Work and Energy

Objectives:

- Students will be able to explain what work is and what energy does
- Students will understand energy storage and transfer and be able to describe examples of each
- Students will be able to relate force, displacement, and work
- Students will be able to solve problems involving work, force, kinetic energy, displacement, and velocity

What is energy?

We often refer to energy as "the ability to do work".

No one really knows WHAT it is ... but it is useful and it can be:

1. Stored (in one object or entity)
2. Transferred (to another object or entity)

Energy has NO DIRECTION (+/- indicates an increase or decrease, not a direction along an axis)

Energy Transfers	Energy Storages
WORK Transmission of the energy of one object to a 2nd object via the application of a force	KINETIC ENERGY KE = (1/2) mv^2 $= \frac{1}{2}mv^2$ (energy stored in motion)
HEAT A transfer of internal energy from one object to another	POTENTIAL ENERGY (PE) Gravitational (GPE) Elastic (EPE) Chemical Nuclear
ELECTROMAGNETIC RADIATION	INTERNAL ENERGY Energy associated with the motion of an object's molecules, not its bulk motion.
SOUND	
CHEMICAL REACTIONS	
ELKTRICAL CIRCUITS	

...ETIC

SOUND

CHEMICAL REACTIONS

ELELCTRICAL CIRCUITS

Energy ...
motion of an object's ...
not its bulk motion.

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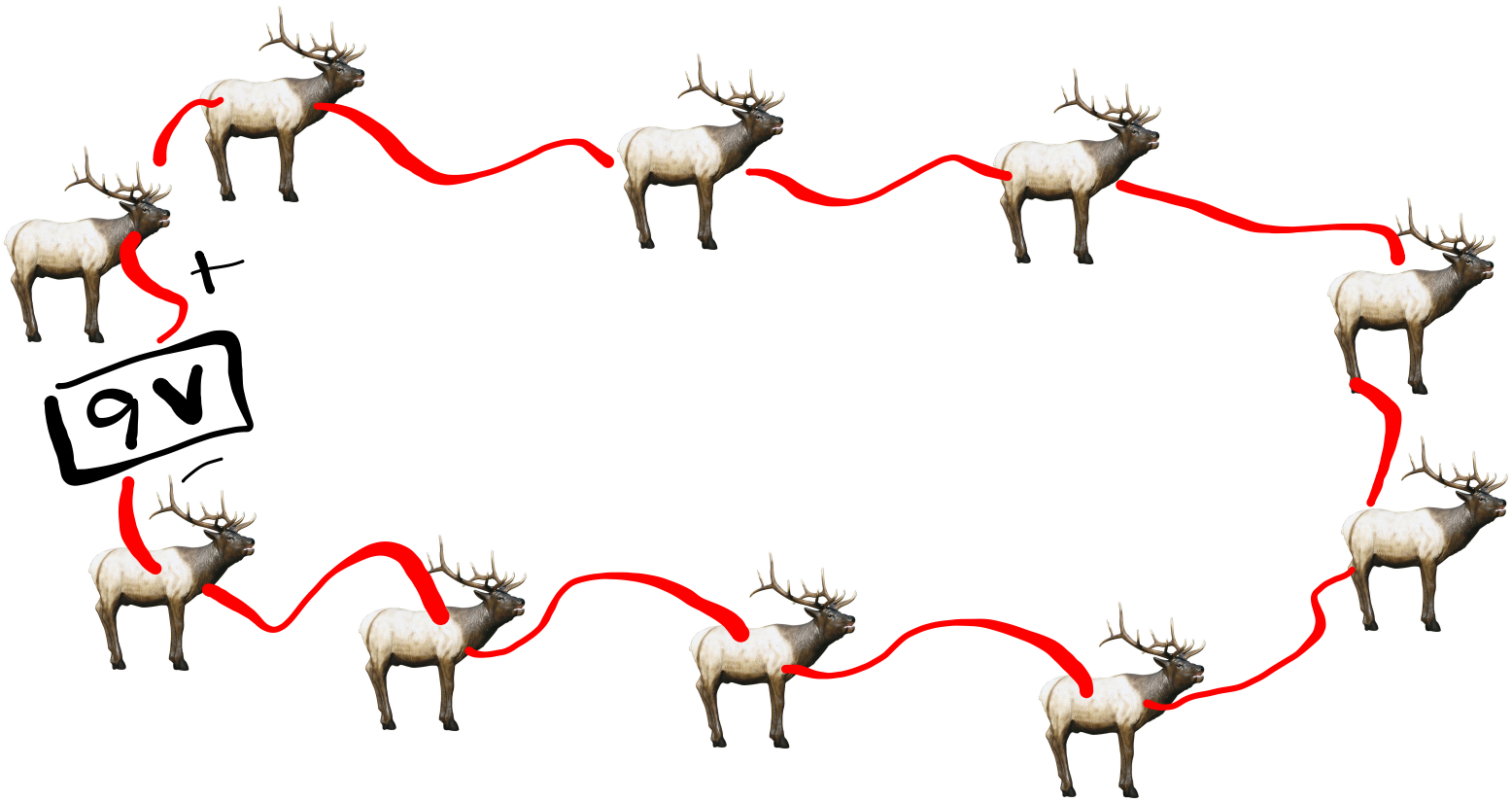
WORK (In Physics)

When a force is exerted over a displacement.

$W = F \times d$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WORK (In Physics)

The energy transferred from one object to another through a force that changes the motion of the second object.

$$\text{WORK} = W = F_{\parallel} \times d = \text{Energy}$$

$F_{\parallel}$ = the force between objects parallel to their movement (N)
d = the displacement over which the force is applied (m)

The force must be applied in the direction of the displacement. When these two things are not colinear, only consider the component of the force parallel to movement.

Units for Work (and Energy): N x m = Joule (J)

1 J = .7376 lbs x ft

$F = m \cdot a$

$= kg \cdot m/s^2$

$W = F \cdot d$

$= \frac{kg\ m}{s^2} \cdot m = \boxed{\frac{kg\ m^2}{s^2}} \Rightarrow 1$ Joule

Work has NO DIRECTION! +/- indicate whether an object is the receiver or giver of energy that is transferred through work.

WORK: energy is transferred FROM one object TO another ... (there is an exchange! so the sign depends on the object)

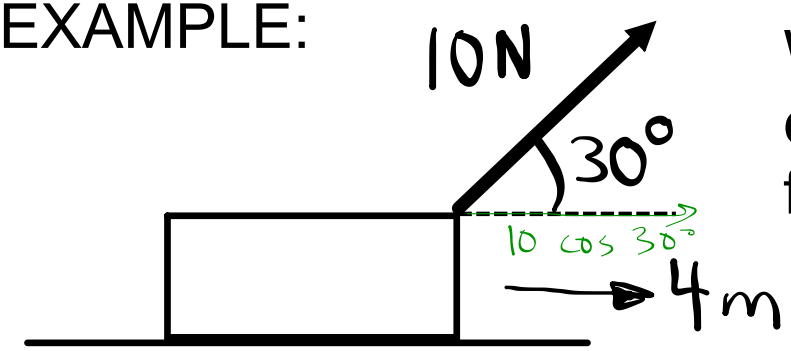
When an object experiences a force in the same direction as its motion:

- Work is done TO the object
- Work will be a positive quantity (DIRECTIONLESS!)
- Energy is being transferred into the object (e.g. its KE increases)

When an object experiences a force in the opposite direction as its motion:

- Work is done BY the object
- Work will be a negative quantity (DIRECTIONLESS!)
- The object transfers energy into something else (e.g. its KE decreases)

EXAMPLE:



What work does the 10 N force do on this mass? Assume no friction.

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

$W = (10 \cos 30)(4)$

$= 34.64 \text{ J}$

If net work is done on an object, we should expect the energy stored in the object to change. If the only form of energy storage available is kinetic energy, the following equation will be true:

Work done to an object = change in kinetic energy

$W = \Delta KE$

$$W = \frac{1}{2}mv^2 - \frac{1}{2}mv_0^2$$

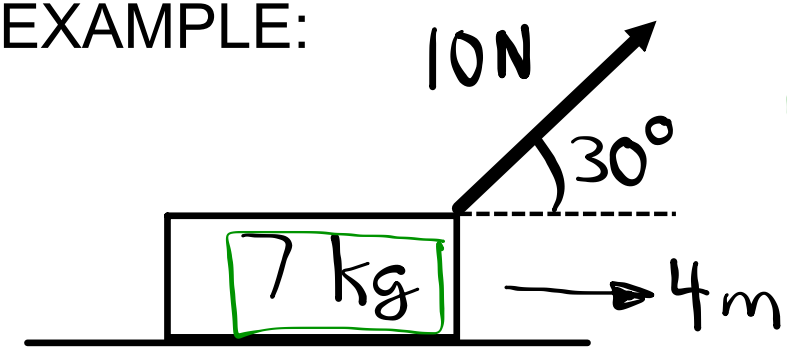
Work - KE theorem

BE VERY SPECIFIC WHEN TALKING ABOUT WORK:

All these are different concepts (although they may have the same value!):

- **Work done on an object** (work is potentially done by each force acting on an object)
- **Work done by an object** (on something else)
- **Net work done on an object** (by all forces acting on the object)
- **Total work done on an object** (aka net work)

EXAMPLE:



If the mass is initially moving at 5 m/s to the right as the 10 N force acts on this mass, how fast is it moving when it has travelled the four meters? Assume no friction and no other forms of energy storage besides kinetic energy.

Work-KE theorem:

$$W = \Delta KE = \frac{1}{2}mv^2 - \frac{1}{2}mv_0^2$$

$$34.64\,J = \frac{1}{2}(7)v^2 - \frac{1}{2}(7)(5^2)$$

v

Homework Hint:

"Minimum work" exists when there is

NO ACCELERATION.

W = Fd so ...

Minimum work means minimum force.

means...
constant velocity...
OVERALL work is ∅

The minimum force is the smallest force necessary to keep an object moving in order to achieve the necessary displacement.