Work and Power

When you think of 'work' you think of... studying, doing homework, a job, etc.

but in physics, work is the energy that a force gives to an object when the force moves the object

In everyday life you do work when... lift your backpack to your shoulders, when you throw a ball

Work can be calculated using: $W = F \Delta d \cos\theta$

Where W = work, measured in N·m or J (joule)
F = magnitude of the applied force, measured in N
Δd = magnitude of displacement, measured in m
θ = the angle between F and Δd

notice work is scalar

Example: A box that weighs 200.0 N is lifted a distance of 0.50 m straight up. How much work is done?

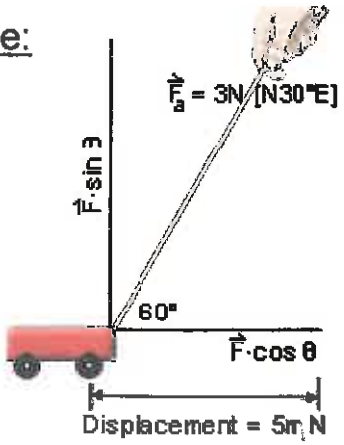
$W = F \Delta d \cos\theta$
$= 200\ N \cdot 0.5\ m \cos 0°$
$= 100\ N \cdot m \cdot 1 = 1.0 \times 10^2\ J$

When the applied force is in the same direction as the object's displacement...

Positive work occurs.

Work is also positive when the direction of the object's displacement is between 0° and 90° to the applied force.

Example:



$W = F \Delta d \cos\theta$
$= 3\ N \cdot 5\ m \cos 60°$
$= 7.5\ N \cdot m = 8\ J$

What happens when a moving object slides to rest? This means that a force has done...

negative work

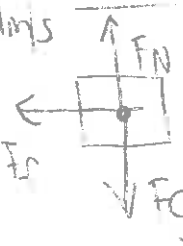
Negative work happens when an object moves in a direction opposite to the applied force, usually due to friction.

Negative work causes a loss of kinetic energy. Forces that cause negative work are exerted at angles between 90° and 180°, opposite to the object's direction.

Example: A 1385 kg car traveling at 61 km/h is brought to a stop while skidding 42 m. What is the work done on the car by frictional forces?

Given: $m = 1385\ kg$
$v_i = 61\ km/h = 16.94\ m/s$
$v_f = 0\ m$
$\Delta d = 42\ m$

Need: W



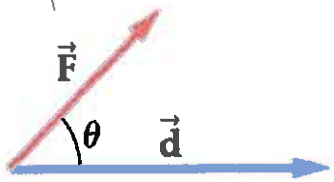
① $W = F \cdot d$
$= -4737\ N \cdot 42\ m$
$= -2.0 \times 10^5\ J$ $= -4737\ N$

② $a = \frac{v_f^2 - v_i^2}{2d}$
$= \frac{0^2 - 16.94\ m^2/s}{2(42\ m)}$
$= -3.42\ m/s^2$

③ $F_{net} = ma$
$F_f = ma$
$= 1385\ kg \cdot a$

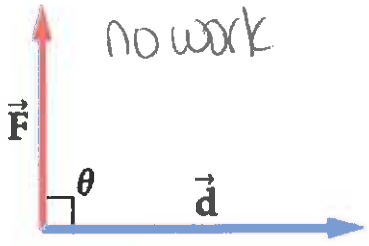
When the direction of the object's displacement is exactly 90° to the applied force, the force does: zero work

positive work



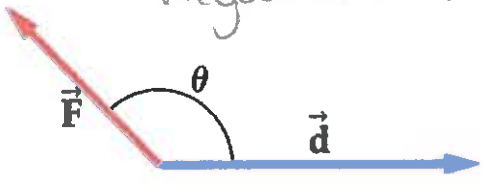
$\theta < 90°$
$W > 0$

no work



$\theta = 90°$
$W = 0$

negative work



$\theta > 90°$
$W < 0$

There is zero work done on an object when any of the force, displacement, or the cosine of the angle between the force and the displacement is zero. aka 90°

Example: A 3.0 kg pineapple is held 1.2 m above the floor for 15 s. How much work is done on the pineapple?

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

↑

zero displacement ∴ zero work or 0 J