Physical Science Chapter 7-

Work and Simple Machines

**Work and Mechanical Advantage**

**Mechanical Work**

1. Basics
   1. The exchange of energy for some change in a physical system
   2. A scalar quantity
   3. Symbolized by W and measured in joules
   4. Three Conditions for work to occur
      1. A force must be applied
      2. The object must move
      3. The object in the direction of motion
   5. When work is done on a system, it gains energy
   6. Work= force x distance  
       W=Fd

**Power**

1. Basics
   1. Power is the rate of work. It is how fast the energy is released.
   2. The unit of power is the watt
   3. Power= work/time  
      Power= force x distance/ time
   4. A machine doing more work in the same amount of time or the same work in less time than another machine has more power.

**Simple Machines**

1. Basics
   1. Simple Machines can help do work faster and easier
   2. They help reduce the toll of work caused by the curse on fallen man
   3. They do not change the amount of work necessary to do the job
2. Types
   1. Levers
   2. Wheels and axels
   3. Inclined planes

**Efficiency**

1. Basics
   1. Theoretically, a machine can be no more than 100% efficient
   2. Practically, a machine must be less that 100% efficient
   3. Efficiency is expressed as a percentage using the formula  
       Wout/Win x100

**Distance Principle**

1. Basics
   1. Machines make work easier by reducing the amount of force needed to do the work
   2. W=Fd
      1. If the W stays the same and F decreases, d must increase
      2. So the force is reduced by exerting that force over a longer distance

**Mechanical Advantage**

1. Basics
   1. The reduction of force is called the Mechanical Advantage (MA)
   2. MA has no unit
2. Types
   1. Actual Mechanical Advantage (AMA)
      1. To calculate the AMA, use:   
         weight = resistance = Fr  
          force effort Fe
      2. The AMA shows the helpfulness or usefulness of a machine
      3. The AMA includes the effects of friction
      4. If we assume that there is no friction (often) the we are computing the IMA
      5. The AMA will always be less that the IMA
   2. Ideal Mechanical Advantage (IMA)

**Levers and the Law of Moments**

**Lever**

1. Definition and Terms
   1. A rigid bar that turns around a point
   2. The fixed point is called the pivot point
   3. A common lever is a see-saw
   4. ***If the weights and positions of people on a seesaw are balanced, the see-saw is said to be in a state of*** **rotational equilibrium**
   5. Any time a force acts perpendicularly on a rotating lever, it produces a quantity called a **moment** or **torque**

**The Law of Moments**

1. Formula
   1. The formula for the law of moments is  
       w1l1=w2l2
      1. w= weight in N
      2. l= Distance from the fulcrum (m)
2. Terms and Application
   1. The l can also be called the **torque arm** or **moment arm**
   2. When a see-saw is balanced, the torques are equal

**First-Class Levers**

1. Definition
   1. In first-class levers, the fulcrum is in the middle
   2. The push (effort) is at one end
   3. The weight (resistance) is at the other
   4. Ex: see-saw
2. Terms
   1. The side on which the push occurs is called the effort arm
   2. The side on which the weight is found is called the resistance arm
   3. The Law of Moments allows us to solve problems involving levers
   4. First-class levers have an IMA of less than one, one, or greater than one depending on the lengths of the moment arms
   5. If they are unequal, one side has an MA>1 and the other side has and MA<1
   6. MA= Resistance  
       Effort

**Second-Class Levers**

1. Definition
   1. A second-class lever has the resistance in the middle
   2. Ex: Door hinge, wheelbarrow
   3. The MA of second-class levers will always be greater than one because the effort arm is longer than the resistance arm
   4. MA= Effort  
       Resistance
   5. MA>1
   6. Second-class levers allow for a smaller effort by exerting that force over a longer distance

**Third-Class Levers**

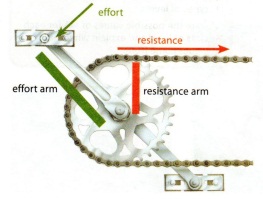
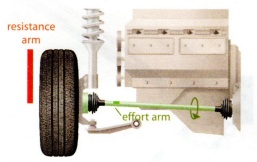
1. Definition
   1. A third-class lever has an effort applied between the fulcrum and the resistance
   2. Because this makes the effort arm shorter, the MA is always less than one
   3. A MA that is less than one multiplies the amount of effort motion
   4. A MA that is greater than one multiplies the effort force
   5. MA= Effort   
       Resistance
   6. MA<1

**Wheels, Gears, & Pulleys**

1. Introduction
   1. In many cases, a lever’s motion is restricted
   2. Other simple machines do not have this limitation

**Wheel and Axle**

1. Definition and Terms
   1. A rotating object where the force is applied at some distance from the axis
   2. This turning force creates a moment or torque
   3. The effort arm is the distance from the center to the applied force
   4. The resistance arm is the distance from the center to the resistance

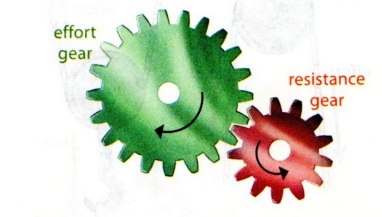
Effort Resistance ↑

The effort arm is from the center of the axle to the outside

* 1. Any device with a handle that turns in a circular direction is most likely a wheel and axle
  2. IMA= Effort  
      Resistance

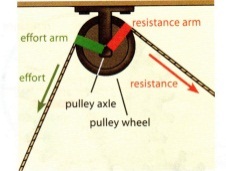
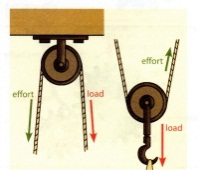
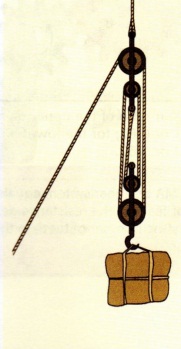
**Gears**

1. Definition and Terms
   1. Gears are wheel and axle combinations with notches or teeth around the circumference
   2. ***When two gears touch, they always turn in*** **opposite directions**
   3. The IMA of two gears can be determined by the ratio of the number of teeth with the following formula:  
       IMA= Resistance Gear Teeth  
       Effort Gear Teeth

   
 Increases Speed Decreases Speed

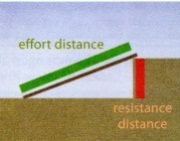
* 1. Gears can also change the direction of motion
  2. Gears can be combined into systems that can be very complex

**Pulleys**

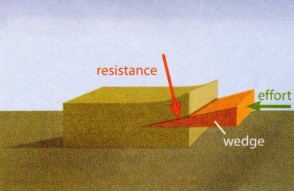
1. Definition and Terms
   1. ***A pulley is a wheel with a groove containing a rope or cable***
   2. The effort arm length and the resistance arm length are the same distance from the center to the outside of the pulley
2. Pulley Types
   1. Single fixed
      1. A single fixed pulley has an IMA of 1
      2. Why do we use it then?
      3. We use it because you are able to use your weight to lift the object
   2. Single Movable
      1. A single movable pulley has an IMA of 2
      2. The rope is supported at both ends, so only half of the weight is at each end
   3. Block and Tackle
      1. A group of pulleys working together is called a **pulley gang** or **block and tackle**
      2. To find the IMA of a block and tackle, count the number of supporting ropes
      3. DO NOT count the section of rope which supplies the effort
      4. Block and tackle greatly increase the MA

**Inclined planes, wedges, and screws**

**Inclined planes**

1. Definition and Terms
   1. ***An*** ***inclined plane or ramp is a tilted surface which allows resistance to be lifted with less effort***
   2. The reduction in effort is accompanied by an increase in force
   3. The AMA of an inclined plane is resistance (weight) divided by the effort
      1. AMA = resistance  
          effort
   4. ****The IMA of an inclined plane is the length of the incline divided by the height of the incline
      1. IMA = length  
            
          height

**Wedge**

1. Definition
   1. A wedge is normally shaped like two inclined planes back-to-back
   2. ****It is used to split an object and it is forced into the object

**Screw**

1. Definition and Terms
   1. A screw is an inclined plane wrapped around a central shaft in a spiral shape
   2. The ridges on a screw shaft are called **threads**
   3. The distance between the threads is called the **pitch**
   4. The lower the pitch, the higher the MA

Test Info

Date: 2/18/13

Room: 208

Instructor: Mr. Jones

Time: 9:15- 10:00