9/3/20

UN 2801 Orientation

I A two-semester course covering

- Mechanics
- Special relativity
- Electricity & Magnetism

  Maxwell's equations & light

  (approached from special relativity

  - not historical)
- Quantum mechanics

  Measurement theory

  Schrödinger equation

  Quantization of E&M - quantum field theory

II Difficult 4.5 point course,

8-9 problems per week

III Numerical solutions using Python

- gravitational motion
- electrostatics
- Some numerical homework problems

IV Math plays a central role

- Essential language of physics

  linear algebra, tensors, partial differential equations, Hilbert space
- Rotational motion

(x, y, z)

$$\begin{pmatrix} x(t) \\ y(t) \\ z(t) \end{pmatrix} = \underbrace{\begin{pmatrix} R_{11} & R_{12} & R_{13} \\ R_{21} & R_{22} & R_{23} \\ R_{31} & R_{32} & R_{33} \end{pmatrix}}_{R(t)} \begin{pmatrix} x(0) \\ y(0) \\ z(0) \end{pmatrix}$$

$$R(t)^{-1} \frac{dR}{dt}(t) = \begin{pmatrix} 0 & \omega_z & -\omega_y \\ -\omega_z & 0 & \omega_x \\ +\omega_y & \omega_x & 0 \end{pmatrix}$$

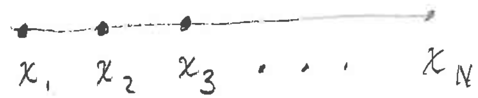
$\vec{\omega} = (\omega_x, \omega_y, \omega_z)$ is the angular velocity

- use a 4x4 matrix to relate space-time coordinates of an event specified in two inertial frames
- recognize $F_{\mu\nu} = \begin{pmatrix} 0 & B_3 & -B_2 & E_1 \\ -B_3 & 0 & B_1 & E_2 \\ B_2 & -B_1 & 0 & E_3 \\ -E_1 & -E_2 & -E_3 & 0 \end{pmatrix}$

  as a Lorentz tensor constructed from electric $(\vec{E})$ and magnetic $(\vec{B})$ fields

IV Math continued

- If we replace the continuous space coordinate $-\infty < x < +\infty$ by N points $x_1, x_2, x_3 \cdots x_N$;



and introduce a complex number $\psi(x_i)$ for each position x_i, then

$$\begin{pmatrix} \tilde{\psi}(p_1) \\ \tilde{\psi}(p_2) \\ \tilde{\psi}(p_3) \\ \vdots \\ \tilde{\psi}(p_N) \end{pmatrix} = \frac{1}{\sqrt{N}} \underbrace{\begin{pmatrix} e^{-ip_1x_1/\hbar} & e^{-ip_1x_2/\hbar} & \cdots & e^{-ip_1x_N/\hbar} \\ e^{-ip_2x_1/\hbar} & e^{-ip_2x_2/\hbar} & \cdots & e^{-ip_2x_N/\hbar} \\ \vdots & \vdots & & \vdots \\ e^{-ip_Nx_1/\hbar} & e^{-ip_Nx_2/\hbar} & \cdots & e^{-ip_Nx_N/\hbar} \end{pmatrix}}_{U} \begin{pmatrix} \psi(x_1) \\ \psi(x_2) \\ \vdots \\ \psi(x_N) \end{pmatrix}$$

A unitary transformation in quantum mechanics from position probability amplitudes to momentum probability amplitudes.

V Details

- Limited registration
  - [5 in BC calculus
  - 4's and at least one 5 in BC physics Mechanics and E&M

    or

  - [good score on placement quiz
- First class Tuesday at 10:15 AM EDT, Lectures recorded and posted