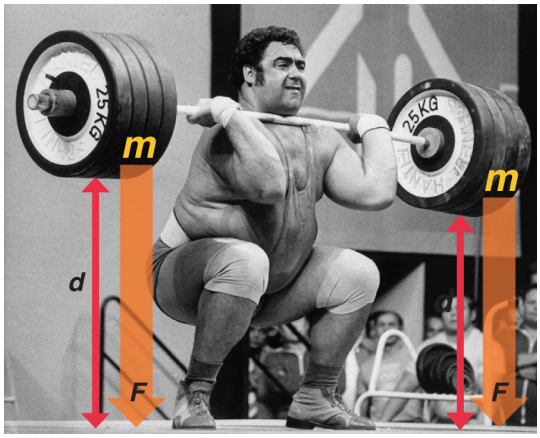
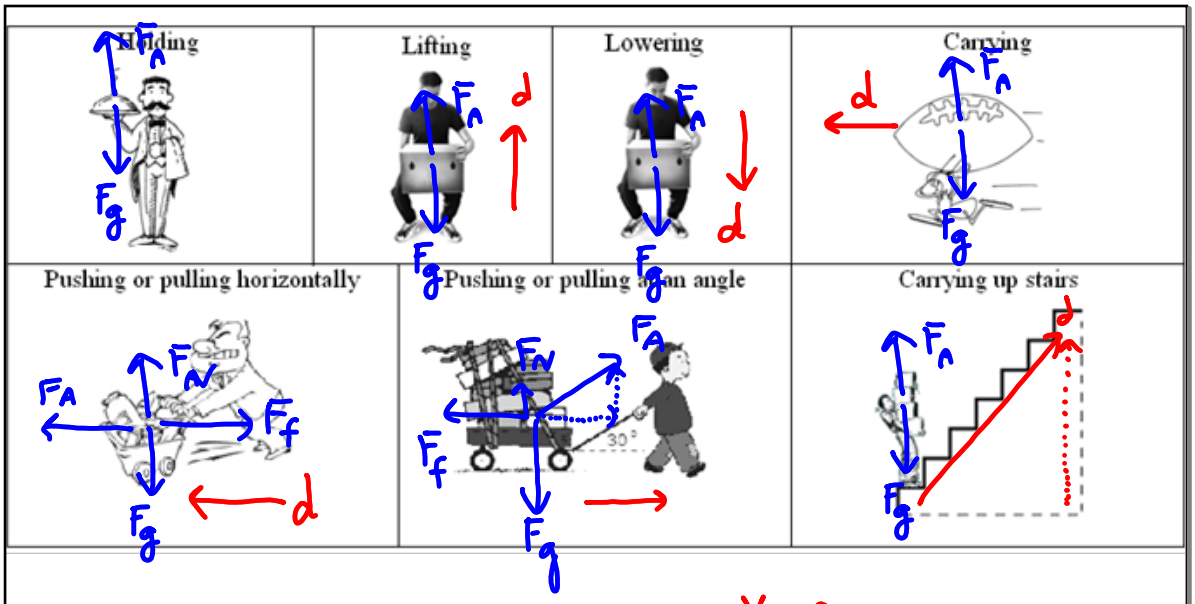
Work and Energy





Work:

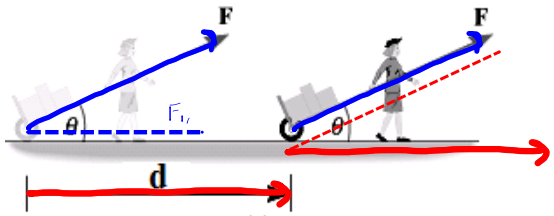
1) Product of a force and the component of the displacement in the direction of the force.

2) Product of a displacement and the component of the force in the direction of the displacement.

Formula:

$$W = \vec{F} \cdot \vec{d}$$

$$= F \cdot d \cdot \cos\theta$$



$$W = \int \vec{F} \cdot d\vec{s}$$

W	F	d	θ
Work	Force	displacement	angle between $\vec{F}$ & $\vec{d}$
$[N \cdot m] = [J]$	$[N]$	$[m]$	
scalar	vector	vector	

1. Work is a scalar but it can be positive or negative. Explain.

Positive Work:

force and displacement are in same direction
($\theta = 0^o$)

Negative Work:

force and displacement are in opposite directions
($\theta = 180^o$)

2. Express the units for work in terms of fundamental units.

$$[J] = [N \cdot m] = \left[kg \frac{m^2}{s^2}\right]$$

Power:

a) the rate at which work is done

b) the rate at which energy is transferred or transformed

Formula:

$$P = \frac{W}{t} \text{ or } \frac{\Delta E}{t} = \frac{F \cdot d}{t}$$

Alternate Formula:

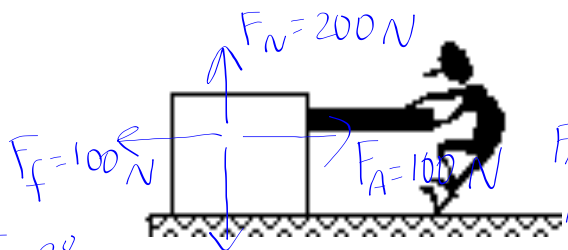
$$P = F \cdot \vec{v}$$

P	W	t
power	work	time
$[J/s] = [W]$	$[J]$	$[s]$
scalar	scalar	scalar

1. Express the units for power in terms of fundamental units.

$$[W] = [kg\ m^2/s^3]$$

2. A student drags a 20.0 kg box horizontally across the floor at a constant speed for a distance of 3.00 meters by applying a force of 100. newtons for 8.0 seconds. Calculate how much work the student did and how much power was dissipated.



$W = F \cdot d \cos\theta$

$F_n: \; 100N \cdot 3m$

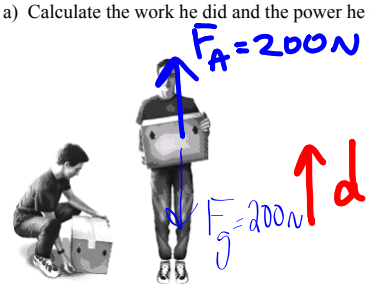
$F_f: \; -100N \cdot 3m$

$F_g, F_N: \cos 90 = 0 \rightarrow 0$

$P = \frac{W}{t} = \frac{300J}{8s} = 38w$

3. The student then lifts the same 20.0 kilogram box 1.50 meters straight up in the air in 4.0 seconds at a constant speed.

a) Calculate the work he did and the power he used.



300J

75 w

$W = F \cdot d$

$= 200N \cdot 1.5m$

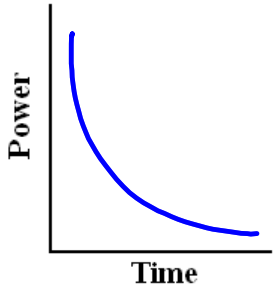
NOTE: When lifting or lowering an object at a constant speed . . .

The applied force is equal to the force of gravity (weight) of the object.

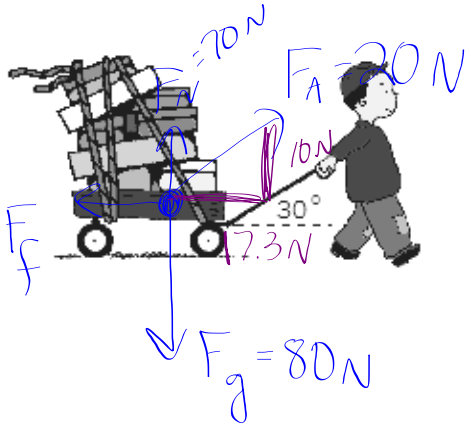
b) A second student lifted the same box to the same height at a constant speed but in only 2.0 seconds. Compare the work she did and the power she generated to those of the first student.

300 J

150 W



4. If a child drags a 8.0 kilogram wagon for 10. meters by using a force of 20. newtons at an angle of 30.° with the horizontal, how much work does he do?

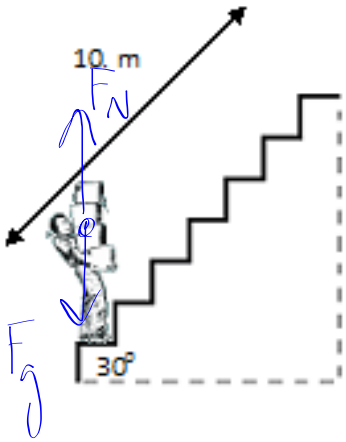


$W = F \cdot d \cdot \cos\theta$

$20\,N \cdot 10\,m \cdot \cos 30^\circ$

$= 173\,J$

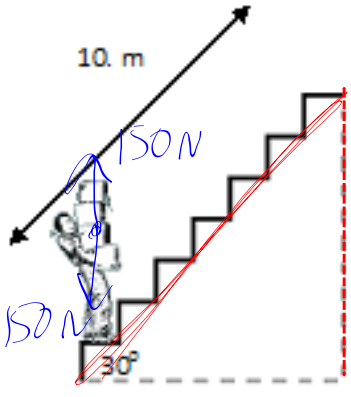
5. A student carries 150. newtons worth of books 10. meters up a flight of stairs which are inclined at an angle of 30^0 from the horizontal. How much work does he do?



$F \cdot d \cdot \cos\theta$

$150\,N \cdot 10\,m \cdot \cos 60^\circ$

$= 750\,J$



$d_{\perp} = d \sin 30^\circ$

$\Rightarrow F \cdot d \sin 30^\circ$

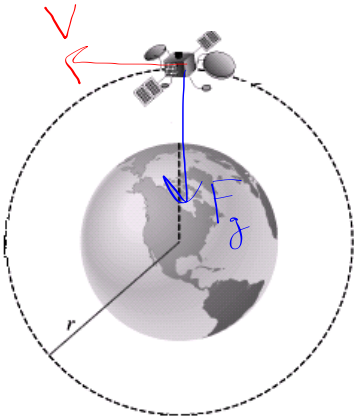
$150\,N \cdot 10\,m \cdot \sin 30^\circ = 750\,J$

6. How much work is done on a 120.-kilogram satellite as it orbits the Earth?

centripetal forces never do work

F is in, V is tangent

cos (90) = 0



Efficiency:

the ratio of the amount of useful work done to the amount of total work done

Formula: