Physics I

Lecture 1

Text Book :

Thornton and Marion : Classical Dynamics of Particles and Fields

- John Taylor : Classical Mechanics
- Gregory : Classical Mechanics
- Morin : Classical Mechanics (Lots of Problems)

Marks Distribution:

Homework : 30

Quizzes :30

Final : 40

Classical Mechanics

↳ Newtonian Mechanics and a bit of foray into reformulation by Lagrange and Hamilton

Larger picture : How Newtonian Dynamics fits into rest of Physics

Basic Question : studying particles/bodies in motion → planets, balls, ... atoms

Greeks : Aristotle

2000 yrs ago

Galileo (1564 – 1642) experiment ⟶ laws.

Newton (1642 – 1727) Expt + mathematical formulation

↓ starting point.

Classical Mechanics

Newton ($\vec{F} = m\vec{a}$).

explained planets, apples, tides! 200+ years

No experimental contradictions!!

20th Century

breaks down for $v/c \simeq 1$

Einstein → Special Relativity (1905).

breaks down for very small objects → atoms, subatomic particles

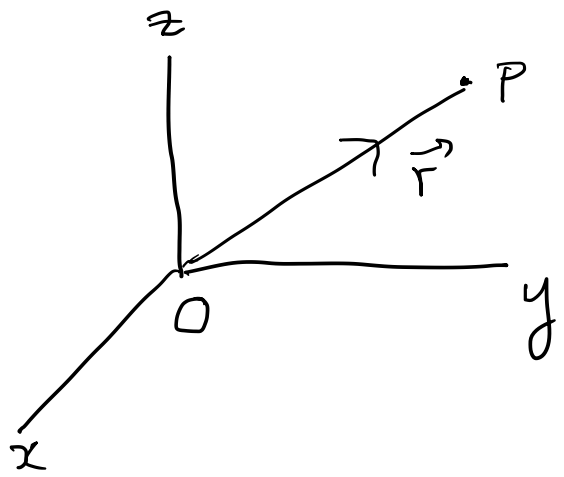
Quantum Mechanics

↳ Reduce to Newton in appropriate limits.

Newtonian dynamics has a wide range of applicability

Reference frames / coordinate systems

- To describe dynamics need to specify location of a particle
- Must specify coordinate system



$\vec{r}$ (depends on choice of origin)

$\vec{r} = (x, y, z)$ Cartesian components

vector $\vec{r}$: geometrical object

components are not.

$$\vec{r} = x\hat{x} + y\hat{y} + z\hat{z}$$

$$\equiv x\hat{i} + y\hat{j} + z\hat{k}$$

$$\vec{r} = \sum_i r_i \hat{e}_i \quad \hat{e}_1 = \hat{x}, \hat{e}_2 = \hat{y}, \hat{e}_3 = \hat{z}$$

Time : In Newtonian dynamics time is absolute quantity. Does not depend on reference frame. All observers agree on time measured. Only freedom is in choice of origin of time.

Reference frame :

Every problem in classical mech is formulated w.r.t a specific ref. frame $\longrightarrow$ choice of spatial axes and origin.

- An important diff arises when two ref frames are in relative motion.

Newton's Laws

1st Law: In absence of external forces, a particle moves with constant vel $\vec{v}$.

second Law: $\vec{F} = m\vec{a} = \frac{d\vec{p}}{dt}$ $\quad \vec{p}$: momentum

$$\vec{a} = \frac{d\vec{v}}{dt} = \dot{\vec{v}} = \frac{d^2\vec{r}}{dt^2} = \ddot{\vec{r}}$$

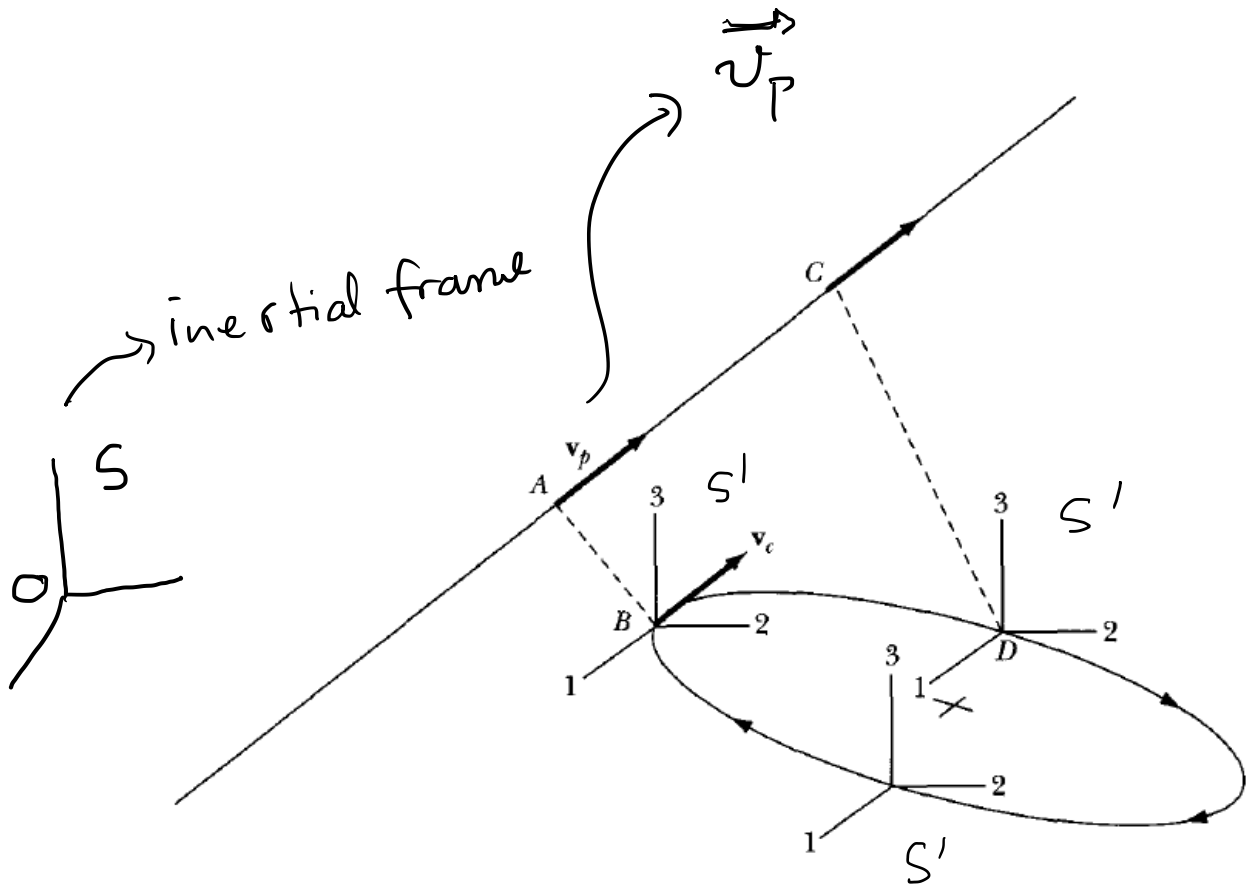
$$\boxed{\vec{F} = m\ddot{\vec{r}}} \longrightarrow \text{given initial conditions solve for } \vec{r}(t)$$

- Is the 1st Law merely a special case of second law?

↓ related to issue of ref frames. Newton's Law does not hold for all ref frames!

The special class of ref. frames in which the first law holds ~~are~~ is called inertial reference frames.

↳ 1st Law ⇒ inertial frames exist in nature



So S observes particle with uniform vel.
S' observes particle accelerating.
when there is no force!

What does S' observe?
When particle is at A
in frame S moving with $\vec{v}_P$
S' measures $\vec{v}_C = \vec{v}_P$
S' will observe particle at rest at A' when S' is at B.

When particle is at C
S measures vel $\vec{v}_P$
At C, S' at D will observe particle moving with non-zero velocity!