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) $y = \frac{2\cos 3x}{x^3}$; find $\frac{dy}{dx}$

Let $u = 2\cos 3x$; $du/dx = -6\sin 3x$

$v = x^3$; $dv/dx = 3x^2$

Using quotient rule; $\frac{dy}{dx} = \frac{v\,du/dx - u\,dv/dx}{v^2}$

$$\frac{dy}{dx} = \frac{(x^3)(-6\sin 3x) - (2\cos 3x)(3x^2)}{x^6} = \frac{-6x^3\sin 3x - 6x^2\cos 3x}{x^6}$$

$$= \frac{-6x^2(x\sin 3x + \cos 3x)}{x^6}$$

$$= -\frac{6(x\sin 3x + \cos 3x)}{x^4}$$

2. Prove $\frac{d^2y}{dx^2} - 4\frac{dy}{dx} + 4y = 0$; $y = xe^{2x}$

Solution

$$\frac{dy}{dx} = \frac{d(x)}{dx} \times e^{2x} + \frac{d(e^{2x})}{dx} \times x$$

$= (1e^{2x}) + (2e^{2x} \times x) = e^{2x} + 2xe^{2x}$

$\frac{d^2y}{dx^2} = \frac{d}{dx}(e^{2x}) + \left[\frac{d}{dx}(2x) \times e^{2x} + \frac{d}{dx}(e^{2x}) \times 2x\right]$

$= 2e^{2x} + (2xe^{2x}) + (2e^{2x} \times 2x) = 2e^{2x} + 2e^{2x} + 4xe^{2x}$

$\frac{d^2y}{dx^2} = 4e^{2x} + 4xe^{2x}$

$\therefore \frac{d^2y}{dx^2} - 4\frac{dy}{dx} + 4y = 0$

$\Rightarrow 4e^{2x} + 4xe^{2x} - 4(e^{2x} + 2xe^{2x}) + 4(e^{2x} \cdot x)$

$= 4e^{2x} + 4xe^{2x} - 4e^{2x} - 8xe^{2x} + 4xe^{2x}$

$= 4e^{2x}x - 8xe^{2x} + 4xe^{2x} + 4e^{2x} - 4e^{2x} = 0$

$= 0 + 0 = 0$

$\therefore \frac{d^2y}{dx^2} - 4\frac{dy}{dx} + 4y = 0$

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4 $\int e^x \sin 2x \, dx$

$= \int \sin 2x \, dx \times \int x$

$= \sin 2x \times e^x - \int -e^x \cos 2x \times 2 \, dx$

$= \sin 2x \times e^x - 2 \times \int \cos 2x \times e^x \, dx$

$\int u\,dv = uv - \int v\,du$ where $u = \cos 2x$, $du = e^x dx$

$= \sin(2x) \times e^x - 2(\cos 2x \times e^x - \int e^x \times (-\sin 2x) \times 2\,dx)$

$= \sin 2x \times e^x - 2(\cos 2x \times e^x - 1 \times (-2) \times \int e^x \times \sin 2x\,dx$

$= \sin 2x \times e^x - 2(\cos 2x \times e^x + 2 \times \int e^x \times \sin 2x\,dx$

$\int e^x \times \sin 2x\,dx = \sin 2x \times e^x - 2(\cos 2x \times e^x + 2 \times \int e^x \times \sin 2x\,dx)$

$\int e^x \times \sin 2x\,dx + 4 \times \int e^x \times \sin(2x)\,dx = \sin 2x \times e^x - 2\cos 2x \times e^x$

$5 \times \int e^x \sin 2x\,dx = \sin 2x \times e^x - 2\cos 2x \times e^x$

$\int e^x \times \sin 2x\,dx = \frac{\sin 2x \times e^x}{5} - \frac{2\cos(2x) \times e^x}{5}$

$\therefore \int e^x \sin 2x\,dx = \frac{\sin 2x \times e^x - 2e^x \times \cos 2x}{5} + c$