



## UNIT - II

### Differential Equation:

An eqn. involving differential coefficients or derivatives is called differential eqn.

### Ordinary differential eqn.

A differential eqn. which depends on only one independent variable is called ordinary differential eqn.

### Order and degree:

\* The order of the highest derivative occurring in the given eqn is called the order of a differential eqn.

\* The degree of the highest derivative occurring in the given eqn. is called the degree of a differential eqn.

### Second order linear ODE with constant coefficients:

The general linear ODE with constant coefficients is of the form

$$a_0 \frac{d^2 y}{dx^2} + a_1 \frac{d^{n-1} y}{dx^{n-1}} + a_2 \frac{d^{n-2} y}{dx^{n-2}} + \dots + a_n y = f(x) \quad \rightarrow (1)$$

where  $a_0, a_1, \dots, a_n$  are constants and

$f(x)$  is a function of  $x$ .

When  $f(x) = 0$  in (1) is called homogeneous ODE &

If  $f(x) \neq 0$  in (1) is called non-homogeneous ODE.



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UNIT-II ORDINARY DIFFERENTIAL EQUATIONS

Homogeneous Linear ODE with constant coefficients

This eqn. can be written as,

$$[a_0 D^n + a_1 D^{n-1} + a_2 D^{n-2} + \dots + a_n] y = f(x)$$

$$\text{where } D = \frac{d}{dx}$$

$$\text{Solution} = \text{CF} + \text{PI}$$

= Complementary function + Particular integral

To find CF:

Roots

CF

i). Roots are real & different  
 $m_1 \neq m_2$

$$A e^{m_1 x} + B e^{m_2 x}$$

ii). Roots are real & same  
 $m_1 = m_2 = m$

$$(A + Bx) e^{mx}$$

iii). Roots are imaginary.  
(or complex)  
 $m = \alpha \pm i\beta$

$$e^{\alpha x} [A \cos \beta x + B \sin \beta x]$$

To find PI:

$$PI = \frac{1}{f(D)} f(x)$$

$$RHS = 0$$

J. Solve  $(D^2 - 5D + 6) = 0$

Soln.

The auxiliary eqn. is

$$m^2 - 5m + 6 = 0$$

$$(m-3)(m-2) = 0$$

$$m = 2, 3$$

$\therefore$  The roots are real and different.



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UNIT-II ORDINARY DIFFERENTIAL EQUATIONS

Homogeneous Linear ODE with constant coefficients

$$CF = Ae^{2x} + Be^{3x}$$

$$\therefore y = CF = Ae^{2x} + Be^{3x}$$

2]. Solve  $\frac{d^2 y}{dx^2} - 6 \frac{dy}{dx} + 9y = 0$

Soln.

$$(D^2 - 6D + 9)y = 0$$

The Auxiliary eqn is

$$m^2 - 6m + 9 = 0$$

$$(m-3)^2 = 0$$

$$m = 3, 3$$

The roots are real and same.

$$CF = (A + Bx)e^{3x}$$

$$\therefore y = CF = (A + Bx)e^{3x}$$

3]. Solve  $(D^2 + 1)^2 y = 0$

Soln.

The Auxiliary eqn. is  $(m^2 + 1)^2 = 0$

Taking square root on both sides

$$m^2 + 1 = 0$$

$$m^2 = -1$$

$$m = \pm i$$

The roots are  $\pm i$  and  $\pm i$  imaginary

$$\text{Here } \alpha = 0, \beta = 1$$

$$\therefore CF = e^0 (A \cos x + B \sin x)$$

$$= A \cos x + B \sin x$$

$$\therefore y = CF = A \cos x + B \sin x$$

4]. Solve  $(D^4 - 1)y = 0$

Soln.

The auxiliary eqn. is  $m^4 - 1 = 0$



$$(m^2)^2 - 1^2 = 0$$

$$(m^2+1)(m^2-1) = 0$$

$$\left. \begin{array}{l} m^2+1=0 \\ m^2=-1 \\ m=\pm i \end{array} \right\} \begin{array}{l} m^2-1=0 \\ m^2=1 \\ m=\pm 1 \end{array}$$

$$\therefore \text{CF} = Ae^{\alpha} + Be^{-\alpha} + C \cos \alpha + D \sin \alpha .$$