Classical Mechanics – Lecture – 1

04.08.2015

Range is 7 to 8 orders.

	Smallest				largest (Sun)
Mass, M (kg)	10^{-30} (me)	–	10^{-4} (fraction of grams)	– 10^{3}	– $10^{30} \times 10^{22} = 10^{52}$ (mass of universe)
Length, L (m)	10^{-35} (lp)	–	10^{-4}	– 10^{4}	– 10^{26} (radius of universe)
Time T (s)	10^{-42} (T_p)	–	10^{-1} (Processing centre of brain)	– 10^{7} (Put you in a closed room)	– 13.7 billion – 10^{17} sec

100 days
A day – 10^{5} sec
100 day – 10^{7} sec.

80 orders Nature.

A lump of metal and did not give you density.

World of middle dimensions.

$M\ L\ T$

1. density of universe & radius of universe.
   size of universe (very tricky).

10^{52} (Age of Universe – 13.7 billion years).

× light years.

Stars are receding at "c"

You at Centre of universe and rest of it is expanding.

[Speed] = $\frac{[L]}{[T]}$

[density] = $\frac{[M]}{[L^3]}$

Volume = $[L^3]$

acceleration = $\frac{[L]}{[T^2]}$

$\hbar, c, G$

Natural constants.
M, L, T
We created.

Planck's const $\hbar$ – $J/s - ML^2T^{-1}$

c – LT^{-1}

G – find from Newtons equation

Planck length, mass, time.

Range is Absolutely incredible – 80 orders of magnitude.

Hard wired in to brains. – Classical physics.

Microscopes etc – You can extend the range

Why you cannot tell a diff between ps and ns. (You didn't need it for survival reflex time)

A fraction of second enough to fall down

mg and pico gm – NO

gm – kg – Yes.

$\hbar, c, G$ – lower limit

Longtime to discover

Push an object you change its velocity and not position

$F \propto$ rate of change of momentum

Classical physics is one portion of this range

Classical physics is a non trivial extension of Quantum Mechanics.

Statistical physics - ensemble etc.

non-relativistic.

$\hbar$ c g α

0 ∞ no

Switch off gravitation

Classical electromagnetic waves

Physical & Mechanical.

Classical Physics $c = \infty$ $\hbar = 0$

You know Complex number

If all measurement are real then why we need complex numbers.

Weighted Matrices; Combination of numbers; the word imaginary does not mean anything

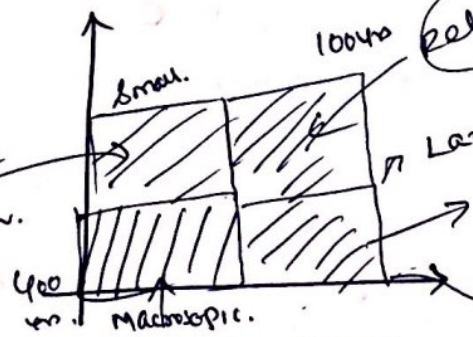
Phy means: $2+3i$

" of -3.

dynamics: particles in flavor

Very slow velocities.

length scales. Macroscopic. Non-relativistic Quantum mech.



Relativistic Q. M. $\Rightarrow E = mc^2$

QFT

no. of particles is no longer conserved

Relativistic mechanics or physics.

Astrophysics

non-relativistics

Classical Mechanics or Newtonian.

Thermodyn: Ideal gas:

QM: Hydrogen atom.

Relativistic is no longer for single particle.

Emergent properties: Water molecules - Phases.

Electron is wave or pa

It is meaningless.

failure of language

what is this chalk?

(Only for bacterias. F ∝ Position.

Mechanics.
relation.

Classical dynamics (Newtonian). lecture - 2 06. 08 2015

...grees of freedom:- Collection of Particles:

Single Particle - three co-ordinates - three degrees of freedom

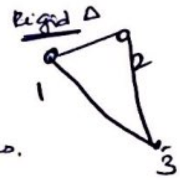
Two Particles - six degrees of freedom.

does not matter - Cartesian or Polar. or cylindrical.

N - Particle System has 3N co-ordinates - Generalised. - No constraint

Plane - two degree ✓ | Count the no. of degrees of freedom
line - single degree ✓ | before solving equations of motion.

Constraints :



distance is fixed.

r_{12} = Constant (5 degree of freedom).

r_{23} = constant (Seven)

r_{13} = Constant (Six).

N, 3N Co-ordinates.

r_{ij} = const for $1 \leq i, j \leq N$

No. of Constraint Pairs = $^NC_2$:- $\frac{N(N-1)}{2}$; No. of Independent degrees of freedom.

? $3N - \frac{N(N-1)}{2}$ (3N-N(N-1)/2) N=8

($^nC_2$)

This is a rigid body.
Distance between any pairs is fixed.

Some of the constraints are redundant

Independent degrees of freedom (Six degrees). of freedom.

Remaining Constraints are redundant

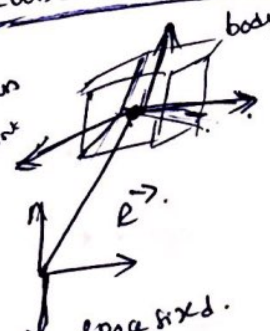
Cannot have Negative degrees of freedom
linear in N
and that increases $\sqrt{N}$.

Count the degrees of freedom:

3×5 15 - 16 20

3×8 = 24 - 28 56 8×7

Centre of mass is at some point



body fixed.

→ twisted or turn.

$\vec{e}$.

Space fixed.

Co-ordinates fixed

Body fixed co-ordinate system.

twisted or turned.

& Space fixed

3 Euler rotations

three axes & three angles

...need to reach the other co-ordinate system

to discover

Spectra of diatomic molecules. two degree of rotational
three degree of translational.

A constraint does not always eliminate degrees of freedom (Particle moves in XY quadrant only. Plane in first quadrant still have two degrees of freedom)

Eliminate degree of freedom ⇐ Holonomic constraints ; Integrable $f(r_1, r_2, \ldots) = 0$

⇐ Non-holonomic " ; (Can't be used to eliminate deg of freedom)

Gravitational field e Particle placed on the surface of sphere. Slide down

Beads of abacus — One dimn. (They could involve velocities. which case not all clear

Gas molecules move in container. Particle on surface of solid sphere. Point particle. You can integrate matter out to eliminate degrees of freedom

$i = 1, \ldots N$. Chalk under the action of earth's gravity = Can you predict its future motion (Point particle moving in space)

$v_i(t) = \dot{r}_i(t)$ horizontal velocity ⇒ elliptic path (parabolic) ⇒ escapes with hyperbolic orbit

$a_i(t) = \dot{v}_i(t) = \ddot{r}_i(t)$

Initial position or force ⇒ does not sufficient

$\dot{r} = \frac{dr}{dt}$ you need Initial velocities and position ⇒ Newton's second order equation.

$p_i = m_i v_i$

$\dot{p}_i = m_i a_i = F_i$ Both Initial position and velocities dynamics is happening phase space.

$F_i = F_{i1} + F_{i2} + \ldots F_{iN}$ — degrees of freedom. (slopes).

$= \sum_{j=1}^{N} F_{ij}$ This is the idea behind dynamics

$F_{ii} = 0$ A. The number of independent degrees of freedom has to be determined first

$F_{ij} = -F_{ji}$ B. the corresponding generalized velocities have also to be added on the set of dynamical variables.

Generalized co-ordinates $q_1, q_2 \ldots q_N$

velocities $\dot{q}_1, \dot{q}_2 \ldots \dot{q}_N$

$\frac{dq_i}{dt} = \dot{q}_i$

N independent degrees of freedom

To solve the equations of motion, you need to know certain amount of initial data. The value of these generalized co-ordinates & generalized velocities at an initial instant of time. In this sense Newtonian mech dynamics are deterministic.