Work & Power

**Work done by a force**

A force can do work on an object if the object moves while the force acts on the object. It is possible for a force to do NO work even though the force acts on a moving object. If the force tends to make the object change speed, (slow down or speed up) then the force does work on the object. Work is a method of transferring energy from one object (the object that does the work) to another object (the object on which the work is done).

Forces: gravity

 normal force

 friction

 spring force

 other contact force

**Work by any force**

The work done by a force :

 work by force: 

*W* – work in joules

*F* – size of the force on the object in newtons

*D* – distance the object moves while the force acts on the object in meters

**- angle the force vector makes with the line of motion of the object

**If the force is in the same direction as the motion** then **and **.

This makes the work equation: .

**If the force is opposite the direction of motion** then **and **.

This makes the work equation: .

**If the force is perpendicular to the direction of motion** then **and **.

This makes the work equation: *W* *= zero*.

A force perpendicular to the direction of motion NEVER does work.

***Work by special forces***

**Work done by gravity**

Gravity does work on an object whenever the object changes height.

 work by gravity: 

*W* – work in joules

*m* – mass of the moving object in kilograms

*g* – acceleration due to gravity, 9.8 m/s2

Δ*h* – how far upward or downward the object moves in meters

**Work done by the normal force**

The normal force **NEVER** does work! work by normal force = zero

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**Work by friction**

Static friction does no work because the object does not move.

Sliding friction always does work on a moving object.

 work by friction: *W = (friction)(distance the object moves)* or 

*W* – work in joules

*f* – size of the friction on the sliding object in newtons

*D* – distance the object moves while friction acts on the object in meters

**Work done by a spring**

The spring transfers elastic energy to an object the spring pushes or pulls on. The energy the spring loses or gains is the work done on the object.

 work by spring: 

*W* – work in joules

*K* – force constant of spring in N/m

*D* – distance the object moves while the spring acts on the object; change in length of the spring in meters

**Work done on an object**

Work is a means of transferring energy from one object to another object. The object that applies the force loses energy and the object on which the force acts gains energy. The energy gained by the moving object is the work done on the object. This energy shows up as a change in the kinetic energy of the moving object.

 **work done on an object = ΔKE of the object = KEafter work – KE before work**

The work done on the object comes from the work done by the forces that act on the object.

 **work done on an object = Σ works done by the forces on the object**

The work done by the forces causes the speed of the object to change. The speed can change by increasing the speed or by decreasing the speed.

When the speed of the object increases, the kinetic energy of the object increases. The work done on the object is **positive work**. Positive work gives energy to the object.

When the speed of the object decreases, the kinetic energy of the object decreases. The work done on the object is **negative work**. Negative work takes energy from the object.

If you use the equation: **work done on an object = Σ works done by the forces on the object**

then you must assign a positive or negative sign to work done by a force before adding the forces.

**Work by a force is given a positive sign if the force tries to speed up the object.**

**Work by a force is given a negative sign if the force tries to slow the object.**

Signs on work by certain forces:

 Work by **friction** is ALWAYS negative.

 Work by **gravity** is positive if the object moves downward.

 negative if the object moves upward.

 Work by a **spring** is positive if the spring pushes or pulls in the direction the object moves.

 negative if the spring pushes or pulls opposite the direction the object moves.

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**Power**

Power is defined as the rate at which work is done or the rate at which energy is transformed. The unit of power is joules per second. This combination of units is given its own name, the watt, whose symbol is W. Power is calculated by the equation:

 OR 

*P* – power in watts, W

*W* – work in joules, J

t – time to do the work in seconds, s

The “power” usually means the power output of an object which does the work. The object that does the work must exert a force on a moving object.

IF object **A** exerts a force on object **B** AND object **B** moves *at constant speed* THEN the power output of object **A** can be calculated using the following equation:

 **power output of object A = (force of object A)(constant speed of object B)**

Power is the *rate* at which work is done by an object.

**More power** **means more work in the same amount of time** **or less time to do the same amount of work.**

Power does not relate directly to force. A less powerful motor may be able to produce a larger force. The size of the force a device can produce is determined by the design of the device. An electric toothbrush may be fairly powerful. The toothbrush produces a small force but moves the bristles of the brush at high speed. The work done may be small but the time to do the work is small also.

The power of a motor does not increase as the time of operation increases. The rate at which work is done remains constant. Operating a motor for a longer amount of time increase the amount of WORK the motor does.