1. Solve $x^2y'' + 2xy' = 0$

Soln

Given $(x^2D^2 + 2xD)y = 0 \rightarrow (1)$

Take $x = e^z$

$z = \log x$

$xD = D'$

$x^2D^2 = D'(D'-1) = D'^2 - D'$

Subs. the above eqn (1),

$[D'^2 - D' + 2D']y = 0$

$[D'^2 + D']y = 0$

AE $m^2 + m = 0 \quad D' \rightarrow m$

$m(m+1) = 0$

$m = 0, \ m = -1$

$CF = Ae^{0z} + Be^{-z}$

$= A + Be^{-z}$

$\therefore$ The soln. is, $y = CF = A + Be^{-\log x} = A + \frac{B}{x}$.

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2. Solve $x^2\frac{d^2y}{dx^2} - 3x\frac{dy}{dx} + 4y = x\sin(\log x)$

Soln.

Given $(x^2D^2 - 3xD + 4)y = x\sin(\log x) \rightarrow (1)$

Take $x = e^z$

$z = \log x$.

$xD = D'$

$x^2D^2 = D'(D'-1) = D'^2 - D'$

Subs. the above eqn (1)

$[D'^2 - D' - 3D' + 4]y = e^z \sin z$

$[D'^2 - 4D' + 4]y = e^z \sin z$

AE $m^2 - 4m + 4 = 0$

$(m-2)^2 = 0$

$m = 2, 2$

$$CF = (A + Bx)\, e^{2x}$$

$$CF = [A + B\log x]\, x^2$$

$$PI = \frac{1}{D'^2 - 4D' + 4}\, e^x \sin x$$

$$= e^x \frac{1}{(D'+1)^2 - 4(D'+1) + 4} \sin x \qquad D' \to D' + a = D' + 1$$

$$= e^x \frac{1}{D'^2 + 1 + 2D' - 4D' - 4 + 4} \sin x$$

$$= e^x \frac{1}{D'^2 - 2D' + 1} \sin x$$

$$= e^x \frac{1}{-1 - 2D' + 1} \sin x \qquad D'^2 \to -b^2 = -1^2 = -1$$

$$= e^x \frac{1}{-2D'} \sin x$$

$$= \frac{e^x}{-2} \left[\frac{1}{D'} \sin x\right]$$

$$= \frac{e^x}{-2} [-\cos x]$$

$$PI = \frac{e^x \cos x}{2} \Rightarrow PI = \frac{x \log(\log x)}{2}$$

The Soln. is,

$$y = CF + PI$$

$$y = [A + B\log x]\, x^2 + \frac{x \cos(\log x)}{2}$$