MM2090-Introduction to Scientific Computing

ASSIGNMENT 4

Team-6

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1.1 Biot-Savart law

The Biot–Savart law is an equation describing the magnetic field generated by a constant electric current. It relates the magnetic field to the magnitude, direction, length, and proximity of the electric current. The Biot–Savart law is fundamental to magnetostatics, playing a role similar to that of Coulomb's law in electrostatics.[5]

1.1.1 Equation:

$$d\vec{B} = \frac{\mu_0 I \vec{dl} \times \hat{r}}{4\pi r^2} \tag{1}$$

1.1.2 Analysis:

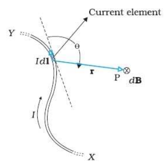

Figure 1: A current element Idl produces a magnetic field at point P given by the Biot-Savart law [1]

Consider a wire carrying current I as shown in figure 1. Equation 1 gives the magnetic field $d\vec{B}$ produced by an element $\vec{dl}$ of the wire at the point P situated at a distance **r** from it. Here, μ_0 is the permeability of free space, and has value $4\pi \times 10^{-7}$.[2] The magnitude of $d\vec{B}$ is given by:

$$dB = \frac{\mu_0 I dl sin\theta}{4\pi r^2} \tag{2}$$

1.1.3 Applications

The Biot–Savart law can be used in the calculation of magnetic responses even at the atomic or molecular level, e.g. chemical shieldings or magnetic susceptibilities, provided that the current density can be obtained from a quantum mechanical calculation or theory.The Biot–Savart law is also used in aerodynamic theory to calculate the velocity induced by vortex lines.[5]

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2.1 Viscous Force

The viscous force [8] is the force between a body and a fluid (liquid or gas) moving past it, in a direction so as to oppose the flow of the fluid past the object. In particular, the force acts on the object in the direction in which the fluid is moving relative to it and hence, opposite to the direction in which it is moving relative to the fluid.The equation of viscous force is given by:

$$F = \eta A \frac{\partial v}{\partial z} \tag{3}$$

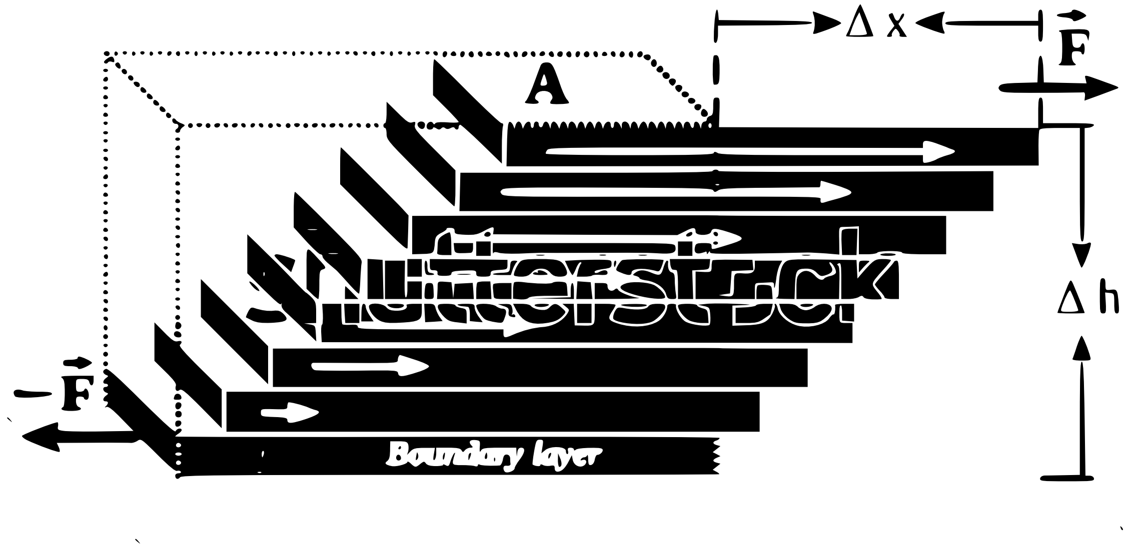


Figure 2: Viscosity between the layers of a fluid

2.1.1 Terms used in the equation

- F - Viscous Force
- η - viscosity of fluid
- A - Area of each plate
- $\frac{\partial v}{\partial z}$ - Velocity gradient

2.1.2 Importance of Viscous Force

Viscous Force obtained using Equation 3 helps us to find out the viscous force existing between two surfaces. Viscosity is a kind of friction which exists between fluids. As shown in Figure . 2 each layer of a fluid experiences different viscous force compared to other.

3 Monisha C ME20B112

3.1 poisson's equation

[4]

$$\nabla \cdot E = \frac{\rho_v}{\varepsilon} = \nabla^2 V \tag{4}$$

$E =$ Electric field
$\rho =$ volume charge density
$\varepsilon =$ premittivity
$V =$ Electric Potential

Note that Poisson's Equation is a partial differential equation, and therefore can be solved using well-known techniques already established for such equations. In fact, Poisson's Equation is an inhomogeneous differential equation, with the inhomogeneous part -ρv/ϵ representing the source of the field. In the presence of material structure, we identify the relevant boundary conditions at the interfaces between materials, and the task of finding V(r) is reduced to the purely mathematical task of solving the associated boundary value problem.

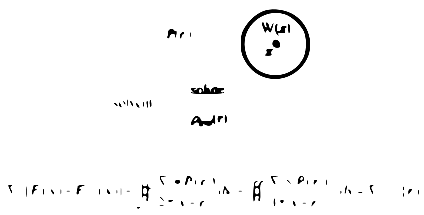


Figure 3: ME20B112
[3]

4 Swapnil Paresh Mehta

4.1 Clausius Theorem

The Clausius theorem (1855) states that for a thermodynamic system (e.g. heat engine or heat pump) exchanging heat with external reservoirs and undergoing a thermodynamic cycle,

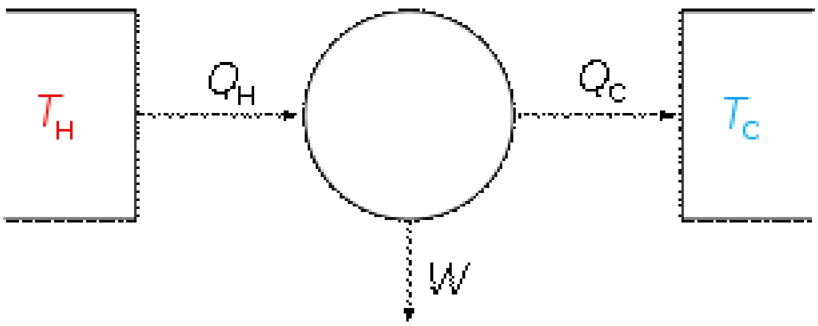
$$\oint \frac{\delta Q}{T_{Surr}} \leqslant 0 \tag{5}$$

- δQ - The infinitesimal amount of heat absorbed by the system from the reservoir
- T_{Surr} - The temperature of the external reservoir (surroundings) at a particular instant in time.

4.2 Importance

The Clausius theorem 5 is a mathematical explanation of the second law of thermodynamics. It was developed by Rudolf Clausius who intended to explain the relationship between the heat flow in a system and the entropy of the system and its surroundings. Clausius developed this in his efforts to explain entropy and define it quantitatively. In more direct terms, the theorem gives us a way to determine if a cyclical process is reversible or irreversible. The Clausius theorem provides a quantitative formula for understanding the second law.

Figure 4: Carnot Engine



[6]

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5.1 Coloumbs Law

Coulomb force [7] is the force between two stationary electric charge particle .The equation of coulumb force is given by:

$$F = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r^2} \tag{6}$$

5.1.1 Terms used in the equation

1. F-viscous forece
2. ϵ-constant
3. $\frac{q_1 q_2}{r^2}$-product of magnitude of two charges divided by square of distance between two charges

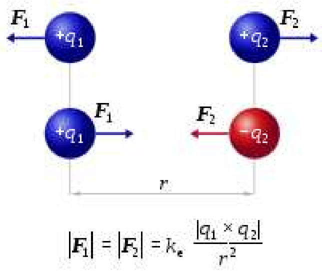

Figure 5: coulomb force between electric charges

5.1.2 Description

coulomb force obtained by using the equation 6 above helps us to find force between two electrically charged particles which is essential in development of theory of electromagnetism. The same is mentioned in Figure 5.

References

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