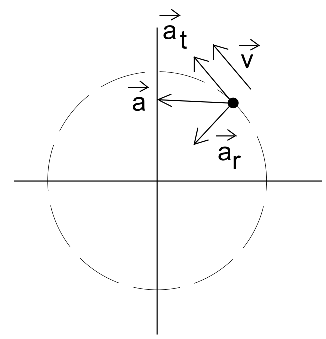
LECTURE #10 – SUMMARY

(3) Non-Uniform Circular Motion

For non-uniform circular motion, the speed of the object is NOT constant.
i.e., both the magnitude and the direction of the velocity change.

This means that the acceleration vector must have:

- one component $\perp$ to velocity which changes only the direction of the object
  $\vec{a}_\perp = \vec{a}_r = \vec{a}_c \rightarrow$ radial acceleration or centripetal acceleration
- one component || to velocity which changes only the speed of the object
  $\vec{a}_{||} = \vec{a}_t \rightarrow$ tangential acceleration



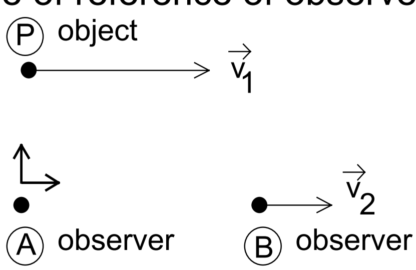
$$|\vec{a}_t(t)| = a_t(t) = \frac{dv(t)}{dt} \qquad \text{(= 0 for UCM)}$$

$$|\vec{a}_r(t)| = a_r(t) = \frac{v(t)^2}{R} \qquad \text{(like UCM but v is changing)}$$

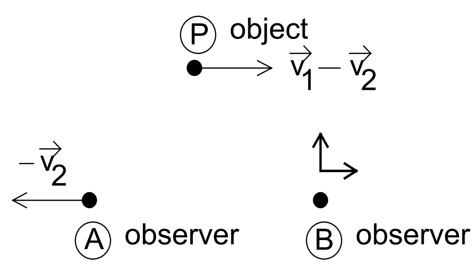
Section II.6 Relative Motion

A frame of reference is a co-ordinate system with respect to which the motion is measured. The frame of reference can be moving (e.g., a person).

Frame of reference of observer A:



Frame of reference of observer B:



The Chain Rule

Define $\quad \vec{v}_A^B \equiv \vec{v}_B - \vec{v}_A \equiv$ velocity of B relative to A

Then $\quad \vec{v}_B^P = \vec{v}_A^P + \vec{v}_B^A = \vec{v}_1 - \vec{v}_2$, i.e., $\vec{v}_P - \vec{v}_B = (\vec{v}_P - \vec{v}_A) + (\vec{v}_A - \vec{v}_B)$

In general: $\quad \boxed{\vec{v}_A^D = \vec{v}_C^D + \vec{v}_B^C + \vec{v}_A^B} \quad \& \quad \boxed{\vec{a}_A^D = \vec{a}_C^D + \vec{a}_B^C + \vec{a}_A^B}$

In our example: $\vec{a}_B^P = \vec{a}_A^P + \vec{a}_B^A$, giving two possibilities for the motion of A and B:

(1) A & B move with constant relative velocity, so $\vec{a}_B^A = 0$, $\vec{a}_B^P = \vec{a}_A^P$.
i.e, observers see the same acceleration for the object, but not the same velocity.

(2) A & B do NOT move with constant relative velocity, so $\vec{a}_B^A \neq 0$, $\vec{a}_B^P = \vec{a}_A^P - d\vec{v}_2/dt$
i.e, observers do NOT see the same acceleration for the object.

Principle of Galilean Relativity The laws of motion are the same in all frames of reference that are in uniform motion, i.e., in all inertial frames of reference.