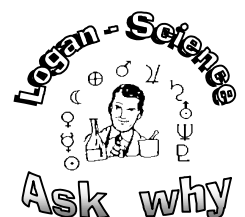


## Work and Energy

### Key Terms and Matching Definitions

- |                              |                           |
|------------------------------|---------------------------|
| _____ conservation of energy | _____ power               |
| _____ energy                 | _____ watt                |
| _____ kinetic energy         | _____ work                |
| _____ potential energy       | _____ work-energy theorem |



1. The product of the force and the distance through which the force moves:  $W = Fd$
2. The time rate of doing work: Power = work/time.
3. The unit of power, the joule per second.
4. The property of a system that enables it to do work.
5. The stored energy that a body possesses because of its position.
6. Energy of motion, described by the relationship: Kinetic energy =  $1/2 mv^2$
7. The work done on an object is equal to the energy gained by the object. Work =  $\Delta E$
8. Energy cannot be created or destroyed; it may be transformed from one form into another, but the total amount of energy never changes. In an ideal machine, where no energy is transformed into heat,  $work_{input} = work_{output}$  and  $(Fd)_{input} = (Fd)_{output}$

### Review Questions

#### 6.1 Work–Force $\times$ Distance

1. A force sets an object in motion. When the force is multiplied by the time of its application, we call the quantity *impulse*, which changes the *momentum* of that object. What do we call the quantity *force  $\times$  distance*?
2. Cite an example where a force is exerted on an object without doing work on the object.
3. Which requires more work—lifting a 50kg sack up a distance of 2 m or lifting a 25kg sack up a distance of 4 m?

#### 6.2 Power–How Quickly Work Gets Done

4. If both sacks in the preceding question are lifted their respective distances in the same time, how does the power required for each compare? How about for the case where the lighter sack is moved its distance in half the time?
5. What are the two main forms of mechanical energy?

#### 6.3 Mechanical Energy

6. Exactly what is it that a body having energy is capable of doing?

## 6.4 Potential Energy Is Stored Energy

7. A car is lifted a certain distance in a service station and therefore has potential energy relative to the floor. If it were lifted twice as high, how much potential energy would it have?
8. Two cars are lifted to the same elevation in a service station. If one car is twice as massive as the other, how do their potential energies compare?
9. How many joules of potential energy does a 1-N book gain when it is elevated 4 m? When it is elevated 8 m?

## 6.5 Kinetic Energy Is Energy of Motion

10. A moving car has kinetic energy. If it speeds up until it is going four times as fast, how much kinetic energy does it have in comparison?

## 6.6 Work-Energy Theorem

11. Compared to some original speed, how much work must the brakes of a car supply to stop a car moving four times as fast? How will the stopping distance compare?

## 6.7 Conservation of Energy

12. What will be the kinetic energy of pile driver ram when it undergoes a 10 kJ decrease in potential energy? (Assume no energy goes to heat.)

## 6.10 Sources of Energy

13. What is the ultimate source of energies of fossil fuels, dams, and windmills?
14. What is the source of geothermal energy?

## 6.11 Energy Is Needed for Life

15. The energy we require for existence comes from the chemically stored potential energy in food, which is transformed into other forms when it is metabolized. What happens to a person whose work output is less than the energy he or she consumes? Whose work output is greater than the energy he or she consumes? Can an undernourished person perform extra work without extra food? Briefly discuss.

## Exercises

1. When the mass of a moving object is doubled with no change in speed, by what factor is its momentum changed? Its kinetic energy?
2. When the velocity of an object is doubled, by what factor is its momentum changed? Its kinetic energy?
3. Consider a ball thrown straight up in the air. At what position is its kinetic energy a maximum? Where is its gravitational potential energy a maximum?
4. At what point in its motion is the KE of a pendulum bob a maximum? At what point is its PE a maximum? When its KE is half its maximum value, how much PE does it have?
5. A physical science teacher demonstrates energy conservation by releasing a heavy pendulum bob, as shown in the sketch, allowing it to swing to-and-fro. What would happen if in his exuberance he gave the bob a slight shove as it left his nose? Explain.



6. Discuss the design of the roller coaster shown in the sketch in terms of the conservation of energy.



7. Suppose that you and two classmates are discussing the design of a roller coaster. One classmate says that each summit must be lower than the previous one. Your other classmate says this is nonsense, for as long as the first one is the highest, it doesn't matter what height the others are. What do you say?
8. Consider molecules of hydrogen (tiny ones) and oxygen (bigger ones) in a gas mixture. If they have the same average kinetic energy (they will at the same temperature), which molecules have the greatest average *speed*?
9. On a slide a child has potential energy that decreases by 1000 J while her kinetic energy increases by 900 J. What other form of energy is involved, and how much?
10. According to the work-energy theorem, in the absence of friction, if you do 100 J of work on a cart, how much will you increase its kinetic energy?
11. Does speed affect the friction between a road and a skidding tire?

12. Consider the identical balls released from rest on Tracks A and B as shown. When they reach the right ends of the tracks, which will have the greater speed? (Hint: Will their KEs be the same at the end?) Which will get to the end in the shortest time? (Hint: Considering the extra speed in the lower part of track B, which ball has the greatest average speed on the ramps?)



13. Two lumps of clay with equal and opposite momenta have a head-on collision and come to rest. Is momentum conserved? Is kinetic energy conserved? Why are your answers the same or different?
14. A friend says the energy of oil and coal is actually a form of solar energy. Is your friend correct, or mistaken?

## Problems

1. How many joules of work are done when a force of 1 N moves a book 2 m?
2. (a) How much work is done when you push a crate horizontally with 100 N across a 10-m factory floor? (b) If the force of friction on the crate is a steady 70 N, how much KE is gained by the crate? (c) How much of the work you do converts to heat?
3. This question is typical on some driver's license exams: A car moving at 50 km/h skids 15 m with locked brakes. How far will the car skid with locked brakes at 150 km/h?
4. A force of 50 N is applied to the end of a lever, which is moved a certain distance. If the other end of the lever moves one-third as far, how much force can it exert?
5. How many watts of power are expended when a force of 1 N moves a book 2 m in a time interval of 1 s?
6. Which produces the greater change in kinetic energy: exerting a 10-N force for a distance of 5 m, or exerting a 20-N force over a distance of 2 m? (Assume that all of the work goes into KE.)
7. Consider the inelastic collision between the two freight cars in chapter 5 (Figure 5.13). The momentum before and after the collision is the same. The KE, however, is less after the collision. How much less, and what becomes of this energy?