Lecture 7, Blackboard #1

Uniform Circular Motion
- Constant speed
- Circle of radius R
- Velocity change in magnitude
  - $\vec{a} = \frac{d\vec{v}}{dt} \Rightarrow \text{acceleration}

\[ \vec{v} = \frac{d\vec{r}}{dt}, \quad \vec{a} = \frac{d\vec{v}}{dt} = \frac{d}{dt}\left(\frac{d\vec{r}}{dt}\right) = \frac{d^2\vec{r}}{dt^2} \]

\[ \vec{v} = \vec{v}_0 + \vec{v}\,dt, \quad \vec{a} = \vec{a}_0 + \vec{a}\,dt \]

\[ \ddot{r} = \frac{v^2}{R}, \quad \ddot{	heta} = \frac{v^2}{R} \]

\[ \ddot{x} = \frac{v^2}{R} \cos \theta, \quad \ddot{y} = \frac{v^2}{R} \sin \theta \]

\[ \ddot{x} = \ddot{y} = \frac{v^2}{R} \]

\[ \ddot{r} = \frac{v^2}{R} \]

\[ \ddot{\theta} = \frac{v^2}{R} \]

\[ \ddot{r} = \frac{v^2}{R}, \quad \ddot{\theta} = \frac{v^2}{R} \]

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**Lecture 7, Blackboard #2**

**Example: Rotating Earth**
- At equator:
  \[ a_L = \frac{v^2}{R} = \omega^2 R \]
  \[ v = \frac{2\pi R}{T} \]
  \[ R = \frac{2\pi R}{2\pi} = 6384 \times 10^3 \text{ m} \]
  \[ a_L = \left( \frac{2\pi R}{2\pi} \right)^2 \times 6384 \times 10^3 \times \frac{2\pi R}{T} \]
  \[ = 0.0387 \text{ m/s}^2 \]

**Uniform Circular Motion**
- \( \alpha = \frac{\Delta v}{\Delta t} \)
- \( \alpha\) may be constant.
- \( \alpha\) may change.
- \( \Delta v/\Delta t \) is not equal to \( \alpha \).

**Non-Uniform Circular Motion**
- \( a = \sqrt{a_L^2 + a_N^2} \)

**Example: Carousal Ride**
- \( \alpha = \frac{4.5}{2.5} \text{ m/s}^2 \)
- \( v = 2\pi R = 2\pi (2.5) = 7.85 \text{ m/s} \)
- \( a_L = \frac{v^2}{R} = \frac{7.85^2}{2.5} = 1.25 \text{ m/s}^2 \)
- \( a_N = \frac{v}{R} = \frac{7.85}{2.5} = 3.14 \text{ m/s}^2 \)
- \( a = \sqrt{1.25^2 + 3.14^2} = 3.35 \text{ m/s}^2 \)
Lecture 7, Blackboard #4

Relativity :: Motion, 1D

A. Simultaneity
B. Twin Paradox
C. Proper Time

\[ x_{PA} = x_{PB} + x_{BA} \]

\[ \frac{dx}{dt} = \frac{dx}{dt}_{PB} + \frac{dx}{dt}_{BA} \]

\[ v_{PA} = v_{PB} + v_{BA} \]

\[ \frac{dv}{dt} = \frac{dv}{dt}_{PB} + \frac{dv}{dt}_{BA} \]

\[ \frac{dv}{dt}_{PB} = \frac{dv}{dt}_{PA} \]

\[ \frac{dv}{dt}_{BA} = \frac{dv}{dt}_{PA} \]

Relativity Motion General 3D

- Motion is relative
- Vel/Accel depend on frame?
- Ground Rel. F. \((x, y, z, t)\)
- Ship Rel. F. \((x', y', z', t')\)
- Time is Absolute \(\Delta T\)
- \(\vec{F} = \text{Const. vel} \) ship rel. to ground
- \(\vec{F}_{x} = \vec{F} \) ship rel. to ship

\[ \vec{F} = \vec{F} + \vec{F}_{x} \]

\[ \vec{v}_{x} = \frac{\vec{F}}{m} \]
Lecture 7, Blackboard #5

- First sub on LHS = First sub on RHS.
- 2nd sub on LHS = 2nd sub on RHS in boat frame, expl.
- Sub on LHS = match + cancel.

Example:
\[ \mathbf{v}_{Bw} = \mathbf{v}_{E} + \mathbf{v}_{sw} \]
\[ \mathbf{v}_{sw} = \mathbf{v}_{sw} = 12 \text{ km/h West} \]
\[ \mathbf{v}_{Bw} = 20 \text{ km/h North} \]
\[ \mathbf{v}_{ws} = \mathbf{v}_{w} + \mathbf{w} = \text{North} \]
\[ \mathbf{v}_{w} = \mathbf{v}_{w} = 12 \text{ km/h} \]
\[ \mathbf{v}_{w} = 60 \text{ km/h} \]
\[ \theta = \frac{12}{60} = 0.20 \]
\[ \theta = 36.9^\circ \text{ East of North, upstream} \]

Relative Motion Cart:
\[ y' = y_0 + v_{y0} t - \frac{1}{2} a t^2 \]
\[ x' = 0 \]

Cart Frame:
\[ x(t) = v_x t \]
\[ y(t) = y_0 + v_{y0} t - \frac{1}{2} g t^2 \]