PHYSB-CA · Physics B — Energy, Thermal Physics, Electromagnetism and Waves (California)

Unit 1: Energy, Work and Power

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

Name _____ Period _____

Lesson 1.1 — Pumped Storage: Work, Kinetic and Potential Energy

FLUENCY

1. Find the kinetic energy of a 2 kg object moving at 25 m/s.

2. Find the kinetic energy of a 2 kg object moving at 5 m/s.

3. Find the gravitational potential energy gained when a 2 kg object is lifted 10 m ($g = 9.8\ m/s^2$).

4. Find the gravitational potential energy gained when a 70 kg object is lifted 40 m ($g = 9.8\ m/s^2$).

5. You push a lawnmower 12 m with 250 N along the handle, which points 20° below horizontal. How much work do you do on it?

6. How much gravitational potential energy does lifting 1,000 kg of water through 300 m store? Express it in joules and kilowatt-hours.

APPLICATION

7. A 1,500 kg car speeds up from rest to 20 m/s over 60 m. Use the work-energy theorem to find its kinetic energy and the average net force.

8. A frictionless roller coaster starts from rest 40 m up. How fast is it at a point 15 m above the ground? Does the answer depend on the car's mass?

9. An upper reservoir holds 5.0×10^6 m^3 of water 350 m above the turbines (illustrative). How much energy does it store, in GWh?

CHALLENGE

10. A 2.0 kg box slides down a 5.0 m long ramp inclined at 30° with 4.0 N of kinetic friction, starting from rest. Use energy to find its speed at the bottom.

REVIEW

11. An object starts at 2 m/s and accelerates at 1 m/s^2 for 6 s. How far does it travel?

12. An object starts at 1 m/s and accelerates at 1.5 m/s^2 for 6 s. How far does it travel?

Lesson 1.2 — Ramp Lab: Measuring Energy Transfer and Efficiency

FLUENCY

1. A device takes in 3600 J and delivers 928 J of useful energy. What is its efficiency, and where did the rest go?

2. A device takes in 1200 J and delivers 520 J of useful energy. What is its efficiency, and where did the rest go?

3. A device takes in 500 J and delivers 149 J of useful energy. What is its efficiency, and where did the rest go?

4. A ball is released from rest 30 m above the ground. Use conservation of energy (ignore air resistance) to find its speed just before impact.

5. A ball crosses a 1.00 m level run in 20 frames of 30 fps video. Find its speed.

6. A 0.060 kg ball is released 0.25 m above the floor and reaches the speed above. Find mgh, $\frac{1}{2}mv^2$ and their ratio.

APPLICATION

7. Include rolling for the same ball: a solid ball's total kinetic energy is $0.7mv^2$. What fraction of mgh does the ball keep, and what is the ideal rolling speed from 0.25 m?

8. A v^2-versus-h graph for a rolling ball has slope 13.2 m/s^2. Compare it with the rolling ideal 10g/7 and state the efficiency.

9. With a stopwatch (±0.15 s) instead of video, a 0.67 s run has what percent timing uncertainty, and roughly what percent uncertainty in kinetic energy?

CHALLENGE

10. A student measures h along the ramp's slope (0.50 m) instead of vertically (0.25 m). What efficiency would they report for the ball above, and why is it wrong?

REVIEW

11. What net force gives a 0.5 kg object an acceleration of 3 m/s^2?

12. A net force of 10 N gives an object an acceleration of 2 m/s^2. What is its mass?

Lesson 1.3 — Where Did the Energy Go? Springs, Rubber Bands and Thermal Energy

FLUENCY

1. Find the kinetic energy of a 0.15 kg object moving at 5 m/s.
2. Find the kinetic energy of a 1000 kg object moving at 20 m/s.
3. A 500 g mass stretches a spring 8.0 cm. Find k.
4. The spring above is stretched 12 cm. How much elastic energy does it store?
5. A spring launcher (k = 400 N/m) is compressed 5.0 cm and fires a 40 g ball straight up. Ignoring losses, how high does it rise?

6. The same launcher fires the ball horizontally on a frictionless track. What is its launch speed?

APPLICATION

7. A rubber band's force-stretch data are (0, 0), (0.05 m, 2.0 N), (0.10 m, 3.5 N), (0.15 m, 4.5 N). Use trapezoids to find the stored energy at 0.15 m.

8. An 1,800 kg car brakes from 22 m/s to rest. Where does its kinetic energy go, and how much is there?

9. Respond to the claim "The launcher lost energy because the ball rose only 0.52 m instead of the predicted height."

CHALLENGE

10. A 60 kg skateboarder rolls off a 1.5 m high ramp at the bottom speed of 4.8 m/s. How much energy became thermal, and what average friction force acted over the 6.0 m ramp?

REVIEW

11. A 0.25 kg object moving at 1.2 m/s collides and sticks to a 1.5 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. An object is dropped from rest 2.5 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?

Lesson 1.4 — Power and a Pumped-Storage Day: A Computational Energy Model

FLUENCY

1. A motor does 3000 J of work in 5 s. What is its power output?

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

3. A motor does 600 J of work in 2 s. What is its power output?

4. Convert 100 kPa to atm.

5. A 62 kg student climbs 4.5 m of stairs in 5.0 s. Find the power.

6. A 1.5 kW space heater runs for 3.0 h. How much energy does it use, in kWh and joules?

APPLICATION

7. A crane lifts 500 kg of steel 12 m in 20 s at steady speed. What is its output power?

8. A car at 30 m/s faces 650 N of drag and rolling resistance. What power keeps it at that speed?

9. A pumped-storage plant pumps at 250 MW for 5 h with 85% pump efficiency. How much energy is stored (MWh)?

CHALLENGE

10. The plant above delivers its stored energy with 88% generator efficiency over 3 h. What average power does it deliver, and what is the round-trip efficiency?

REVIEW

11. What net force gives a 2 kg object an acceleration of 0.5 m/s^2?

12. A car moving at 14 m/s speeds up at 2 m/s^2 for 3 s. What is its final speed?

Unit 1 checkpoint

1. A force does no work on a moving object when the force is
   A. parallel to the motion
   B. perpendicular to the motion
   C. opposite the motion
   D. larger than the weight
2. A 2.0 kg ball moving at 6.0 m/s has _____ J of kinetic energy.
3. Lifting 50 kg through 3.0 m stores _____ J of gravitational potential energy.
4. True or false: Doubling an object's speed doubles its kinetic energy.
5. A plant stores 87 units of every 100 pumped and returns 86% of what is stored. The round-trip efficiency is about
   A. 87%
   B. 75%
   C. 86%
   D. 173%
6. A spring with k = 200 N/m compressed 0.10 m stores _____ J.
7. True or false: When a sliding box stops because of friction, its kinetic energy becomes thermal energy in the box and floor.
8. At the particle scale, elastic potential energy in a stretched rubber band is stored
   A. in the band's color
   B. in the electric fields between stretched molecules
   C. as heat only
   D. in the air around it
9. A 70 kg person climbing 3.0 m in 6.0 s develops _____ W.
10. True or false: MW and MWh measure the same quantity.
11. In the energy-converter task, what makes version 2 demonstrably better than version 1?
    A. It looks better
    B. Its mean efficiency exceeds version 1's by more than the trial-to-trial spread
    C. It was built second
    D. It is heavier
12. A falling 2.0 kg mass drops 1.0 m and lifts a 1.0 kg load 1.2 m. The efficiency is _____%.