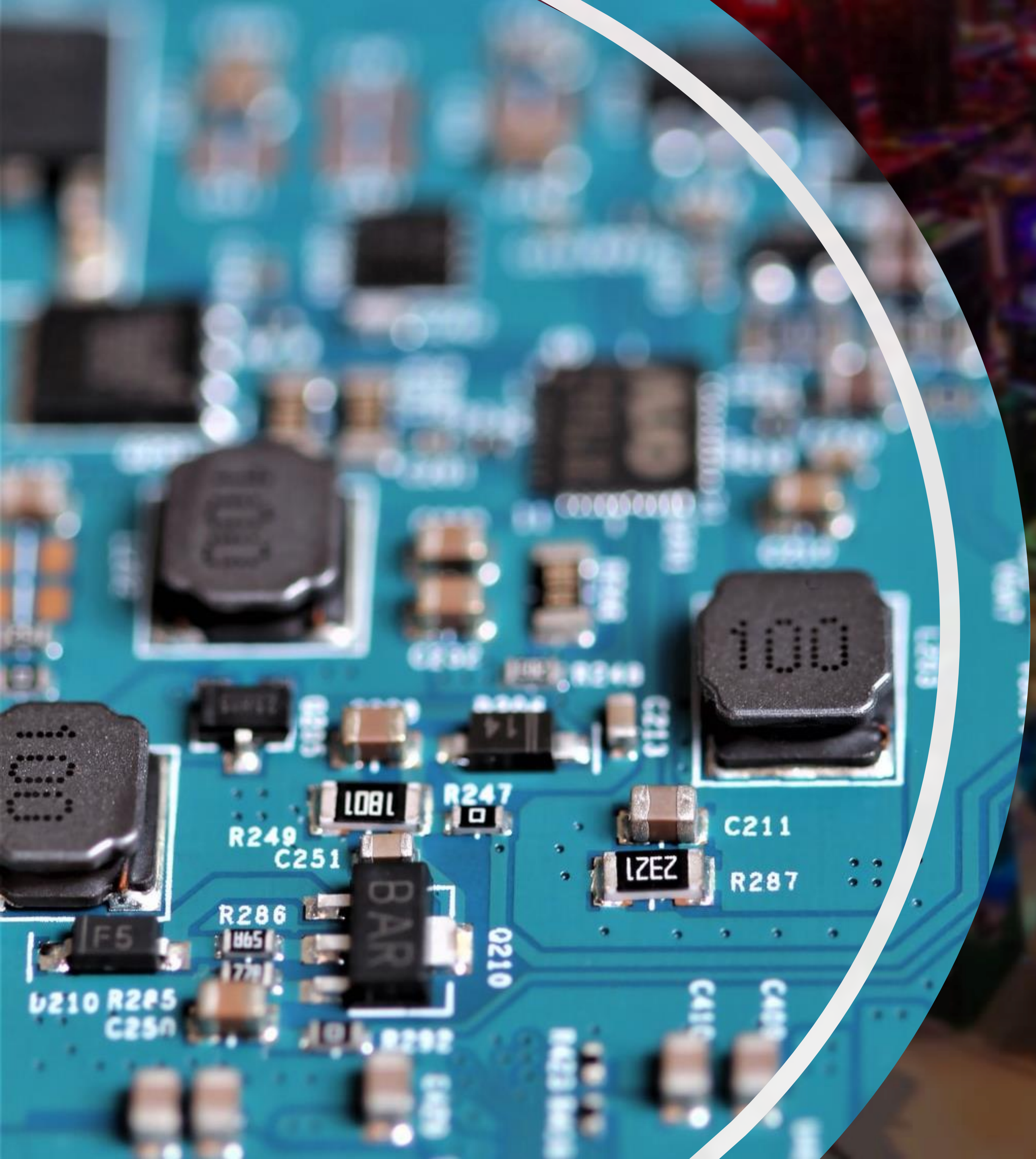


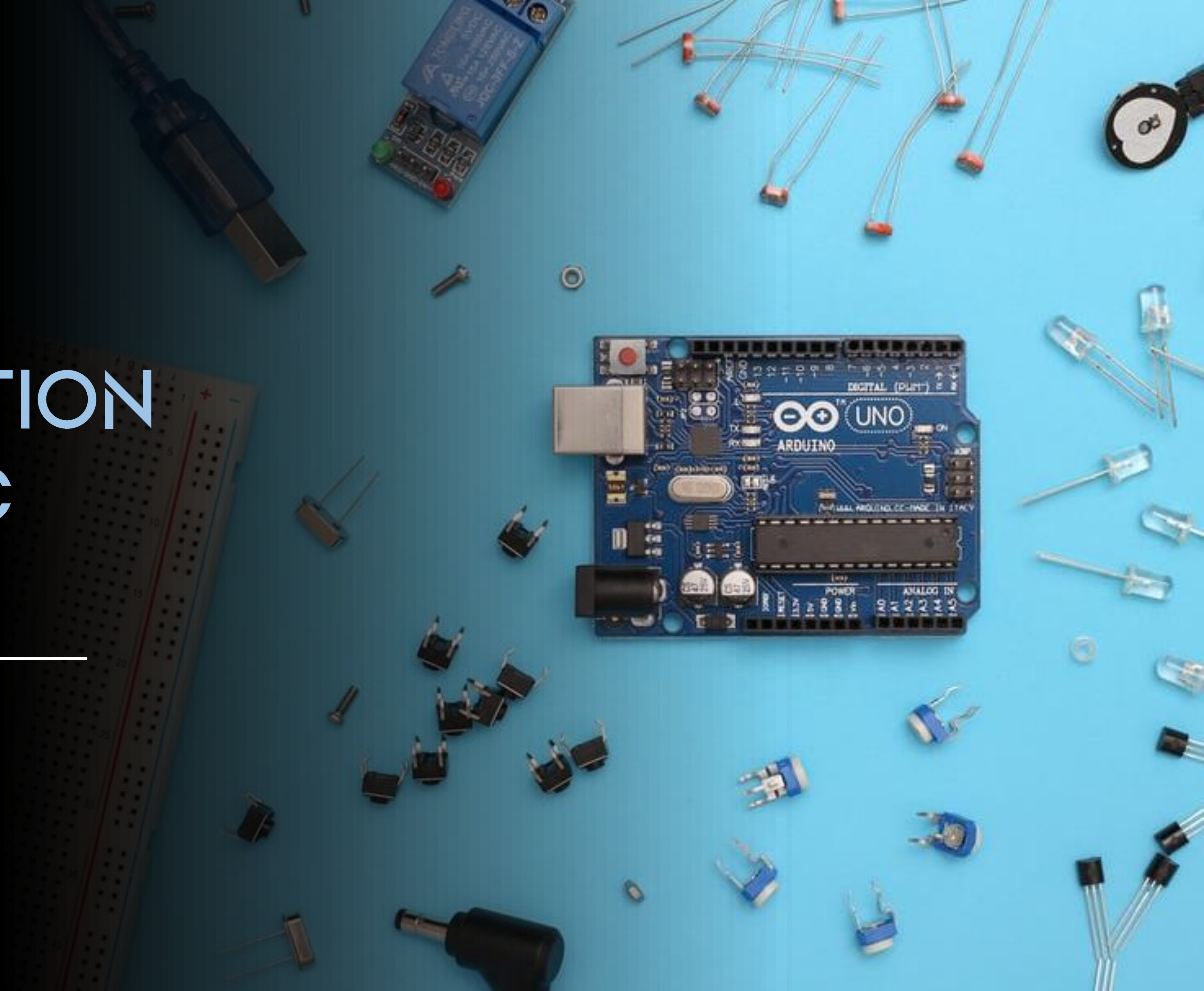
INTEGRAL CALCULUS IN ELECTRICAL CIRCUITS

Group Presentation in Integral Calculus

CONTENTS

INTRODUCTION AND BASIC SYMBOLS

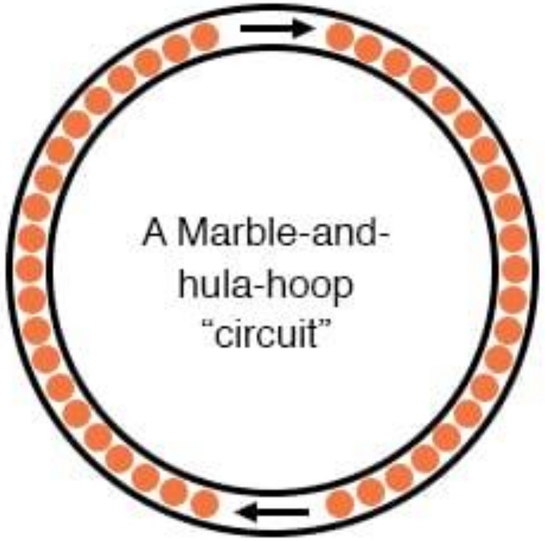
71. Pranav Walvekar



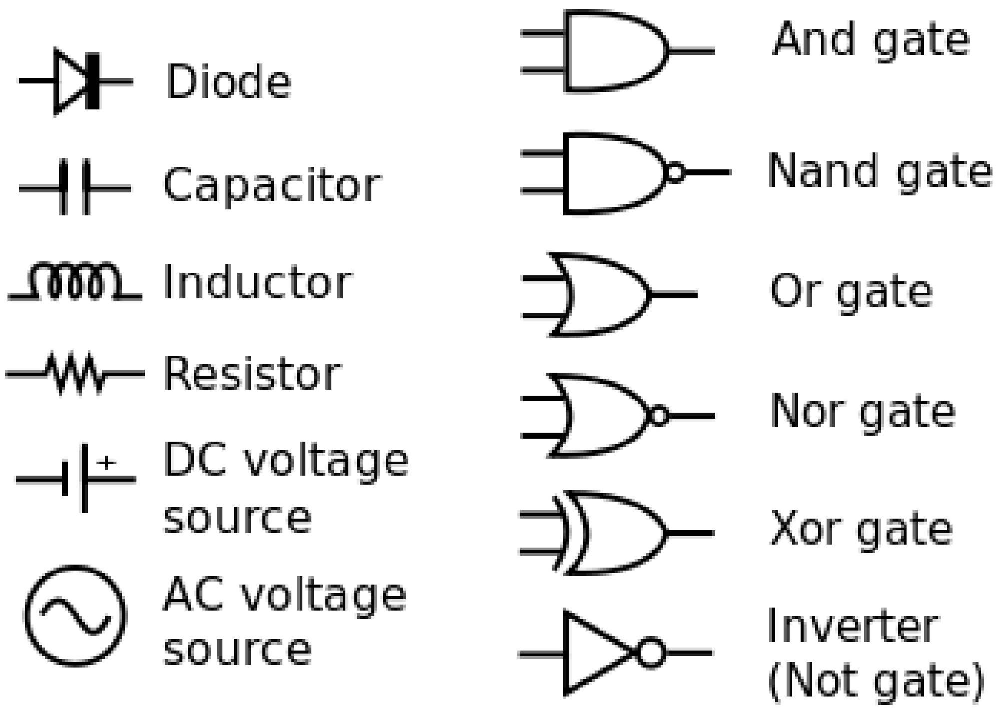
What are electric circuits?

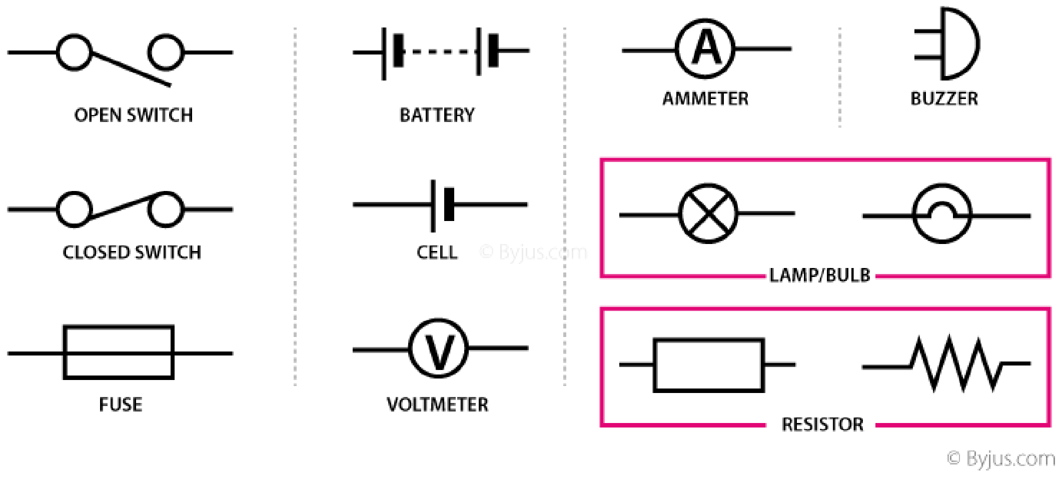
The electric circuits are closed-loop or path which forms a network of electrical components, where electrons are able to flow. This path is made using electrical wires and is powered by a source, like a battery.

The start of the point from where the electrons start flowing is called the source whereas the point where electrons leave the electrical circuit is called the return.



BASIC SYMBOLS





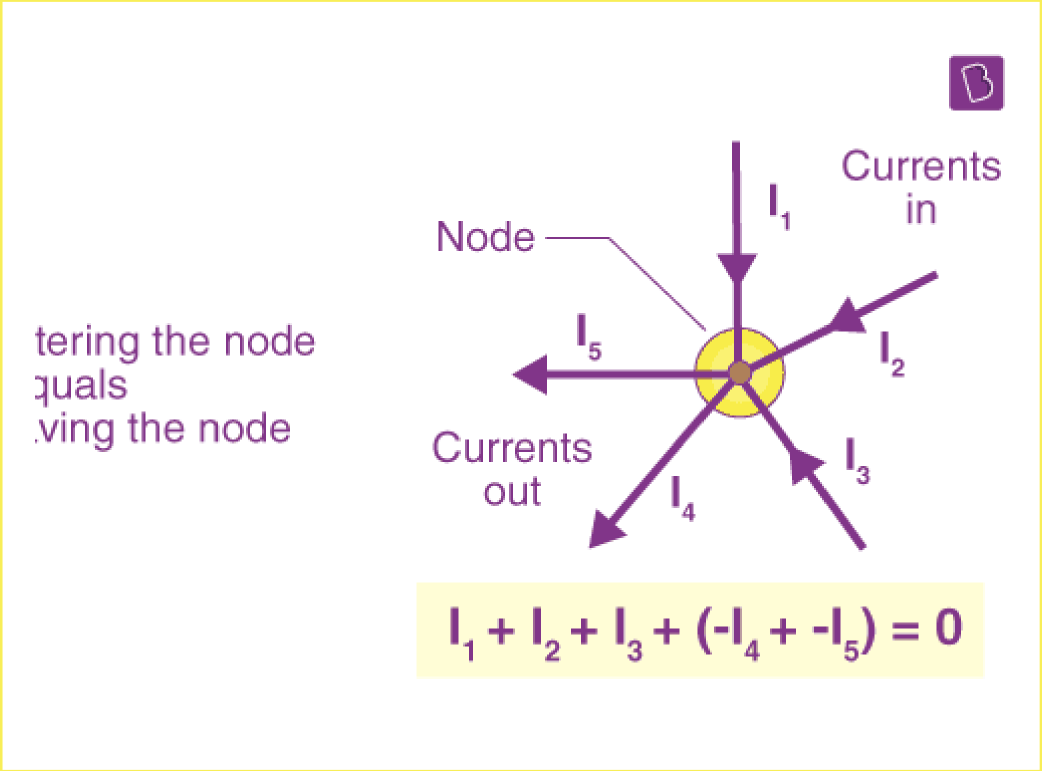
BASIC FORMULAS

Quantity	Formula	Notations
Electric current	$I = \frac{Q}{t}$	• I is the current • Q is the charge flowing • t is the time period
Resistance	$R = \rho . \frac{L}{A}$	• R is the resistance • ρ is the resistivity value of the wire • L is the length of the wire • A is the cross-sectional area
Voltage	$\Delta V = I . R$	• ΔV is the electric potential difference
Power	$P = \frac{\Delta E}{t}$	• P is the power • ΔE is the energy gain or loss • t is the time period
Series circuit	$R_{eq} = R_1 + R_2 + R_3 + \ldots$	• Req is the total resistance of the resistors placed in series • R_1, R_2... are the resistors placed in series
Parallel circuit	$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$	• Req is the total resistance of the resistors placed in parallel • R_1, R_2... are the resistors placed in parallel

KIRCHHOFF'S CURRENT LAW

52. Arnav Tavergeri

KIRCHHOFF'S CURRENT LAW



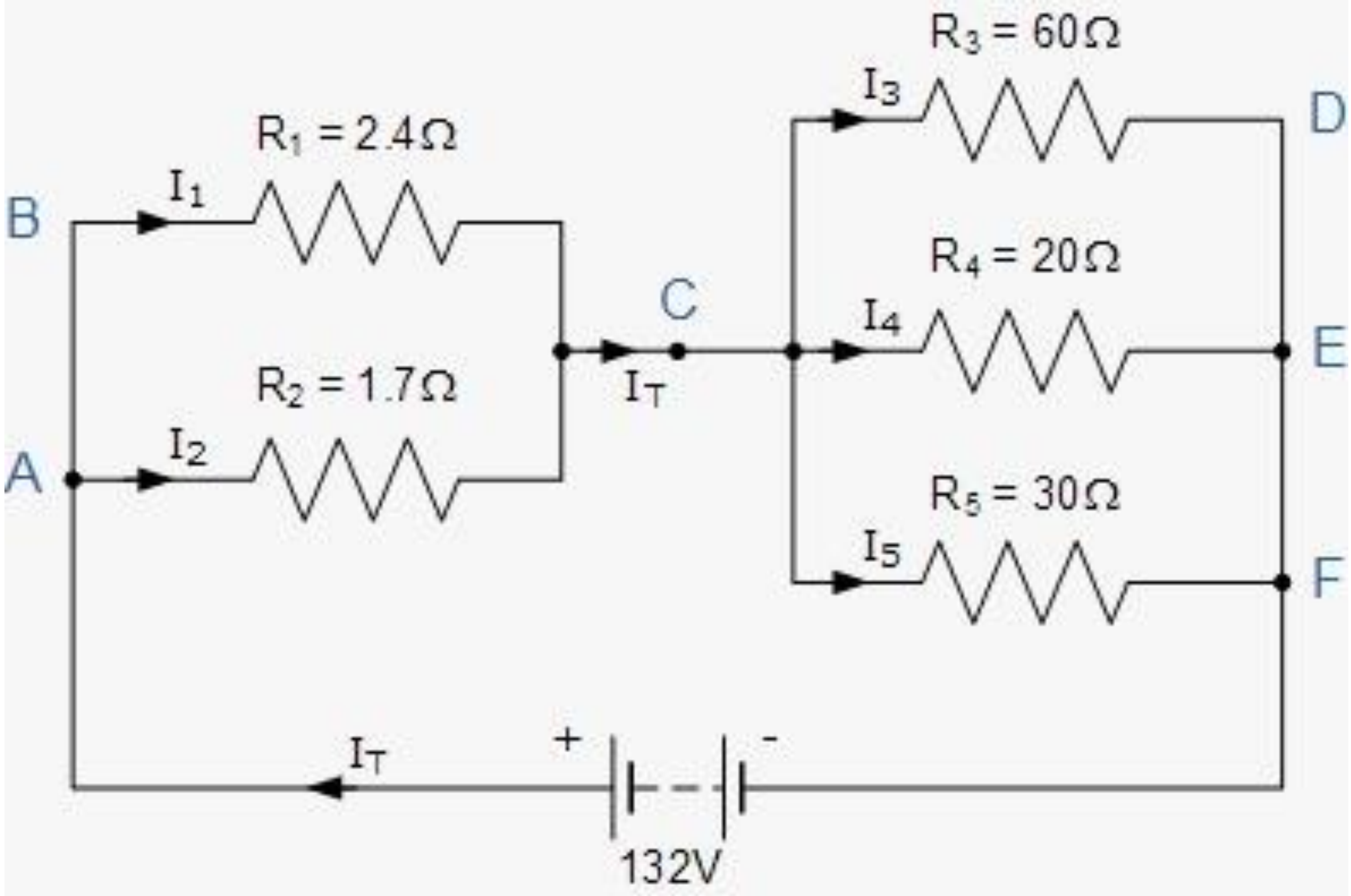
- According to this law, the total current entering a junction is equal to the charge leaving the node as no charge is lost.
- The equation for this diagram is $I_1 + I_2 + I_3 – I_4 – I_5 = 0$
- This law is applicable only when electric charge in circuit is constant.

- The kirchhoff's circuit law (KCL) is also based upon the property of Conservation of Charge. It relies on the fact that net charge in wires and components is constant.
- This law has many uses but at it's most basic, it is used with Ohm's law to perform Nodal Analysis.

BASIC EXAMPLE INCLUDING KIRCHHOFF'S CURRENT LAW

51. Balraj Tavanandi

PROBLEM 1 – FINDING CURRENT THROUGH EACH RESISTOR



Circuit Resistance R_{AC} and R_{AF}

$$\frac{1}{R_{(AC)}} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{2.4} + \frac{1}{1.7}$$

$$\frac{1}{R_{(AC)}} = 1 \qquad \therefore R_{(AC)} = 1\Omega$$

$$\frac{1}{R_{(CF)}} = \frac{1}{R_3} + \frac{1}{R_4} + \frac{1}{R_5} = \frac{1}{60} + \frac{1}{20} + \frac{1}{30}$$

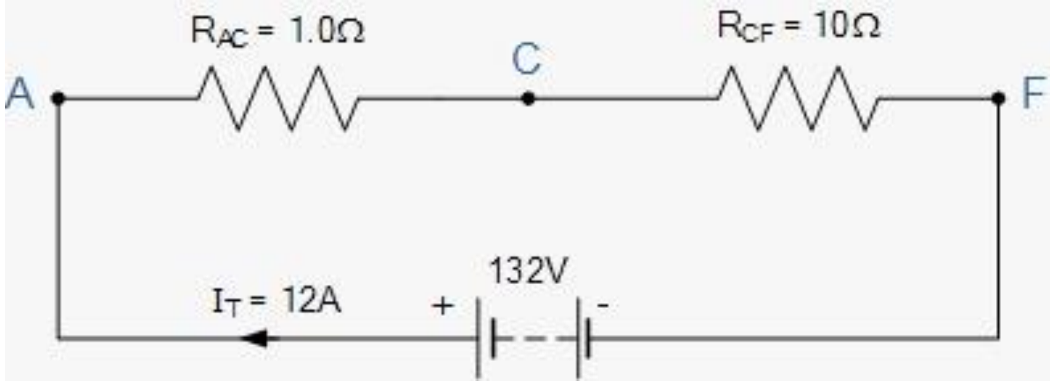
$$\frac{1}{R_{(CF)}} = 0.1 \qquad \therefore R_{(CF)} = 10\Omega$$

Circuit Current I_T and Equivalent KCL Circuit

Therefore, V = 132V, RAC = 1Ω, RCF = 10Ω's and IT = 12A.

$$R_T = R_{(AC)} + R_{(CF)} = 1+10 = 11\,\Omega$$

$$I_T = \frac{V}{R_T} = \frac{132}{11} = 12 \text{ Amperes}$$



RESULT

We can also double check to see if Kirchhoff's Current Law holds true as the currents entering the junction are positive, while the ones leaving the junction are negative, thus the algebraic sum is: I1 + I2 – I3 – I4 – I5 = 0 which equals 5 + 7 – 2 – 6 – 4 = 0.

So we can confirm by analysis that Kirchhoff's current law (KCL) which states that the algebraic sum of the currents at a junction point in a circuit network is always zero is true

$$V_{AC} = I_T \times R_{AC} = 12 \times 1 = 12\,\text{Volts}$$

$$V_{CF} = I_T \times R_{CF} = 12 \times 10 = 120\,\text{Volts}$$

$$I_1 = \frac{V_{AC}}{R_1} = \frac{12}{2.4} = 5\,\text{Amps}$$

$$I_2 = \frac{V_{AC}}{R_2} = \frac{12}{1.7} = 7\,\text{Amps}$$

$$I_3 = \frac{V_{CF}}{R_3} = \frac{120}{60} = 2\,\text{Amps}$$

$$I_4 = \frac{V_{CF}}{R_4} = \frac{120}{20} = 6\,\text{Amps}$$

$$I_5 = \frac{V_{CF}}{R_5} = \frac{120}{30} = 4\,\text{Amps}$$

KIRCHOFF'S VOLTAGE LAW

60. Ashutosh Ukande

STATEMENT

Kirchhoff's voltage law states that the voltage around a loop equals the sum of every voltage drop in the same loop for any closed network and equals zero.

$$\sum_{k=1}^{n} V_k = 0$$

EXAMPLE WITH RELATION TO CALCULUS

56. Tirth Thesiya

PROBLEM 2

In an electric circuit containing an inductance $L = 640\,H$; a resistance $R = 250\,\Omega$ & voltage $E = 500\,V$. Find current 'i' at any time 't'. Also find time that ellapses before the current reaches 90% of its max value.

Given

$R = 250\Omega$; $L = 640H$; $E = 500V$

By KVL;

(V.D across R) + (V.D across L) = E

$\therefore \quad Ri + L\frac{di}{dt} = E$

$\therefore \quad \frac{di}{dt} + \frac{R}{L} i = \frac{E}{L}$

$\therefore \quad \frac{di}{dt} + \frac{250}{640} i = \frac{500}{640}$

$\therefore$ It is LDE in 'i' ;

So Here

$$P = \frac{25}{64} \quad \& \quad Q = \frac{50}{64}$$

$$\therefore \quad IF = e^{\int 25/64\, dt}$$

$$= e^{(25/64)t}$$

$\therefore$ G.E sol^n will be

$$i \times e^{(25/64)t} = \int e^{(25/64)t} \times \frac{50}{64}\, dt + K$$

$$\therefore i e^{\frac{25}{64}t} = \frac{50}{64} \int e^{\frac{25}{20}t}\, dt + K$$

$$\therefore i e^{25/64 t} = \frac{25}{32} \times e^{\frac{25}{64}t} \times \frac{64}{25} + K$$

$\therefore \; i = 2 + K e^{-\frac{25}{64}t}$ — (1)

At $t = 0$; $i = 0$

$\therefore \; 0 = 2 + K$

$\therefore \; \boxed{K = -2}$

$\therefore \; \boxed{i = 2\left(1 - e^{-\frac{25}{64}t}\right)}$ — (2)

for

$\therefore \; i_{max} \Rightarrow t \to \infty$

$\therefore \; i_{max} = 2\left(1 - e^{-\infty}\right)$

$\boxed{i_{max} = 2}$

So 90% of imax $\Rightarrow \frac{90}{100} \times i_{max} = \underline{\underline{1.8}}$

$\therefore$ at $i = 1.8$; $t = ?$

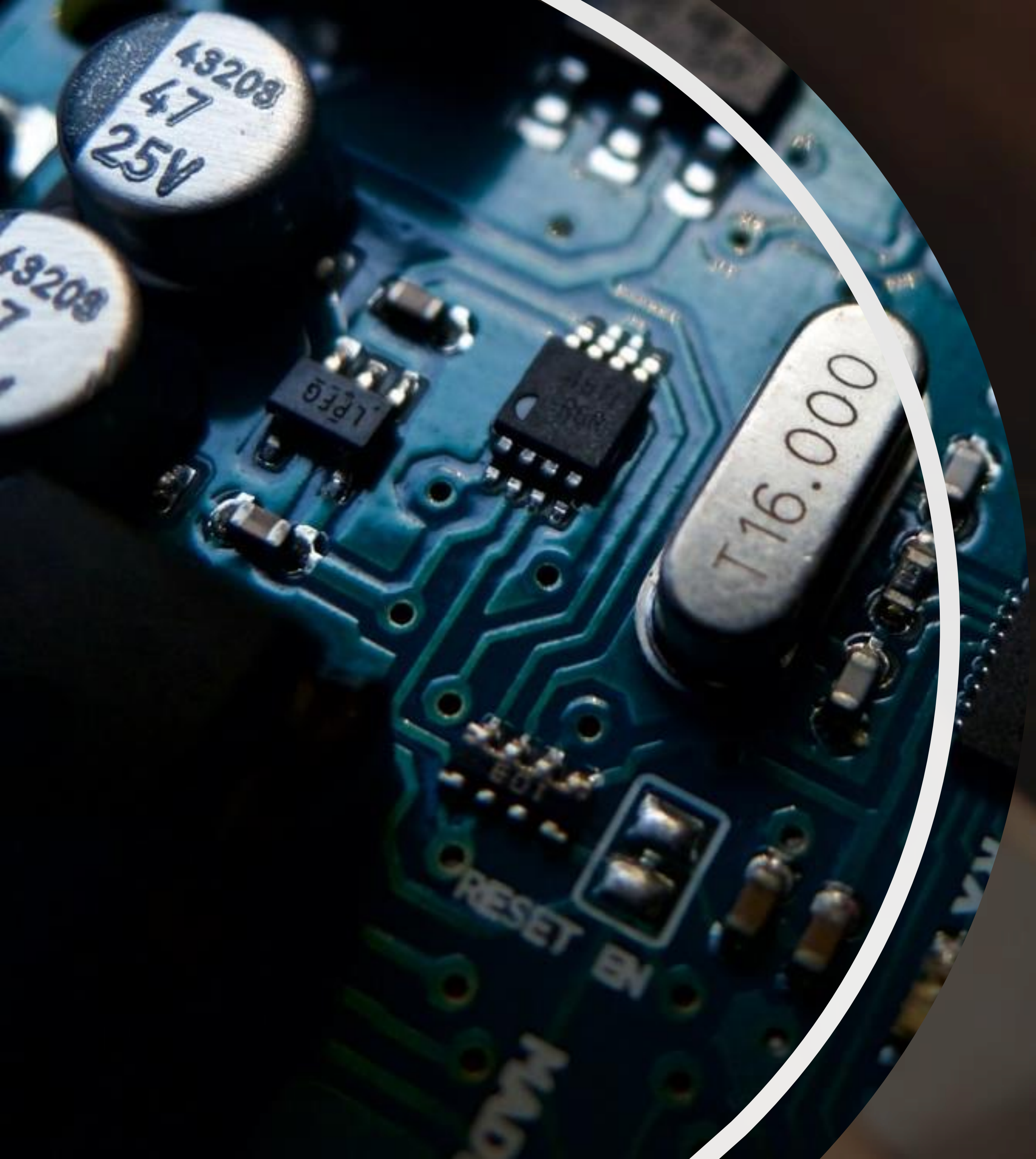
$\therefore \quad 1.8 = 2\left(1 - e^{-\frac{25}{64}t}\right)$

$\therefore \left(0.9 = \left(1 - e^{-\frac{25}{64}t}\right)\right.$

$\therefore \quad e^{-\frac{25}{64}t} = 0.1$

$\therefore \quad -\frac{25}{64}t = -\ln(0.1)$

$\therefore \boxed{t = 5.89 \text{ sec}}$



Applications of Integral Calculus in Electric Circuits and Music

50. Atharva Tanawade

1. PROTECTING CIRCUITS WITH RESISTORS

As mentioned, KVL applies to simple circuits, such as lighting up an LED. As an LED has a specific junction voltage and the voltage source is often way higher, the difference will have to be dissipated elsewhere in the circuit according to the KVL.

If a limiting resistor is omitted, the copper trace takes the brunt of the voltage difference and gets overheated or broken in the process.

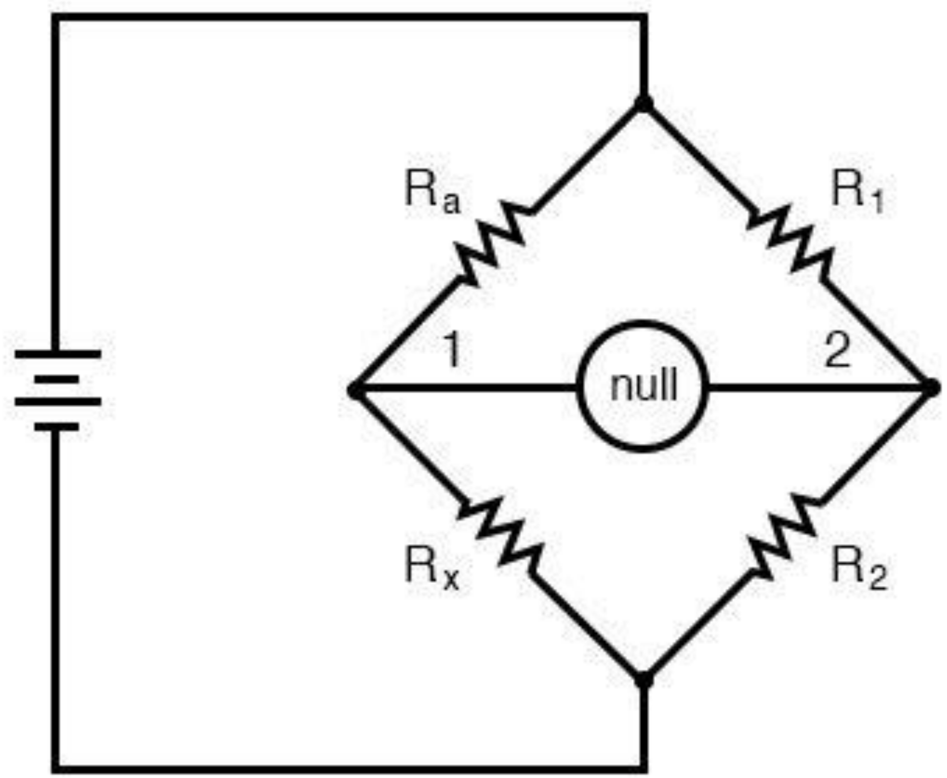
2. SIGNALING

But KVL is more than lighting up an LED without burning the copper trace. The whole idea that defines KVL is about the conservation of energy. The energy source (power voltage), is being dissipated in a closed loop. However, the unchanging constant is the current flowing through it. This phenomenon has led to the popular usage of the 4-20 mA current loop *signaling in industrial application.*

LIMITING RESISTORS

A simple circuit for an LED light KVL is the reason for a limiting resistor in LED circuitry.

WHEATSTONE'S BRIDGE



Bridge circuit is balanced when:

$$\frac{R_a}{R_x} = \frac{R_1}{R_2}$$

IC IN ELECTRONICS

Integral and differential calculus are crucial for calculating voltage or current through a capacitor. Integral calculus is also a main consideration in calculating the exact length of a power cable necessary for connecting substations that are miles apart from each other.

EXAMPLES

$i = \frac{dq}{dt}$ (current i Amps is the rate of change of charge q Coulombs).

$i = C\frac{dv}{dt}$ (current i Amps flowing in a capacitor is the capacitance C farads times the rate of change of voltage v Volts across the capacitor).

$v = L\frac{di}{dt}$ (voltage v Volts across an inductor is the inductance L henrys times the rate of change of current i Amps flowing in the inductor).

In an RLC circuit in series, by combining the above equations and Ohm's law ($v = iR$), we have $Ri(t) + L\frac{di}{dt} + \frac{1}{C}\int_0^t i(T)\,dT = v(t)$, which may be converted into a second order differential equation to solve for $i(t)$.

YEP, CALCULUS IS EVEN USED IN MUSIC

We often wonder while staring at equations in class, and listening to music whether or not any of it is useful in daily life. Turns out, it is.

Harmonics

An oscillation created by a damped harmonic is not infinite, as friction and air resistance will dissipate the energy. Calculus is used to anticipate these motions to make the proper adjustments and provide the best musical experience to the listeners.

ACOUSTICS

Resonance and forced oscillation can be computed using calculus. Air resistance varies at different frequencies and resonates throughout an enclosed space whenever a musical instrument is played. Through calculus, we can make improvements on acoustics and improve the listener's experience.

Application of Calculus in Daily Life and Other Fields

21. Vedant Shirode

CIVIL ENGINEERING

When designing bridges, civil engineers need to consider three structural elements: beams, tension, and compression members. Using calculus, we can determine the amount of force acting on the beam including the weight of pedestrians, weight of vehicles, and the amount of traffic anticipated on that bridge

MECHANICAL ENGINEERING

The pump used for filling an overhead tank, gardening tools, cars, motorcycles, robots, and many household appliances are designed using the principles of calculus.

CANCER RESEARCH

Calculus is used to determine the growth or shrinkage and number of cells of a cancerous tumor. Using an exponential function, oncologists analyze the progression or regression of a disease.

BACTERIAL GROWTH

Biologists use differential calculus to compute the exact bacterial growth rate in a culture by varying environmental factors such as temperature and food source.

HEART TRANSPLANTS

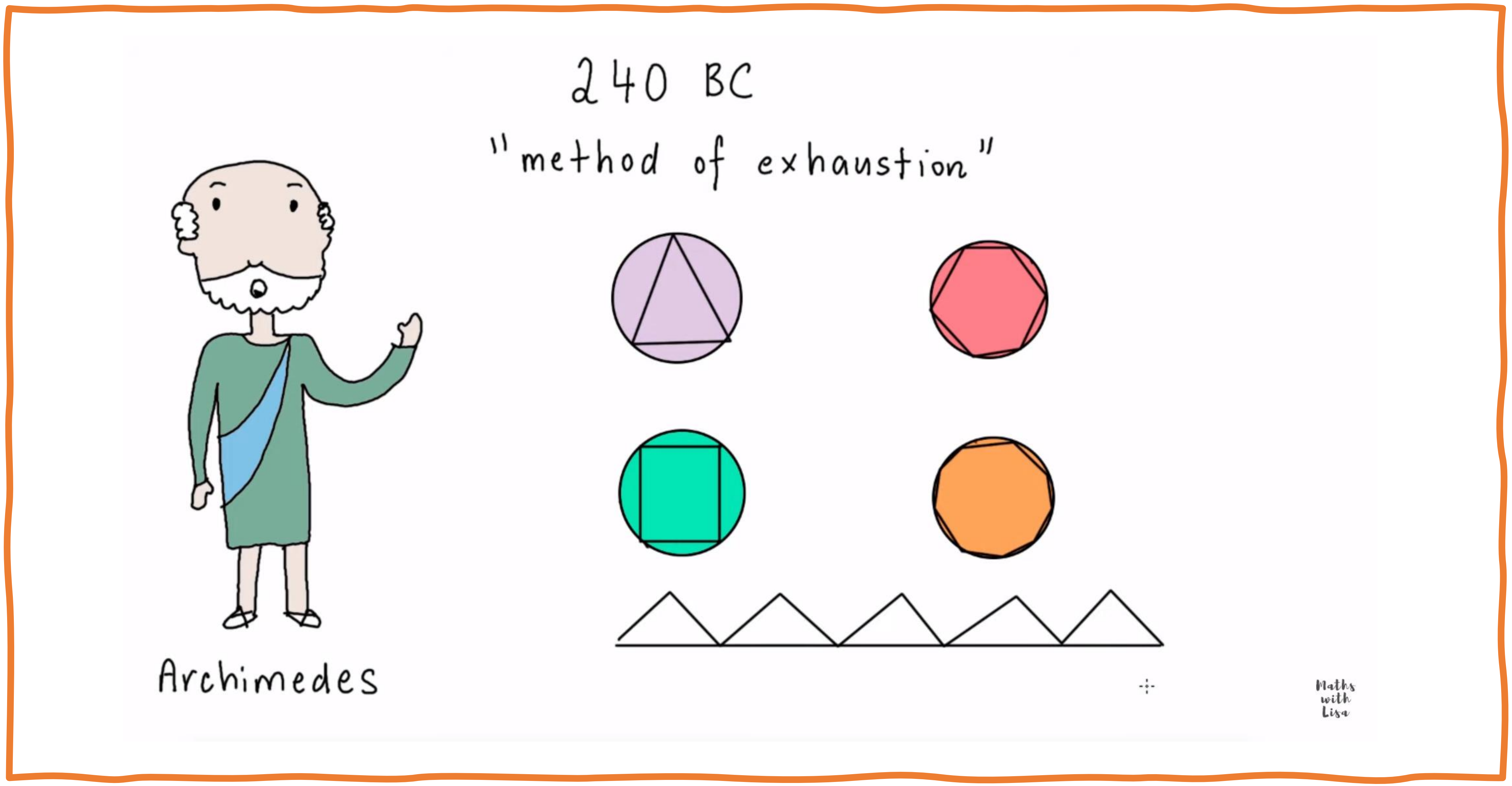
Cardiologists use differential calculus to understand the blood flow dynamics needed for building an artificial aorta model in order to make sure it is placed correctly during transplant.

CREDIT CARD PAYMENTS

Calculus is used for setting payment structures and the minimum due amount by the credit card company by considering variables such as interest rates and fluctuating balance.

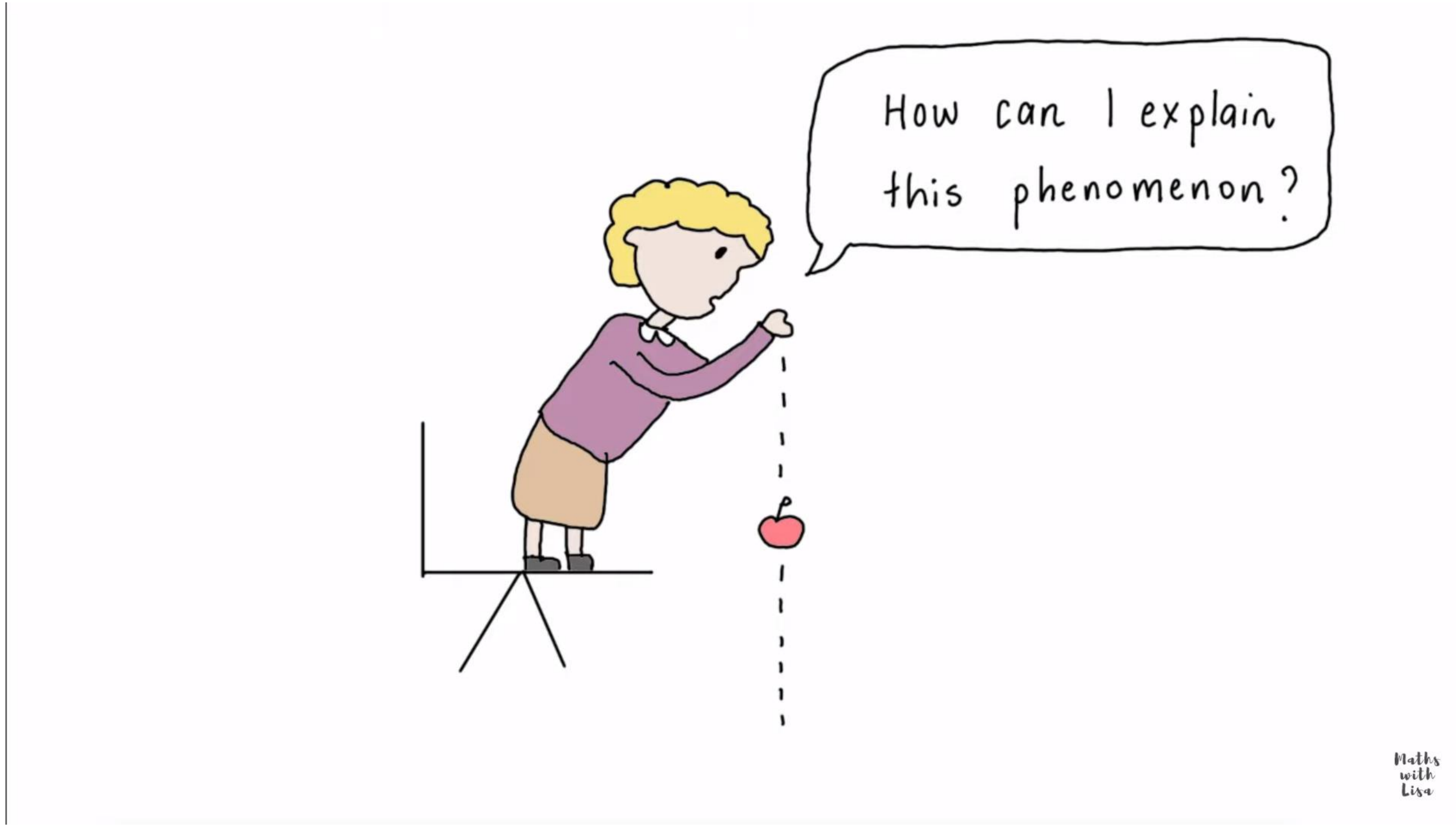
History and Evolution of Integral Calculus

54. Krishnaraj Thadesar

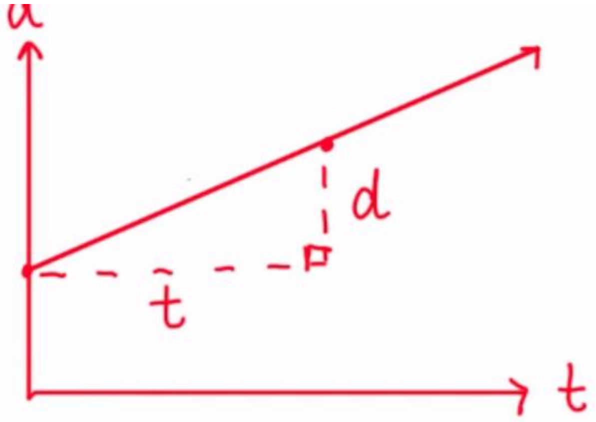


240 BC
"method of exhaustion"
Archimedes
Maths with Lisa


Maths with Lisa

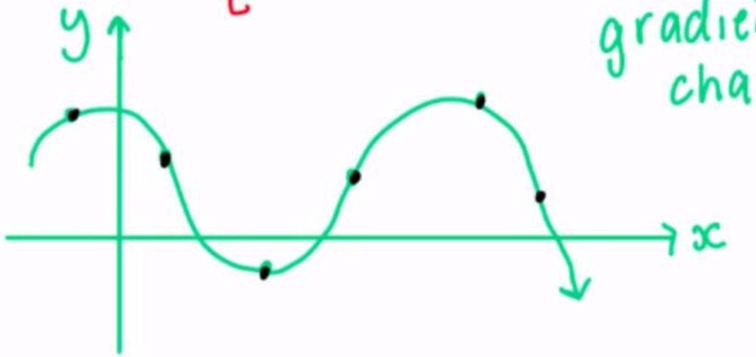

How can I explain this phenomenon?
Maths with Lisa

How do I find the gradient anywhere on the function?

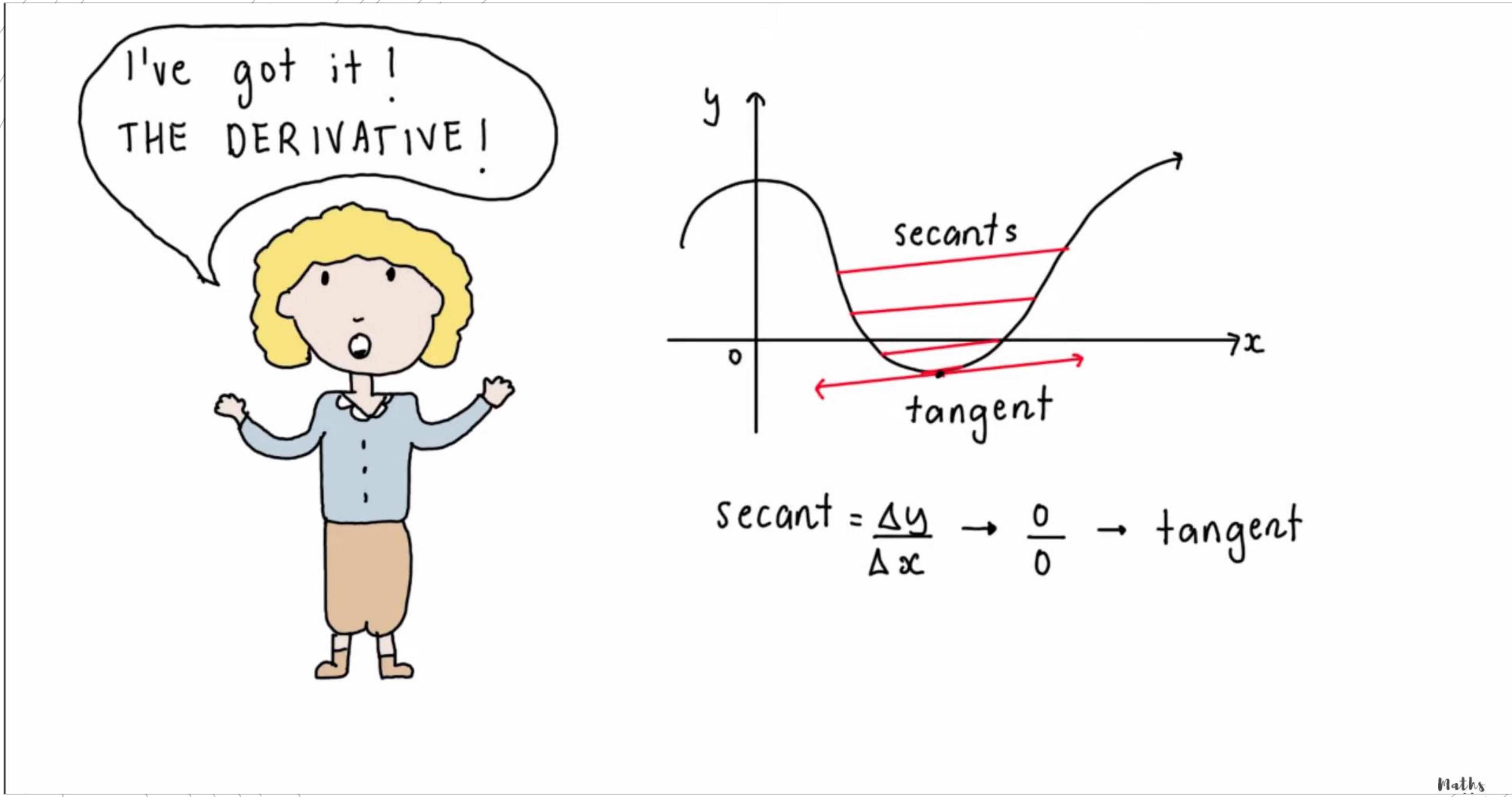


constant gradient

$s = \frac{d}{t}$



gradient always changing


I've got it !
THE DERIVATIVE !
y
x
0
secants
tangent
secant = $\frac{\Delta y}{\Delta x}$ → $\frac{0}{0}$ → tangent


The Derivative
We are on the verge of a breakthrough!


Rene Descartes
Pierre De Fermat
motion, gravitation, orbits
Maths with

Fundamental Theorem of Calculus

Integration $\longleftrightarrow$ Differentiation

(method of fluents) (fluxion)

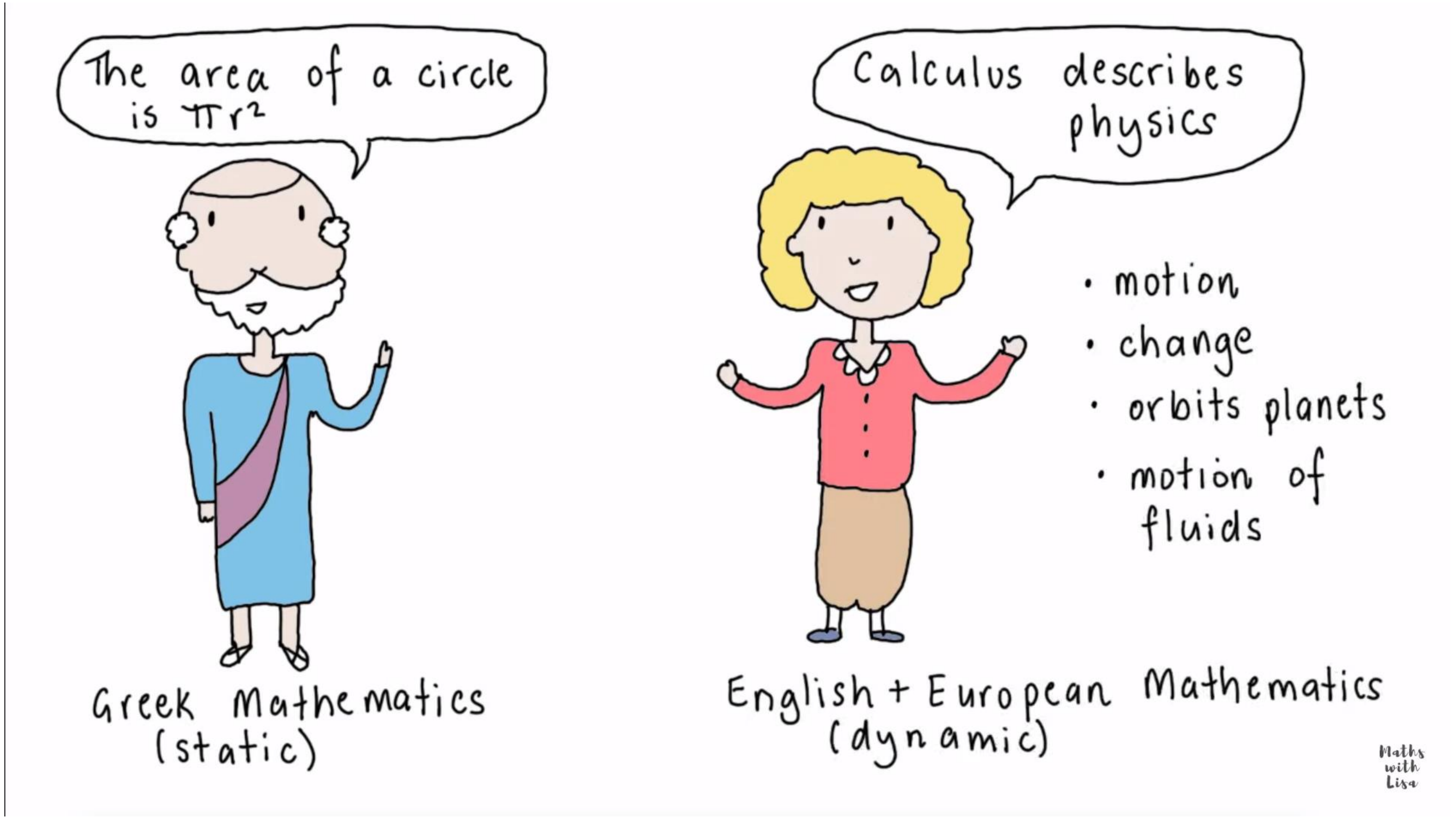
INVERSE OPERATIONS

$$\frac{d}{dx}\ \underline{4x^3 + x}$$

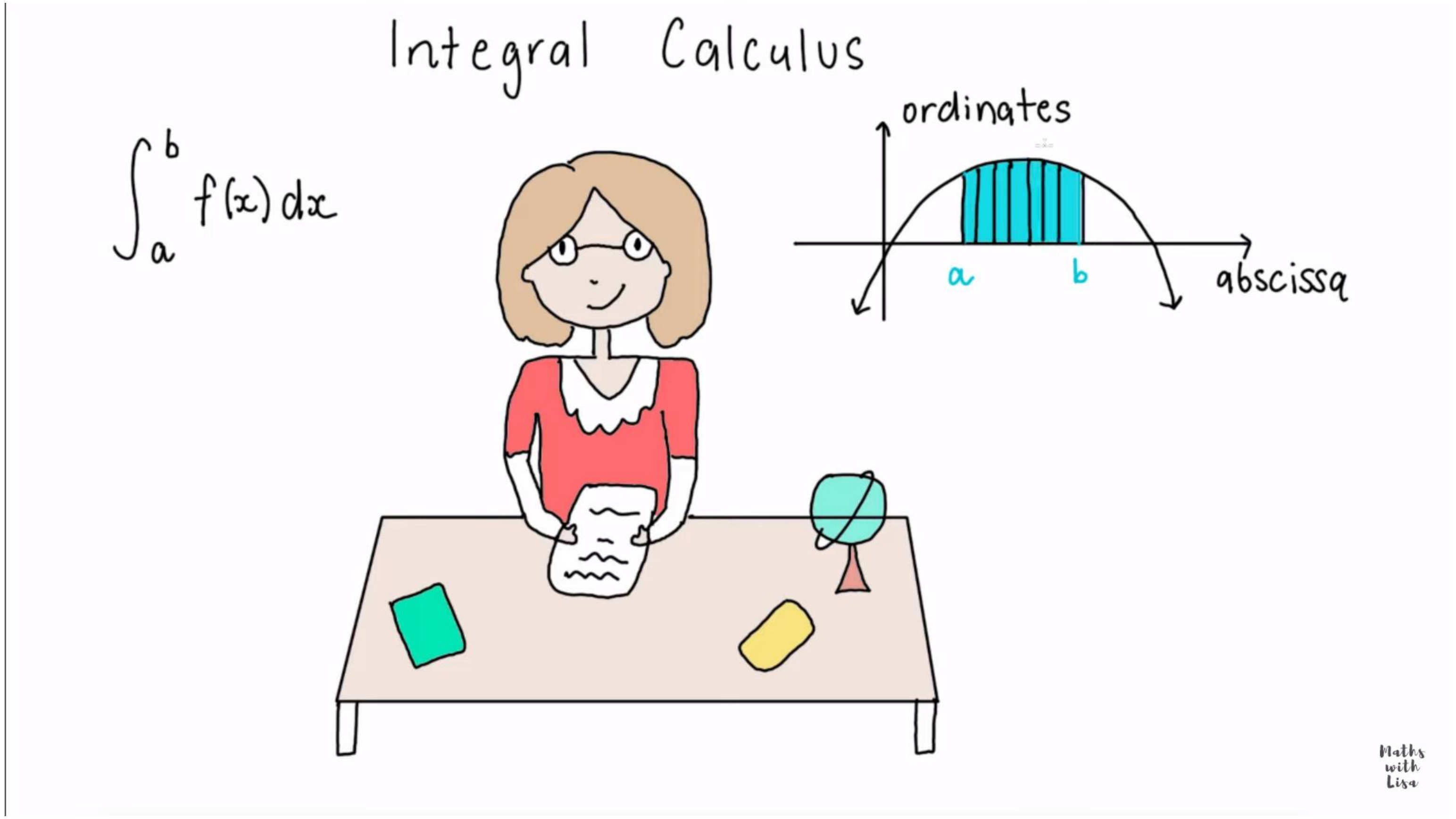
$$= 12x^2 + 1$$

$$\int 12x^2 + 1 \ dx$$

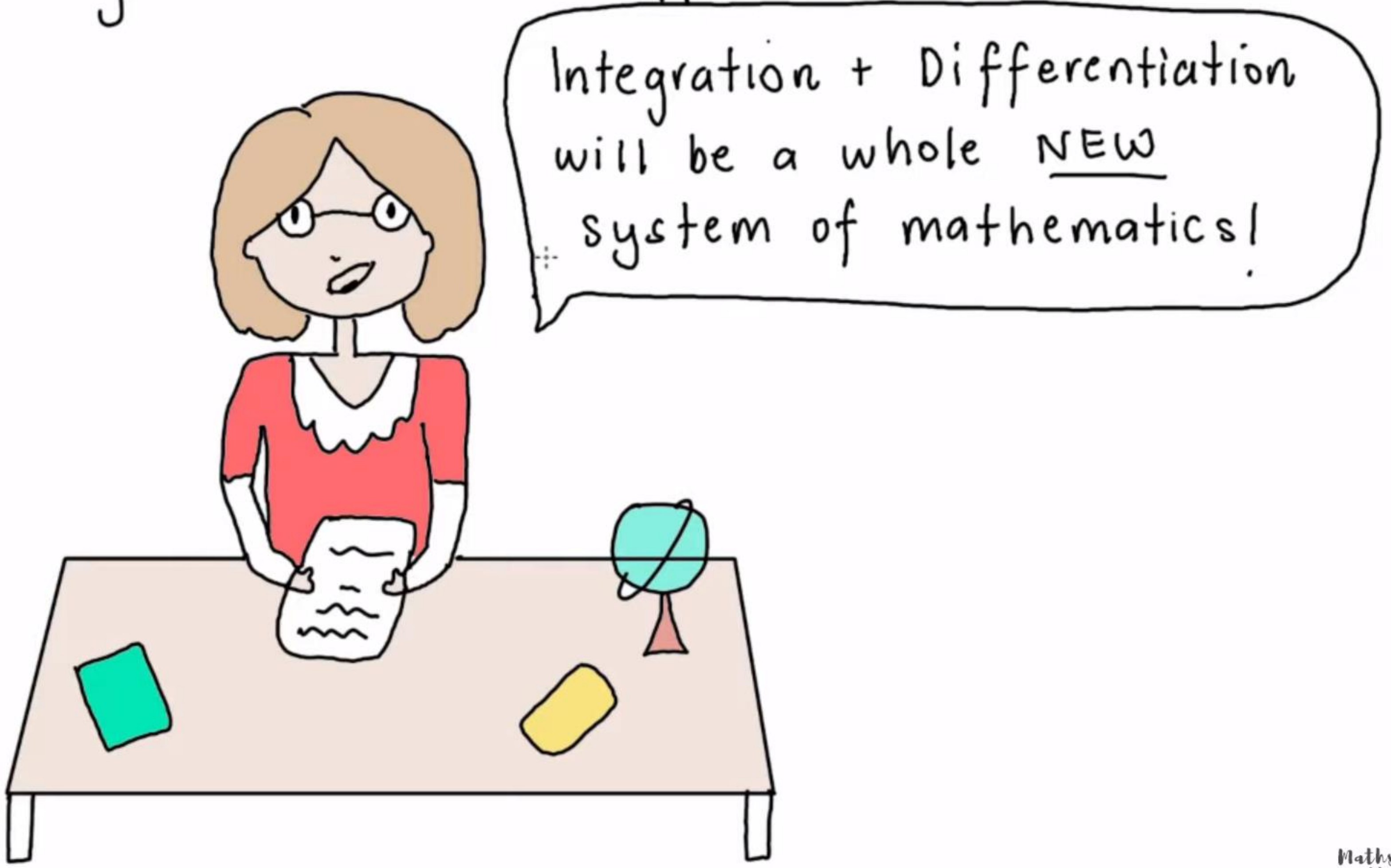
$$= \underline{4x^3 + x + C}$$


The area of a circle is πr^2
Calculus describes physics
• motion
• change
• orbits planets
• motion of fluids
Greek Mathematics (static)
English + European Mathematics (dynamic)
Maths with Lisa

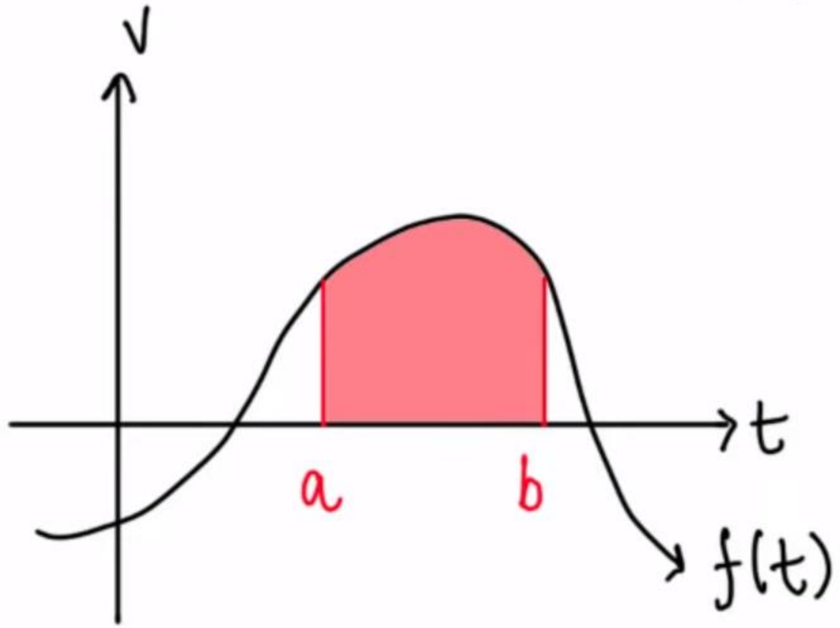

1646
Germany
Professor of moral philosophy
Hi, I'm Gottfried


Integral Calculus
$\int_a^b f(x)\,dx$
ordinates
a
b
abscissa
Maths with Lisa

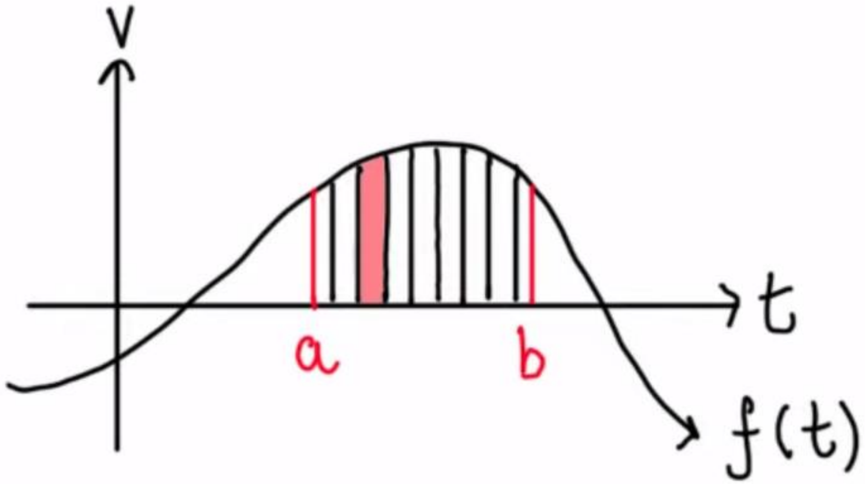
Integration ⟷ Differentiation



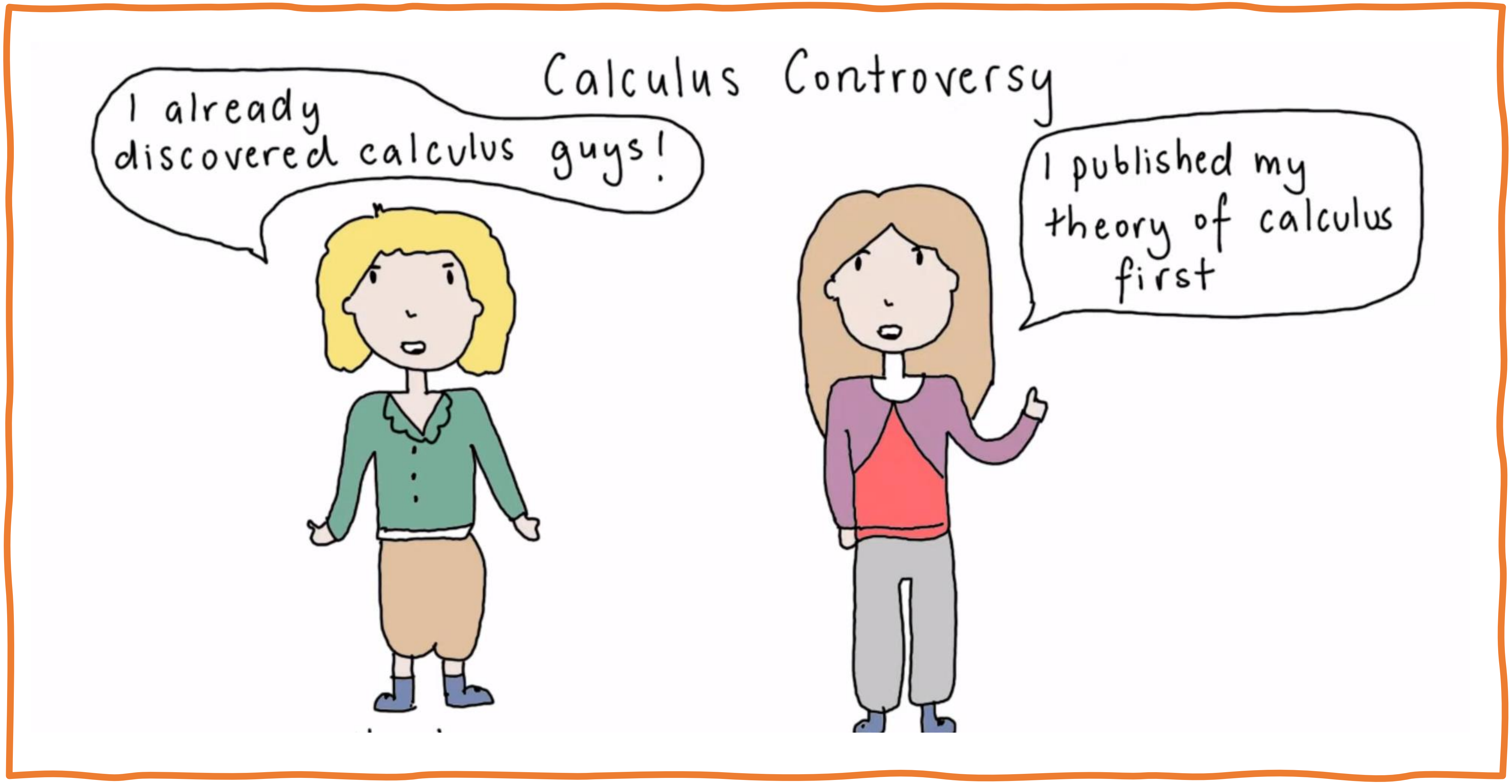
Integral Calculus

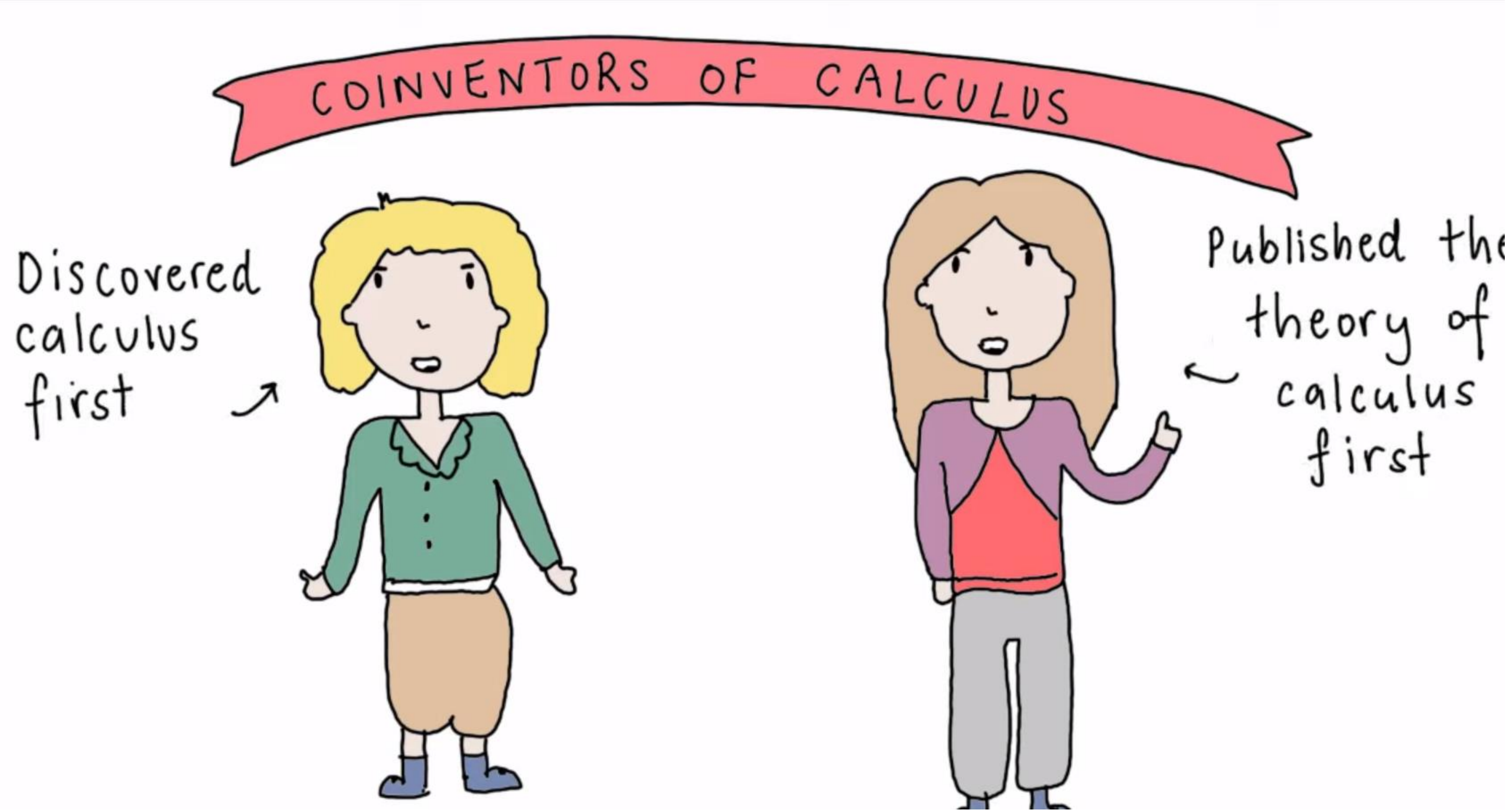


area = distance travelled
(d = primitive of velocity)



width each rectangle → 0
= exact area under function


Calculus Controversy
I already discovered calculus guys!
I published my theory of calculus first


COINVENTORS OF CALCULUS
Discovered calculus first
Published the theory of calculus first

Leibniz's modern notation of calculus

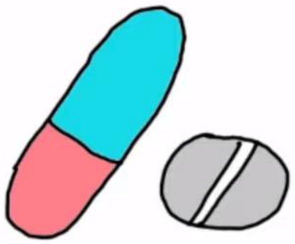
$$\int_a^b f(x)\,dx = F(b) - F(a)$$

$$\frac{d}{dx}\int_a^x f(t)\,dt = f(x)$$

$$f'(x) = \lim_{h \to 0}\left(\frac{\delta y}{\delta x}\right) = \frac{dy}{dx}$$

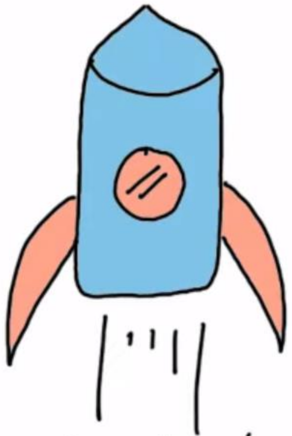
FUNDAMENTAL THEOREM OF CALCULUS

Calculus models



medicine

economics



physics/
engineering

Maths with Lisa

GROUP MEMBERS

109054. Krishnaraj Thadesar
109051. Balraj Tavanandi
109056. Tirth Thesiya
109052. Arnav Tavergeri
109050. Atharva Tanawade
109071. Pranav Walvekar
109021. Vedant Shirode
109060. Ashutosh Ukande

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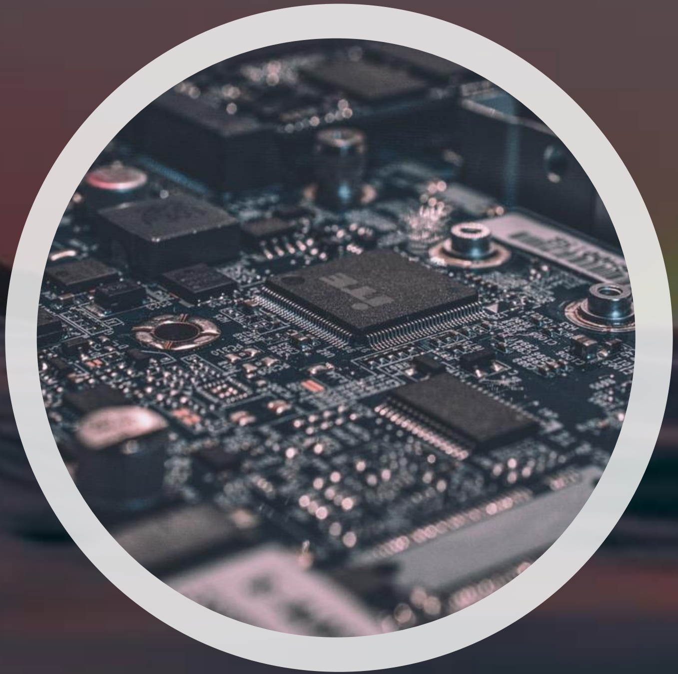
- https://www.quora.com/Why-is-the-application-of-integral-calculus-in-physics






Thank You!