VP160 RC1

Github: https://github.com/joydddd/VP160-2020-SU-NOTES

you may need chrome + MathJax Plugin for Github to view properly

Github version will the most up to date one.

Concepts

Physical Quantities: ALWAYS number + unit

Scale / Vector ?

Numbers

- Scientific notation: 6.02×10^{23}
- significant figures
- uncertainty
  - e.g. $1.259 \pm 0.001 \mu A$

Units

- unit prefixes: nm($10^{-9}, nano$),\mu m(10^{-6}, $micro$), um(10^{-3}, $mili$), km(10^3, kilo) ...
- unit conversions

Vectors

- addition/ constant multiplication/ subtraction --> vector
- dot product --> scale
  - e.g. $P = \overrightarrow{F} \cdot \overrightarrow{v}$ = $|\overrightarrow{F}||\overrightarrow{v}|cos\theta$
- cross product
  - e.g. $\overrightarrow{F} = I\overrightarrow{L} \times \overrightarrow{B}$
  - length: the cross section area of two vector $|\overrightarrow{F}| = I|\overrightarrow{L}||\overrightarrow{B}|sin\theta$
  - direction: right handed rule

Coordinate Systems

- Cartesian
  - $|\overrightarrow{w}| = \sqrt{w_x^2 + w_y^2 + w_z^2}$
  - {$\hat{n_x}$, $\hat{n_y}$, $\hat{n_z}$} / {$\hat{i}$, $\hat{j}$, $\hat{k}$}
    - mutually perpendicular $\hat{n_x} \cdot \hat{n_y} = 0$
    - unit length $|\hat{n_x}| = 1$
    - Right-hand Rule $\hat{n_x} \times \hat{n_y} = \hat{n_z}$
  - $\overrightarrow{r} = x\hat{n_x} + y\hat{n_y} + z\hat{n_z}$
    - differentiate:
      $\frac{\mathrm{d}\overrightarrow{u}}{\mathrm{d}t} = \frac{\mathrm{d}}{\mathrm{d}t}(u_x(t)\hat{n_x} + u_y(t)\hat{n_y} + u_z(t)\hat{n_z}) = \dot{u_x}(t)\hat{n_x} + \dot{u_y}(t)\hat{n_y} + \dot{u_z}(t)\hat{n_z} \ \backslash$

        - integrate
        - dot product $\overrightarrow{u} \cdot \overrightarrow{w} = u_x w_x + u_y w_y + u_z w_z$
        - cross product $\overrightarrow{u} \times \overrightarrow{w} = (u_y w_z - u_z w_y)\hat{n_x} + (u_z w_x - u_x w_z)\hat{n_y} + (u_x w_y - u_y w_x)\hat{n_z}$
- Cylindrical
    - $\{\hat{n_\rho}, \hat{n_\varphi}, \hat{n_z}\}$
        - $\rho = \sqrt{x^2 + y^2}$
        - $\varphi = \arctan\frac{y}{x}$
        - $z = z$
        - $x = \rho\cos\varphi$
        - $y = \rho\sin\varphi$
    - $\overrightarrow{r} = \rho\hat{n_\rho} + z\hat{n_z}$
        - NOT directly differentiable!!! Will discuss later
- Spherical
    - longitude and latitude system
    - $\{\hat{n_r}, \hat{n_\varphi}, \hat{n_\theta}\}$
        - $\rho = \sqrt{x^2 + y^2 + z^2}$
        - $\varphi = \arctan\frac{y}{x}\ (0, \pi)$
        - $\theta = \arctan\frac{\sqrt{x^2+y^2}}{z}\ (0, \pi/2)$
        - $x = r\sin\theta\cos\varphi$
        - $y = r\sin\theta\sin\varphi$
        - $z = r\cos\theta$
    - $\overrightarrow{r} = r\hat{n_r}$
        - NOT directly differentiable!!! Will discuss later
- 2D polar coordinates
    - Cylindrical coordinates with $z = 0$
    - Spherical coordinates with $\theta = 0$

1D kinematics

Average vs. Instantaneous

Velocity

- average velocity:
    - $v_{\mathrm{av,x}} = \frac{x(t+\Delta t) - x(t)}{\Delta t}$
- velocity
    - When the time interval Δt -> 0
    - $\frac{\mathrm{d}x(t)}{\mathrm{d}t} = \dot{x}(t) \stackrel{\mathrm{def}}{=} v_x(t)$
    - velocity is location change rate w.r.t time

Acceleration

- average acceleration
    - $a_{\mathrm{av,x}} = \frac{v_x(t+\Delta t) - v_x(t)}{\Delta t}$
- acceleration

- When time interval Δt -> 0
- $a_x(t) = \frac{\mathrm{d}v_x(t)}{\mathrm{d}t} = \dot{v_x}(t) = \frac{\mathrm{d}^2 x(t)}{\mathrm{d}t^2} = \ddot{x}(t)$
- acceleration is velocity change rate w.r.t and twice differentiation of position w.r.t time.

see lecture notes for pics

Relativity of Velocity/acceleration