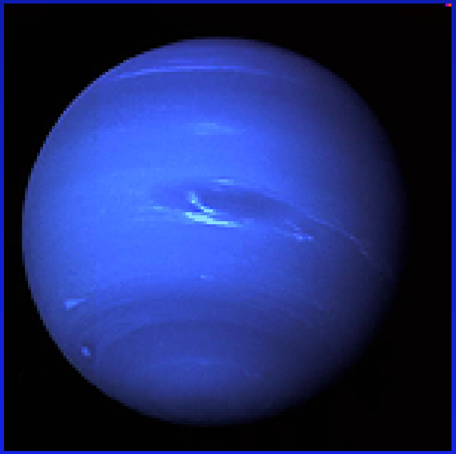
Physics 101: Lecture 04

Kinematics + Dynamics

- **Today's lecture will cover Textbook Chapter 4**

If you are new to the course, please read the course description on the course web page.



Neptune

Review

- Kinematics : Description of Motion

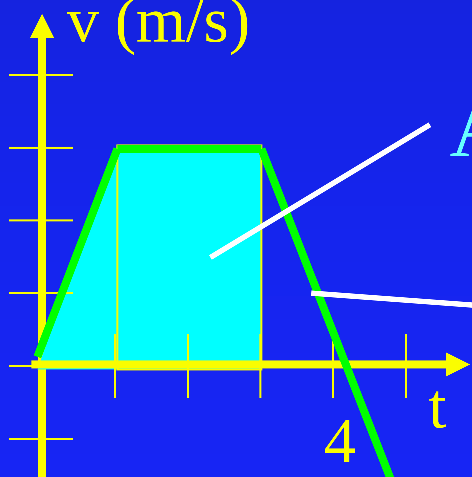
1. Displacement, Δx
2. Velocity, $v = \Delta x / \Delta t$
3. Acceleration, $a = \Delta v / \Delta t$

Slope of Δx vs. t

Slope of v vs. t

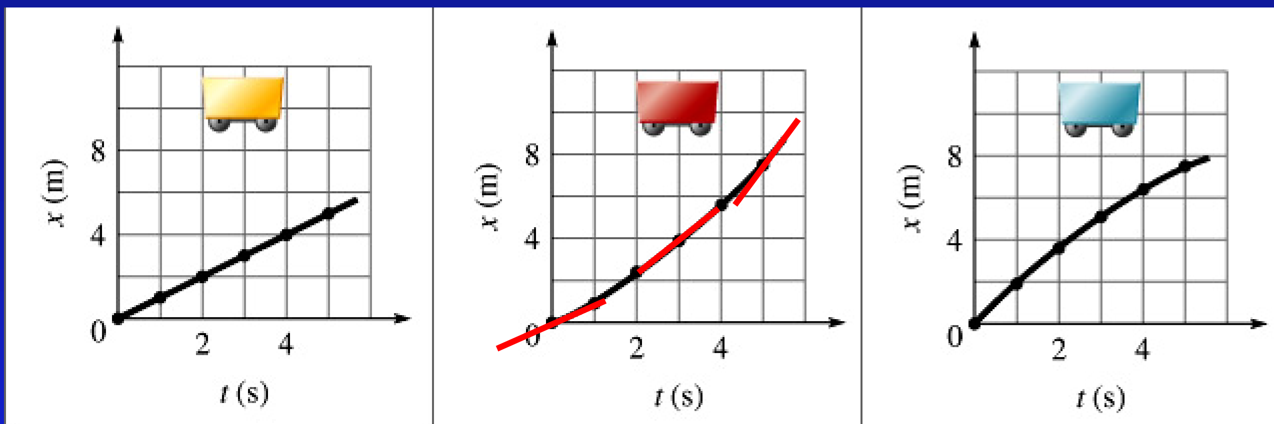
Area under v vs. t

Area under a vs. t

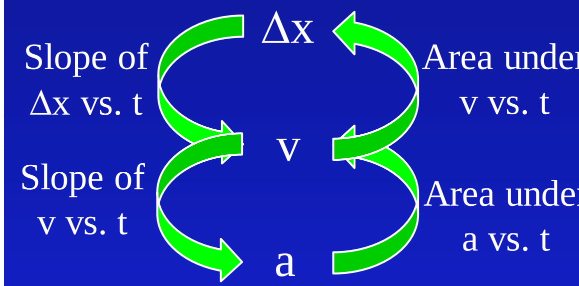


Checkpoint

…interpreting graphs…



(A) (B) (C)

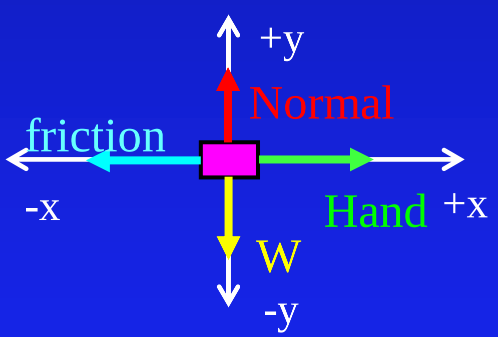


- Which x vs t plot shows positive acceleration?

Overview

Week 1!

Draw a FBD to determine F_{Net}

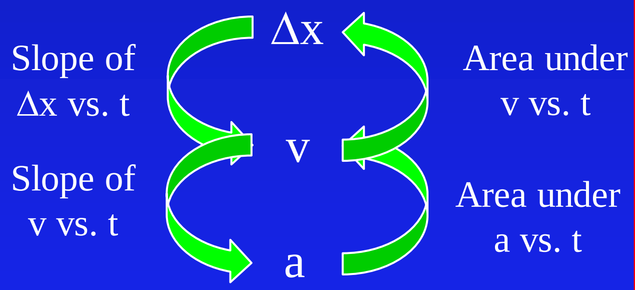


Apply Newton's 2nd Law to determine acceleration

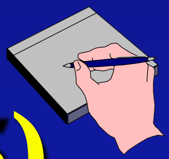
$$\vec{F}_{Net} = m\vec{a}$$

Next!

Use Kinematics to determine/describe motion of the object

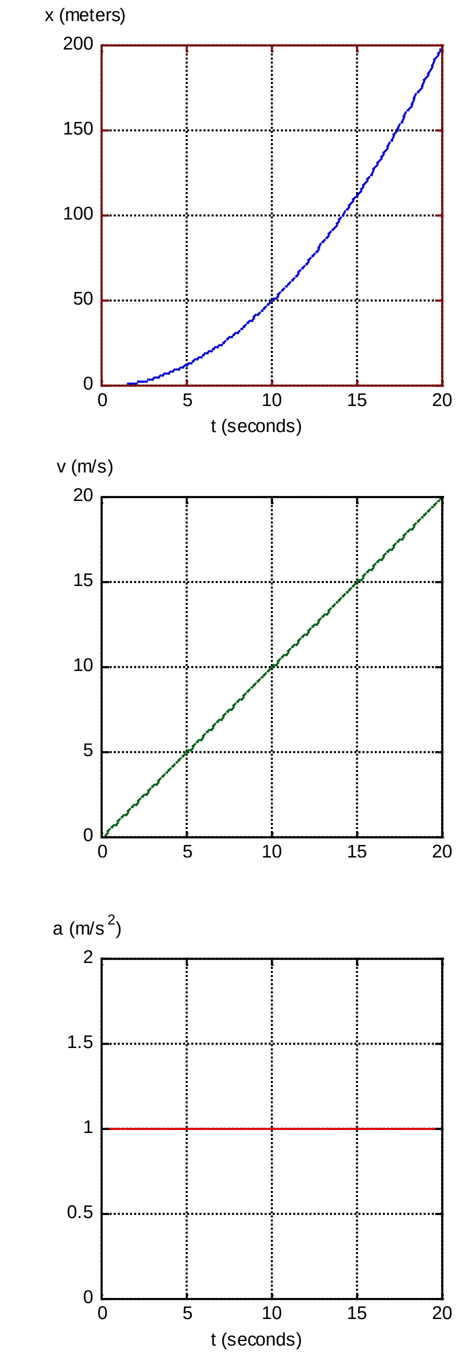


Equations for Constant Acceleration (text, page 124-125)

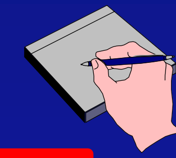


- $x = x_0 + v_0 t + 1/2\ at^2$
- $v = v_0 + at$
- $v^2 = v_0^2 + 2a(x-x_0)$

Use these equations to predict the future path and speed of an object under constant acceleration!



Kinematics Example

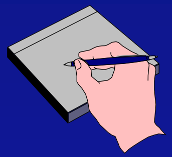


- A car is traveling 30 m/s and applies its breaks to stop after a distance of 150 m.
- How fast is the car going after it has traveled ½ the distance (75 meters) ?

A) $v < 15$ m/s B) $v = 15$ m/s C) $v > 15$ m/s

- $x = x_0 + v_0 t + 1/2\ at^2$
- $v = v_0 + at$
- $v^2 = v_0^2 + 2a(x-x_0)$

Acceleration ACT



A car accelerates uniformly from rest ($v_0 = 0$). If it travels a distance D in time t then how far will it travel in a time 2t ?

A. D/4
B. D/2
C. D
D. 2D
E. 4D

$$x - x_0 = 1/2\ at^2$$

$$v = at$$

$$v^2 = 2a(x-x_0)$$

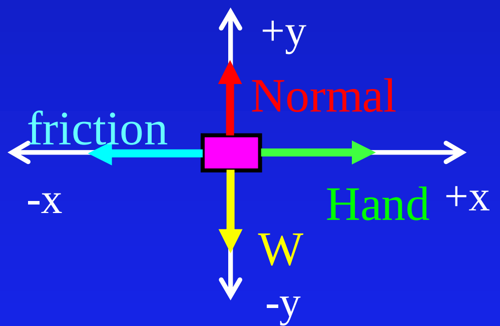
Follow up question: If the car has speed v at time t then what is the speed at time 2t ?

A. v/4
B. v/2
C. v
D. 2v
E. 4v

Overview

Next!

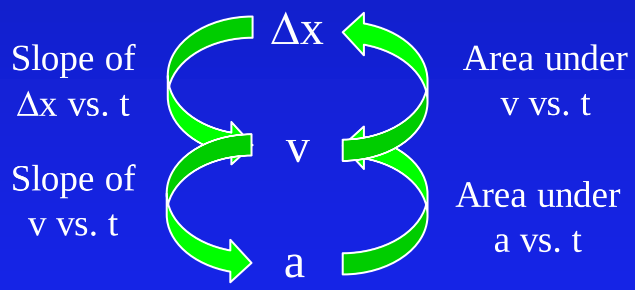
Draw a FBD to determine F_{Net}



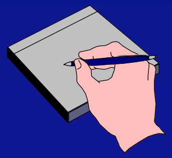
Apply Newton's 2nd Law to determine acceleration

$$\vec{F}_{Net} = m\vec{a}$$

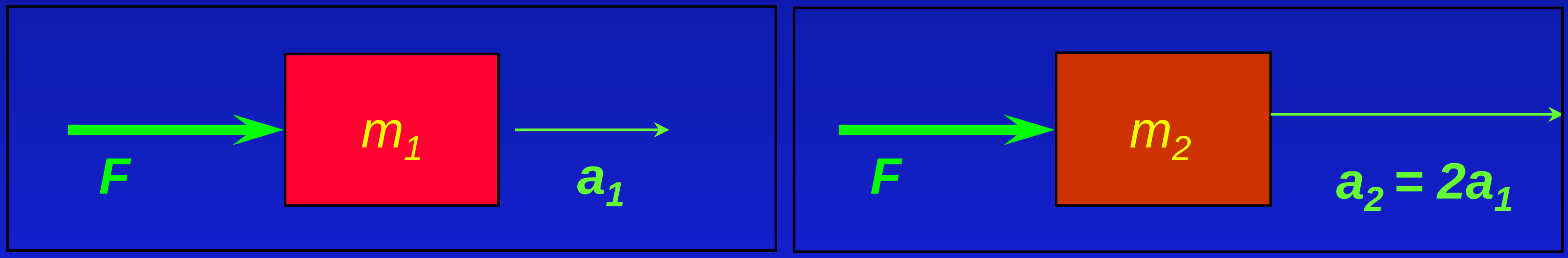
Use Kinematics to determine/describe motion of the object



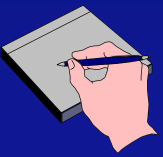
ACT



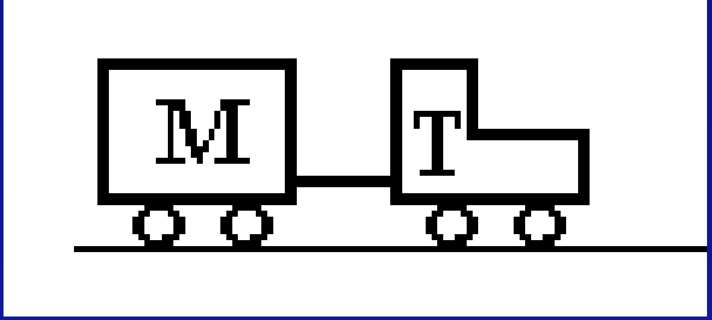
- A force F acting on a mass m_1 results in an acceleration a_1.The same force acting on a different mass m_2 results in an acceleration $a_2 = 2a_1$. What is the mass m_2?



(A) $2m_1$ (B) m_1 (C) $1/2\ m_1$

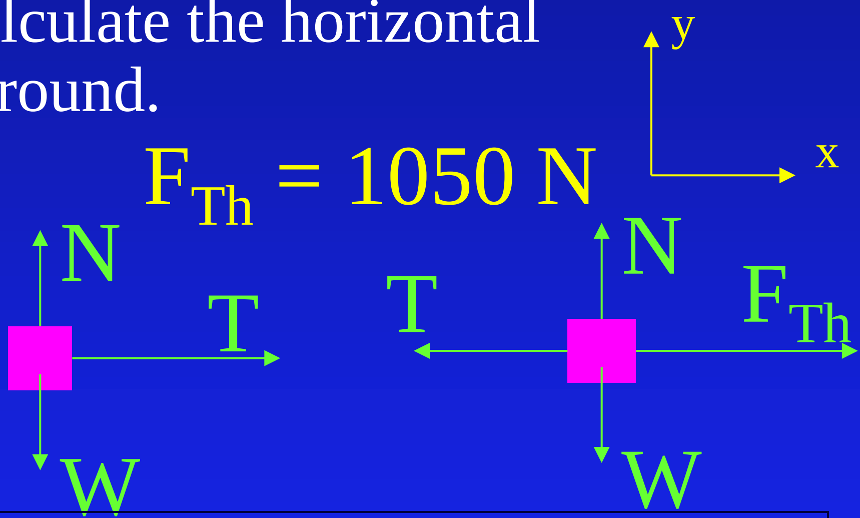


Example:



A tractor T (m=300Kg) is pulling a trailer M (m=400Kg). It starts from rest and pulls with constant force such that there is a positive acceleration of 1.5 m/s^2. Calculate the horizontal thrust force on the tractor due to the ground.

F_{Th} = 1050 N



Tractor – x direction

$F_{Net} = ma$

$F_{Th} - T = m_{tractor}a$

$F_{Th} = T + m_{tractor}a$

Trailer – x direction

$F_{Net} = ma$

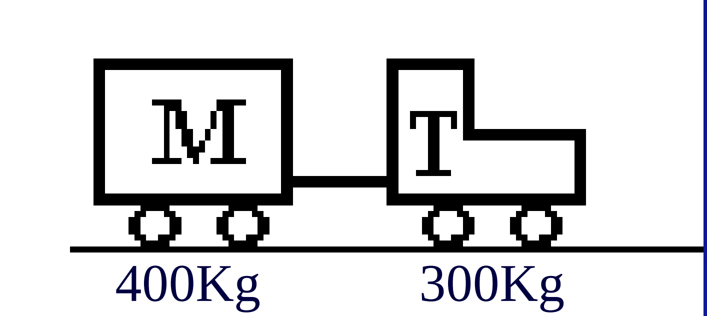
$T = m_{trailer}a$

Combine:

$F_{Th} = m_{trailer}a + m_{tractor}a$

$F_{Th} = (m_{trailer} + m_{tractor})\, a$

Net Force ACT



Compare $F_{tractor}$ the net force on the tractor, with $F_{trailer}$ the net force on the trailer from the previous problem.

A) $F_{tractor} > F_{trailor}$

B) $F_{tractor} = F_{trailor}$

C) $F_{tractor} < F_{trailor}$

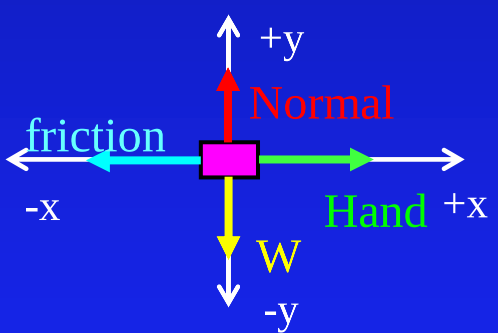
Overview

Next!

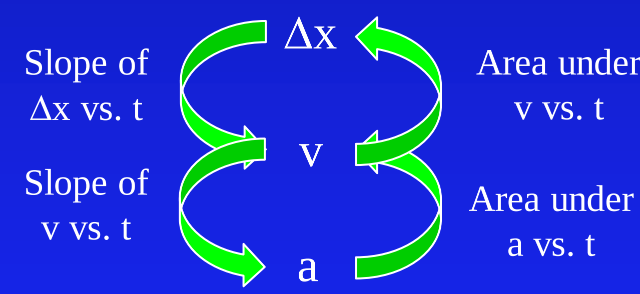
Draw a FBD to determine F_{Net}

Apply Newton's 2nd Law to determine acceleration

Use Kinematics to determine/describe motion of the object



$$\vec{F}_{Net} = m\vec{a}$$

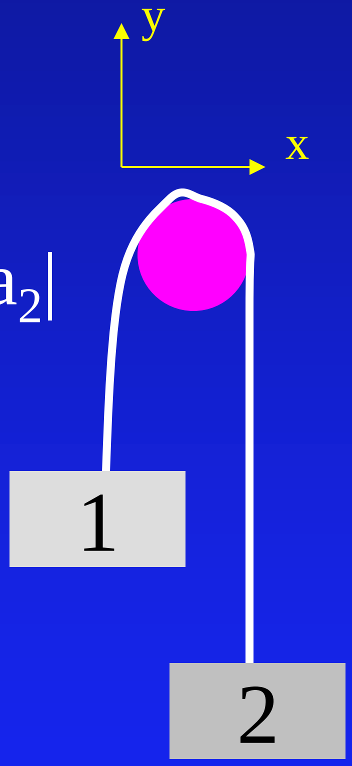


Pulley Example

- Two boxes are connected by a string over a frictionless pulley. Box 1 has mass 1.5 kg, box 2 has a mass of 2.5 kg. Box 2 starts from rest 0.8 meters above the table, how long does it take to hit the table.

•Compare the acceleration of boxes 1 and 2

A) $|a_1| > |a_2|$ B) $|a_1| = |a_2|$ C) $|a_1| < |a_2|$

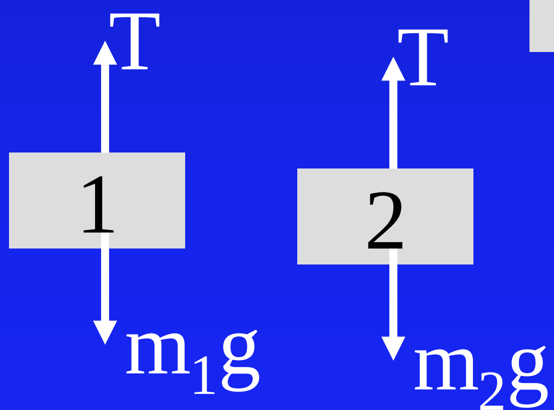


1) $T - m_1 g = m_1 a_1$
2) $T - m_2 g = -m_2 a_1$

2) $T = m_2 g - m_2 a_1$

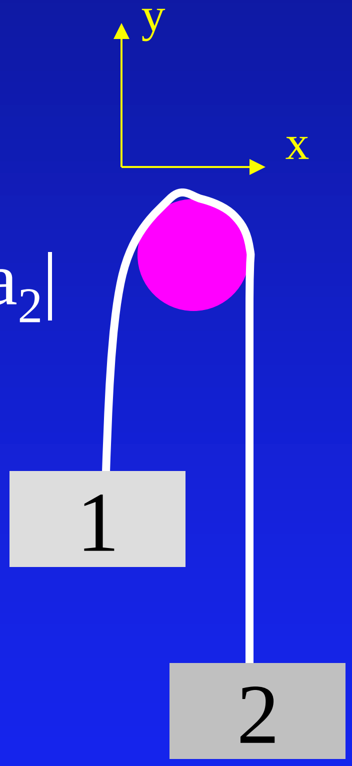
1) $m_2 g - m_2 a_1 - m_1 g = m_1 a_1$

$a_1 = (m_2 - m_1)g / (m_1 + m_2)$



Pulley Example

- Two boxes are connected by a string over a frictionless pulley. Box 1 has mass 1.5 kg, box 2 has a mass of 2.5 kg. Box 2 starts from rest 0.8 meters above the table, how long does it take to hit the table.



•Compare the acceleration of boxes 1 and 2

A) $|a_1| > |a_2|$ B) $|a_1| = |a_2|$ C) $|a_1| < |a_2|$

$a_1 = (m_2 - m_1)g / (m_1+m_2)$

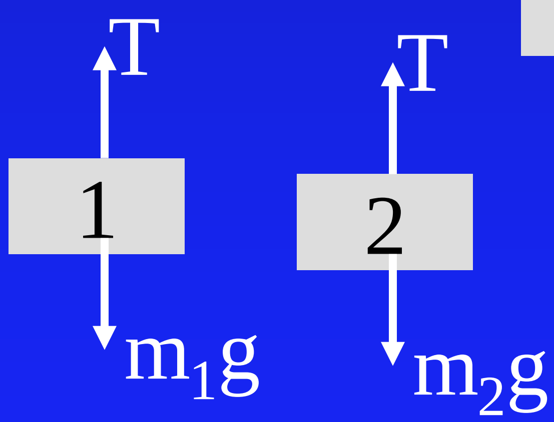
$a = 2.45 \text{ m/s}^2$

$\Delta x = v_0 t + ½ a t^2$

$\Delta x = ½ a t^2$

$t = \text{sqrt}(2 \Delta x/a)$

t = 0.81 seconds



Summary of Concepts

- Constant Acceleration
  - $x = x_0 + v_0t + 1/2\ at^2$
  - $v = v_0 + at$
  - $v^2 = v_0^2 + 2a(x-x_0)$
- F = m a
  - Draw Free Body Diagram
  - Write down equations
  - Solve
- Next time: textbook section 4.3, 4.5