# 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 be the most up to date one.

## Concepts

Physical Quantities: ALWAYS number + unit

Scale / Vector ?

Numbers

- Scientific notation: $6.02 \times 10^{23}$
- 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

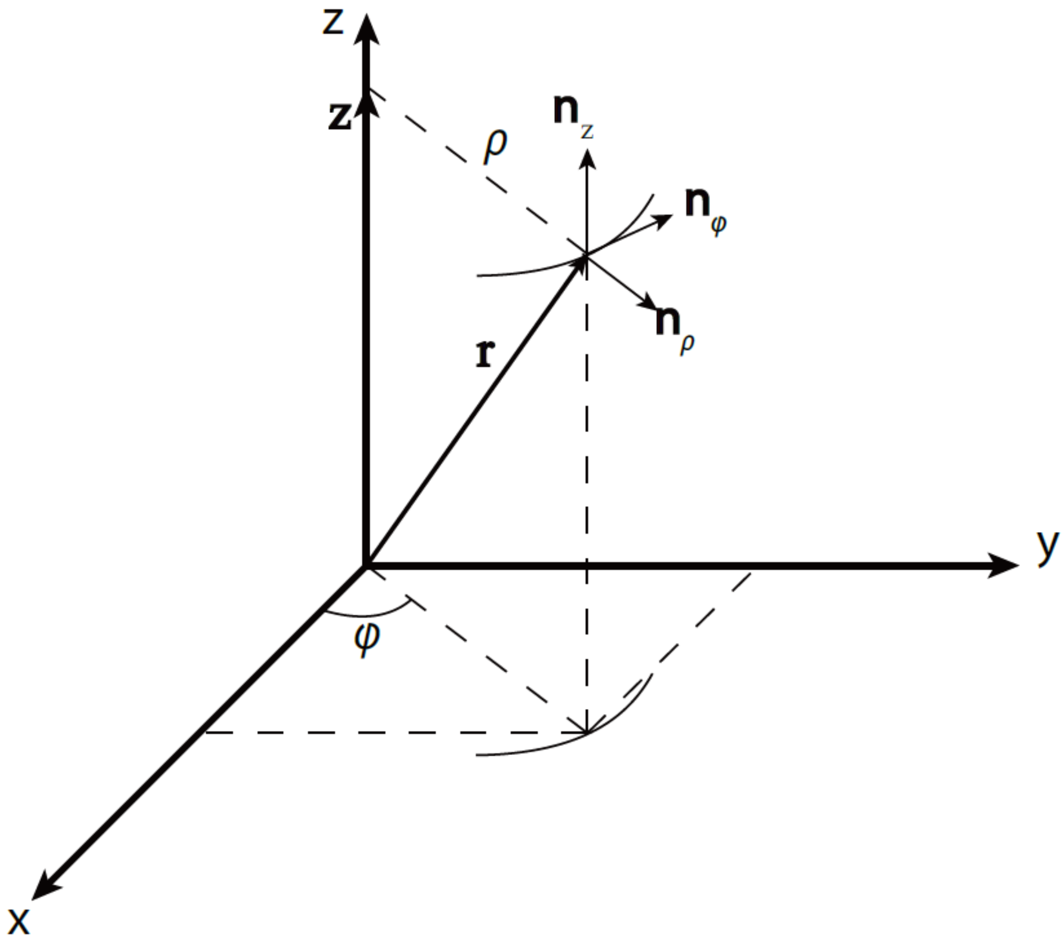
Vectors

- addition/ constant multiplication/ subtraction --> vector
- dot product: vector . vector --> scale
  - $$\overrightarrow{u}\cdot\overrightarrow{v} = \left<\left(\begin{matrix} u_x\u_y\u_z \end{matrix}\right), \left(\begin{matrix} v_x\v_y\v_z \end{matrix}\right)\right> =u_x v_x
  - u_y v_y + u_z v_z
  - e.g. $P = \overrightarrow{F} \cdot \overrightarrow{v}$ = $|\overrightarrow{F}||\overrightarrow{v}|cos\theta$
- cross product: vector x vector --> vector
  - ```
    \overrightarrow{u} \times \overrightarrow{v} =
    \left|\begin{matrix}
    \hat{x} & \hat{y} &\hat{z} \
    u_x & u_y & u_z\
    v_z & v_y & v_z\
    \end{matrix}
    \right|
    = \left|\begin{matrix} u_y & v_z \v_y & v_z \\end{matrix}\right|\hat{x}-\left|\begin{matrix} u_x & v_z \v_x & v_z \\end{matrix}\right|\hat{y}+\left|\begin{matrix} u_x & v_y \v_x & v_y
    ```
  - 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

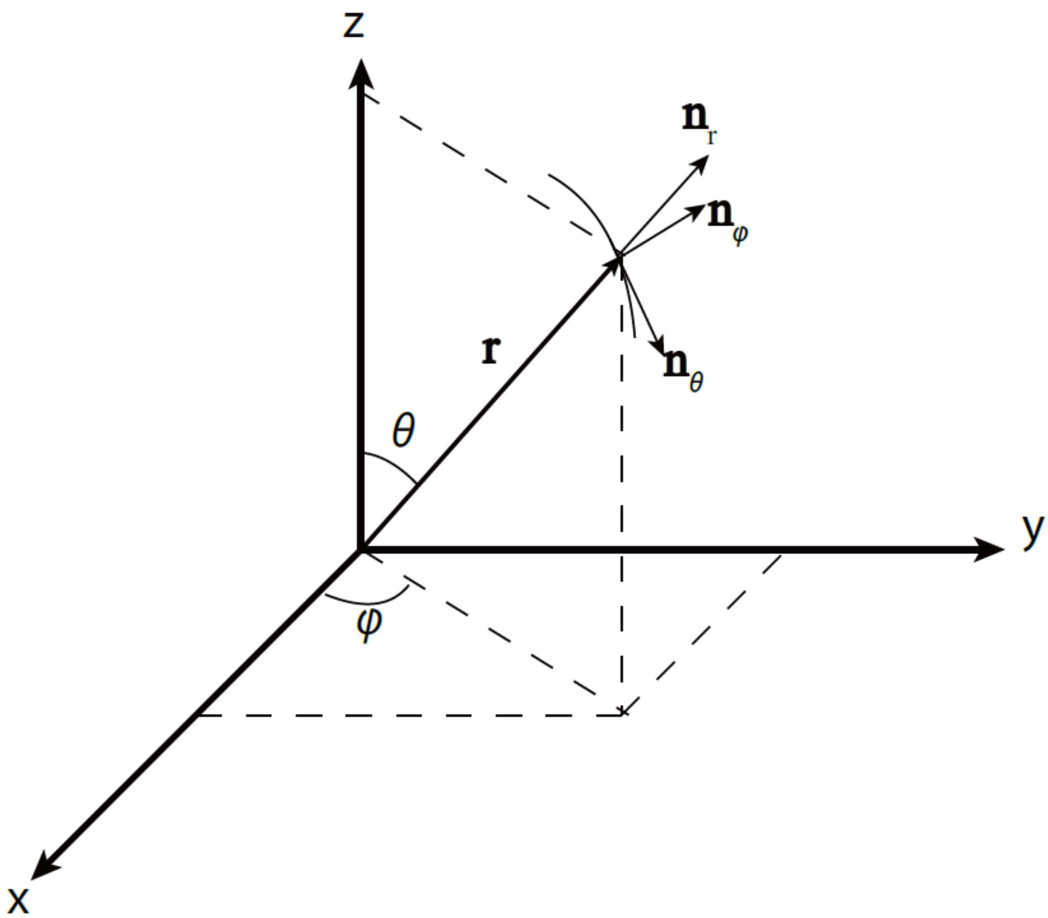
- Cartesian
  - $|\overrightarrow{w}| = \sqrt{w_x^2 + w_y^2 + w_z^2}$
  - {$\hat{n_x}$, $\hat{n_y}$, $\hat{n_z}$} / {$\hat{i}$, $\hat{j}$, $\hat{k}$}
    - mutually perpendicular $\hat{n_x} \cdot \hat{n_y} = 0$
    - unit length $|\hat{n_x}| = 1$
    - Right-hand Rule $\hat{n_x} \times \hat{n_y} = \hat{n_z}$
  - $\overrightarrow{r} = x\hat{n_x} + y\hat{n_y} + z\hat{n_z}$
    - 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:
  - $v_{\text{av,x}} = \frac{x(t+\Delta t) - x(t)}{\Delta t}$
- velocity
  - When the time interval $\Delta t$ -> 0
  - $\frac{\mathrm{d}x(t)}{\mathrm{d}t} = \dot{x}(t) \overset{\text{def}}{=} v_x(t)$
  - velocity is location change rate w.r.t time

Acceleration

- average acceleration
  - $a_{\text{av,x}} = \frac{v_x(t+\Delta t) - v_x(t)}{\Delta t}$
- acceleration
  - When time interval $\Delta t$ -> 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