Chapter 5. Work & Energy

In everyday terms, **work** is defined as:

> *to do something that takes physical or mental effort*

However in science, **work** is defined as:

> *the product of the component of a force along the direction of a displacement and the magnitude of the displacement*

$$\text{Work} = \text{Force} \cdot \text{displacement}$$

if $d = 0$ then $W = 0$

Work is not done on an object unless the object is moved with the action of a force. Meaning that simply applying a force does not constitute that work is being done.

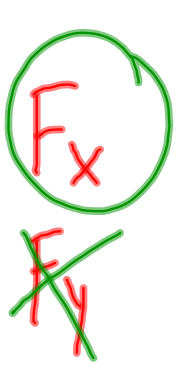
ie: A student is holding a chair at arm's length. A force is being exerted to support the chair, however the chair does not move. Is work being done?

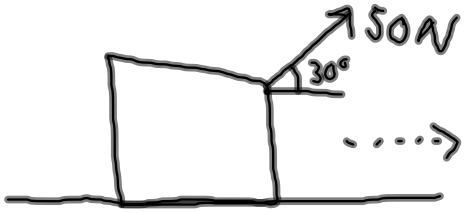
Work is done only when components of a force are parallel to a displacement.

force and displacement in same direction!

When force on an object and the object's displacement are in different directions, only the component of the force that is parallel to the object's displacement does work.

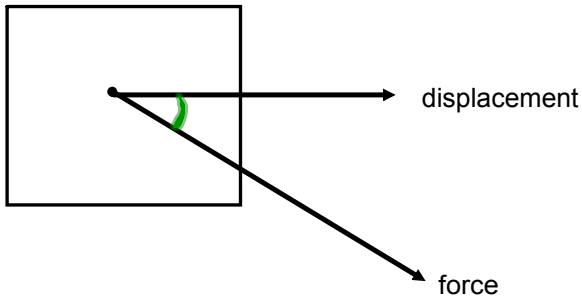
Perpendicular components of the force do not do work.





if d is along X axis

Example:



You need to resolve the force into *x* and *y* components. Only the component parallel to the displacement (*x* for this example) is doing work.

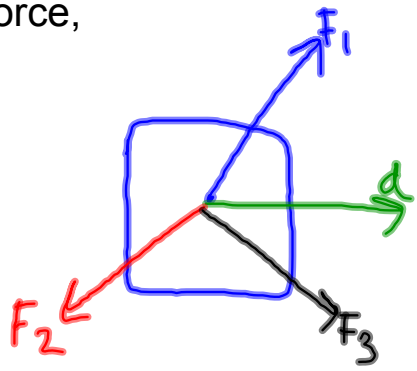
To solve for the work done on the box, use the equation:

$F\cos\theta = F_x$

$W = Fd \cos \theta$

To solve for Net Work done by a constant force,

$$W_{net} = F_{net} \cdot d \cdot \cos\theta$$



Use if many constant forces are acting upon an object.
First find net force and then solve for net work.

Work has dimensions of force x length

N x m

Joule (J)

Problem 1:

How much work is done on a vacuum cleaner pulled 3.0 m by a force of 50.0 N at an angle of 30 degrees above the horizontal?

F = 50 N

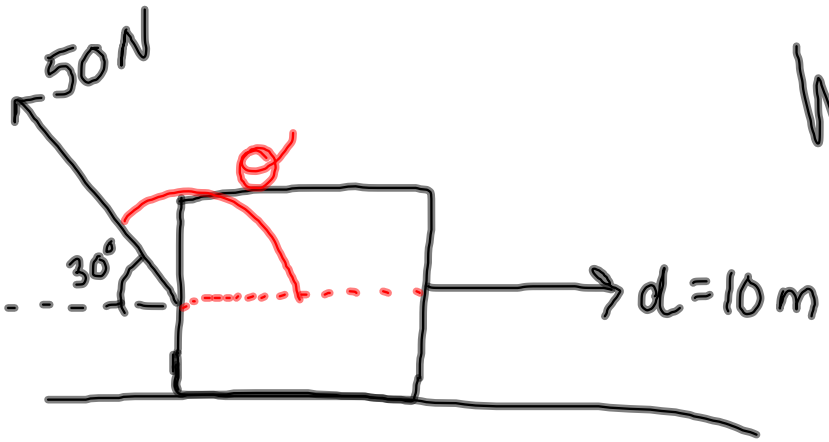
θ = 30

d = 3.0 m

W = ?

$W = Fd\cos\theta$

$W = 130\,J$



$W_{50} = ? = -433\,J$

$W = Fd\cos\theta$

$F = 50N$

$d = 10$

$\theta = 150°$

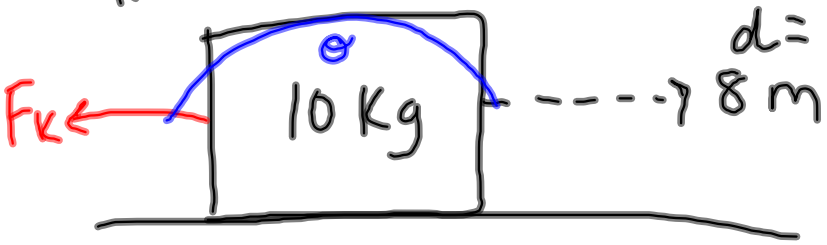
$50(10)\cos 150$

The sign of work is important.

Work is scalar and can be positive (+) or negative (-).

Force is in direction of motion	Positive work
Force opposes motion	Negative work
Force is 90^{o} to motion	No work
Object is not in motion	No work

$W_{F_K} = ?$



$\mu_K = 0.3$

$F_K = \mu_K F_N$

$= \mu_K m g$

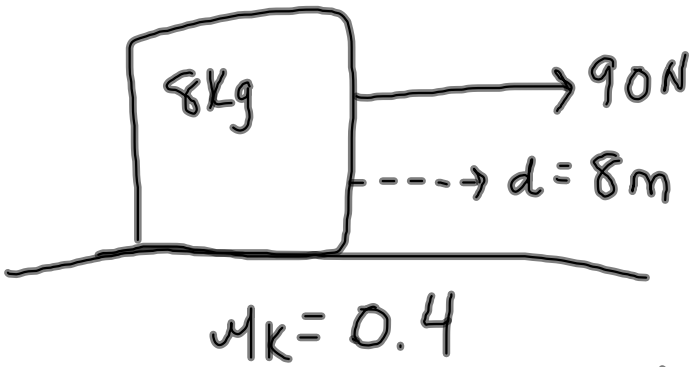
$= .3(10)(9.81)$

$F_K = 29.4 N$

$W = F_K d \cos\theta$

$29.4(8)\cos 180$

$W_{F_K} = -235.2 J$



a) $W_{90} = ?$

b) $W_{F_N} = ?$

c) $W_{gravity} = ?$

d) $W_{F_f} = ?$

e) $W_{net} = ?$

$$W_{net} = W_{90} + W_{F_N} + W_{F_g} + W_{F_f}$$

$$= 720 + 0 + 0 + -250$$

$$W_{net} = 469\ J$$

a) $W = F d \cos\theta$

$= 90(8)\cos 0$

$W_{90} = 720\,J$

b) $W_{F_n} = F_N d \cos\theta$

$= (78.5)\,8 \cos 90$

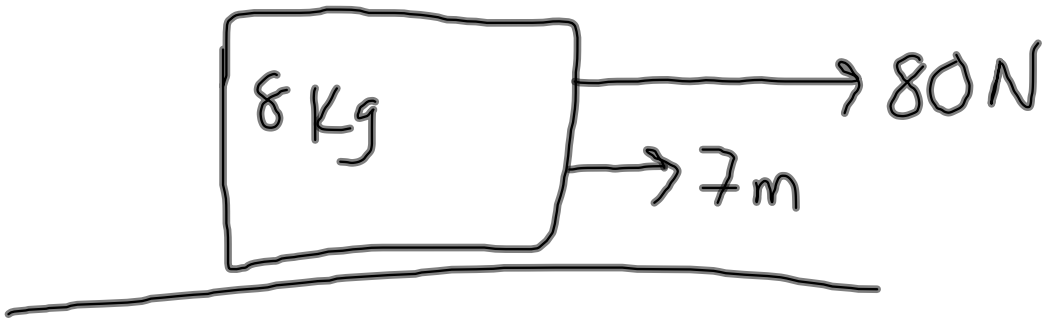
$W_{Fn} = 0\,J$

c) $W_{gravity} = 0\,J$

d) $W_f = F_K d \cos\theta$

$= (31.39)\,8 \cos 180$

$W_f = -250\,J$



$\mu_k = 0.3$

a) $W_{80} = ?$

b) $W_{FN} = ?$

c) $W_{Fg} = ?$

d) $W_{Fk} = ?$

e) $W_{net} = ?$

a) $W_{80} = F d \cos\theta$

$= 80(7)\cos 0$

$= 560\,J$

b) $W_{Fn} = 0\,J$

c) $W_{Fg} = 0\,J$

d) $W_{Fk} = F_k d \cos\theta$

$= -1$