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1 find $\frac{dy}{dx}$ of $y = \frac{2\cos 3x}{x^3}$ $-u$ $-v$

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

$du/dx = -6\sin 3x$

$dv/dx = 3x^2$

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

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

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

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

2 If $y = xe^{2x}$ $\quad dy/dx = v\,du/dx + u\,dv/dx$

$u \quad v$

$du/dx = 1 \quad dv/dx = 2e^{2x}$

$$\frac{dy}{dx} = e^{2x} + x \cdot 2e^{2x}$$

$$= e^{2x} + 2xe^{2x}$$

$$dy/dx = e^{2x}(1 + 2x)$$

$$\frac{d^2y}{dx^2} = 4e^{2x}(x+1)$$

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

$$= 4e^{2x}(x+1) - 4e^{2x}(1+2x) + 4(xe^{2x}) = 0$$

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

$$= 4e^{2x}(x + 1 - 1 - 2x + x) = 0$$

$$= 4e^{2x}(1 - 1 + 2x - 2x) = 0$$

$$= 4e^{2x}(0) = 0$$

$$0 = 0$$

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

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④ $\int e^x \sin 2x \, dx$

$dv = e^x$ $\quad u = \sin 2x$

$v = e^x$ $\quad du = 2\sin 2x \, dx$

$$\int u\,dv = uv - \int v\,du$$
$$= e^x \sin 2x - 2\int e^x \cos 2x \, dx \quad -(1)$$

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

$dv = e^x$ $\quad u = \cos 2x$

$v = e^x$ $\quad du = 2\cos 2x$

let $\int e^x \sin 2x \, dx = I$

substitute (2) in (1)

$$I = e^x \sin 2x - 2(e^x \cos 2x + 2I)$$
$$I = e^x \sin 2x - 2e^x \cos 2x - 4I$$
$$5I = e^x \sin 2x - 2e^x \cos x + C$$

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