Hello Fellow Physicists,

I am Aman Patel, 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 Wednesday from 6:45-7:45 pm in the Sid Richardson building basement, Room 74. See you there!

Last week, your professors will have covered Uniform Circular Motion. This week, you will begin exploring energy and learn to use conservation of energy to solve problems!

**Keywords:** Work, Energy, Conservation of Energy

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**Work**

In the world of physics, the definition of work is a lot different from the 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 because this is a concept you will have to apply when looking at energy problems. After understanding this, we determine the formula for work as

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

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

$$W = F \cdot d \cdot \cos \theta$$

When looking at varying forces, which is depicted by a graph. The work done will be the area under the graph.

**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 $37^\circ$ angle. The floor exerts friction $F_r = 50$ 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 $F_p$,

$$W_p = F_p \cdot d \cdot \cos \theta$$
\[ W_{fr} = F_{fr} \cdot d \cdot \cos \Theta \]
\[ = (50) (40) (\cos 180) \]
\[ = -2000 \text{ J} \]
\[ W_{net} = W_p + W_{fr} \]
\[ = 3200 - 2000 \]
\[ = 1200 \text{ J} \]

Energy

There are different types of energy. In the universe, there is a definite amount of energy and all the things we see are due to the continuous conversion of energy into different forms. Throughout this, energy is always conserved. This 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 follows:

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

\[ KE = \frac{1}{2} (mv^2) \quad W_{net} = \Delta KE = ((1/2)m(v_2)^2) - ((1/2)m(v_1)^2) \]

**Gravitational Potential Energy:** this 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.

\[ PE_g = mgh \quad W = mg(h_2 - h_1) \]

**Elastic Potential Energy:** this 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.

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The force does work on the spring to compress it, which gives it the 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

**Example:**

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?

**Solution:**

\[
E_{\text{before}} = E_{\text{after}}
\]

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

\[
v = \left[\frac{(1/2) (250)(-0.06)^2}{(1/2)(0.1)}\right]^{\frac{1}{2}}
\]

\[
v = 3 \text{ m/s}
\]
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?

THINGS YOU MAY STRUGGLE WITH

1. The concept of work and separating the physics definition from the general definition we have for work. In physics, remember that for work to be done on an object, the net force exerted must cause a non-zero net displacement on the object. If the position of the object remains unchanged or if the object returns to the same position. The net work for that system is zero.

2. Analyzing a system in terms of change in energy and applying the concept of conservation of energy. Remember to start your problems as energy before must equal the energy after.

3. Seeing where work goes in the equations for conservation of energy. Work will cause a change in the energy for a system and will be converted into a different type of energy. So work is the change in kinetic or potential energy for system. Whenever there is a net force causing a change in the motion for an object in a system, work will be involved in that part of equation (energy before vs energy after).

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

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