Vectors – Continued

- Unit Vectors
  - Calculation

$$\hat{r} = \frac{\bar{r}}{|\bar{r}|} = \frac{\langle r_x, r_y, r_z \rangle}{\sqrt{(r_x)^2 + (r_y)^2 + (r_z)^2}}$$

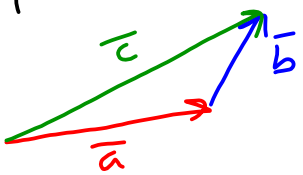
- Adding and subtracting
  - Algebraically

$$\bar{a} + \bar{b} = \langle (a_x + b_x), (a_y + b_y), (a_z + b_z) \rangle$$

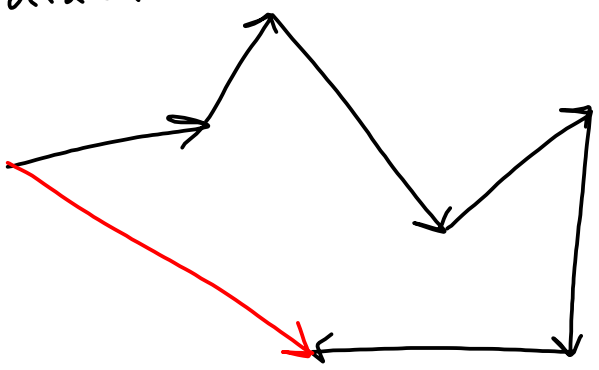
answer is known as the resultant

  - Graphically

head → tail



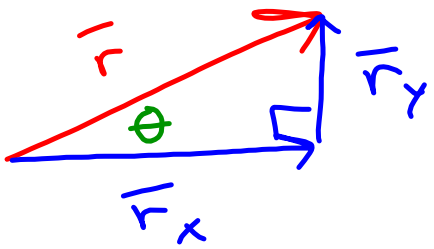
  - put vectors together head-to-tail when adding
  - resultant goes from head of the first vector drawn to tail of last vector drawn



- Vector addition is commutative
- Vector subtraction is NOT commutative
- Associative property is true for both addition and subtraction

$$(\bar{a}+\bar{b})-\bar{c} = \bar{a}+(\bar{b}-\bar{c})$$

- Finding components of a vector:



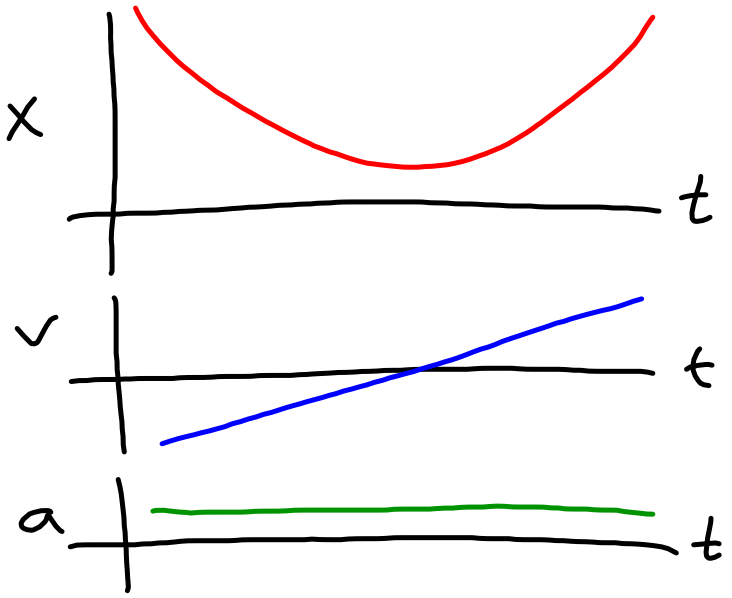
Use sine, cosine, and tangent to find $\bar{r}$, $\bar{r}_x$, and $\bar{r}_y$

Other operations:

- Differentiate a vector: $\frac{d\bar{r}}{dt}$
- Dot product: $\bar{a} \cdot \bar{b}$
  (scalar product)
- Cross product: $\bar{a} \times \bar{b}$
  (vector product)

GOAL: Characterize the motion of the cart on an inclined ramp

- Graphically: x-t, v-t
- Written description
- Motion map



$$\text{acceleration} \equiv \frac{\text{change in velocity}}{\text{change in time}}$$

Linearizing data:

x	t	$\sqrt{t}$
0	0	0
1	1	1
2	4	2
3	9	3

x