October 1, 2010 Physics 121 Prof. E. F. Redish

- **Theme Music:** **Tom Petty**

  Free Fallin'

- **Cartoon:** **Rick Detorie**

  One Big Happy

10/1/10 Physics 121 4

Outline

- Free fall motion
- Recap: N2 as a Vector Law
- Examples
  - Vertical motion
  - Object on an Incline
  - Getting movin

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A juggler is juggling three tennis balls. At the instant shown, ball A is going up; ball B is coming down. Both balls have negligible horizontal motion

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Our velocity and acceleration definitions generalize easily

$$\langle \vec{v} \rangle = \frac{\Delta \vec{r}}{\Delta t} \qquad \Delta \vec{r} = \vec{r}_f - \vec{r}_i$$

$$\langle \vec{a} \rangle = \frac{\Delta \vec{v}}{\Delta t} \qquad \Delta \vec{v} = \vec{v}_f - \vec{v}_i$$

$$\langle v_x \rangle = \frac{\Delta x}{\Delta t} \qquad \langle v_y \rangle = \frac{\Delta y}{\Delta t}$$

$$\langle a_x \rangle = \frac{\Delta v_x}{\Delta t} \qquad \langle a_y \rangle = \frac{\Delta v_y}{\Delta t}$$

If a is constant

$$\langle v \rangle = \frac{v_i + v_f}{2}$$

for either v_x or v_y.

9/30/09 Physics 121 9

Newton 2 is a vector equation

- We have sort of been assuming that up and down forces were independent of sideways forces.
- This tests out true in detail. It means N2 is a vector equation: $\vec{a} = \vec{F}^{net}/m$
- A vector equation is a way of writing 2 equations at once:

$$a_x = F_x^{net}/m \qquad a_y = F_y^{net}/m$$

9/30/09 10

Recap: Coordinates and Vectors

- Set up a coordinate system
  - Pick an origin
  - Pick 3 perpendicular directions
  - Choose a measurement scale
- Each point in space in then specified by three numbers: the x, y, and z coordinates.
- The position vector for a particular position is an arrow drawn from the origin to that position.

9/29/10 Physics 121 11

Recap: Motion in a plane (2-dimensional coordinates)

- We now have 2 directions to specify. We must
  - Choose a reference point (origin)
  - Pick 2 perpendicular axes (x and y)
  - Choose a scale
- We specify our x and y directions by drawing little arrows of unit length in their positive direction.

$$\hat{i}, \hat{j}$$

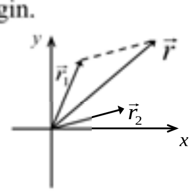
- A position specified by a point (x,y) is written

$$\vec{r} = x\hat{i} + y\hat{j}$$

9/29/10 Physics 121 **12**

Adding Vectors: Meaning

- A position vector, $\vec{r}$, represents a displacement from the origin.
- We define the sum of two vectors as the results of their successive displacements.



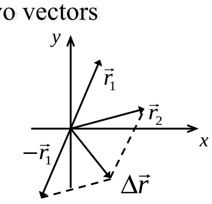
$$\vec{r} = \vec{r}_1 + \vec{r}_2$$

9/29/10 Physics 121 **13**

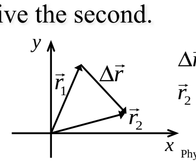
Subtracting Vectors: Meaning

- We define the difference of two vectors from the definition of sum.

$$\Delta\vec{r} = \vec{r}_2 - \vec{r}_1 = \vec{r}_2 + (-\vec{r}_1)$$

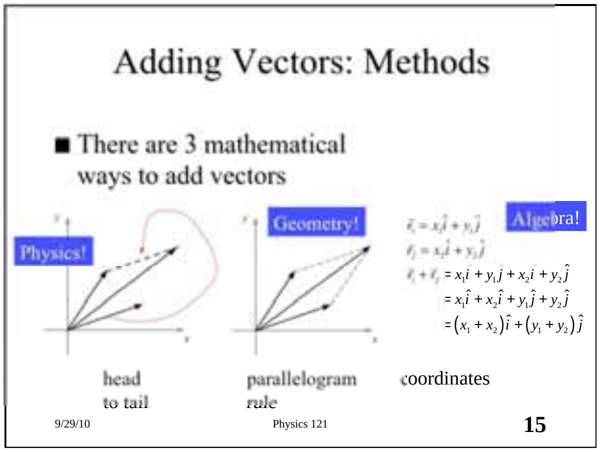


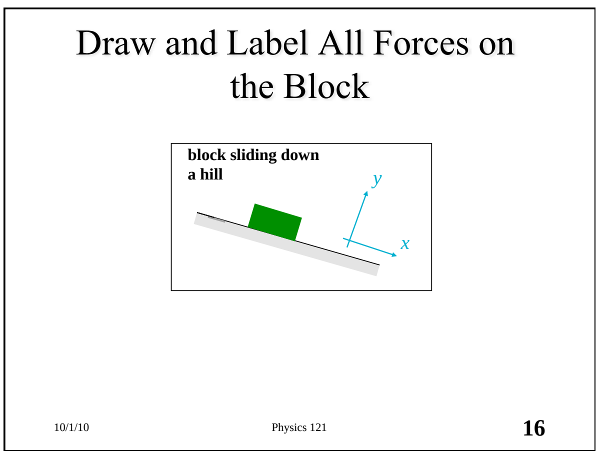
- Or: The difference is what has to be added to the first to give the second.



$$\Delta\vec{r} = \vec{r}_2 - \vec{r}_1$$
$$\vec{r}_2 = \vec{r}_1 + \Delta\vec{r}$$

9/29/10 Physics 121 **14**


Adding Vectors: Methods
There are 3 mathematical ways to add vectors
Physics!
Geometry!
Algebra!
head to tail
parallelogram rule
coordinates
9/29/10
Physics 121
15


Draw and Label All Forces on the Block
block sliding down a hill
y
x
10/1/10
Physics 121
16