

# Work and Energy

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Side # 1

# Work and Energy

- Force is a push or a pull
- How long** is a force applied?
  - Can measure **how long** in units of **time** or **distance**

If **time**... (last unit)

$$F \Delta t = \Delta mv$$

**impulse** = change in **momentum**

If **distance**...

$$F \Delta d = \Delta E$$

**work** = change in **energy**

Side # 2

# Work and Energy

- A **force (F)** was exerted on an object while the object moved a **distance, ( d )**
- If ...
  - F is a constant force,
  - exerted in the direction in which the object is moving,
- then ...
  - work(W)** is the **product** of the **force** and **displacement**.

$$W = F d$$

Side # 3

# Work and Energy

- Consider a **force** exerted on an object while the object moves a certain **distance**.
  - Because there is a net force, the object will be accelerated, **a = F/m**, and its velocity will increase.
  - In the equation...
 
$$v_f^2 = v_i^2 + 2ad, \text{ or } 2ad = v_f^2 - v_i^2$$

if you use Newton's second law to replace **a** with **F/m** and multiply both sides by **m/2**, you obtain:

$$Fd = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2$$

**work = change in energy**

Side # 4

# Kinetic Energy

- Kinetic energy (KE) is energy in the form of **motion**
  - Depends directly on **mass** and **velocity**

$$KE = \frac{1}{2} m v^2$$

Side # 5

# Work-Energy Theorem


- the **net work done** on an object is equal to its **change in kinetic energy**
- $F \Delta d = W = \Delta KE$        $W = KE_f - KE_i$
- $W = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2$

**if work is positive (+), then KE increases; velocity increases**  
**if work is negative (-), then KE decreases; velocity decreases**

Side # 6

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## What is Energy?



- Difficult to define because...
  - you usually can't see it and
  - it exists in many different forms (*radiant, mechanical, electrical, chemical, thermal, nuclear*)
  - $E = m c^2$  "energy of being"
- traditionally defined as **the ability to do work**
- energy is **the ability to cause change**
- Measured in **joules (J)**
- A scalar quantity; has NO direction


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## What is WORK?

- Work is the transfer of energy through motion (mechanical means)
- **$W = F \Delta d$** 
  - units: 1 newton·meter = 1 **joule** or  $1 \text{ N}\cdot\text{m} = 1 \text{ J}$
- Scalar quantity (no direction)
  - **F** is the magnitude of force;
  - **d** is the magnitude of displacement
- Work is done on an object only...
  - if it moves!
  - when components of a **force** are parallel to the **displacement**

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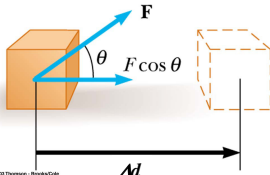
## What is WORK?



- The work,  $W$ , done by a constant force on an object is defined as the product of
  - the **component of the force** along the direction of displacement
  - and the **magnitude of the displacement**


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

or

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


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## What is WORK?

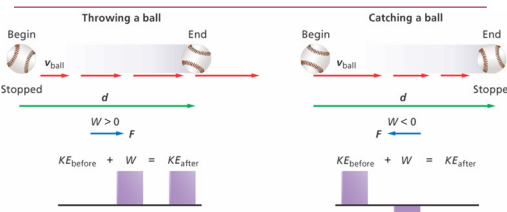


- Work can be positive or negative
  - **Positive** if the force and the displacement are in the same direction (lifting)
  - **Negative** if force and displacement are in the opposite direction (lowering)
- Can work be zero?
  - Force and displacement are perpendicular
  - $\cos 90^\circ = 0$  **no work** is done on the object

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

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## What is WORK?




**if work is positive (+),  $F$  and  $d$  in the same direction then KE increases; velocity increases**

**if work is negative (-),  $F$  and  $d$  in opposite direction then KE decreases; velocity decreases**

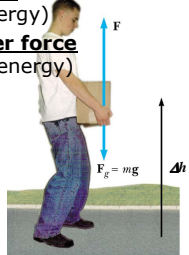
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## What is WORK?



- Work generally falls into 2 categories:
  - Work done to **change speed** (work = chg in **kinetic** energy)
  - Work done **against another force** (work = chg in **potential** energy)

Gravitational potential energy (PE)

$$PE = mg \Delta h$$


## What is POWER?

- How does *time* fit in to doing work?
- 20 seconds or 2 minutes... *does it make a difference in the amount of work done?....NO!*
- **Power** is the rate at which...
  - **Work is done or**
  - **Energy is transferred**

## What is Power?



- **Power** = work / time      **$P = W / t$**
- Measured in **watts** (W)  
1 **watt** = 1 joule / 1 second
- Watt is a small unit, power often measured in **kilowatts** (kW)
- English unit is *horsepower*  
(1 HP = 746 watts)