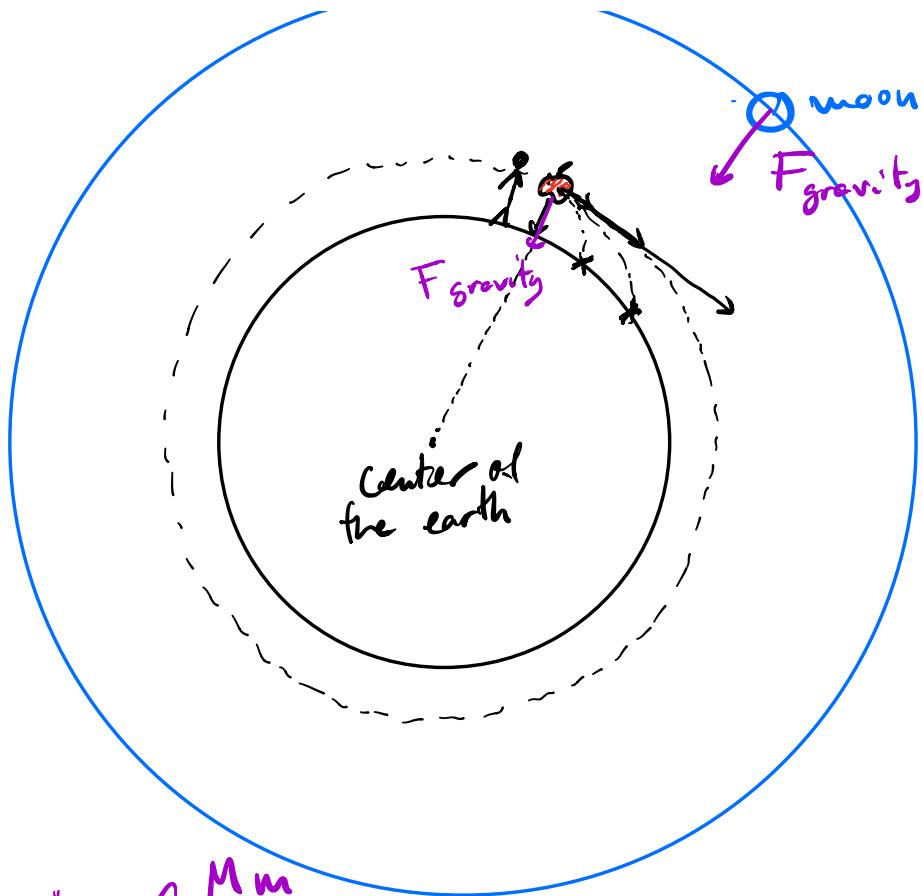


Lecture 4: Basic concepts of Newton's theory of classical mechanics & the "law of inertia".

- In the previous lecture we introduced a new theory to explain / describe / predict motion of physical objects.
- This theory is known as Newton's theory of classical mechanics. a 1700 and for the next 200 years physicists tried to explain every phenomena using Newton's theory.
- It satisfied the 2 criteria to consider it better than previous theories.
 - * It explains / predicts new phenomena e.g. the return of a comet.
 - * Unifies older independent theories to a simpler framework.
e.g. same theory (Newton's theory) explains motion of planets and falling objects on earth.



$$F_{\text{gravity}} = G \frac{Mm}{d^2}$$

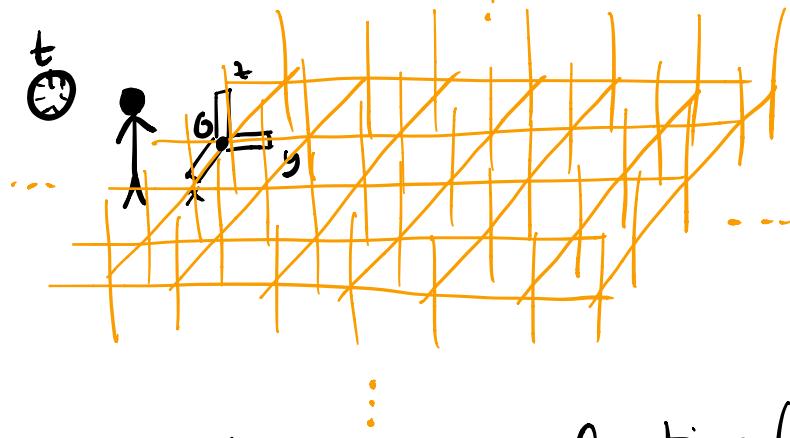
- Basic concepts of Newton's theory

- Physical objects: Point particles, systems of point particles, rigid bodies, fluids, gases, ...
- Physical system: Set of physical objects that we are addressing.
- Physical event: Anything that happens at a specific location and time.

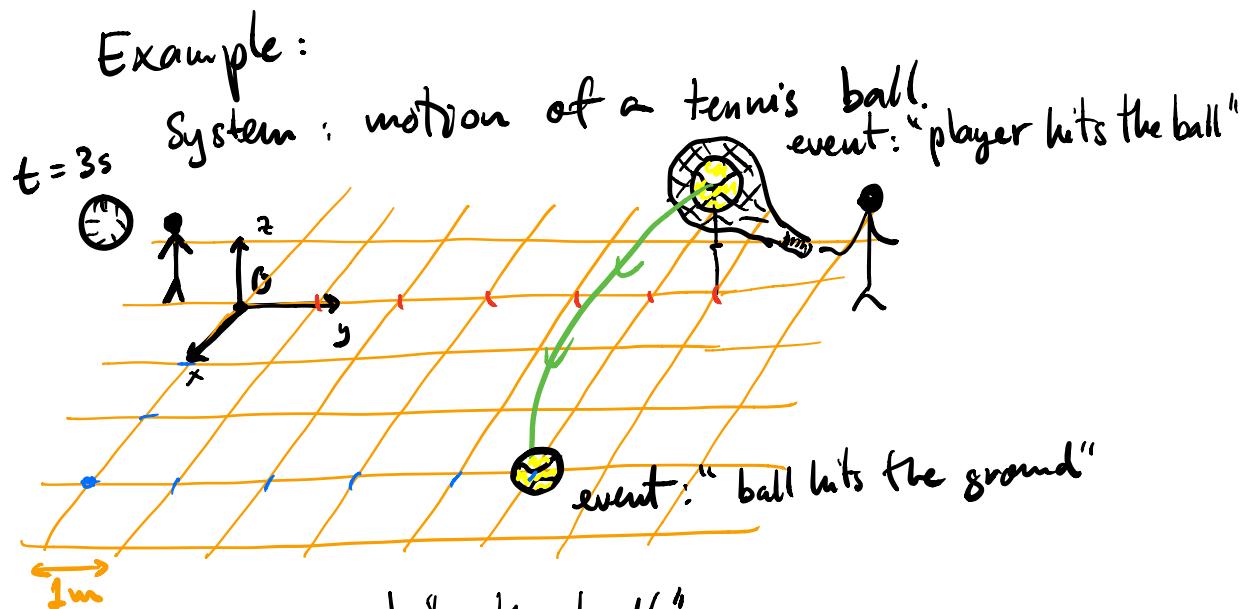
- Observer: Individual that can make measurements (of length, time, mass, ...). Carries a set of measuring sticks that maintain their length and angles fixed (w.r.t each other) together with a clock. This allows the observer to construct a frame of reference.



- Frame of reference: It consists of an imaginary spatial grid constructed by the observer's rigid frame. ...



... It selects an origin for time (when to start the clock) and an origin G for the grid.



Event "player hits the ball"

happens according to our
observer at {
 $x = 0\text{ m}$
 $y = 6\text{ m}$
 $z = 2\text{ m}$
 $t = 3\text{ s}$

Event "ball hits the ground"

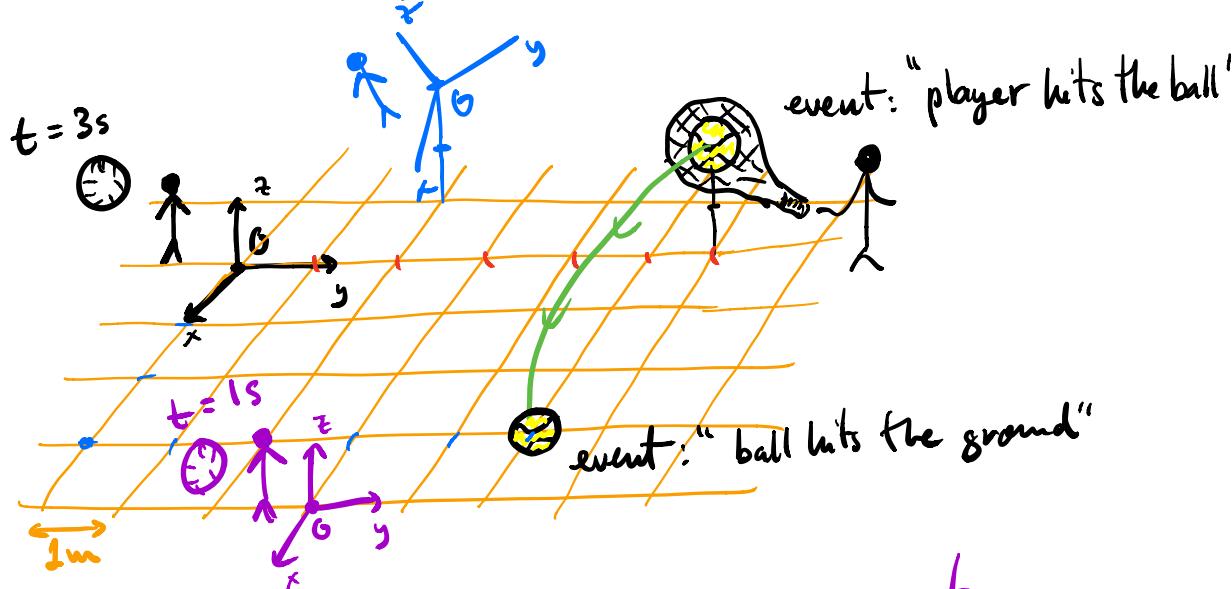
happens according to our
observer at

{
 $x = 3\text{ m}$
 $y = 5\text{ m}$
 $z = 0\text{ m}$
 $t = 3.6\text{ s}$

- Coordinates of an event: the 4 numbers (x, y, z, t) that specify the location & time of an event.

* Goal of Newton's theory : Given the "state of motion" of an object at an instant of time, predict the "state of motion" at any other instant of time. ↑
eg location of the object.

* Remark: The coordinates of an event change if we change the observer (frame of reference)



According to observer 2 the event "player hits the ball" happens at

$$x = -4 \text{ m}$$

$$y = 3 \text{ m}$$

$$z = 2 \text{ m}$$

$$t = 1 \text{ s}$$

- Inertial observers (or inertial frames of reference): observers that are not subject to the action of a force. In other words, isolated from any external interaction.

Newton considered that distant stars are isolated enough from any external interaction that they are ideal inertial "observers" / inertial frames of reference.

- ▲ An observer that is at rest or moves with constant speed in a straight line w.r.t. an inertial observer is also an inertial observer.



There are 3 fundamental laws in
Newton's theory.

due to Galileo

- 1st Newton law ("law of inertia"):

For an inertial observer (or inertial frame of reference)

an object either remains at rest or
continues to move at constant speed in a
straight line, unless acted upon by a force.

spinning w.r.t distant stars

