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4.) Integral of $e^x \sin x$

Let's call our integral I

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

Let $u = \sin 2x$, $du = 2x \cos 2x$

$dv = e^x$, $v = e^x$

Using the formula $\int u\,dv = uv - \int v\,du$

$$\text{SO } I = e^x \sin(2x) - \int e^x \times \cos(2x)\, dx$$

pull the 2 out of the Integral

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

For the new integral, we have

$$\int e^x \cos(2x)\, dx$$

$u = \cos(2x)$, $du = -2\sin 2x$

$dv = e^x$, $v = e^x$

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

$$= e^x \cos(2x) + 2\int e^x \sin(2x)$$

Joining it with the first equation, we have

$$I = e^x \sin(2x) - 2\left(e^x \cos(2x) + 2\int e^x \sin(2x)\right).$$

MAT 104 07/05/2020

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1.) $y = \frac{2\cos 3x}{x^3}$ is a quotient

$\therefore$ let $y = 2\cos 3x$

$v = x^3$

$\frac{dy}{dx} = -6\sin 3x$

$\frac{dv}{dx} = 3x^2$

Quotient rule: $\frac{v\frac{du}{dx} - y\frac{dv}{dx}}{v^2}$

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

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

$= \frac{6x^2}{x^6}\left[x\sin 3x - \cos 3x\right]$ //

2.) $y = xe^{2x}$ show that the differential equations

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

If $y = xe^{2x}$ $\frac{dy}{dx} = 2xe^{2x}$ $\frac{d^2y}{dx^2} = 4xe^{2x}$

$\therefore 4xe^{2x} - 4\left[2xe^{2x}\right] + 4\left[xe^{2x}\right] = 0$

$= 0$ //