Work

Definition of Work
Work Causes Displacement
Force is Parallel to Displacement

MCHS Honors Physics 2014-15

Definition

- Many of the terms we have studied so far have meanings in physics that are similar to their meanings in everyday life.
- In its everyday sense, the term *work* means to do something that takes physical or mental effort. In physics, work has a distinctly different meaning.

Definition

- Examples:
  - » A student holds a heavy chair at arm's length for several minutes.
  - » A student carries a bucket of water along a horizontal path while walking at constant velocity.
- It might surprise you to know that as the term work is used in physics, there is no work done on the chair or the bucket, even though effort is required in both cases.
- We will come back to that.

Work Causes Displacement

- Imagine that your car has run out of gas and you have to push it down the road to the gas station.
- If you push the car with a constant horizontal force, the work you do on the car is equal to the magnitude of the force, *F*, times the magnitude of the displacement of the car.
- Using the symbol *d* instead of Δx for displacement, we define work for a constant force as:

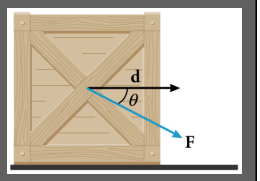
$$W = Fd$$

Work Causes Displacement

- Work is not done on an object <u>unless</u> the object is moved with the action of a force.
- The application of a force alone <u>does not</u> constitute work.
- For this reason, no work is done on the chair when a student holds the chair at arm's length.
- Even though the student exerts a force to support the chair, the chair does not move. The student's tired arms suggest that work is being done.
- However, work is not done on the chair.

Force is Parallel to Displacement

- Work is done only when components of a force are parallel to a displacement .
- When the force on an object and the object's displacement are in different directions, only the component of the force that is parallel to the object's displacement does work.
- Components of the force perpendicular to a displacement do not do work.



Force is Parallel to Displacement

- For example, imagine pushing a crate along the ground. If the force you exert is horizontal, all of your effort moves the crate.
- If your force is at an angle, only the horizontal component of your applied force causes a displacement and contributes to the work.
- If the angle between the force and the direction of the displacement is θ, work can be expressed as follows:

$$W = Fd\cos(\theta)$$

Force is Parallel to Displacement

- If θ=0°,then cos0°=1 and *W*=*Fd*, which is the definition of work given earlier.
- If θ=90°, however, then cos 90°= 0 and *W*=0. So, no work is done on a bucket of water being carried by a student walking horizontally.
- The upward force exerted by the student to support the bucket is perpendicular to the displacement of the bucket, which results in no work done on the bucket.

Force is Parallel to Displacement

- Many constant forces are acting on an object, but if you find the *net* work done on the object by first finding the net force on the object.

NET WORK DONE BY A CONSTANT NET FORCE

$$W_{net} = F_{net} d \cos\theta$$

net work = net force × displacement × cosine of the angle between them

- Work has dimensions of force times length and has a unit of newtons times meters (N • m), or joules (J).
- A joule is about the work done lifting an apple from your waist to the top of your head.

The Sign of Work is Important

- Work is a scalar quantity and can be positive or negative.
- Work is positive when the component of force is in the same direction as the displacement.
- Work is negative when the force is in the opposite direction of the displacement.
- If you are careful with your work when applying our equations, your answers will have the correct sign.
- If the work done on an object changes the object's speed, the sign of the net work indicates an increase or decrease in speed.