Algebra-based Physics-1: Mechanics (PHYS135A-01): Week 7

Jordan Hanson

October 16th - October 20th, 2017

Whittier College Department of Physics and Astronomy

WEEK 6 REVIEW

Week 6 Review

1. Angular kinematics and dynamics
    - Angular displacement
    - Angular velocity
    - Centripetal acceleration
2. Newton's Law of Gravity and circular orbits
3. Kepler's Laws

WEEK 6 REVIEW PROBLEM

WEEK 6 REVIEW PROBLEM

On the game show Wheel of Fortune, a large wheel is divided into sections worth varying dollar amounts. Contestants try to spin the wheel such that they get the good ones. Player 1 notices that the $10,000 marker is on the opposite side (180 degrees away). What is this angle in radians? If she has great luck and spins such that the wheel turns exactly 180 degrees, in 2 seconds, what is the angular speed in radians per second?

- A: $\pi/2$ radians, $\pi/4$ radians per second
- B: 0 radians, 0 radians per second
- C: π, $\pi/2$ radians per second
- D: π, $\pi/4$ radians per second

WEEK 6 REVIEW PROBLEM

Astronomers are observing two planets orbiting a star for several months. They observe that planet 1 orbits twice as fast as planet 2. If the orbital radius of planet 1 is 1 AU, what is the orbital radius of planet 2, in AU?

- A: 1 AU
- B: 1.6 AU
- C: 4 AU
- D: 3.2 AU

WEEK 7 SUMMARY

WEEK 7 SUMMARY

1. Work has a scientifically precise definition
    - Units
    - As a product of force and displacement vectors
2. Kinetic Energy and the Work-Energy Theorem
3. Gravitational potential energy
    - Potential energy
    - *Simplifying otherwise complex calculations*
    - Potential energy near Earth's surface
    - ...in space
4. Definition of a **conservative force**
    - Relationship between conservative forces and potential energy
    - Conservation of energy for conservative forces

DEFINITIONS OF WORK

Physical Definition of Work

Let $\vec{F}$ be a force exerted on a system, which is displaced by a displacement $\vec{x}$. The **work** done on the system is $W = \vec{F} \cdot \vec{x}$

The units of work are N m = kg m/s^2, or *Joules*.

Extra credit opportunity: **Do you like beer**? Write a 10-page paper on the on the scientific challenge faced by James Prescott Joule, who began to formulate the modern view of energy in the 19th century, contrary to *caloric theory*. **Upon completion of this assignment I will change two homework scores to perfect scores.**

Let θ be the angle between the force and the displacement. Then this equation

$$W = \vec{F} \cdot \vec{x} \tag{1}$$

becomes

$$W = Fx \cos\theta \tag{2}$$

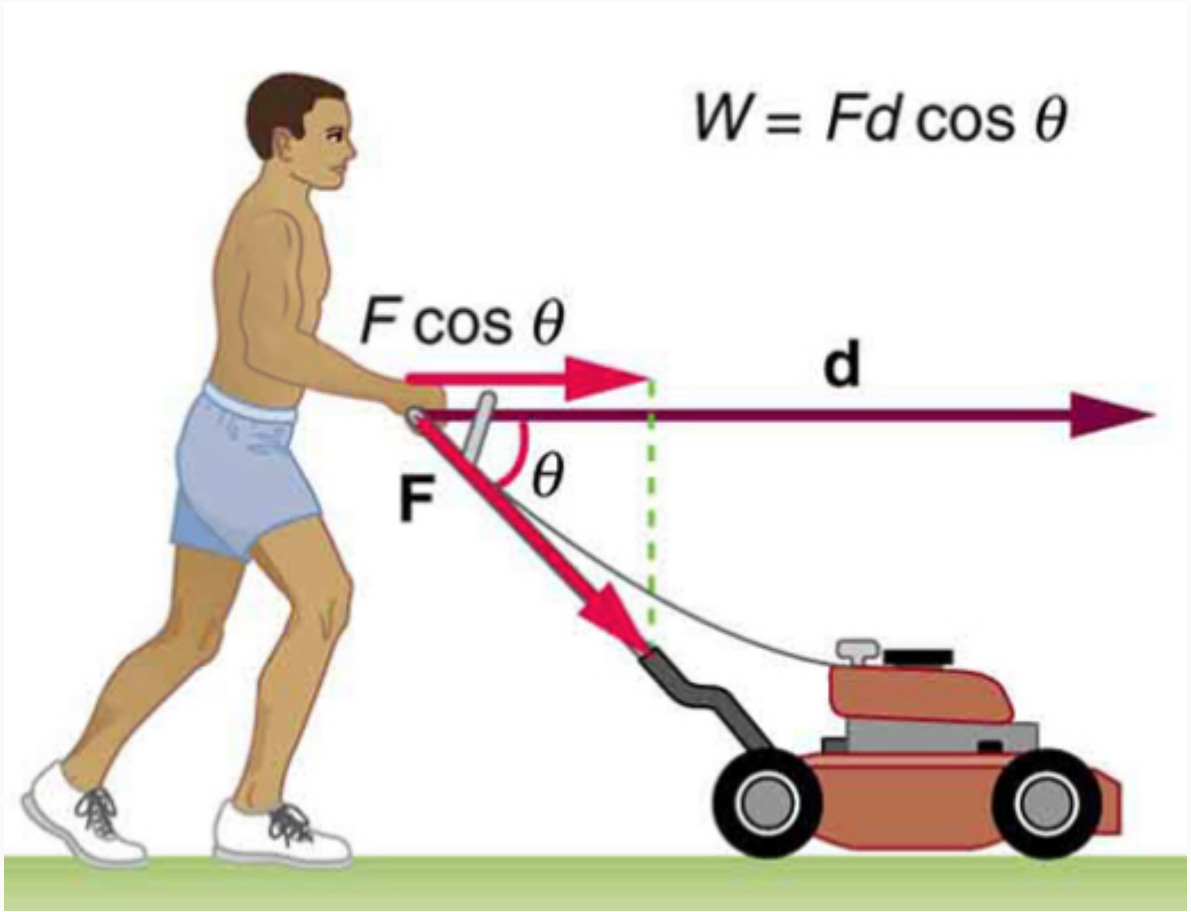

Figure 1: A case where $\theta \neq 0$.

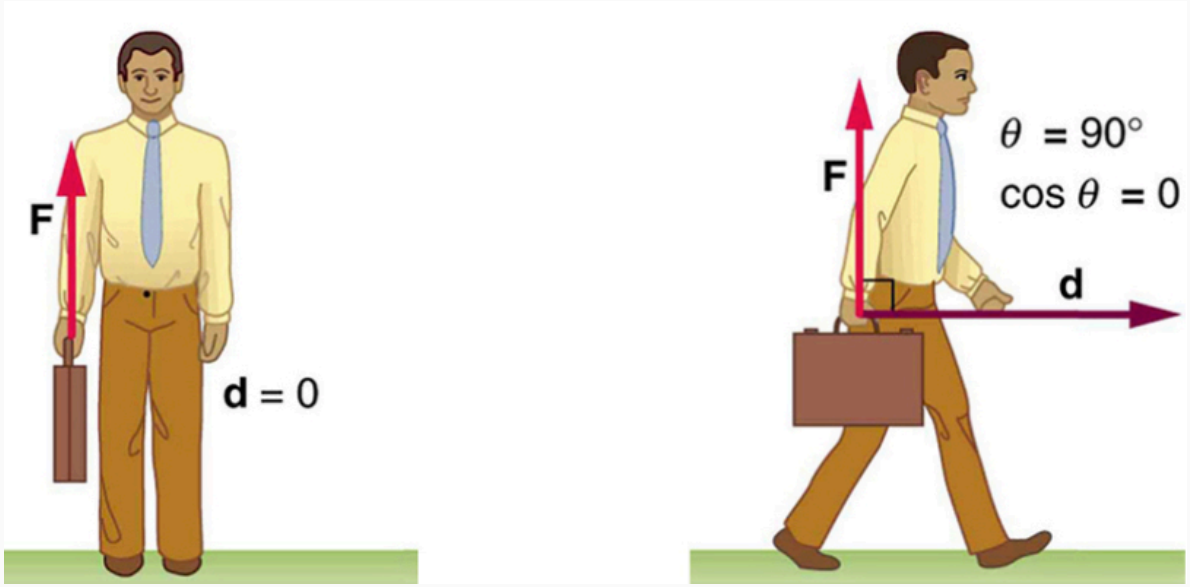

Figure 2: (Left): A case where $x = 0$, so $W = 0$. (Right): A case where $\theta = 90°$, so $W = 0$.

Just because an action requires *energy* doesn't mean we are performing *work*. It requires muscular energy to hold up a heavy briefcase but this is not what we mean by work. Work is about moving objects.

What about Newton's 3rd Law? If one system A exerts a force F_{AB} on a system B, then Newton's 3rd law states that system B exerts a force $-F_{\mathrm{AB}}$ on system A.

If the work done by A on B is $W = (F_{\mathrm{AB}})x\cos\theta$, then the work done by B on A is $W = -(F_{\mathrm{AB}})x\cos\theta$.

In Fig. 1, the work done by the man on the mower is positive, but the work done by the mower on the man is negative.

More units of energy:

Unit Name	Definition	Value
electron-volt (eV)	energy of 1 e^- through 1 V	1.60×10^{-19} J
1 Rydberg (Rd)	ionize 1 hydrogen atom	21.8×10^{-19} J
Joule	**1 N·m**	**1.0 J**
foot-pound	1 ft·lb	1.36 J
calorie	Raise 1 gram of water 1° C	4.184 J
British Thermal Unit	Raise 1 lb of ice to boil (°F)	1054.3 J
food calorie (kcal)	1000 calories	4184 J
kilowatt hours	1 kilowatt system for 1 hr	3.6×10^6 J
gasoline galon equiv.	burning a galon of gas	$\approx 120 \times 10^6$ J
$E = mc^2$, 1 mole of H^+	Rest mass (fusion/fission)	9×10^{13} J

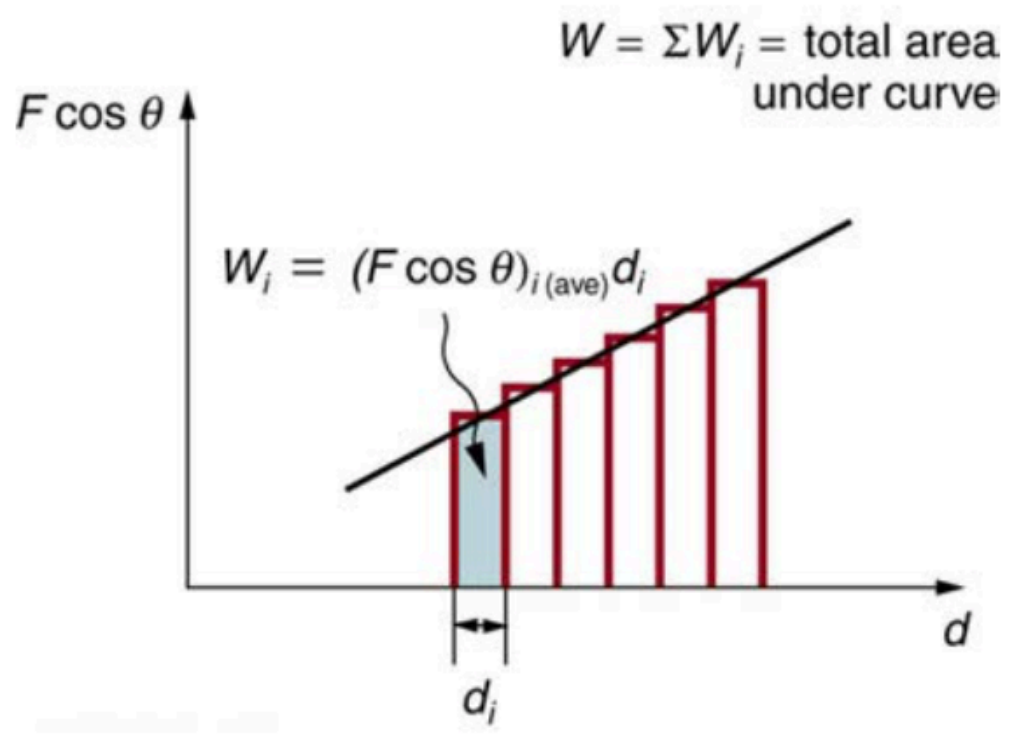

Figure 3: Breaking the displacement $\vec{x}$ into pieces, and summing them.

This interpretation naturally leads to the subject of *integration* in calculus.

CONCLUSION

WEEK 7 SUMMARY

1. Work has a scientifically precise definition
    - Units
    - As a product of force and displacement vectors
2. Kinetic Energy and the Work-Energy Theorem
3. Gravitational potential energy
    - Potential energy
    - *Simplifying otherwise complex calculations*
    - Potential energy near Earth's surface
    - ...in space
4. Definition of a **conservative force**
    - Relationship between conservative forces and potential energy
    - Conservation of energy for conservative forces

ANSWERS

ANSWERS

- π, $\pi/2$ radians per second
- 1.6 AU
- ...