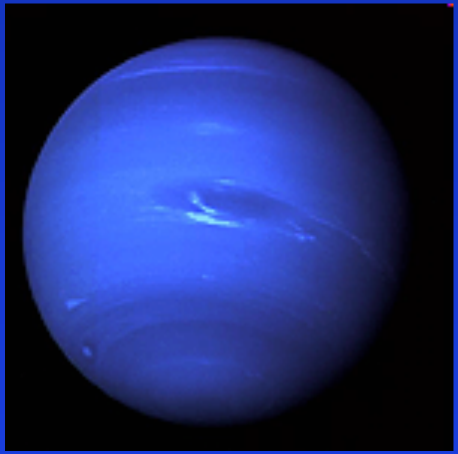
Physics 101: Lecture 04

Kinematics + Dynamics

- Today's lecture will cover Textbook Chapter 4



neptune

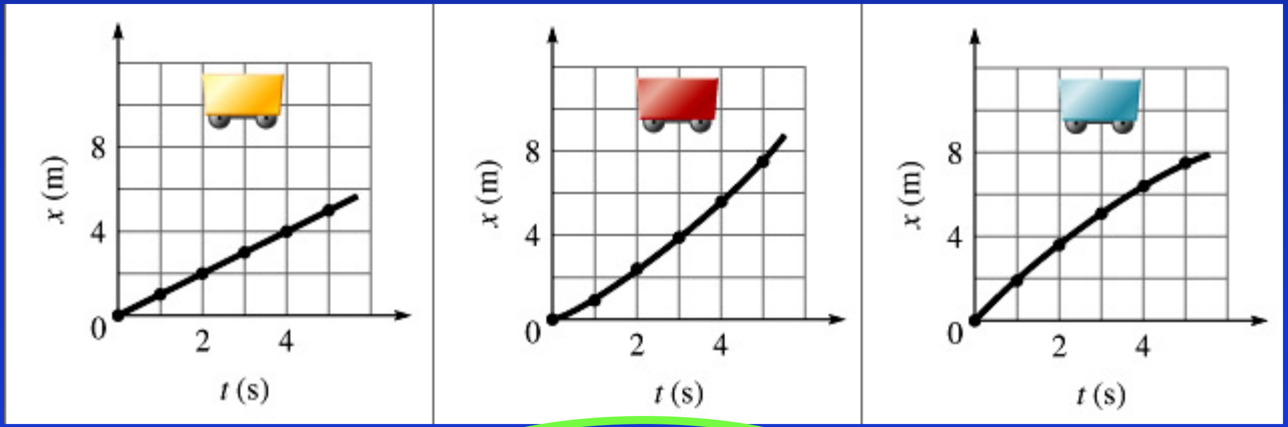
If you are new to the course,
please read the course description
on the course web page (and email policy
from Lecture 1 note)!

Review

- Kinematics : Description of Motion
  - Position
  - Displacement
  - Velocity $v = Dx / Dt$
    - » average
    - » instantaneous
  - Acceleration $a = Dv / Dt$
    - » average
    - » instantaneous
  - Relative velocity: $v_{ac} = v_{ab} + v_{bc}$

Preflight 4.1

...interpreting graphs...



(A) (B) (C)

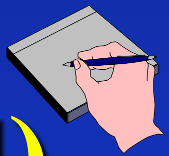
- Which x vs t plot shows positive acceleration?

89% got this correct!!!!

"This shows that more distance is being covered per second as the graph proceeds. This means that the speed of the car is increasing which means a positive acceleration."

This is x(t) graph, not v(t)

Equations for Constant Acceleration (text, page 113-114)



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

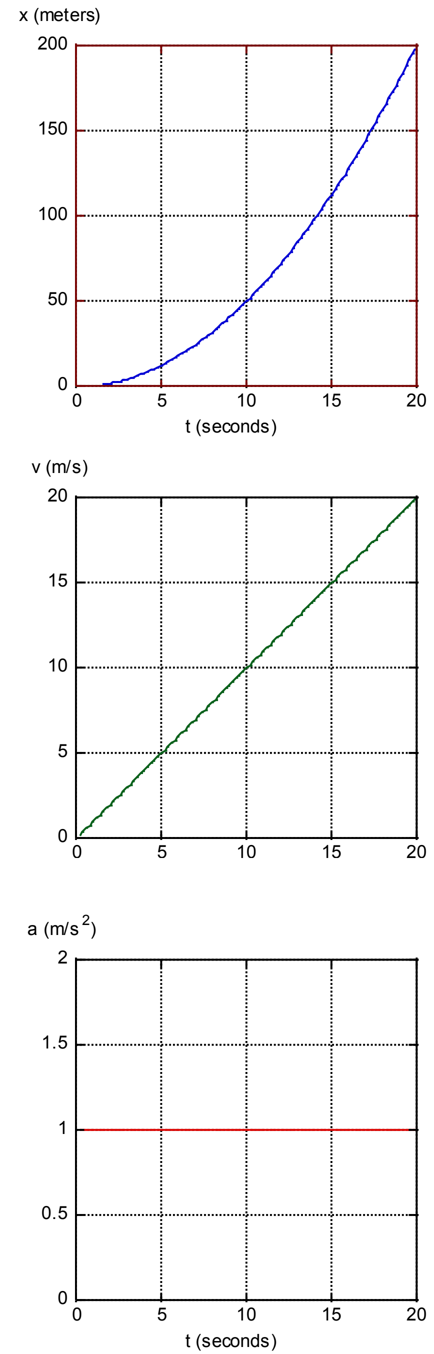
$$\bar{v} = (x - x_0)/t$$

$$x = x_0 + v_0 t + \frac{1}{2}at^2$$

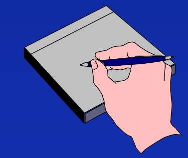
$$x = x_0 + \bar{v}\ t$$

$$x = x_0 + (v_0 + \frac{1}{2}at)t$$

$$\bar{v} = (v_0 + \frac{1}{2}at)$$



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

$$v^2 = v_o^2 + 2a\Delta x$$

$$a = \frac{v_f^2 - v_o^2}{2(150)} = \frac{-30^2}{2(150)}$$

$$v_{75}^2 = 30^2 + 2a(75)$$

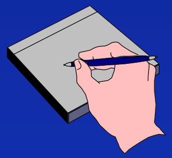
$$v_{75}^2 = 30^2 + 2\frac{(-30^2)}{2(150)}(75)$$

$$v_{75}^2 = 30^2 + \frac{1}{2}(-30^2)$$

$$v_{75}^2 = \frac{1}{2}30^2$$

$$v_{75} = \sqrt{\frac{1}{2}}30 = 21 m/s$$

Acceleration ACT



A car accelerates uniformly from rest. 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 ← Correct $x=1/2\ at^2$

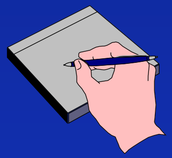
Demo...

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

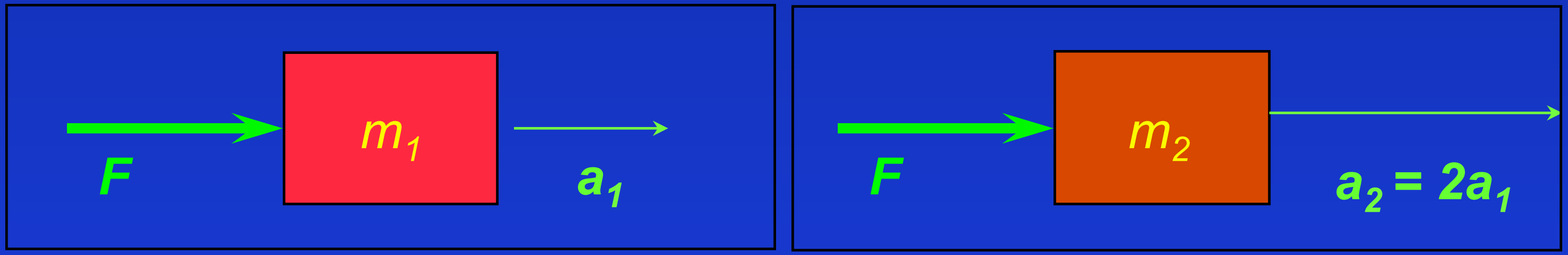
A. v/4
B. v/2
C. v
D. 2v ← Correct $v=at$
E. 4v

Newton's Second Law $F_{Net}=ma$

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?

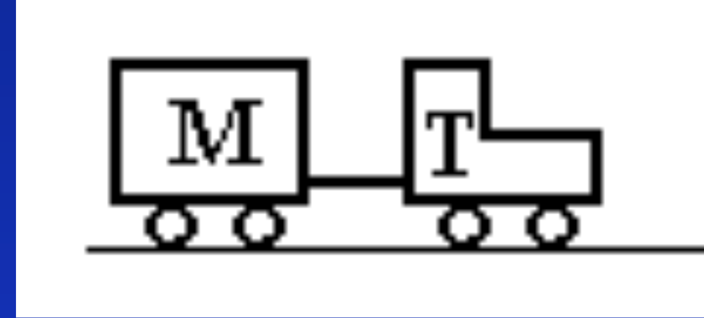


(A) $2m_1$ (B) m_1 (C) $1/2\ m_1$

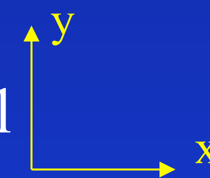
- $F_{Net} = ma$
- $F_{Net} = m_1 a_1 = m_2 a_2 = m_2(2a_1)$
- Therefore, $m_2 = m_1/2$

- Or in words…twice the acceleration means half the mass

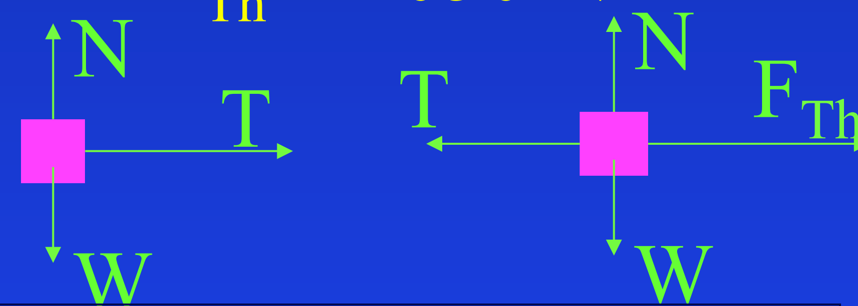
Example:



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.



$$F_{Th} = 1050 \text{ N}$$



X direction: Tractor

$$F_{Net} = ma$$
$$F_{Th} - T = m_{tractor}a$$
$$F_{Th} = T + m_{tractor}a$$

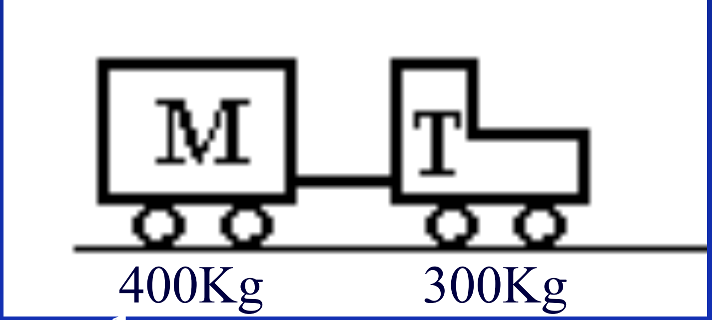
X direction: Trailer

$$F_{Net} = ma$$
$$T = m_{trailer}a$$

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

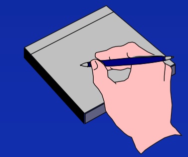
C) $F_{tractor} < F_{trailor}$

$$SF = m\,a$$

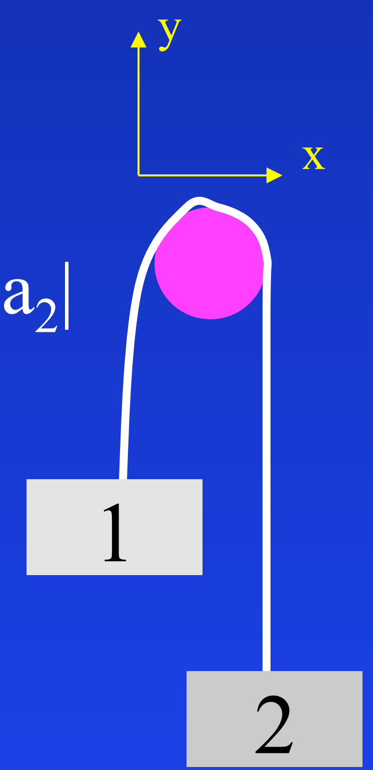
$$F_{tractor} = m_{tractor}\,a$$
$$= (300\text{ kg})\,(1.5\text{ m/s}^2)$$
$$= 450\text{ N}$$

$$F_{trailer} = m_{trailer}\,a$$
$$= (400\text{ kg})\,(1.5\text{ m/s2})$$
$$= 600\text{ N}$$

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

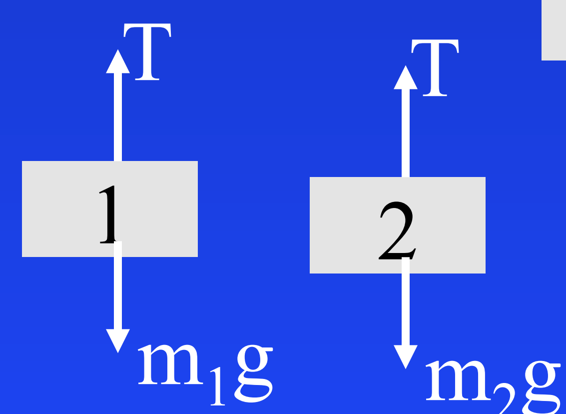
A) $|a_1| > |a_2|$ B) $|a_1| = |a_2|$ C) $|a_1| < |a_2|$

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

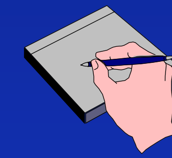
2) $T = m_2 g - m_2 a_1$

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



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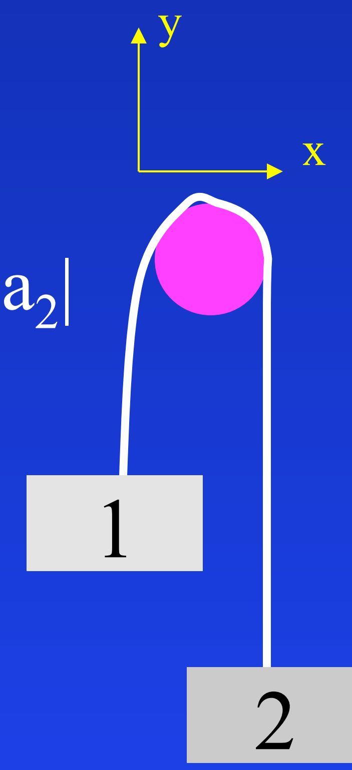


•Compare the acceleration of boxes 1 and 2

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

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

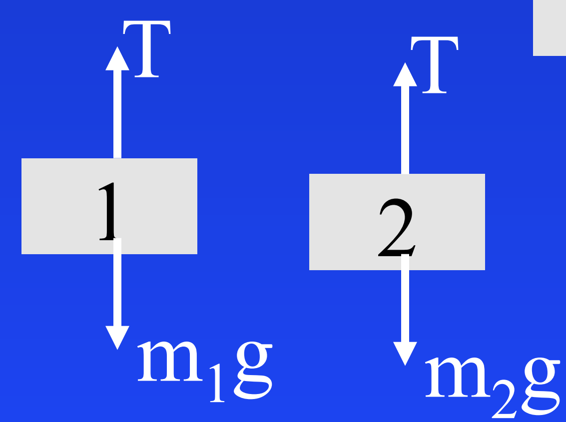
$a = 2.45\ m/s^2$

$\Delta x = v_0 t + \frac{1}{2} a t^2$

$\Delta x = \frac{1}{2} a t^2$

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

$t = 0.81$ seconds



Summary of Concepts

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