Work, Force and Displacement

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Work: is done whenever a force makes something move over a distance.

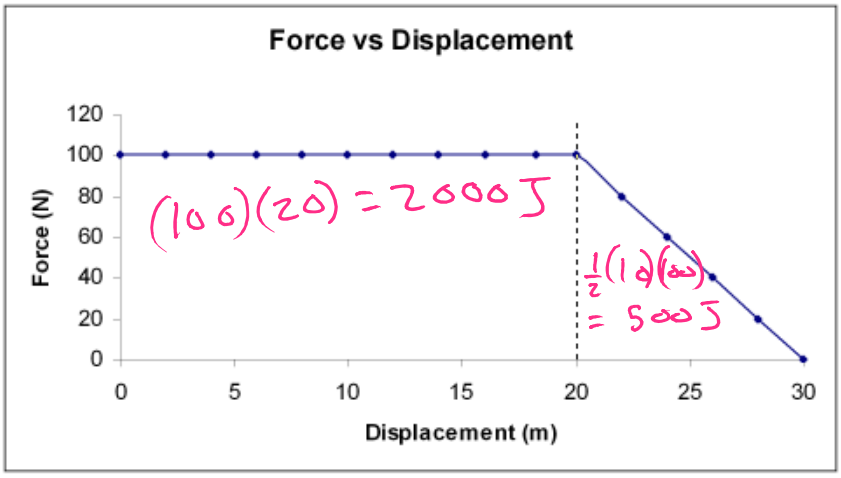
Work (Scalar)
Symbol: W
Unit: Joule (J) - no direction

$$W=F\cdot d$$

(the force needs to be parallel to the distance moved)

If 1 N of force moves an object 1 m, then 1 J of work has been done. Work is only done if the object moves.

A Force vs. Displacement graph can indicate the work done.



Find the Area to find the Work

According to the graph, how much work has been done? over the 30m?

$$(100)(20) + \tfrac{1}{2}(10)(100) = 2500\ J$$

minimum

$a=0$

Question: What work is done by lifting a 5 kg object on the moon, 2 meters? (g=1.6 N/kg)

$W = F\cdot d$

$= F_g \cdot d$

To lift an object you must fight against gravity

$= (5)(1.6)(2)$

$W = 16\,J$

$F_A - F_g = ma$ ($a = 0$)

$F_A = F_g$

Power: is the rate of doing work. Rate means the change in something per unit time. Acceleration is the rate at which velocity changes. Velocity is the rate at which distance changes.

Power (Scalar)
Symbol: P
Unit: watt (W) - no direction

$$P = \frac{W}{t}$$

Power is how fast I can do work!!!!!!!!!

Example: How powerful is person 1 (55 kg) if he runs up a 10 meter staircase in 10 seconds. Who is more powerful, person 2(40 kg) runs up the same staircase in 7 seconds?

(Look at vertical only)

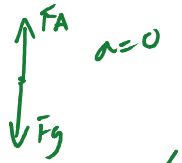
Person 1

$W = F_g \cdot d$

$W = F_g \cdot d$

$= (55)(9.8)(10)$

$W = 5390\,J$



$F_A - F_g = ma$ ($a = 0$)

$F_A = F_g$

Person 2

$W = F_A \cdot d$

$= F_g \cdot d$

$= (40)(9.8)(10)$

$= 3920\,J$

$P = \frac{W}{t}$

$= \frac{5390}{10}$

$P = 539\,W$

$P = \frac{W}{t}$

$= \frac{3920}{7}$

$P = 560\,W$

How high would person 2 have to climb in order to have done the same amount of work? As Person 1

$W = F \cdot d$

$\frac{5390}{(40)(9.8)} = \frac{(40)(9.8)\,d}{40\,(9.8)}$

$13.75\text{m} = d$

How high does Person 1 have to climb to have the same Power output as Person 2 doing the 10 m staircase)

If $P = 560$ and $t = 10\text{sec}$

$P = \frac{W}{t}$

$P \cdot t = W$

$(560)(10) = W$

$5600\text{J} = W$

$W = F \cdot d$

$\frac{5600}{(55)(9.8)} = \frac{(55)(9.8)(d)}{(55)(9.8)}$

$d = 10.4\text{m}$

Energy: is the ability to produce a change in itself or its surroundings. Also energy is the ability to do work.
Each time work is done, energy is transferred from the object doing the work to the object being worked on. Work is the transfer of energy.
It is convenient to measure both work and energy in the same unit, the joule.

Energy (Scalar)
Symbol: E
Unit: Joule (J) - no direction

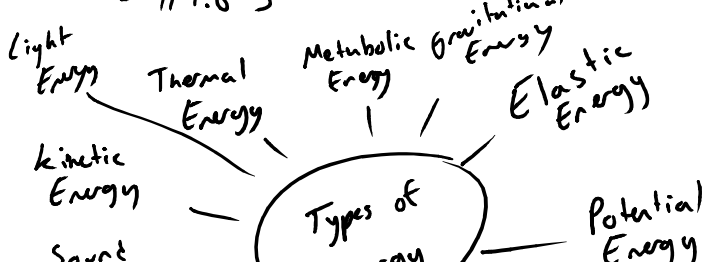
$$W = \Delta E = E_f - E_i$$

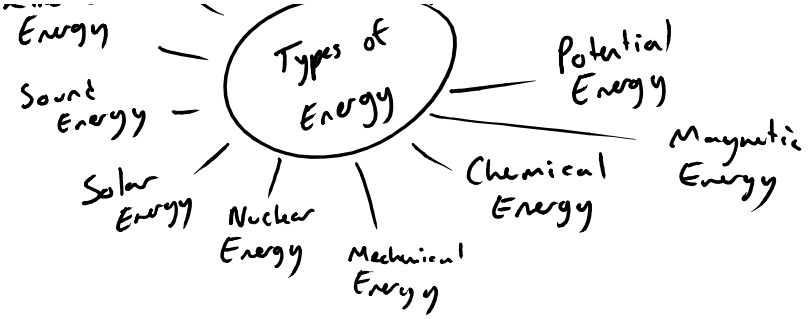
If you do 5000 J of work on an object, you have transferred 5000 J of your energy to it. Doing work on an object increases its energy.

Ex: If we lift an object (3 kg), 4m How much energy have we use?

$W = F \cdot d$
$= F_g \cdot d$
$= mgd$
$W = (3)(9.8)(4)$
$= 117.6\text{ J}$

$\Delta E = W$
$\Delta E = 117.6\text{ J}$

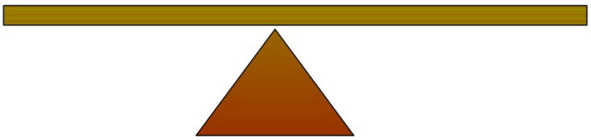




Energy cannot be created or destroyed, but it can be transformed from one kind of energy to another.

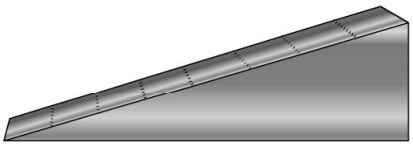
1. Gravitational Potential Energy: any raised object, has energy and can do work as it falls.
2. Kinetic Energy: Any moving object, such as a fast-moving baseball, has energy and can do work on any object it hits.
3. Heat Energy: Hot objects have energy and can do work. Boiling water produces steam which can turn a steam turbine (force).
4. Chemical Potential Energy
5. Elastic Energy
6. Light
7. Electrical Energy
8. Nuclear Energy

Simple Machines ease the load either by changing the magnitude or the direction of a force, but does not change the amount of work done.

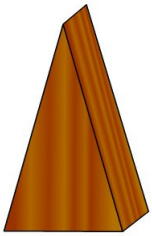


LEVER

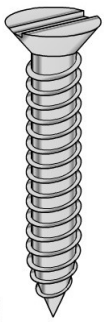
PULLEY



INCLINED PLANE



WEDGE



SCREW

Efficiency is the ratio of the work done by the machine to the work put into the machine.

$$\text{Efficiency} = \frac{W_{Output}}{W_{Input}} \times 100\%$$

Efficiency

Symbol: ε

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Symbol: ε

Units: %

$$\varepsilon = \frac{P_{out}}{P_{in}} \times 100\%$$

I buy a 1000 w motor that is 70% eff. How long does it take to raise 20 kg, 5 meters?

$P_{in} = 1000\,W$

$\varepsilon = \frac{P_{out}}{P_{in}}$

$0.7 = \frac{P_{out}}{1000}$

$700\,W = P_{out}$

$P = \frac{W}{t}$

$W = \Delta E = \Delta PE$

$W = mg\Delta h$

$= (20)(9.8)(5)$

$W = 980\,J$

$P = \frac{W}{t}$

$700 = \frac{980}{t}$

$t = \frac{980}{700}$

$t = 1.4\,sec$

An ideal machine has equal output and input work, $W_O/W_I=1$ and the efficiency is 100%. Machines lose efficiency due to friction.

Homework: Page 213. Section 10.1 (Work)Q 1-7,12,13,16,
(Power) Q 17,18,19,20,21,25,26,27,28
(Efficiency) Q 30,33,34