CHAPTER 12 WORK AND ENERGY

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Section 1: Work, Power, and Machines

Key Terms

Work
Power
Mechanical Advantages
Machines no matter how simple or complex help people get things done every day

What Is Work?
No matter how much force you exert work is not done unless an object changes position or motion
Work is done only when force causes a change in the position or the movement of an object in the direction of the applied force.

To calculate work you multiply the force by the distance over which the force is applied.

\[
\text{Work} = \text{Force} \times \text{distance} \\
W = F \times d
\]
Work is measured in joules

Because work is calculated as force times distance, it is measured in units of newtons times meters (N*m)

1 N*m = 1 J = 1 kg*m^2/s^2

Since these units are equal, you can choose whichever unit is easiest for solving a particular problem
Power

Power is a quantity that measures the rate at which work is done or energy is transformed.

\[ \text{power} = \frac{\text{work}}{\text{time}} \]

\[ P = \frac{W}{t} \]
A watt is the amount of power required to do 1 J of work in 1 s.

Machines and Mechanical Advantages

Machines multiply and redirect forces
Machines can change the direction of an input force, and they can also increase or decrease force by changing the distance over which the force is applied.

Different forces can do the same amount of work
By applying a smaller amount of force over a longer distance the amount of work done on an object that is lifted straight up is the same.

Remember that Work = Force * distance

Mechanical advantages tells how much a machine multiplies force or increases distance
To determine how long a ramp should be, scientists use a number that describes how much the force or distance is multiplied by a machine.

Mechanical advantage

= output force/input force

= input distance/output distance
Mechanical advantage is a quantity that measures how much a machine multiplies force or distance.

A machine with a mechanical advantage greater than 1 multiplies the input force.

A machine with a mechanical advantage less than 1 does not multiply force, but increases distance and speed.
Simple Machines

Key Terms

Simple Machines

Compound Machines
The most basic machines are called simple machines. Other machines are either modifications of simple machines or combinations of several simple machines.

Simple machines are divided into two groups the lever family and the inclined plane family.
The Lever Family

All levers have a rigid arm that turns around a point called the fulcrum.
Levers are divided into three classes

First-class levers - have a fulcrum located between the points of application of the input and output forces.

Second-class levers - the fulcrum is at one end of the arm and the input force is applied to the other end. The wheel of a wheelbarrow is a fulcrum.

Third-class levers - multiply distance rather than force. As a result, they have a mechanical advantage of less than 1. The human body contains many third-class levers.
Pulleys are modified levers

The point in the middle of pulley is like the fulcrum of a lever. The rest of the pulley behaves like the rigid arm of a first-class lever.

Multiple pulleys are sometimes put together in a single unit called a block and tackle.
A wheel and axle is a lever or pulley connected to a shaft

The Incline Plane Family

Incline planes multiply and redirect force

When you push an object up a ramp, you apply a force to the object in a direction parallel to the ramp.
What happens to the force?

The ramp redirected the force to lift the object up.

The output force is the force needed to lift the object straight up.

An inclined plane works by turning a small input force into a large output force by spreading the work over a large distance.
A wedge is a modified incline plane

How does a wedge work?

A wedge functions like two inclined planes back to back. A wedge turns a single downward force into two forces directed out to the sides.
A screw is an inclined plane wrapped around a cylinder

Compound Machines

These are machines that combine two or more simple machines
Chapter 12 Section 3

What is Energy?

Key Terms

Potential Energy
Kinetic Energy
Mechanical Energy
Energy and Work

Whenever work is done, energy is transformed or transferred to another system. One way to define energy is the ability to do work.

Energy is measured in joules.
What is the difference between work and energy?

Energy can be present in an object or a system when nothing is happening. However, energy can only be observed when it is transferred from one object or system to another.
Because energy is a measure of the ability to do work, energy and work are expressed in the same units - joules.

Potential Energy

Potential energy is stored energy
The energy stored in any type of stretched or compressed elastic material, such as a spring or a bungee cored, is called *elastic potential energy*.

Any system of two or more objects separated by a distance contains gravitational potential energy resulting from the gravitational attraction between the objects.
Gravitational potential energy depends on both mass and height.

Gravitational Potential Energy Equation

grav. PE
= mass x free-fall acceleration x height

PE = mgh
Note: mass x free-fall acceleration (mg) = Newtons

This equation is similar to the work equations $W = F \times d$
Kinetic Energy

The energy that an object has because of its motion is called kinetic energy

Kinetic energy depends on mass and speed
Kinetic Energy Equation

kinetic energy = \( \frac{1}{2} \times \text{mass} \times \text{speed} \text{ squared} \)

\[ KE = \frac{1}{2}mv^2 \]

Kinetic energy depends on speed more than mass
In the kinetic energy equation, speed is squared, so a small increase in speed produces a large increases in kinetic energy.
Other Forms of Energy

The sum of the potential energy and the kinetic energy in a system is called mechanical energy.

Mechanical energy can also be thought of as the amount of work an object can do because of the object’s kinetic and potential energies.
Atoms and molecules have kinetic energy

high temperature = kinetic energy increase

lower temperature = kinetic energy decreases
Living things get energy from the sun

Plants use photosynthesis to turn the energy in sunlight into chemical energy

The sun gets energy from nuclear reactions
Electricity is a form of energy

Light can carry energy across empty space
Chapter 12 Section 4

Conservation of Energy

Key Terms

Efficiency
Energy Transformation

Potential energy can become kinetic energy

Kinetic energy can become potential energy

Mechanical energy can change to other forms of energy
When a ball bounces or a car on a roller coaster travel over the tracks some of the energy is transformed to other forms of energy and back and forth between kinetic and potential energy.

The ball and car also increase the temperature of the surroundings and also cause sound energy.
The Law of Conservation of Energy

Energy cannot be created or destroyed

The law of conservation of energy requires that at any given time, the total energy should be the same

Scientists study energy in systems
Systems may be open or closed

When the flow of energy into and out of a system is small enough that it can be ignored, the system is a closed system.

Most systems are open systems, which exchange energy with the space that surround them.
Efficiency of Machines

Not all of the work done by a machine is useful work.

Because of friction and other factors, only some of the work done by a machine is applied to the task at hand.

Efficiency is the ratio of useful work out to work in.
The efficiency of a machine is a measure of how much useful work it can do.

Efficiency Equation

\[
\text{Efficiency} = \frac{\text{useful work output}}{\text{work input}}
\]
Efficiency is usually expressed as a percentage.

Can a machine be 100% efficient?

No. some of the work will be lost.
Machines need energy input

Because energy always leaks out of a system, every machine needs at least a small amount of energy input to keep going.