Quantum physics 1

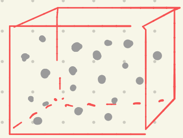
Class 1

Class 1

Physics Overview

Classical Physics

- single object, laws of motion
  $F = ma$
  EM, Gravitational laws
- many particle behaviour
  Energy distribution, e^{-E/k_BT}



Modern Physics

- single particle, laws of motion
  Quantum mechanics
  (6 postulates)
- laws of many body quantum objects
  Quantum Statistics
  $\Downarrow$
  "Quantum Physics"

A Math Review:

1. Complex Variables

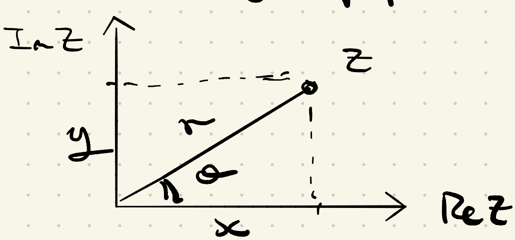
$i = \sqrt{-1}$

$z = x + iy$

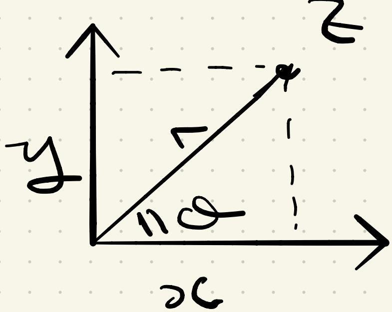
$z^* = x - iy$

$z^* z = x^2 + y^2 = r^2$

$|z| = \sqrt{z^* z} = r$



(ii) Euler Formula



$$z = x + iy = r\cos\theta + i r\sin\theta$$

$$\frac{dz}{d\theta} = r(-\sin\theta + i\cos\theta)$$

$$dz = i(r\cos\theta + i r\sin\theta)\, d\theta$$

$$dz = i z\, d\theta$$

$$\frac{dz}{z} = i\, d\theta \Longrightarrow \ln z = i\theta + c$$

$$z = e^{c} e^{i\theta}$$

at $\theta = 0$, $z = x = e^{c} = r$

$$\boxed{z = r e^{i\theta}}$$

Do in-class #1, 2, 3

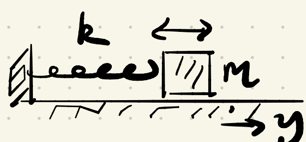
2nd Order Linear Differential Equations

$$A(x)\frac{d^2y}{dx^2} + B(x)\frac{dy}{dx} + C(x)\, y = D(x)$$

let $B = D = 0$, & $A, C =$ constant

$$\Rightarrow \frac{d^2y}{dx^2} + Cy = 0$$

Classical Harmonic oscillator



$$x \rightarrow t\ ;\ \frac{d^2y}{dt^2} + Cy(t) = 0$$

Ansatz: $y(t) = y_0 \cos(\omega t)$

$\Rightarrow \quad -y_0 \omega^2 \cos \omega t + c y_0 \cos(\omega t) = 0$

$\Rightarrow \quad \omega^2 = c = k/m$

Also,

$y \approx e^{+i\omega t}$:

$$\left\{ \begin{array}{l} -\omega^2 e^{i\omega t} + c e^{i\omega t} = 0 \\ \Rightarrow \quad c = \omega^2 = k/m \end{array} \right\}$$

$y \approx e^{-i\omega t}$:

$$\left\{ \begin{array}{l} -\omega^2 e^{-i\omega t} + c e^{-i\omega t} = 0 \\ \Rightarrow \quad c = \omega^2 = k/m \end{array} \right.$$

$$\therefore \quad \boxed{y = A e^{+i\omega t} + B e^{-i\omega t}}$$

compare w/ SHO

$F = -kx$

$ma = -kx$

$m \frac{d^2x}{dt^2} = -kx$

$\frac{dx^2}{dt^2} = -\frac{k}{m} x$

$\frac{dx^2}{dt^2} + \left(\frac{k}{m}\right) x = 0$

In-class #4