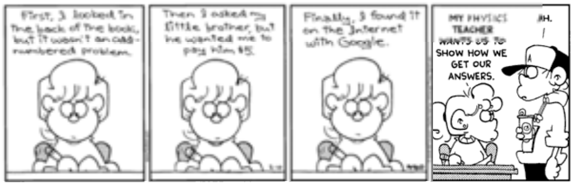
October 13, 2010 Physics 121 Prof. E. F. Redish

- **Theme Music:** **John Williams**
  Learn about the Force (from Star Wars)
- **Cartoon:** **Bill Amend**
  FoxTrot



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Outline

- Recap of Newtonian Foothold Principles
- Properties of Forces
  - Gravity
  - Friction
  - Normal Force (ILD 3)
- Review of basic elements of trig
- Examples

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Newton's Laws

- Newton 0:
  - Objects only feel forces when something touches them. An object responds to the forces it feels when it feels them – plus the non-touching force of gravity (so far).
- Newton 1:
  - An object that feels no unbalanced force keeps moving with the same velocity (which may = 0).
- Newton 2:
  - An object that is acted upon by other objects changes its velocity so that the acceleration is proportional to the net force and inversely proportional to the object's mass. $\vec{a} = \vec{F}^{net}/m$
- Newton 3:
  - When two objects interact the forces they exert on each other are equal and opposite. $\vec{F}_{A \to B} = -\vec{F}_{B \to A}$

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Classification of Forces

- Physical forces are what two objects do to each other that tends to change each other's velocity.
- Touching forces
  - perpendicular to the surface and pressing in (NORMAL – N)
  - hooked to the surface and pulling out (TENSION – T)
  - parallel to the touching surfaces and opposing the relative motion of the surfaces (FRICTION – f)
- Non-touching forces
  - the earth pulling an object down (GRAVITY – W)

$\vec{F}_{A\to B}$ where F is either $N, T, f,$ or W

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ILD 3

- Reconciling Intuition by Looking at it Another Way: The Normal Force

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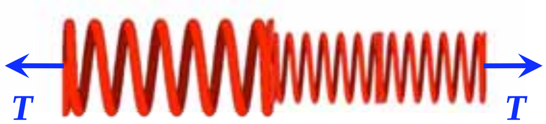
Springs

- What fraction of the total stretch does each spring stretch?
- How do you know?

$$T = k\Delta s$$



k_1 (large) k_2 (small)

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The friction relation

- When the surfaces are not sliding on each other (but something is trying to make them slide), the friction force may take any value up to a maximum.

$$f_{A\to B} \le f_{A\to B}^{\max} = \mu_{AB}^{static} N_{A\to B}$$

- When the surfaces are sliding on each other, the friction force is a constant value (usually a bit less than the maximum possible).

$$f_{A\to B} = \mu_{AB}^{kinetic} N_{A\to B} \qquad \mu_{AB}^{kinetic} \le \mu_{AB}^{static}$$

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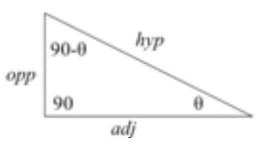
Review of Trig: 1

- Trig is based on a small number of principles:
  - The sum of the angles of a triangle is 180°.
  - The Pythagorian theorem
  - Every right triangle with the same angles is similar (has the same ratio of its sides).



Although *opp*, *adj*, and *hyp* all depend on the size of the triangle, the ratios *opp/adj*, *opp/hyp*, and *adj/hyp* only depend on itsshape (that it, on θ) .

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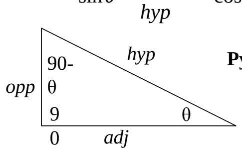
Review of Trig: 2

$$\sin\theta = \frac{opp}{hyp} \qquad \cos\theta = \frac{adj}{hyp} \qquad \tan\theta = \frac{opp}{adj}$$



Pythagorian theorem:

$$(adj)^2 + (opp)^2 = (hyp)^2$$

or

$$\sin^2\theta + \cos^2\theta = 1$$

Physics geometry heuristic: If you are drawing a diagram that is controlled by a single angle θ, and the rest of the lines are constructed as perpendiculars to the original or later lines, then the only angles in the diagram are θ, 90-θ, and 90 –- and it’s easy to tell which is which.

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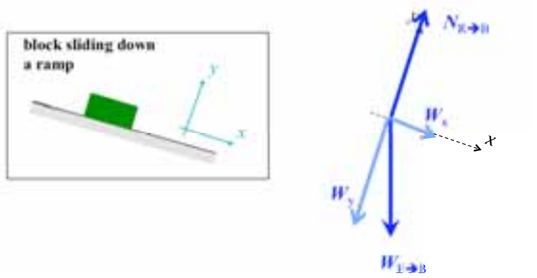
What is the acceleration of a block sliding down a ramp?



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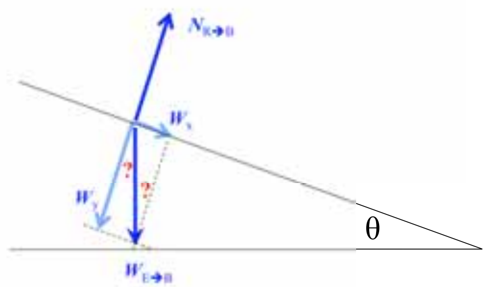

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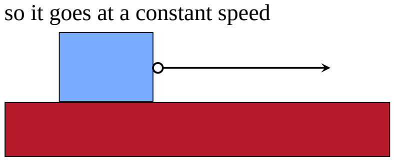
Example

Start from rest
Increase force until box starts moving
Pull so it goes at a constant speed



Graph: position, velocity, acceleration, net force, applied force, friction force

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- Rebecca has put her puppy, Molly, on a skateboard, and has attached a rope to the skateboard in order to give Molly a ride. At time $t = 0$, Rebecca starts pulling on the rope. She is pulling upward at an angle of 37°. Once she is up to speed (at time t_1), she runs along at a constant rate until a time t_2. A little after that, her mother yells at her and she stops.

- (a) While Rebecca is pulling, draw free-body diagrams for Molly and the skateboard.
- (b) Sketch appropriate graphs representing Molly's position, velocity, acceleration, and the friction force Molly is experiencing.