Physics 1408/1420 – General Physics 1

Week of September 19th, 2022

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Hello Fellow Physicists,

I am Jorge, the Master Tutor for Physics this semester. To help you on your journey to learn about this wonderful branch of science and the understanding it gives us of the world around us, I will be preparing this resource every week to give you an additional tool to better prepare for your week. I will also be conducting Group Tutoring sessions every week, the information for which will be given below. If you are unable to attend group tutoring, the tutoring center also offers one-on-one tutoring session, so be sure to visit the tutoring center or visit https://baylor.edu/tutoring.

PHY 1408/1420 General Physics 1 Group Tutoring sessions will be held every Monday from 6:30 to 7:30 pm in the Sid Richardson building basement, Room 75. See you there!

In the past two weeks, your professors will have covered Projectile Motion and Forces. This week, you will finish studying Forces and begin exploring uniform circular motion.

Important Notes
Important Conventions

Keywords: Work, Kinetic Energy, Potential Energy and Conservation of Energy

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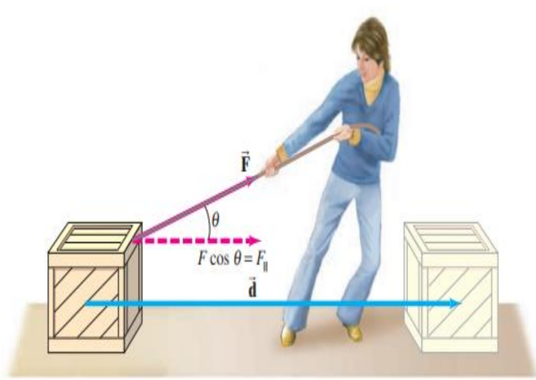
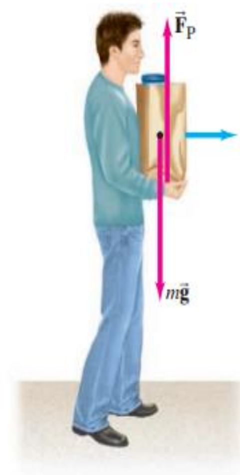
Work

In the world of physics, the definition of work is a lot different from they way we generally think of it. In physics, work is done on an object by a force. When work is done on an object by a constant force, it is defined to be the force applied parallel to the direction of the displacement. There is a magnitude of work done on an object only when there is a displacement.



If you look at the figure here, the x-axis component of the applied force is the force that does work on the box. It's because that is the directional force parallel to the displacement of the box. This also means that there can be force without work done. Look at the figure on the right. The individual is applying an upward force on the bag to hold it up and is walking. But the force is perpendicular to the displacement, hence there is no work done. It is important to understand this caveat as it is something you will have to consider when looking at energy problems. Having this in mind, we define work in the following way:

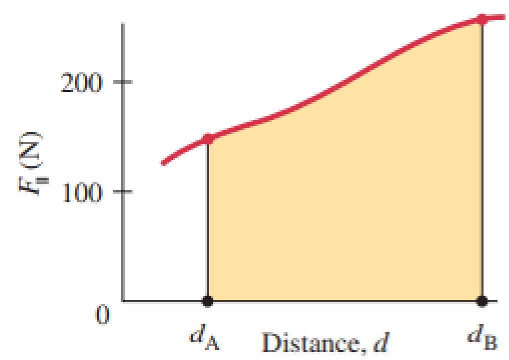


$$W = F_{parallel} \cdot d$$

We can also write the formula as follows to account for forces at an angle

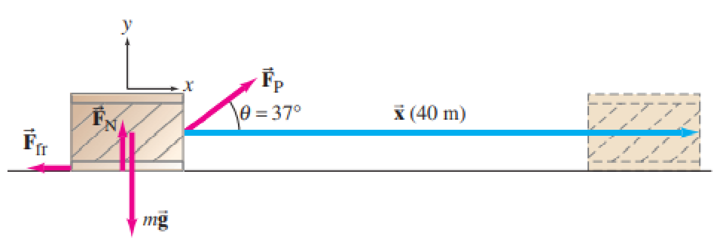
$$W = F.d.\cos \Theta$$

In general, the work done by a force is represented by a the area under the curve in the graph of Force vs. Displacement. For the case of a non-constant force, we would have a plot like the one on the right. Ideally, you would use an integral to find the work done, but that is beyond the confines of the 1408 course. So typically, you will be given area demarcations which you must count to know the magnitude of the work done. Let's look at an example problem.



Example:

A person pulls a 50 kg crate 40 m along a horizontal floor by a constant force F_p = 100 N, which acts at a 37° angle. The floor exerts friction F_{fr} = 50 N. Determine the net work done.



Solution:

The y- axis forces do not do work as they are perpendicular to the direction of displacement.

Work done by F_p

$W_p = F_p \cdot d. \cos \Theta$

$= 100\ (40)\ (\cos 37)$

$= 3200\ J$

$W_{fr} = F_{fr}.\ d.\ \cos \Theta$

$= (50)\ (40)\ (\cos 180)$

$= -\ 2000\ J$

$W_{net} = W_p + W_{fr}$

$= 3200 - 2000$

$= 1200\ J$

Energy

There are different types of energy. In the universe, there is definite amount of energy and all the things we see are due to the continuous conversion energy into different forms. Throughout this, energy is always conserved. The principle of conservation of energy is useful when looking at the changes caused due to conversion of energy. The energies you will discuss in class are as follow:

Kinetic Energy is the energy possessed by an object in motion. Work done can affect the kinetic energy of an object by changing the velocity. The following two formulas can be used to calculate the kinetic energy.

$$KE = (1/2)\ (mv^2) \qquad W_{net} = \blacktriangle KE = ((1/2)m(v_2)^2) - ((1/2)m(v_1)^2)$$

Gravitational Potential Energy is the potential energy possessed by an object due to gravity. As the height of the object increases so does its potential energy. Similar to how work done can cause a change in the kinetic energy of an object, it can cause a change in the gravitational potential energy.

$$PEg = mgh \qquad W = mg(h_2 - h_1)$$

Elastic Potential Energy is the potential energy possessed by springs when they are compressed by a force. The force and the potential energy can be determined by the following formula:

$$F_{spring} = -kx \qquad PE_s = (1/2)\ kx^2$$

The force does work on the spring to compress it, which increases its potential energy. The displacement is x.

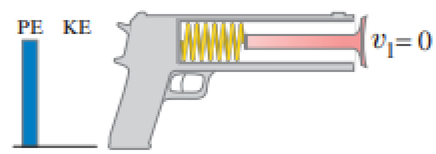
When working with energy, we assume that all the forces in play are conservative forces. So, the mechanical energy, all the energy of the system, is conserved. It neither increases nor decreases.

When looking at the conservation of mechanical energy, the energy before equals the energy in the system after.

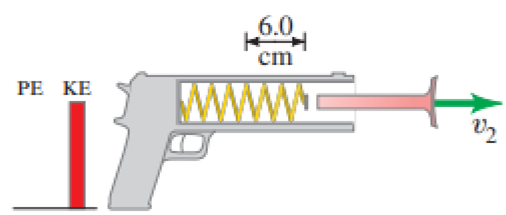
Let’s look at an example:

<u>Example:</u>

A dart of mass 0.1 kg is pressed against the spring of a toy dart gun. The spring with the constant k = 250 N/m and is compressed 6 cm and then released. The dart flies off when the spring is released. What is the speed of the dart?



(a) $E = \frac{1}{2} k x_1^2$



(b) $E = \frac{1}{2} m v_2^2$

Solution:

$E_{before} = E_{after}$

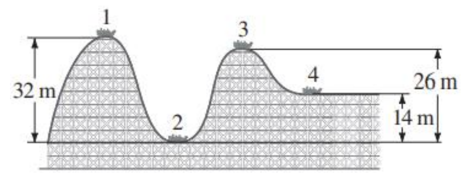
$(1/2)\ k\ x^2 = (1/2)\ m\ v^2$

$v = [((1/2)\ (250)(-0.06)^2)\ /\ ((1/2)(0.1))]^2$

$v = 3$ m/s

CHECK YOUR LEARNING

1. A 700 N crate rests on the floor. How much work is required to move it at constant speed for 20 m along a floor with a coefficient of kinetic friction of 0.2 and static friction of 0.5? How much work is required to hold the crate 0.5 m above the ground for 20 seconds?
2. A baseball (m = 250 g) is travelling toward the catcher at 40 m/s. The catcher exerts a force of 2000 N to stop the ball. How far is the glove displaced when the ball stops?
3. A roller coaster track is as shown in the figure. The ride starts at 1, at which point does the cart have (a) the highest velocity and (b) the highest potential energy. (c) If the height of point 3 was raised to match the height of 1, what would happen to the cart at 3?



4. A 5g locust reaches a speed of 5 m/s during its jump. What is the kinetic energy of the locust at this speed? If the locust transforms energy with 15% efficiency, how much energy was required for the jump?
5. A 50 kg skier start from rest at the top of a 1000-m-long trail which drops 150 m from top to bottom. At the bottom, the skier is moving at 15 m/s. How much energy was dissipated by friction?

THINGS YOU MAY STRUGGLE WITH

1. The concept of work in physics can be tricky, and you should try to separate it from the meaning we attribute to it in our daily life. In physics, remember that for work to be done on an object, the net force exerted must cause a non-zero displacement on the object. If the position of the object remains unchanged or if the object returns to the same position, the net work in that system is zero.
2. You should be able to remember the principle of conservation of energy. Pay attention to the changes in energy in and out. Remember that the amount of energy in the system before must be equal to the amount of energy after.
3. Be aware of how the energy changes in a system. Whenever you encounter changes on either the potential or the kinetic energy of an object, that means that some work had to be done. After you have identified there is some net work, you can start looking for any forces that may have caused it.

I hope you have a wonderful week! Please feel free to reach out to me if you have any questions and check out all the resources the Tutoring Center has to offer at: https://baylor.edu/tutoring

Answer: 1. 2800 J, 0 J, 2. 0.1 m, 3. (a) 2 (b) 1 (c) cart would stop at 3, 4. 0.0625 J, 0.417 J, 5. 67875 J

All images are from Physics: Principles with Applications (7th Edition) by Douglas C. Giancoli