



# Physic<sup>2</sup> 121: Phundament<sup>°</sup>Is of Phy<sup>2</sup>ics I

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PHYS 121



# Demonstration

C7-18 “Astroblaster”



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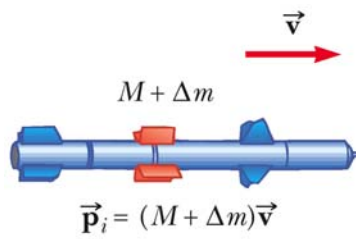
## Rocket Propulsion

- The operation of a rocket depends on the law of conservation of momentum as applied to a system, where the system is the rocket plus its ejected fuel
  - This is different than propulsion on the earth where two objects exert forces on each other
    - road on car
    - train on track

## Rocket Propulsion, 2

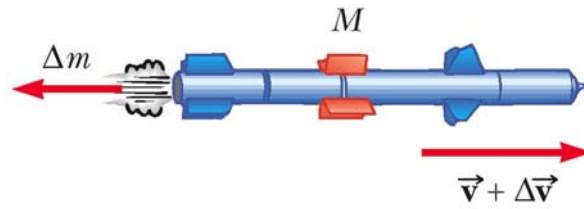
- The rocket is accelerated as a result of the thrust of the exhaust gases
- This represents the inverse of an inelastic collision
  - Momentum is conserved
  - Kinetic Energy is increased (at the expense of the stored energy of the rocket fuel)

## Rocket Propulsion, 3



- The initial mass of the rocket is  $M + \Delta m$ 
  - $M$  is the mass of the rocket
  - $m$  is the mass of the fuel
- The initial velocity of the rocket is  $\vec{v}$

## Rocket Propulsion



- The rocket's mass is  $M$
- The mass of the fuel,  $\Delta m$ , has been ejected
- The rocket's speed has increased to  $\vec{v} + \Delta \vec{v}$



# Demonstration

C5-14



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# Chapter 5

## Energy



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## Forms of Energy

- **Mechanical**
  - Focus for now
  - May be kinetic (associated with motion) or potential (associated with position)
- **Chemical**
- **Electromagnetic**
- **Nuclear**

## Some Energy Considerations

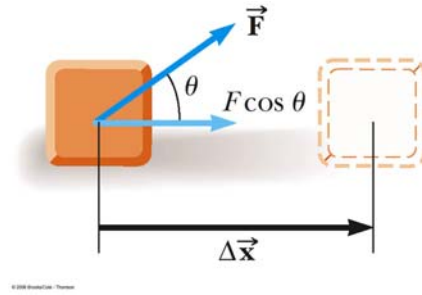
- Energy can be transformed from one form to another
  - Essential to the study of physics, chemistry, biology, geology, astronomy
- Can be used in place of Newton's laws to solve certain problems more simply

## Work

- Provides a link between force and energy
- 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

## Work, cont.

- $W \equiv (F \cos \theta) \Delta x$ 
  - $F$  is the magnitude of the force
  - $\Delta x$  is the magnitude of the object's displacement
  - $\theta$  is the angle between  $\vec{F}$  and  $\Delta \vec{x}$



## Work, cont.

- This gives no information about
  - the time it took for the displacement to occur
  - the velocity or acceleration of the object
- Work is a scalar quantity

## Units of Work

- SI
  - Newton • meter = Joule
    - $\text{N} \cdot \text{m} = \text{J}$
    - $\text{J} = \text{kg} \cdot \text{m}^2 / \text{s}^2$
- US Customary
  - foot • pound
    - $\text{ft} \cdot \text{lb}$
    - no special name

## More About Work

- The work done by a force is zero when the force is perpendicular to the displacement
  - $\cos 90^\circ = 0$
- If there are multiple forces acting on an object, the total work done is the algebraic sum of the amount of work done by each force

## More About Work, cont.

- Work can be positive or negative
  - Positive if the force and the displacement are in the same direction
  - Negative if the force and the displacement are in the opposite direction



## When Work is Zero

- Displacement is horizontal
- Force is vertical
- $\cos 90^\circ = 0$



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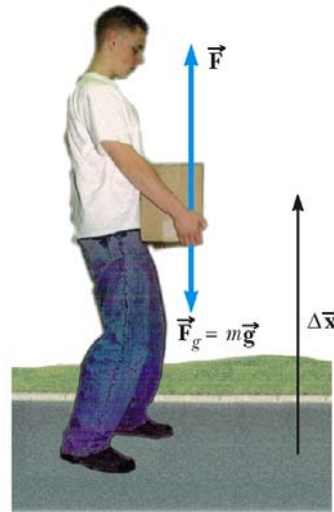
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## Work Can Be Positive or Negative

- Work is positive when lifting the box
- Work would be negative if lowering the box
  - The force would still be upward, but the displacement would be downward
- Some lingo:  
“Work is done *by* something *on* something else”



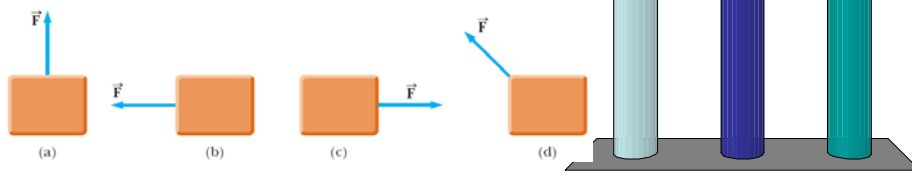
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A block moves to the right in the positive  $x$ -direction (to the right) through the displacement  $\Delta x$  while under the influence of a force with the same magnitude  $F$ . Which of the following is the correct order of the amount of work done by the force  $F$ , from most positive to most negative?



1. d, c, a, b
2. c, a, b, d
3. c, a, d, b



1	2	3	4	5															