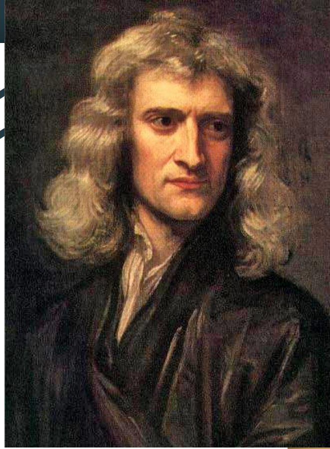
CALCULUS PROJECT



Calculus is the study of how things change. It provides a framework for modeling systems in which there is change, and a way to deduce the predictions of such models

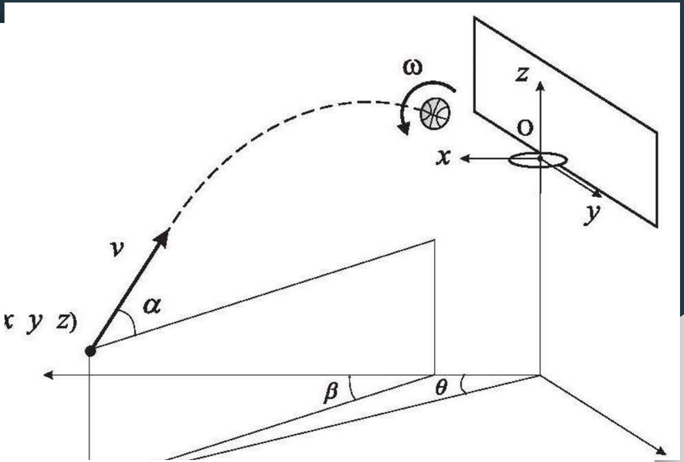
Athletes, trainers, and coaches often use calculus to gain benefits over their counterparts. Calculus can also be used to calculate the projectile motion of baseball's trajectory, speed of baseball when hit, and predict if runners can make it to the next base on time, given their running Speed.

$$f(x) = \int_0^x f'(t)\, dt$$

By :

Aagam Shah(64)
Vivek Shah(65)
Het Shah (66)
Ronit Shah(67)
Vishwaa Shah(68)
Yashvi Shah(69)

Importance of Calculus

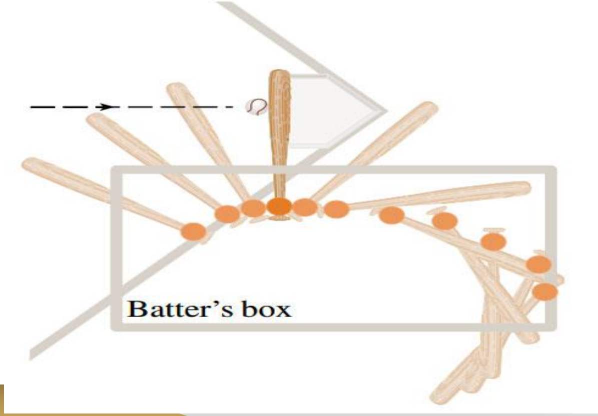


Moment of inertia is an object’s resistance to change in its rotational motion.

Inertia is always measured by a reference line the axis of rotation.

Inertia is the measure of resistance that a body of a certain mass when pushed in motion or stopped from moving. Inertia calculates the difficulty of the object to resist change. For example, heavier objects have difficulty in accelerating and difficulty in stopping.

Calculus is used to calculate the moment of inertia due to its ease of use in sports.



USE OF CALCULUS IN BASEBA

HOW IS CALCULUS USED IN BAS

$K = \frac{1}{2} mv^2$

$K = \int_{x_2}^{x_1} F(S)\, ds$

$K = \frac{1}{2} mv_2^2 - 1/2 mv_1^2$

IMPORTANCE OF CALCULUS IN BASKETBALL

Calculus can be used in basketball to find the exact arc length of a shot from the shooter's hands to the basket. The moment the basketball is released from the shooter's hands, its travelling path creates an arc all the way to the net.Using the angle of release and strength of the release, one can mathematically predict the travelling path and the length of the arc. While the ball is in the air, it is affected by only one force, which is gravity!

Finding the arc length of a basketball throw:

Travel path of a basketball can be divided into two components, the horizontal (x) direction and the vertical (y) direction. These two components can be represented by the following parametric equations:

For horizontal, $x(t)=x_o+v_ocos(\theta)t$

For vertical, $y(t)=y_o+v_osin(\theta)t+1/2gt^2$

x_O is the initial horizontal position of the basketball.
y_O is the initial vertical position of the basketball.
$v_O$is the initial velocity of the basketball.
θ is the angle the ball is projected with respect to the x-axis.
G is the acceleration due to gravity, -9.81 m/s.2
t is the time travelled.
The derivatives of x(t) and y(t) with respect to time t are:

$dxdt=vocos(\theta)t$ $dy/dt=vosin(\theta)-9.81t$
Now, the distance of the travel distance of the basketball can be found using the arc length equation:

L=∫βα(dxdt)2+(dy/dt)2−−−−−−−−−−−√dt,α≤t≤β
Now, by inserting the derivatives of x(t) and y(t) in the arc length equation:

L=∫βα(vocos(θ))2+(vosin(θ)−9.81t)2−−−−−−−−−−−−−−−−−−−−−−−−−−√dt
This equation can be modified based on: (a−b)2=a2−2ab+b2

Cont,

L =∫βαvo2cos2(θ)+vo2sin2(θ)−19.62∗t∗vosin(θ)+96.24t2−−√dt

By further modifying, we can arrive at this formula:

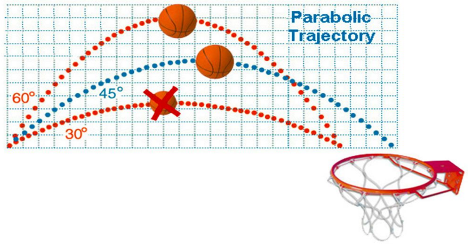
L=∫βαvo2−19.62∗t∗vosin(θ)+96.24t2−−−−−−−−−−−−−−−−−−−−−−−−−−−√dt

An example: If the average velocity of a basketball throw is 2.24 m/s, the angle of release is 45 degreees, and the time t required for the ball to travel is about 2 seconds, then the arc length can be calculated using the above formula:

L=∫202.242−19.62∗t∗2.24sin(45)+96.24t2−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−√dt=17.34m.

APPLICATION 2:

The figure shows different angles and entry points of a basketball into a basketball hoop. The diameter of the hoop ring is 18 inches. As the basketball size is smaller than the hoop ring, there is always a constant hoop margin. **Hoop margin** is the amount of space left in the hoop ring after the basketball enters it.Free throws, jump shots, and three-pointers enter at an angle that gives an oval entrance to the hoop. This changes the given hoop margin. **Apparent hoop size** is the apparent opening of the hoop to the ball. So, flatter the arc of throw, the smaller the ellipse of the hoop ring.An **apparent hoop margin** :is the apparent hoop size minus the basketball's diameter. A basketball can be thrown in different ways and different angles. So, the apparent hoop margin varies with each shot.**Finding the velocity required for the basketball to enter the basket :**One can also find the velocity required for the basketball shot given the height of the player's throw and distance from the hoop. This is the equation for a player to shoot the basketball in order to make it enter the basket perfectly.(x)=(−16v20cos2α)x2+(tanα)x+h0



Where h0 is the height from which the ball is thrown.

α is the angle at which the ball is thrown.v0 is the speed at which the ball is thrown.

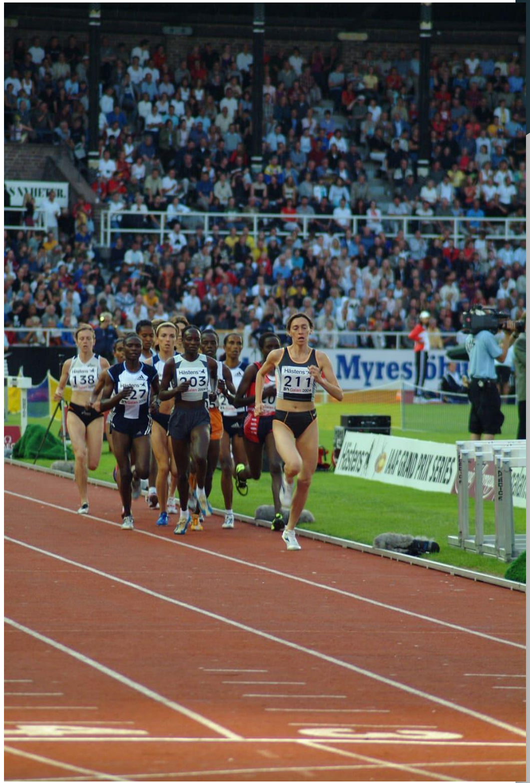
x is the distance the ball travels.

And the formula for the range of a basketball trajectory is

Range=v20sin(2α)/32

USES OF CALCULUS IN RUNNING RACE

- How is mathematics involved in running? I know it surprises most of us.
- To optimize their run, runners must keep themselves at the right speed in order to finish in the shortest time possible
- According to Joseph Keller's, A Theory of Competitive Running, the physiological running capacity of a human body can be measured using a set of differential equations.
- According to this theory, to win a running race under 291 meters, the optimum strategy is to sprint at 100% acceleration for the entire 291 meters. Races above 291 meters require a different strategy to optimize performance.



Finding the optimal velocity for the run while conserving energy

Keller’s theory, which is based on Newton’s second law and the calculus of variations, provides an optimum strategy for running one-lap and half-lap races. Keller wrote the equation of motion as:

$dv/dt + v/t = f(t)$

where v is runner’s speed as a function of time t, t is a constant characterizing the resistance to running, assumed to be proportional to running speed, and

$f(t) \leq F$ is the propulsive force per unit mass.

Empirical knowledge of human exercise physiology is expressed in the assumed relation between propulsive force and energy supply,

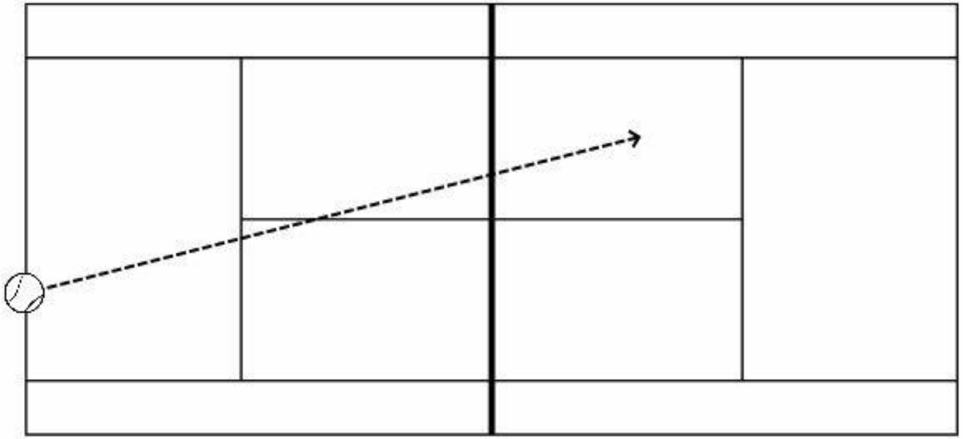
$dE/dt =$

where E $\sigma - fu$;ents the runner’s energy supply, which has a finite initial value E_0, and is replenished at a constant rate σ.

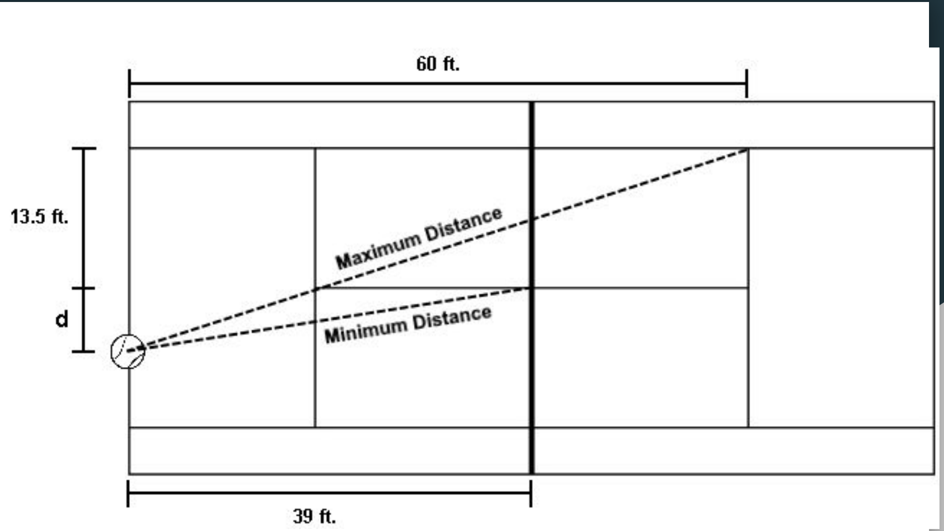
In spite of this replenishment, the energy supply reaches zero at the end of the race. τ, σ , E_0 and F are found by comparing the optimal race times.

Use Of Calculus In Tennis

In tennis, the most important shot is the serve. In order to start a point you must make your serve in. In order for your serve to be in, it must make it over the net and into the service box that is on the opposite side of the court. However, this can be difficult to do without adding an arc to the ball and making it easy for the opponent to hit the ball back. So, for the purpose of this, Calculus is used. It helps in knowing the rotation of the ball, and assuming a straight trajectory of the ball from contact with the racket to contact with the ground.



d with denote the distance the server is from the center of the baseline, and *h* will be the height from the ground at which the ball makes contact with the servers racket.We will be using *d* and *h* to calculate a gradient vector that can be used to determine, at a certain distance and height, where to move the contact point with the ball in order to create a higher angle of acceptance to make the serve into the service box.created an equation of the maximum distance the ball could travel into the court, which would be from contact to the back outside corner of the court, and an equation of the minimum distance which would be from contact to the center and top of the net.Then by treating *d* as a constant, we can derive the equation in terms of *h* in order to get the partial derivative for *h*, which shows how the angle is changing for height at a certain position.Once we have found the two partial derivatives we can then set up a gradient vector. Using this gradient vector we can determine at what rate to increase the distance and height of contact in order to have the greatest angle of acceptance. The Formula is shown as an image.



$$\nabla F = \langle \frac{\partial \theta}{\partial h}, \frac{\partial \theta}{\partial d} \rangle$$