Unit 3 – Work, Energy & Power

Unit 3A – Work

(A) Introduction

In the first two units, we utilized Newton's laws to analyze the motion of objects. Force and mass information were used to determine the acceleration of an object. Acceleration information was subsequently used to determine information about the velocity or displacement of an object after a given period of time.

In this unit, an entirely different model will be used to analyze the motion of objects. Motion will be approached from the perspective of work and energy. The affect that work has upon the energy of an object (or system of objects) will be investigated; the resulting velocity and/or height of the object can then be predicted from energy information.

In order to understand this work-energy approach to the analysis of motion, it is important to first have a solid understanding of a few basic terms. Thus, Lesson 1 of this unit will focus on the definitions and meanings of such terms as work, mechanical energy, potential energy, kinetic energy, and power.

(2) Work

When ____,
it is said that **work** was done upon the object.

There are three key *ingredients* to work - ____.

In order for a force to qualify as having done *work* on an object, there must a

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Read the following four statements and determine whether or not they represent examples of work.

1. A teacher applies a force to a wall and becomes exhausted.

2. A book falls off a table and free falls to the ground.

3. A waiter carries a tray full of meals above his head by one arm straight across the room at constant speed.

4. A rocket accelerates through space.

(3) Work Formula

Mathematically, work can be expressed by the following equation ➔ ______________________________.

where **F** is __________________, **d** is _____________________, and the angle (θ = **theta**) is defined as the angle between ____.

Scenario A: A force acts rightward upon an object as it is displaced rightward. In such an instance, the force vector and the displacement vector are ________________________. Thus, the angle between **F** and **d** is 0 degrees and so **W** = **Fd**

Scenario B: A force acts leftward upon an object which is displaced rightward. In such an instance, the force vector and the displacement vector are in ______________________. Thus, the angle between **F** and **d** is 180 degrees. So **W** = **Fd** x -1 = **-Fd** and we get __________________________________.

On occasion, a force acts upon a moving object to ____. In such instances, the force acts in the direction ____ in order to slow it down. The force doesn't cause the displacement but rather ____________________ it. These situations involve what is commonly called *negative work*.

Scenario C: A force acts upward on an object as it is displaced rightward. In such an instance, the force vector and the displacement vector are at right angles to each other. Thus, the angle between **F** and **d** is 90 degrees. So **W** = **Fd** x 0 = 0 and we get NO work?!?!?!?

A vertical force can __________________________ cause a horizontal displacement; thus, a vertical force does ______________________________on a horizontally displaced object!!

(4) Units of Work

In the case of work (and also energy), the standard metric unit is the **Joule** (abbreviated **J**). One Joule is equivalent to one Newton of force causing a displacement of one meter. In other words,
The Joule is the unit of work.
1 Joule = 1 Newton * 1 meter
1 J = 1 N * m

(5) Examples of Work Calculations

1. How much work is done by a crane that lowers 1,000 newtons of material a distance of 150 meters?

2. How much work is done when a 1 kilogram mass is raised a vertical distance of 1 meter?

3. A 49 newton rock is lifted 2 meters in 5 seconds. How much work is done?

4. A teacher pushed a 98 newton desk across a floor for a distance of 5 meters. She exerted a horizontal force of 20 newtons. How much work was done?

5. A weight lifter lifts a 1000 newton barbell above his head from the floor to a height of 2.5 meters. He holds the barbell there for 5 seconds. How much work does he do during that 5 second interval?

6. A student who weighs 500 newtons climbed the stairs from the first floor to the third floor, 15 meters above, in 20 seconds. How much work did she do?

7. A woman lifts a 300 newton child a distance of 1.5 meters and carries her forward for 6.5 meters. How much total work does the woman do in lifting and carrying the child?