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Integrate the following functions
1) $2x^2 \ln x$
let $u = \ln x$ $dv = 2x^2$
$du = \frac{1}{x} dx$

$\int u dv. uv - \int v du$
$= \ln x \cdot \frac{2x^3}{3} - \int \frac{2x^3}{3} \cdot \frac{dx}{x}$

$= \frac{2x^3}{3} \ln x - \int \frac{2x^3}{3} \ln x = \frac{2x^3}{3} \ln x - \frac{2x^3}{3 \times 3} + C$

$= 2x^3 \ln x dx = \frac{2x^3}{3} \ln x - \frac{2x^3}{9} + C$

OR

$= \frac{2x^3}{3}(\ln x - 1/3) + C$

2) $3te^{2t}$

Solution

let $u = 3t$ $dv = e^{2t}$
$du = 3dx$ $v = 1/2 e^{2t}$
$\int u dv = uv - \int v du$
$\int 3t e^{2t} = 3t \cdot 1/2 e^{2t} - \int \frac{1}{2} e^{2t} \cdot 3dx$
$\int 3t e^{2t} = \frac{3t}{2} e^{2t} - \int \frac{3}{2} e^{2t} \cdot dx$
$= \frac{3t}{2} e^{2t} - \frac{1}{2} \cdot \frac{3}{2} e^{2t} + C$

$\therefore \int 3te^{2t} dt = \left[\frac{3t}{2} e^{2t} - \frac{3e^{2t}}{4} \right] + C$

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3) $x^2 \sin x$

Solution

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

$\frac{du}{x} = 2x \quad v = -\cos x$

$dx = 2x\,dx$

$\int u\,dv = uv - \int v\,dx$

$\int x^2 \sin x\,dx = \ell x^3 - \cos x - \int \cos x \cdot 2x\,dx$

$= -x^2 \cos x + \int 2x \cos x\,dx$

$= -x^2 \cos x + \left[\begin{array}{ll} u = 2x & dv = \cos x \\ du = 2dx & v = \sin x \end{array}\right]$

$= -x^2 \cos x + uv - \int v\,du$

$= -x^2 \cos x + 2x \sin x$

$\int x^2 \sin x = -x^2 \cos x + 2x \sin x - \int \sin x \cdot 2dx$

$\therefore \int x^2 \sin x\,dx = -x^2 \cos x + 2x \sin x - \int 2\sin x$

$= -x^2 \cos x + 2x \sin x + 2\cos x + C$

4) $\cos 5x \cos 6x$

Solution

Let $y = 5x, \quad z = 6x$

Recall that

$\cos A \cos B = \frac{1}{2}\left[\cos(A+B) - \cos(A-B)\right]$

$= \frac{1}{2} \int \cos 11x + \cos x$

$\int \cos 5x \cos 6x\,dx = \frac{1}{2}\left[\frac{\sin 11x}{11} + \sin x\right] + C$

$\therefore \int \cos 5x \cos 6x\,dx = \frac{\sin 11x}{2} + \frac{\sin x}{2} + C$

5) $\sin 7x \cos 2x$

Solution

$y = 7x \quad z = 2x$

Recall that; $\sin A \cos B = \frac{1}{2}\left(\sin(A+B) + \sin(A-B)\right)$

$\int \sin 7x \cos 2x\,dx = \frac{1}{2}(\sin 9x + \sin 5x) = \frac{1}{2}\left[-\frac{\cos 9x}{9} - \frac{\cos 5x}{5}\right] + C$

$\therefore \int \sin 7x \cos 2x\,dx = -\frac{\cos 9x}{18} - \frac{\cos 5x}{10} + C$