Indian Institute of Information Technology, Vadodara

International Campus Diu IIITV-ICD

Project Report

PH Group Project

Report of the Group project to be submitted for the evaluation of Waves and Electromagnetics Lab in 2nd semester of B.Tech (Batch : 2021) to Dr. Varun Kumar

By the group members:

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1. Introduction

This project is based on theoretical understanding from the Waves and Electromagnetics lab course. The main idea of the project is to develop application between course Waves and Electromagnetics and app development. The primary application is to develop an interconnection between concepts of electromagnetism and waves to technological implementation such as application in android or any other operating system, simulating designs in 3-D, animations etc. T

1.1 Aims of the projects:

PROJECT 1:

Design a Graphical User Interface (GUI) that transform the data points of one co-ordinate system to another one

PROJECT 2:

Design a graphical user interface (GUI) to verify the continuity equation.

1.2 Objectives and Scope of Project:

The primary aim of the projects is to understand certain quantities through graphs and animations. The detailed objectives and scope are provided below:

1. Understanding and verifying the continuity equation which can enable to understand continuity equation in different fields like electromagnetics, fluid dynamics, computer vision and heat transfer.
2. Understanding co-ordinate systems helps us identify the location of points in space. Coordinates systems are often used to specify the position of a point, but they may also be used to specify the position of more complex figures such as lines, planes, circles or spheres.

2. PROJECT 1:

Design a Graphical User Interface (GUI) that transform the data points of one co-ordinate system to another one.

2.1Development Method

The application produced in this project is application program as teaching and learning media of co-ordinate systems.

2.1.1 Planning

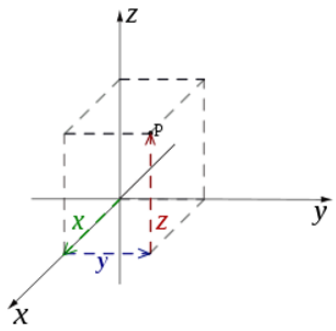
i. We listed out all work needed for making this app and scheduled it.
ii. We distributed work among all of us.

2.2 Understanding co-ordinate systems:

In geometry, a coordinate system is a system that uses one or more numbers, or coordinates, to uniquely determine the position of the points or other geometric elements on a manifold such as Euclidean space.

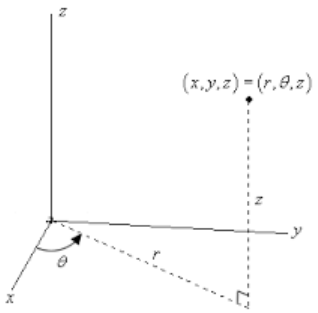
2.2.1 Cartesian Co-ordinate system :

Coordinate system, arrangement of reference lines or curves used to identify the location of points in space. The center of the coordinate system (where the lines intersect) is called the origin. These lengths x, y and z are known as the co-ordinates of the point P in three-dimensional space. These three coordinate planes divide space into eight parts, called octants.



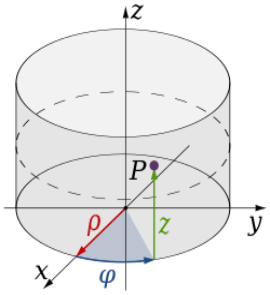
2.2.2 Cylindrical Co-ordinate system :

In the cylindrical coordinate system, a z-coordinate with the same meaning as in Cartesian coordinates is added to the r and θ polar coordinates giving a triple (r, θ, z).



2.2.3 Spherical Co-ordinate system :

Spherical coordinates take this a step further by converting the pair of cylindrical coordinates (r, z) to polar coordinates (ρ, φ) giving a triple (ρ, θ, φ)



The conversions and the factors/parameters of conversions are as per given below,

$$\text{cart} \leftrightarrow \text{cyl} \quad \begin{cases} x = r\cos\theta, \\ y = r\sin\theta, \end{cases} \quad \begin{cases} r = \sqrt{x^2+y^2}, \\ \theta = \arctan\dfrac{y}{x}, \end{cases} \quad \begin{cases} \sin\theta = \dfrac{y}{\sqrt{x^2+y^2}}, \\ \cos\theta = \dfrac{x}{\sqrt{x^2+y^2}}. \end{cases}$$

$$\text{cart} \leftrightarrow \text{sph} \quad \begin{cases} x = \rho\cos\theta\sin\phi, \\ y = \rho\sin\theta\sin\phi, \\ z = \rho\cos\phi, \end{cases} \quad \begin{cases} \rho = \sqrt{x^2+y^2+z^2}, \\ \theta = \arctan\dfrac{y}{x}, \\ \phi = \arctan\dfrac{\sqrt{x^2+y^2}}{z} \\ \quad = \arccos\dfrac{z}{\sqrt{x^2+y^2+z^2}}. \end{cases}$$

2.3 Working of the simulator:

MATLAB Software is used.

The simulator performs:

- Takes the user input of co-ordinate type which is to be converted.

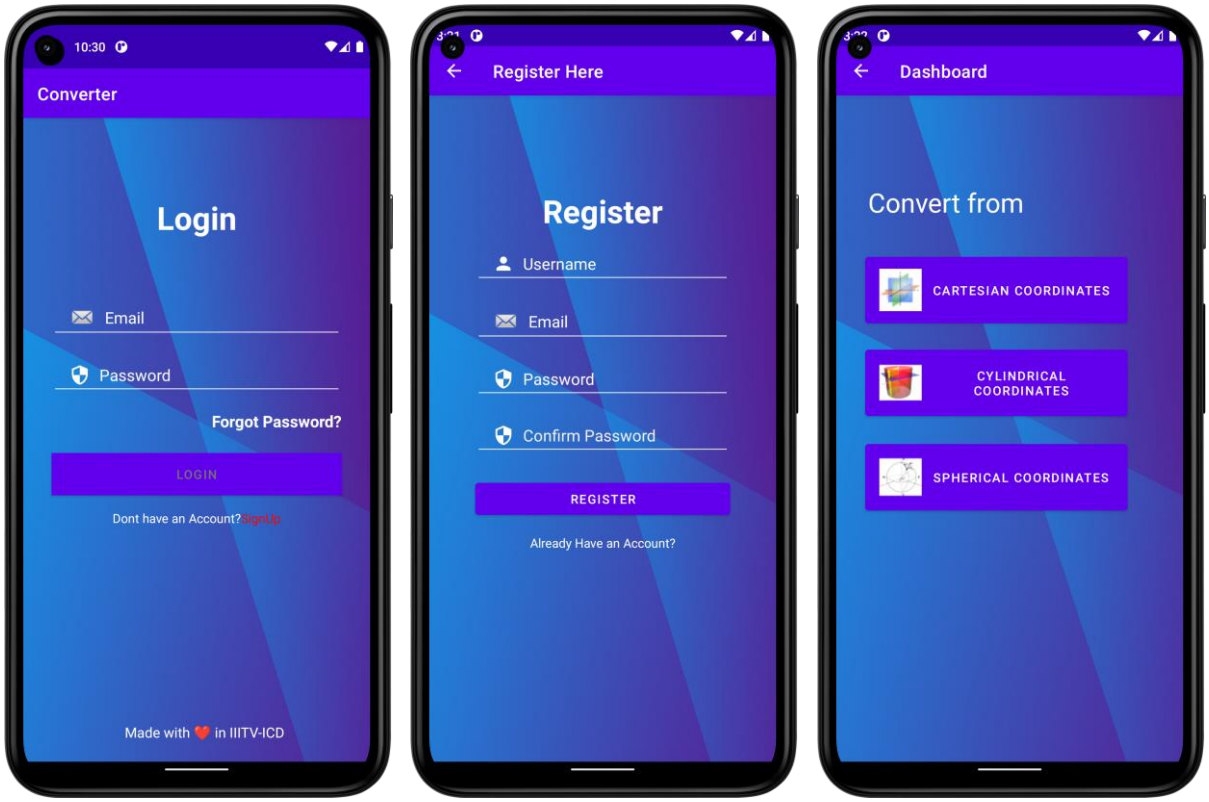
i.e – convert from

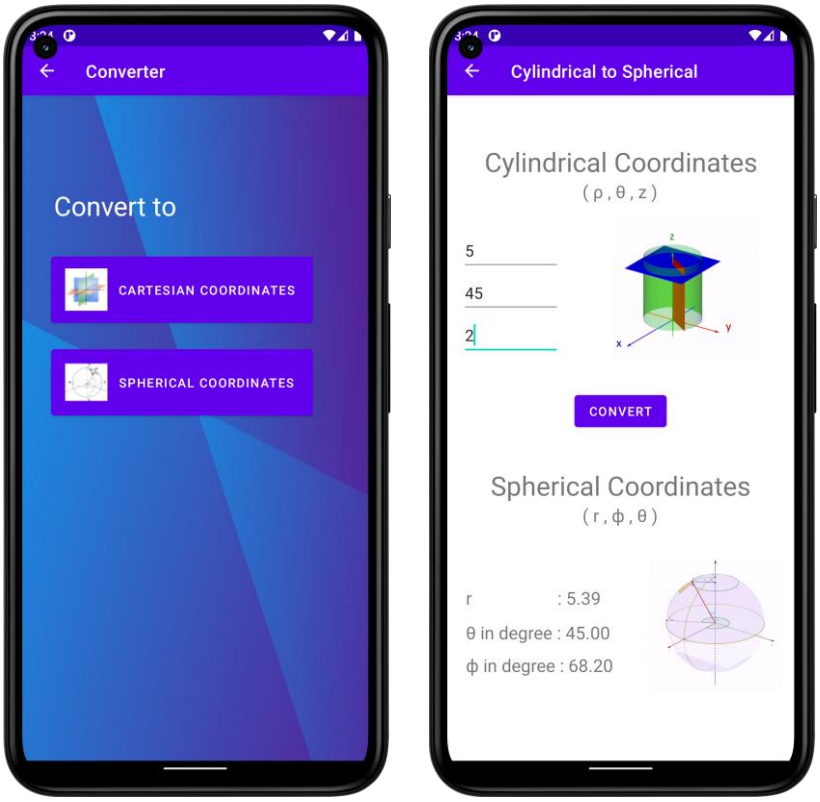
- Takes user input for converting to the type of co-ordinate output you need.

i.e-convert to

- Put in the co-ordinates.

2.3Graphical User Interface (GUI)
2.4





2.6 Conclusion

i. The result of the product developed in the form of an application program which is called "Converter".
ii. We are able to convert among three co-ordinate systems.

3. Project-2

Design a graphical user interface (GUI) to verify the continuity equation.

3.1 Development method

The application produced in this project is an application as program as teaching and learning media of Continuity Equation.

3.1.1 Planning

i. We listed out all work needed for making this app and scheduled it.
ii. ii. We distributed work among all of us.

3.2 Continuity Equation:

The continuity equation is simply a mathematical expression of the principle of conservation of mass. For a control volume with a single inlet and a single outlet, the principle of conservation of mass states that, for steady-state flow**,** the mass flow rate into the volume must equal the mass flow rate out.

$$\dot{m}_{in} = \dot{m}_{out}$$

Mass entering per unit time = Mass leaving per unit time

This equation is called the continuity equation for steady one-dimensional flow. The net mass flow must be zero for a steady flow through a control volume with many inlets and outlets, where negative inflows and outflows are positive.

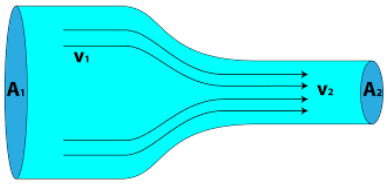
3.2.1 Electromagnetism :

In electromagnetic theory, the continuity equation can either be regarded as an empirical law expressing (local) charge conservation, or can be derived as a consequence of two of Maxwell's equations. It states that the divergence of the current density is equal to the negative rate of change of the charge density,

$$\nabla \cdot \mathbf{J} = -\frac{\partial \rho}{\partial t}.$$

3.2.2 Fluid Mechanics :

- Fluid dynamics studies fluid motion or moving fluids, as opposed to fluid statics, which is the study of fluids that are not moving.
- The word *fluid* often refers to a liquid or an incompressible fluid, but it can also refer to a gas. In general, a fluid is any substance that can flow.
- Fluid dynamics studies patterns in fluid flows. There are two main ways in which fluids are compelled to flow. Gravity can cause fluids to flow downhill, or fluid can flow due to pressure differences.



Equation of Continuity in Fluid Dynamics

- The continuity equation states that in the case of steady flow, the amount of fluid flowing past one point must be the same as the amount of fluid flowing past another point, or the mass flow rate is constant.

- It is essentially a statement of the law of conservation of mass.
- The explicit formula of continuity is the following:

$$\mathbf{A_1v_1=A_2v_2}$$

Where, ρ = density

A = cross-sectional area

v = flow velocity of the fluid.

The subscripts 1 and 2 indicate two different regions in the same pipe.

- The differential form of the continuity equation is :

$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \mathbf{u}) = 0$$

where,

ρ = fluid density,

t = time,

u = the flow velocity vector field.

- The time derivative can be understood as the accumulation (or loss) of mass in the system, while the divergence term represents the difference in flow in versus flow out.
- If the fluid is incompressible (volumetric strain rate is zero), the mass continuity equation simplifies to a volume continuity equation:

$$\nabla \cdot \mathbf{u} = 0$$

Which means that the divergence of the velocity field is zero everywhere.

- Physically, this is equivalent to saying that the local volume dilation rate is zero, hence a flow of water through a converging pipe will adjust solely by increasing its velocity as water is largely incompressible.

3.2.3 Computer vision :

What is computer vision?

Computer Vision, often abbreviated as CV, is defined as a field of study that seeks to develop techniques to help computers “see” and understand the content of digital images such as photographs and videos.

On a certain level Computer vision is all about pattern recognition. So, one way to train a computer how to understand visual data is to feed it lots of images, thousands, millions if possible that have been labeled, and then subject those to various software techniques, or algorithms, that allow the computer to hunt down patterns in all the elements that relate to those labels.

Theoretical understanding and observations:

One of the universal laws in physics is that of conservation, which is represented by the continuity equation. In which computer vision, the brightness, gradient brightness, and phase are the quantities preserved even in space and time variations. If Iv is regarded as a flux, the LBC can be represented by the mass continuity equation:

$$\frac{\partial}{\partial t} I + \nabla \cdot (I\mathbf{v}) = 0, \quad \nabla \mathbf{v} = 0,$$

the vector is constrained to del(v)=0, which means the smoothness constraint, as we will see shortly. In an analogy to fluid dynamics, del. v=0 means that the divergence of the velocity field is zero everywhere, indicating that the local volume dilation rate is zero. If we consider del (Iv) as a flux, the GBC becomes

$$\frac{\partial}{\partial t} \nabla I + \nabla \cdot (\mathbf{v}^T \nabla I) = 0, \quad \nabla \mathbf{v} = 0.$$

The same continuity equation can be applied to the phase. For the phase, we may consider phi(v) as a flux. The LPC then becomes

$$\frac{\partial}{\partial t} \phi + \nabla \cdot (\phi \mathbf{v}) = 0, \quad \nabla \mathbf{v} = 0.$$

Similarly, for the GPC, the continuity equation becomes

$$\frac{\partial}{\partial t}\nabla\phi + \nabla \cdot (\mathbf{v}^T \nabla\phi) = 0, \quad \nabla\mathbf{v} = 0.$$

The LBC can be represented by

$$(\nabla_t I)^T \mathbf{v} = 0,$$

3.2.4 Conservation of energy (heat transfer) :

The analogy of heat can be done with current.so, the equations might resemble current equations. Heat conduction, also called diffusion, is the direct microscopic exchanges of kinetic energy of particles (such as molecules) or quasiparticles (such as lattice waves) through the boundary between two systems.

Heat convection occurs when the bulk flow of a fluid (gas or liquid) carries its heat through the fluid. All convective processes also move heat partly by diffusion, as well. The flow of fluid may be forced by external processes, or sometimes (in gravitational fields) by buoyancy forces caused when thermal energy expands the fluid (for example in a fire plume), thus influencing its own transfer. The latter process is often called "natural convection". The former process is often called "forced convection." In this case, the fluid is forced to flow by use of a pump, fan, or other mechanical means.

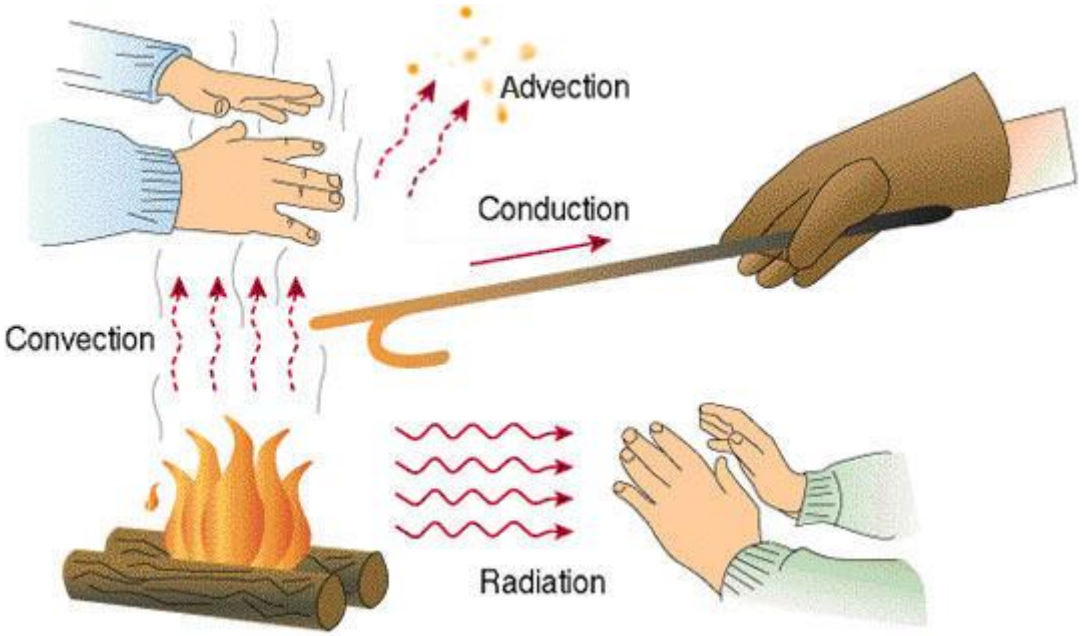
The continuity equation of heat transfer is derived from first law of thermodynamics:

$$\Delta E = Q - W$$

(Net change in total energy) (Heat added) (Work done)

Heat can be broadly transfer in three ways

1) Conduction
2) Convection
3) Radiation



Continuity equation of heat transfer will be -

$$\frac{\partial u}{\partial t} + \nabla \cdot \mathbf{q} = 0$$

3.3 Working of the App:

Android Studio Software is used.

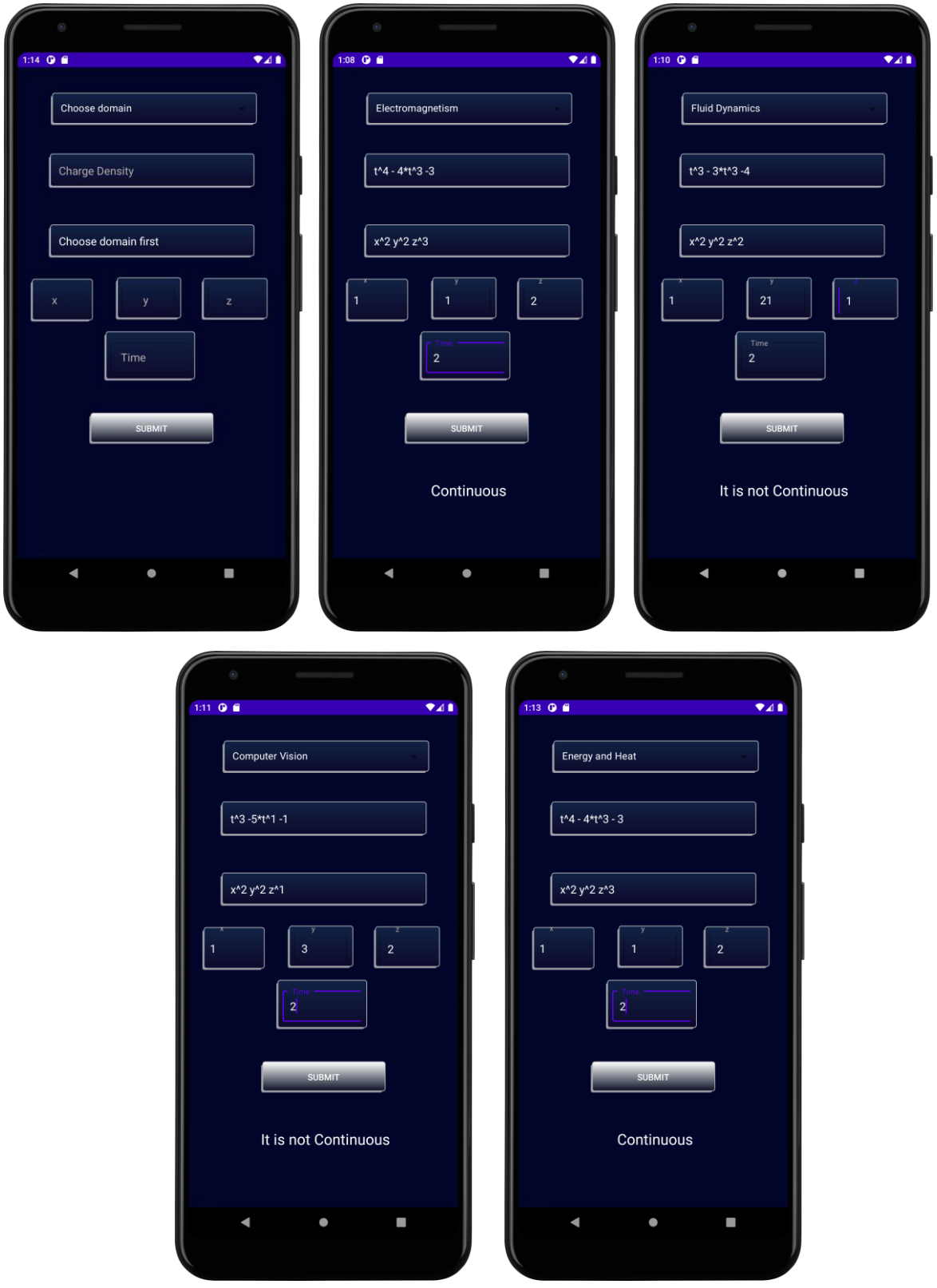
Our App performs four functions:

i. Takes the input

Domain	Electromagnetism Fluid Dynamics Computer Vision Energy and Heat
Charge Density	From user
Co-ordinate Input	x, y and z co-ordinates
Time (input)	In seconds

ii. Calculates value of respective continuity equation.
iii. Calculates value of Induced EMF.
iv. Calculates value of Induced current.

3.4 Graphical User Interface (GUI)



3.6 Conclusion

1. **Conclusion**
    1. The result of the product developed in the form of an application program which is called "Continuity Equation".
    2. We are able to verify continuity equation.

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