Physics 1408/1420

Aman Patel

Hello Fellow Physicists

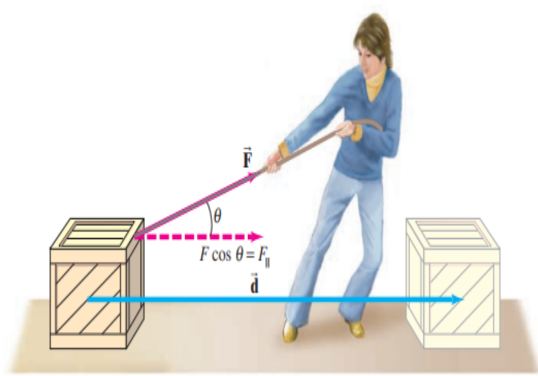
I am Aman Patel, the Master Tutor for Physics this semester. I have created this resource document to help you review some of the topics you have been introduced to this semester to better prepare for your Final in physics

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

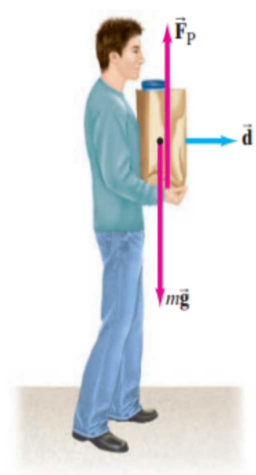
Important Notes

Important Conventions

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 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



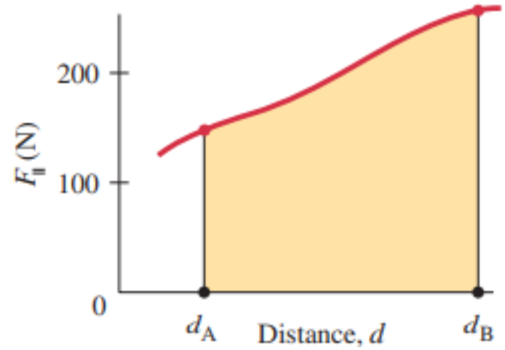
$$W = F_{parallel} \cdot d$$

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

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

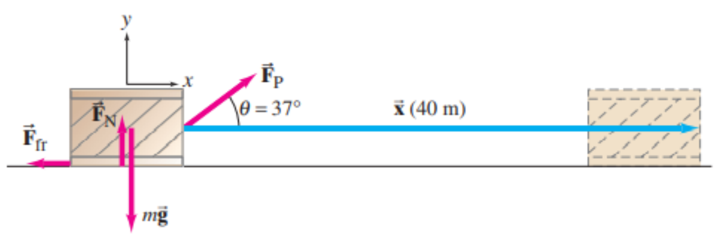
When looking at varying forces, which is depicted by a graph. The work done will be the area under the graph.

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° 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

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

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

$= 3200$ 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. 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 follow

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.

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

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.

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

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

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

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

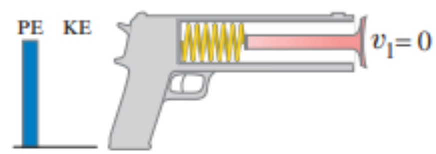
When working with energy, we assume that all the forces in play are conservative forces. So, the mechanical energy, all the energy of the system, is conserved. It neither increases nor decreases.

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

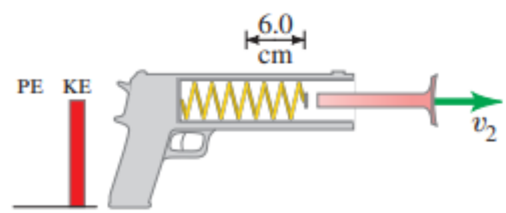
Let's look at an example

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?



(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

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