.5 m keeps 80% of its energy each bounce. Predict its first three rebound heights.

5. A ball rebounds to 0.78 m after being dropped from 1.20 m. What fraction of its energy did it keep?

6. Write a spreadsheet formula for cell B3 that multiplies B2 by the retention fraction stored in cell E1, so that it can be filled down.

APPLICATION

7. A 0.057 kg ball dropped from 1.20 m rebounds to 0.78 m. Calculate its potential energy at each height and the energy transferred out of the ball in the bounce. Name where that energy went.

8. Illustrative data: 100, 72, 52, 37 cm. Show that the retention fraction is roughly constant and use the average to predict the fifth height (after the fourth bounce).

9. A friend says, 'The ball stops bouncing because its energy runs out.' Rewrite the statement so that it is scientifically accurate.

CHALLENGE

10. What retention fraction would make a ball dropped from 100 cm reach 50 cm on its second bounce? Test your answer with the model.

REVIEW

11. An object is dropped from rest 5 m above the ground. Ignoring air resistance ($g = 9.8\ m/s^2$), how long does it fall and how fast is it moving at impact?

12. Predict the final temperature when 100 g of water at 50 °C is mixed with 300 g at 10 °C.

Lesson 3.4 — Designing a Solar Oven

FLUENCY

1. A motor does 3000 J of work in 30 s. What is its power output?

2. A motor does 12000 J of work in 5 s. What is its power output?

3. An oven opening is 0.40 m by 0.30 m. What is its area in m^2?

4. At 1,000 W/m^2, how much light power enters a 0.12 m^2 opening?

5. Name the solar oven design feature that addresses each sub-problem: collecting light, absorbing it, keeping the thermal energy.

6. Why does the solar oven test include a container of water in the sun outside the oven?

APPLICATION

7. An oven with a 0.12 m^2 opening warms 250 g of water from 22 °C to 47 °C in 20 minutes at about 1,000 W/m^2. Find the energy entering, the energy gained by the water and the efficiency.

8. Oven A's water rose 22 °C and its control rose 6 °C; Oven B's water rose 25 °C with a control rise of 12 °C on a hotter afternoon. Which oven performed better, and why must you use the controls to decide?

9. Haze or smoke cuts the sunlight reaching an oven roughly in half on some days (illustrative). If you still use 1,000 W/m^2 in your calculation, will your efficiency estimate be too high or too low? Explain.

CHALLENGE

10. Adding a second foil reflector is expected to increase the light entering by 30%, but it also casts wind on the oven and cools it. Describe a fair test to find out whether the net effect is positive, and what data would show it.

REVIEW

11. Find the kinetic energy of a 1000 kg object moving at 8 m/s.

12. A generator's coil is harder to turn when a lamp is connected. Why?

Unit 3 checkpoint

1. A 2.0 kg object at 4.0 m/s has kinetic energy
   A. 8.0 J
   B. 16 J
   C. 32 J
   D. 4.0 J
2. Gravitational potential energy is stored in
   A. the object alone
   B. the gravitational field of the Earth-object system
   C. the object's speed
   D. the air
3. Lifting a 10 kg box 3.0 m stores _____ J (g = 9.8 m/s²).
4. Mixing 100 g of water at 60 °C with 100 g at 20 °C, with no losses, gives
   A. 40 °C
   B. 80 °C
   C. 30 °C
   D. 50 °C
5. True or false: Thermal energy flows spontaneously from a colder object to a hotter one.
6. Warming 50 g of water by 10 °C takes _____ J (c = 4.18 J/g·°C).
7. A bouncing ball rises lower each time because
   A. energy is destroyed at each bounce
   B. some mechanical energy is transferred to thermal energy and sound
   C. gravity gets stronger
   D. the ball gets heavier
8. A ball keeps 50% of its energy each bounce and is dropped from 80 cm. Its second rebound height is
   A. 40 cm
   B. 20 cm
   C. 10 cm
   D. 60 cm
9. A device takes in 5,000 J and delivers 1,500 J of useful energy. Its efficiency is
   A. 15%
   B. 30%
   C. 33%
   D. 70%

10. True or false: Improving a solar oven one sub-problem at a time (collect, absorb, keep) makes it possible to tell which change helped.

11. What is the main value of a spreadsheet model in the design process?
    A. It replaces testing
    B. It lets you predict and compare the effects of changes before building them
    C. It makes the device work
    D. It measures temperature

12. Which is a criterion rather than a constraint?
    A. Must use only one pizza box
    B. Must fit in one person's arms
    C. Should raise water temperature at least 25 °C above the control
    D. No glass mirrors

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