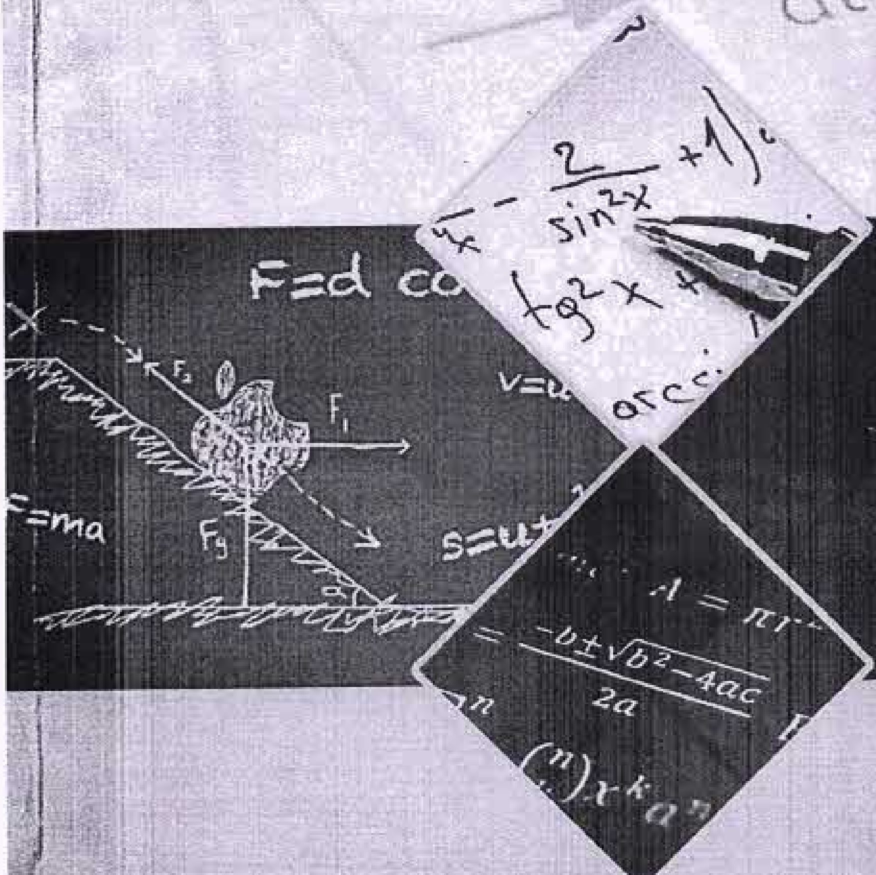
One Day National Conference on
A Glimpse of Differential Equations in Science and Engineering

2019-20



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Education Society Naigaon's

Sharadchandra Arts, Commerce & Science College, Naigaon (BZ.)

Re-accredited by NAAC with 'B' Grade

(Affiliated to Swami Ramanand Teerth Marathwada, University, Nanded. MS)

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ISBN No. 978-81-940206-2-2

Published By

SIDDHI PUBLISHING HOUSE

NANDED – 431605

Mob. No. 9623979067

E mail : shrishprakashan2009@gmail.com

Typesetting

Dr. R. G. Umbarkar

Printers

Anupam Printers,
Nanded.

First Edition : 08 Feb. 2020

Price : Rs. 200

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INDEX

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APPLICATION OF DIFFERENTIAL EQUATION IN PHYSICS

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ABSTRACT:

Differential equation gives us information about how a one of the quantities (i.e. dependent variable) changes with respect to (independent variable). The different variable used in physics are time, position, distance, acceleration, temperature, space etc. In ordinary differential equation of variation of position with respect to time contains the x, t, dx/dt, d^2x/dt and several higher order derivatives. There are different methods to solve differential equation, using that solution we get the information about how quantity changes with respect to expected variable. In physics differential equation are used to represent periodic motion for instance in simple harmonic motion to represent variation of position with respect to time i.e. dx/dt is used.

INTRODUCTION:

An equation involving derivatives or differentiation of one or more dependent variable with respect to one or more independent variable is called differential equation[1-2]. Almost all the theories of physics have expressed physical laws by using differential equation. A law is set of rules followed by particular system. Such a rules are observed by repeated experimentation. For example,Newtone's law are set of rules followed by a system possessing motion. The second law of motion is expressed in the form of second order ordinary differential equation $F(x)= m\ d^2x/d^2t$, here x is distance of a point mass at any instant 't' from point 'o' taken as origin on a straight line[3,4]. The equation of this kind is called differential equation because this equation contains d^2x/d^2y. This is a second order differential equation. The set of rules for making a law are fixed and system follows these rules under different circumstances. However, the laws can break-down in some situations, and therefore a law is true only for a subset of conditions. For example, all macroscopic systems using Newton's laws of motion one can find the exact position and momentum of an object at any instant of time whereas for quantum sized systems one cannot determine momentum and position values at any instant of time with full certainty. Another example is that of ohms law, for certain systems such as copper wire one can find linear relationship between current and voltage, whereas for systems such as transistors such relationship breakdowns.According to classical physics, all systems change continuously as time passes. A physical law expresses a permanent relationship between the state of the system at the present moment and its state immediately following that moment. Therefore, a law must define the connection between successive space-time points. As we can see in equation, Newton's second law of motion defines a relationship that connects the velocity of the body at a present space-time point with the velocity at a point in the immediate neighbourhood of the first space-time point. A majority of physical processes change continuously, and therefore a law must express this continuity of change in a causal chain. In a continuous process, the sequence of states assumed by a physical system forms a continuous chain, which means that the change in state of the system over an infinitesimal period of time is itself infinitesimal. The laws controlling such processes must therefore exhibit continuity of change.

APPLICATION IN WAVE MOTION OF STRING:

When we have a function y(t), we can readily define dy/dx as the slope of the plot y(x). But now consider y(x,t). In our example, this will be the displacement y of a point on a string as a function of position on the string x, and time t. So we can now think of two different derivatives. We write them differently. What we shall do here is to solve the wave equation, the equation of motion for a wave in a string[5].

$\partial y/\partial x$,think of this as dy/dx at a given constant time, t. Imagine taking a photograph (time is constant): in the image at time t, this is the slope of the y(x) shape at the instant of the photograph.

$\partial y/\partial t$. Think of this as dy/dt at a given position, x. This is just the velocity in the y direction at a particular point x on the string. (Not the velocity of the wave, by the way).

Let's take a standard example. A travelling sine wave with amplitude A, frequency $f = 2\pi\omega$ and wavelength $\lambda = 2\pi/k$ has the equation

$$y = A\sin(kx - \omega t),$$

$\partial y/\partial x = kA\cos(kx - \omega t)$,which is the slope of the string at position x and time t,
$\partial y/\partial t = -\omega A\cos(kx - \omega t)$, which is the velocity of a point on the string at x and t.
$\partial y^2/\partial x^2 = -k^2 A\sin(kx - \omega t)$,which is the rate of change in the slope of the string, as x varies,

And

$\partial y^2/\partial t^2 = -\omega^2 A\sin(kx - \omega t)$,which is the acceleration of a point on the string.

These have important physical significance: the first one is determining the curvature of the string. If $\partial y^2/\partial x^2 = 0$, then the slope is constant, so it is straight. That means that the tension T acts in opposite directions at opposite ends, giving no nett force. If a segment is curved, however ($\partial y^2/\partial x^2 \neq 0$), it has a force acting on it. For constant curvature over a small length L, the nett force is proportional to L as shown in Fig. 1.

We know the acceleration so we can apply Newton's second law. The mass of the segment is μL, where μ is the mass per unit length μ. Writing Newton's law as a = F/m gives:

$$\partial y^2/\partial t^2 = (T/\mu)\partial y^2/\partial x^2$$

Looking back at our expressions for the two second derivatives, we see that they our original function $y = A\sin(kx - \omega t)$ is a solution to the wave equation, provided that $T/\mu = \omega^2/k^2$. We also know in wave, that ω/k is the wave speed, v. Which finally relates the wave speed to the physical properties T and μ of the string:

$$v = \sqrt{(T/\mu)}.$$

The wave speed is greater if the string is stretched more tightly, and less if the string has a high mass per unit length.

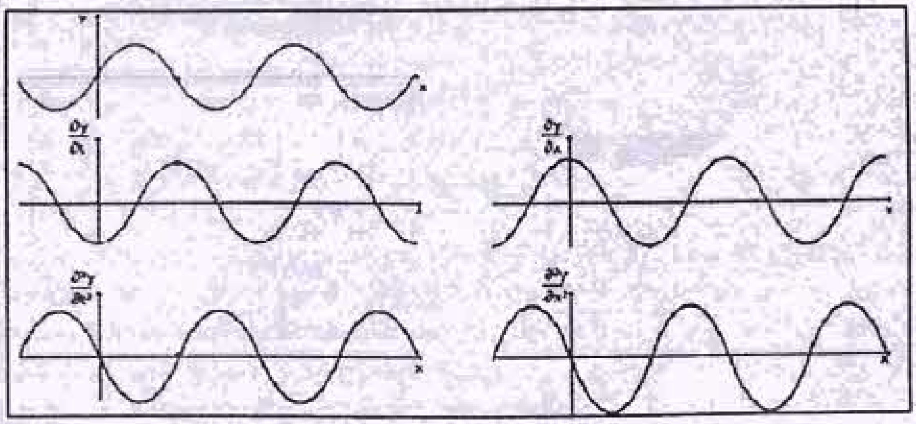

Fig.1 Variation of y, dy/dt, d^2y/dt^2, dy/dx, d^2y/dx^2 with position.

CONCLUSION:

Differential equations are used for formulation of various laws of physics for example Newton's law, wave equation of string, radioactive decay etc. Differential equations are the foundation for understanding many of the most important processes and phenomenon in nature. Technological progress in some area occurred with the solution to differential equation to guide and provide confident solution and insight.

REFERENCES:

1. Simplified course in differential equation, M. D. Raisinghania, H. C. Saxena, H.K. Das, S. chand and comp. private ltd.
2. Advanced engineering mathematics, H. K. Das.S. chand and comp. private ltd.
3. Differential equation and their application, H.T.H. Piaggio, CBS publisher.
4. Why are differential equations used for expressing the laws of physics, Shabnam Siddiqui.
5. Physics UNSW, differential equation.