Physics 101: Lecture 02

Forces: Equilibrium Examples

- **Today's lecture will cover Textbook Sections 2.1-2.7**

- No LAB preflights ☺
- Physics 101 URL: http://online.physics.uiuc.edu/courses/phys101/fall10

Overview

- Last Week
  - ➔Newton's Laws of Motion
    - » Inertia
    - » $\Sigma F = ma$ ($a = \Sigma F/m$)
    - » Forces come in pairs
  - ➔Free Body Diagrams
    - » Draw coordinate axis, each direction is independent.
    - » Simple Picture
    - » Identify/draw all forces
  - ➔Friction $F_f \leq \mu_s N$ (N = normal force)
  - ➔Gravity $W = mg$ ($g=9.8 m/s^2$)
- Today: Forces on objects at rest
  - ➔Contact Force---Springs
  - ➔Contact Force---Tension
  - ➔2-D Examples

Example Solution

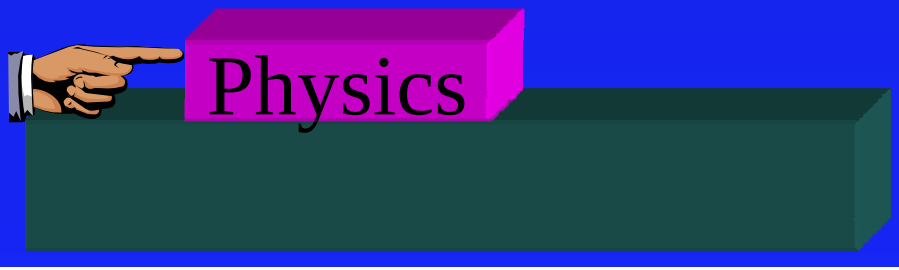
1. Draw Free Body Diagram
   - Of What?
   - What forces do I include?

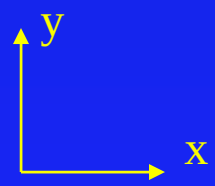
2. Write $\Sigma F = ma$
   - Separate x and y directions
   - What m and a?

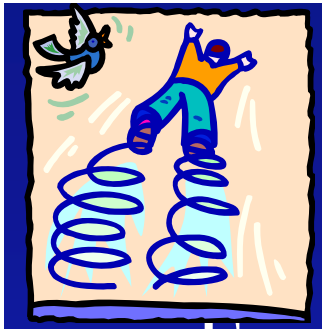
3. Solve

Book Pushed Across Table

- Calculate force of hand to keep the book sliding at a constant speed, if the mass of the book is 1 Kg, $\mu_k = 0.75$.



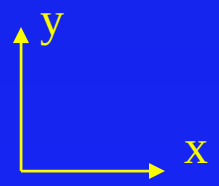




Contact Force: Springs

- Force exerted by a spring is directly proportional to its displacement (stretched or compressed). $|F|_{spring} = k\ x$
- Example: When a 5 Kg mass is suspended from a spring, the spring stretches 8 cm. If it is hung by two identical springs, they will stretch

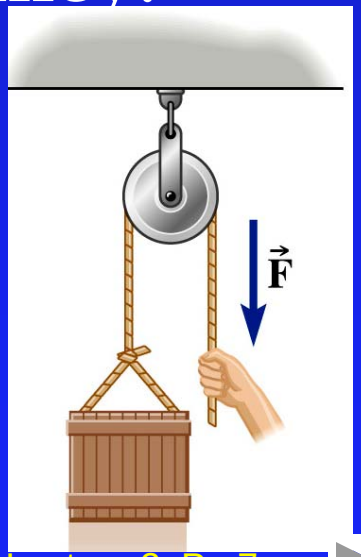
A) 4 cm B) 8 cm C) 16 cm



Contact Force: Tension

- Tension in an Ideal String:
  - ➔Magnitude of tension is equal everywhere.
  - ➔Direction is parallel to string (only pulls)

- Example : Determine force applied to string to suspend 45 kg mass hanging over pulley:
  Answer:
  - ➔FBD
  - ➔$\Sigma F = ma$



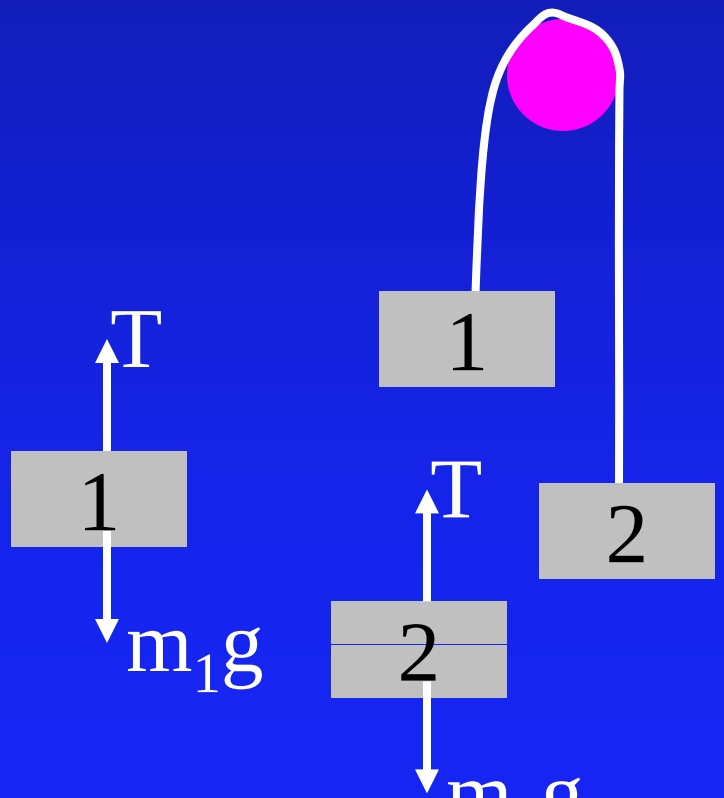
Pulley ACT

- Two boxes are connected by a string over a frictionless pulley. In equilibrium, box 2 is lower than box 1. Compare the weight of the two boxes.

A) Box 1 is heavier

B) Box 2 is heavier

C) They have the same weight

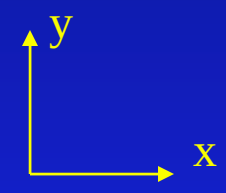


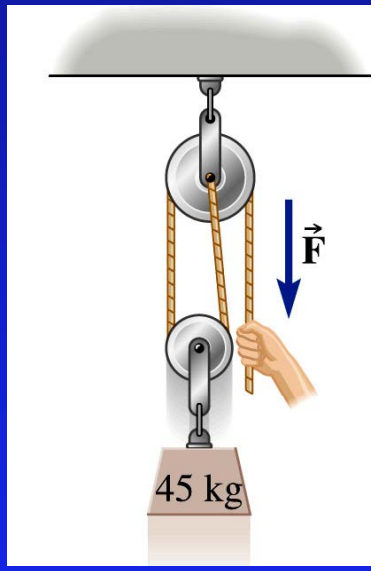
Tension Example:

- Determine the force exerted by the hand to suspend the 45 kg mass as shown in the picture.

A) 220 N B) 440 N C) 660 N

D) 880 N E) 1100 N



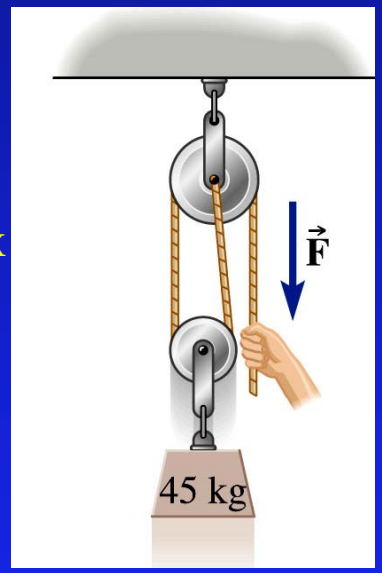


Tension ACT II

- Determine the force exerted by the ceiling to suspend pulley holding the 45 kg mass as shown in the picture.

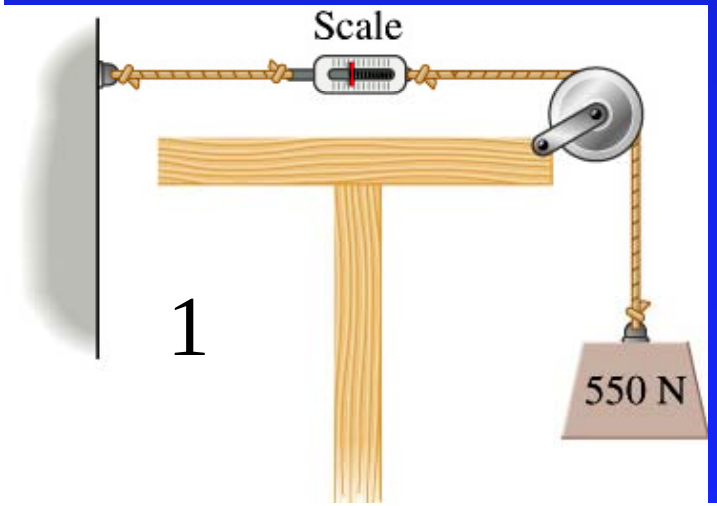
A) 220 N B) 440 N C) 660 N

D) 880 N E) 1100 N



Springs Preflight

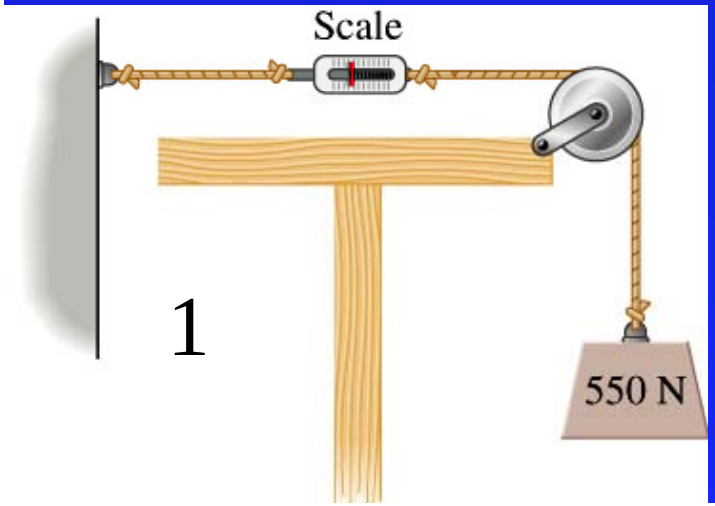
- What does scale 1 read?
- A) 225 N B) 550 N C) 1100 N

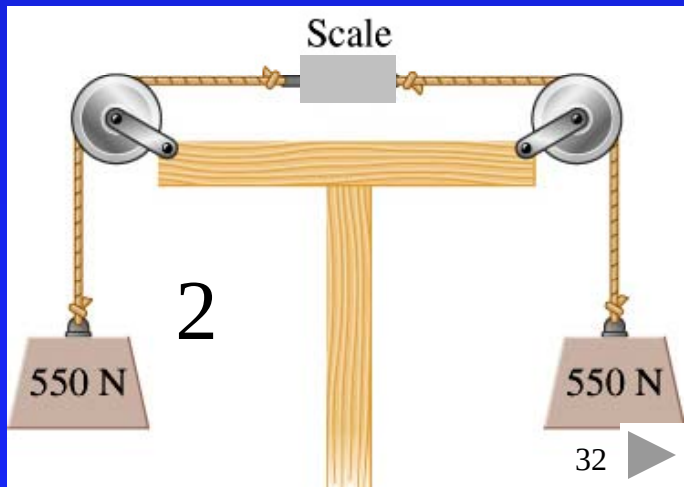


Springs ACT

•Scale 1 reads 550 Newtons. What is the reading on scale 2?

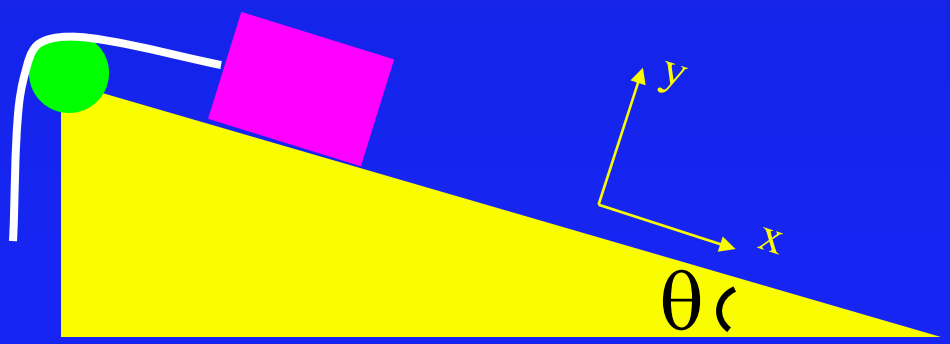
A) 225 N B) 550 N C) 1100 N

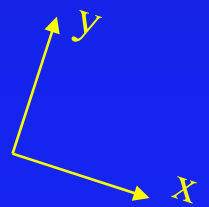




Forces in 2 Dimensions: Ramp

- Calculate tension in the rope necessary to keep the 5 kg block from sliding down a frictionless incline of 20 degrees.

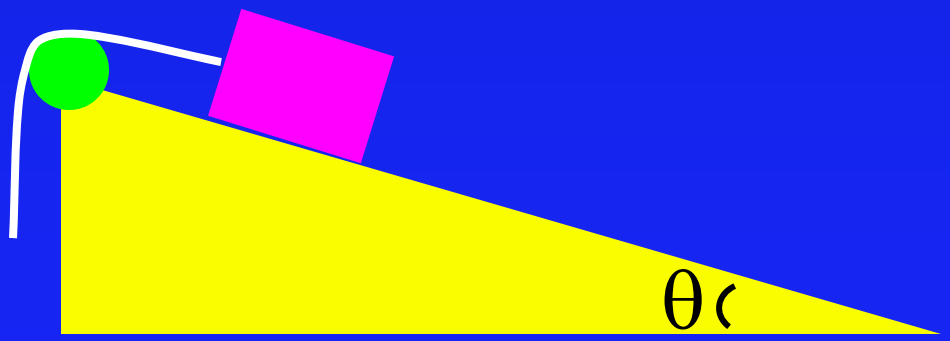




Normal Force ACT

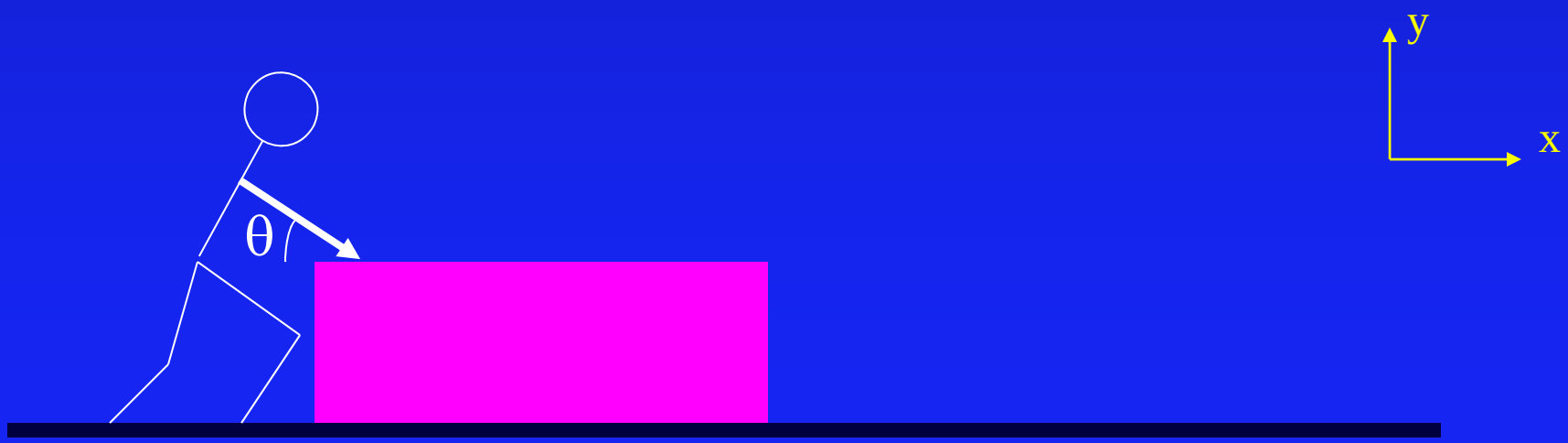
What is the normal force of ramp on block?

A) $F_N > mg$ B) $F_N = mg$ C) $F_N < mg$



Force at Angle Example

- A person is pushing a 15 kg block across a floor with $\mu_k = 0.4$ at a constant speed. If she is pushing down at an angle of 25 degrees, what is the magnitude of her force on the block?



Summary

- Contact Force: Spring
  - ➔Can push or pull, force proportional to displacement
  - ➔$F = k\,x$
- Contact Force: Tension
  - ➔Always Pulls, tension equal everywhere
  - ➔Force parallel to string
- Two Dimensional Examples
  - ➔Choose coordinate system
  - ➔Analyze each direction is independent

Next time: Sections 3.1-3.3