Chapter 8. p. 119, Review Questions

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 the object. What do we call the quantity force x distance and what quantity does it change? We call it WORK, and it changes the object’s energy.

2. Work is required to lift a barbell. How many times more work is required to lift the barbell three times as high?

Three times more work.

3. Which requires more work, lifting a 10-kg load a vertical distance of 2 m or lifting a 5 kg load a vertical distance of 4 m?

\[
W = F \times d = mg \times d
\]

\[
W = 10 \text{ kg} \times 9.8 \text{ m/s}^2 \times 2 \text{ m} = 196 \text{ J}
\]

\[
W = 5 \text{ kg} \times 9.8 \text{ m/s}^2 \times 4 \text{ m} = 196 \text{ J}
\]

4. How many joules of work are done on an object when a force of 10 N pushes it a distance of 10 m?

\[
W = F \times d = 10 \text{ N} \times 10 \text{ m} = 100 \text{ J}
\]

5. How much power is required to do 100 J of work on an object in a time of 0.5 s? 

\[
P = \frac{W}{t} = 100 \text{ J}/0.5 \text{ s} = 200 \text{ W}
\]

6. What are the two main forms of mechanical energy?


7. a. If you do 100 J of work to elevate a bucket of water, what is its gravitational potential energy relative to its starting position? By the Law of Conservation of Energy, it would be 100 J of GPE.

b. What would the gravitational potential energy be if the bucket were raised twice as high? If you changed the height by 2, the GPE would also increase by 2. \[\text{GPE} = \text{mass} \times \text{gravity} \times \text{height}\]. The GPE is directly proportional to the height. If you double the height, you double the GPE.

8. A boulder is raised above the ground so that its potential energy relative to the ground is 200 J. Then it is dropped. What is its kinetic energy just before it hits the ground?

200 J.

9. Suppose an automobile has 2000 J of kinetic energy. When it moves with twice the speed, what will be its kinetic energy? \[\text{Kinetic Energy} = \text{TKE} = \frac{1}{2} \times \text{mass} \times \text{velocity}^2\] If you double the velocity then ...

\[
\text{TKE} = \frac{1}{2} \times m \times (2v)^2
\]

\[
= \frac{1}{2} \times m \times 4v^2
\]

\[
= 4 \left(\frac{1}{2} \times m \times v^2\right)
\]

\[
= 4 \text{ TKE (four times the kinetic energy)}
\]

What’s its kinetic energy at three times the speed?

\[
\text{TKE} = \frac{1}{2} \times m \times (3v)^2
\]

\[
= \frac{1}{2} \times m \times 9v^2
\]

\[
= 9 \left(\frac{1}{2} \times m \times v^2\right)
\]

\[
= 9 \text{ TKE (nine times the kinetic energy)}
\]

10. What will be the kinetic energy of an arrow having a potential energy of 50 J after it is shot from a bow? By the Law of Conservation of Energy, the EPE of the bow will completely convert to the TKE of the arrow. So TKE is 50 J.

11. What does it mean to say that in any system the total energy score stays the same? That energy is conserved. If there are 100 J of energy in, there must be 100 J of energy out. No energy gets away or disappears.

12. In what sense is energy from coal actually solar energy? Coal was plant matter that millions of years ago died, decomposed, was buried, heated, pressurized, and solidified. That is why it – along with oil and natural gas - are called fossil fuels. As a living plant, it absorbed solar energy to do photosynthesis and so still had that energy available to it as Chemical Potential Energy when it died and became Coal.

13. How does the amount of work done on an automobile by its engine relate to the energy content of the gasoline? Because of friction and energy conversion to heat, the work done will always be less than the energy content of the gasoline in the car. A car may be only 40 – 50% efficient in the conversion process from CPE (chemical potential energy) to useful work (W).
Think & Explain.

1. State two reasons why a rock projected with a slingshot will go faster if the rubber is stretched an extra distance. The more stretch means the more EPE (elastic potential energy) the slingshot acquires ($EPE = \frac{1}{2}kx^2$). This EPE will convert into TKE (translational kinetic energy) which means more velocity ($TKE = \frac{1}{2}mv^2$).

2. Does an object with momentum always have energy? Yes. Does an object with energy always have momentum? No. The object may be still and have only potential energy. To have momentum you have to be moving.

3. If a mouse and an elephant both run with the same kinetic energy, can you say which is running faster? Explain in terms of the equation for KE. The mouse is running faster. $TKE = \frac{1}{2}mv^2$ depends on mass and velocity. In order for the two TKEs to be the same, the velocity of the mouse, which has a much smaller mass than the elephant, must be much greater to compensate. EX: $TKE_{mouse} = TKE_{elephant}$

4. An astronaut in full space gear climbs a vertical ladder on earth. Later, the astronaut makes the same climb on the moon. In which location does the gravitational potential energy of the astronaut change more? Explain. On the earth the astronaut will have more GPE. GPE depends on three things, mass, gravity, and height and is directly proportional to all three. The mass and height don’t change between the earth and the moon but the height does. The gravity on the moon is around six times less than the gravity on the earth. So the GPE will be about six times less.

5. Most earth satellites follow an oval-shaped (elliptical) path rather than a circular path around the earth. The PE increases when the satellite moves farther from the earth. According to the law of energy conservation, does a satellite have its greatest speed when it is closest to or farthest from the earth? By the law of conservation of energy, GPE + TKE would have to be the same at any point in the satellite’s revolution around the earth. Therefore, the satellite would have to have its least TKE the further it is from the Earth where it has its greatest GPE and vice-versa, having the greatest TKE when it is closest to the earth.

6. Why does a small, lightweight car generally have better fuel economy than a big, heavy car? The fuel economy is a measure of how much distance the car can travel on a certain amount of fuel. The CPE of the fuel gives a car TKE. The CPE of the fuel can make a car with a small mass move a greater velocity, and thus move a greater distance, than a large car that has a greater mass. How does a streamlined design improve fuel economy? A streamlined design helps reduce the work ($\text{Force} \times \text{distance}$) the car has to do against air resistance.

7. Does using an automobile’s air conditioner while driving increase fuel consumption? Yes. More CPE (chemical potential energy) of the fuel is needed to turn the air conditioner’s compressor. What about driving with the light on? Yes. More CPE (chemical potential energy) of the fuel is needed to run the alternator which charges the battery that runs the lights. What about playing the car radio when parked with the engine off? Explain in terms of the conservation of energy. Yes. More CPE (chemical potential energy) of the fuel will be needed to run the alternator once the car is turned back on to recharge the battery that runs the radio.