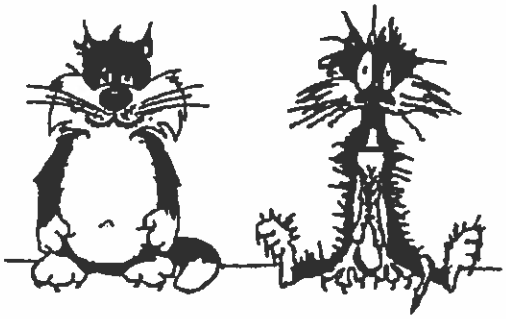
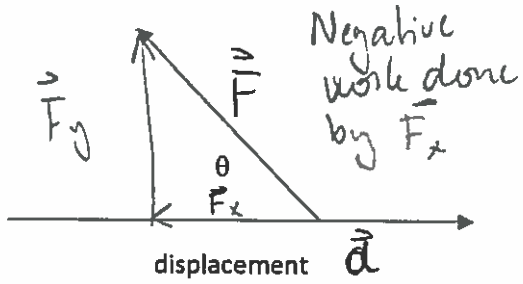
Notes

WORK

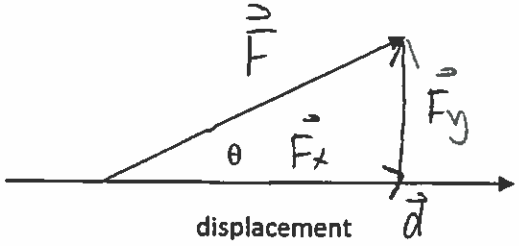


Before Work **After Work**



Negative work done by $\vec{F}_x$

(Positive) work done by $\vec{F}_x$



The work done by a force $\vec{F}$ that is acting on an object that undergoes displacement $\vec{d}$ is given by a dot product of the two vectors:

$W = \vec{F}\vec{d}$, when force is parallel with displacement

Work is done only by the component of the force that is parallel with displacement

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

- scalar quantity
- symbol W
- unit JOULE [J] or [N·m]

Negative Work = work done by force whose direction is opposite to the direction of the displacement vector.

Zero Work = 1. $\vec{F} \perp \vec{d}$

2. $\vec{F} = 0N$ [any]

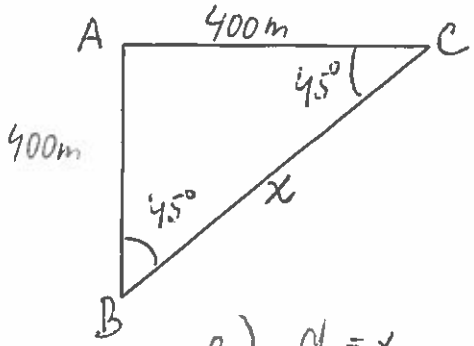
3. $\vec{d} = 0m$ [any]

Example: Find work done by the force of gravity on a 900 kg object displaced as follows:

a) A → B

b) A → C

c) C → B



$\vec{F}_g = mg$
$= 8820\,N\,[D]$

a) $W_{AB} = \vec{F}_g \cdot \vec{d}$
$= (8820)(400)$
$\doteq 3.5 \times 10^6\,J$

b) $W_{AC} = 0\,J$
as $\vec{F}_g \perp \vec{d}$!

c) $d = x$
$= \sqrt{400^2 + 400^2}$
$= \sqrt{320000}\,m$

$W = F\cos\theta d$
$= (8820)(\sqrt{320000})(\cos 45°)$
$= 3.5 \times 10^6\,J$

Practice:

1. Find work done by force 5000 N that moves an object over 3.00 km. What assumptions do you make?

$d = 3000\,m$
$F = 5000\,N$

! Assume $\vec{F} \parallel \vec{d}$.

$W = Fd$
$= 1.5 \times 10^7\,J$

2. a)Find work done by a 750 N force pulling a 20.0-kg object strictly horizontally left over 30.0m.

$\vec{d} = 30.0\,m\,[L]$

$\vec{F} = 750\,N\,[L]$

$W = (750)(30.0)$
$= 2.3 \times 10^4\,J$

5. Where, relative to its initial position, was an object dragged to if force needed was 600 N [left] and work done 750 J?

$W = 750\ J$

$\vec{F} = 600\ N[L]$

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

$= \frac{750}{600}$

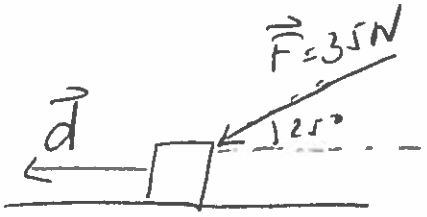
$= 1.25\ m\ [left]$

∴ The object was dragged 1.25 m left from its original position assuming no other forces with a vector component $\parallel \vec{d}$ was acting on the object.

6. Consider a box pushed left on a strictly horizontal floor and moves 50.0m. What work was done if the pushing force of 35 N was applied at an angle of 25° at the top right edge of the box?

$\vec{d} = 50.0\ m\ [L]$

$\vec{F} = 35\ N$ 25° below horizontal



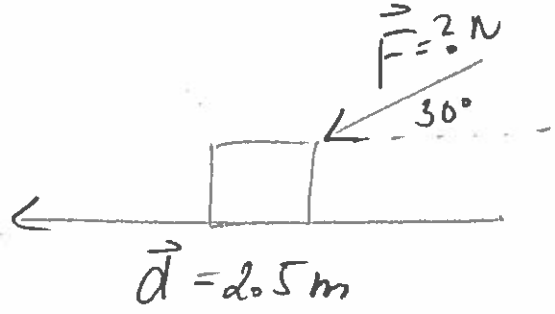
$W = F\cos\theta d$

$= 35(\cos 25°)(50.0)$

$= 1.6 \times 10^3\ J$

∴ Work done was 1.6×10^3 J.

7. How much force at an angle of 30° does one need to apply in order to do work of 5000 J and move an object by 2.5 m?



$W = 5000\ J$

$\frac{W}{\cos\theta d} = \frac{F\cos\theta d}{\cos\theta d}$

$F = \frac{W}{\cos\theta d}$

$= \frac{5000}{(\cos 30°)(2.5)}$

$= 2.3 \times 10^3\ N$

∴ 2.3×10^3 N of force is needed.

b) Does the mass of the object affect the amount of the work done? Explain.

The mass does not affect the amount of work done as the motion is horizontal.

3. A 50.0-kg object was dragged on the ground for 15.0 m left and work done was 2000 J. Find the magnitude and direction of the smallest possible force needed to do this work.

$\vec{d} = 15.0\text{m}\ [L]$ ← ↑ $\vec{F}$ is horizontal and to the left.

$W = 2000\ \text{J}$

$F = \frac{W}{d}$

$F = \frac{2000}{15.0}$

$F = 1.33 \times 10^2\ \text{N}\ [L]$

4. Consider an object with mass 40.0 kg that is pushed across a horizontal floor by a force of 150N [right]. Find the force of friction (magnitude and direction) that acts on the object provided that the coefficient of kinetic friction is 0.34.

$\vec{F} = 150\text{N}\ [R]$ →

$\therefore$ The force of friction is $1.3 \times 10^2\ \text{N}\ [L]$

$F_f = F_N \cdot \mu$

$= mg\mu$

$= (40)(9.8)(0.34)$

$= 1.3 \times 10^2\ \text{N}\ [L]$