Classical Mechanics CM vs Quantum Mechanics QM

energy varies continuously

energy (quantized)

SHO in 1D

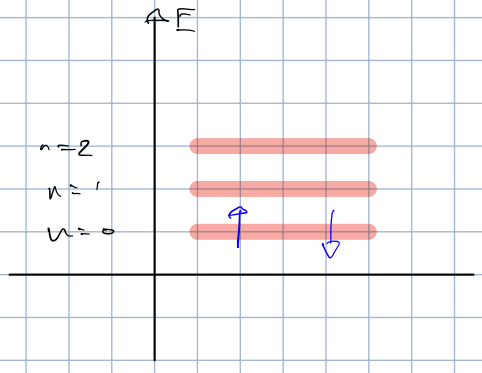
$$E = \frac{p_0^2}{2m} + \frac{1}{2}m\omega^2 x_0^2$$

energy can vary w/time

Quantum Hamiltonian

$$\hat{H} = \frac{\hat{p}^2}{2m} + \frac{1}{2}m\omega^2\hat{x}^2$$

$$E_n = \left(n+\frac{1}{2}\right)\hbar\omega$$



rotation

$$L = I \cdot \dot{\theta}$$

$$L_z = m\hbar$$

$$m = -l, -l+1, \ldots, l$$

$$I^2 = l(l+1)\hbar^2$$

discrete chunks

Deterministic

$$\vec{F} = m\frac{d^2x}{dt^2}$$

x_0, p_0 → $x(t)$ exactly

can predict future

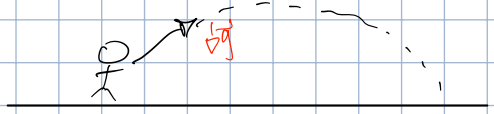
Probabilistic

only probabilities as matter of principal

Translation of math ↔ physics/reality

simple

subtle



$x(0)$ $y(0)$ $\vec{F}=m\vec{a}$ $\Rightarrow x(t)$ & $y(t)$

$\ddot{x}(0)$ $\ddot{y}(0)$

$x, p \rightsquigarrow \hat{x}, \hat{p}$

operators on Hilbert space $\rightsquigarrow \infty \times \infty$ dimensions

wave eq^{n} $\Psi(x,t) \rightarrow$ complex #

no Planck's constant

Hella Planck's constant

$h \approx 6.63 \cdot 10^{-34}$ Joule-sec

Einstein: photons $E_{photons} = hf$

light bulb by 100Watt # of photons

$N_{photons} = (100\ J/s \cdot 1s)\ (h \cdot f_0)$ $\rightarrow$ light $f_0 \sim 5 \cdot 10^{14}$ Hz

Clear distinction: particles vs wave
(electrons,) (EM, ...)

everything is both particle & wave
particle-wave duality

why momentum and not velocity?

Hamiltonian $H(q,p)$ vs Lagrangian $L(q,\dot{q})$

$\downarrow$

path integral formulation

E&M

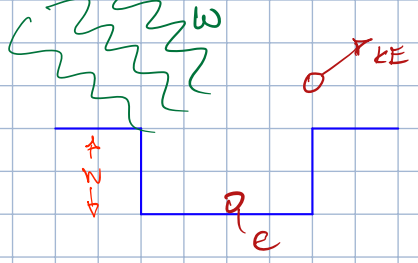
Maxwell's Eq^{n}: have plane wave, monochromatic sol^{n}'s
wave propagating along z-axis

$\vec{E} = E_0 \hat{n} \cos(kz - \omega t)$ $\quad c = \frac{\omega}{k}$

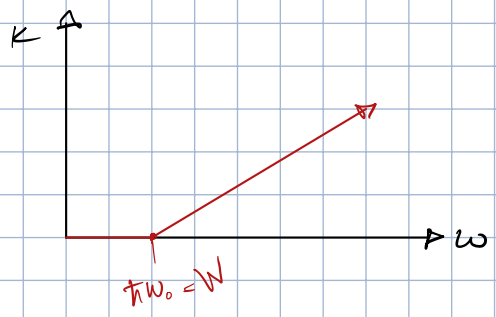
$\hat{n} \cdot \hat{e}_z = 0$ $\quad \hat{n} = \hat{e}_x$ linearly polarized along x
$\hat{n} = \hat{e}_y$ y

Einstein: photons $E_{photon} = \hbar\omega$

photoelectric effect



How does KE depend on Intensity? Frequency?



$$K = \hbar\omega - \hbar\omega_0$$
$$= \hbar\omega - W$$

light beams - laser
beam splitter - Amazon
polarizers