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Integrate the following functions:
1. $2x^2 \ln x$
2. $3te^{2t}$
3. $x^2 \sin x$
4. $\cos 5x \cos 6x$.
5. $\sin 7x \cos 2x$

Solution.

1. $\int 2x^2 \ln x \, dx$

let $u = \ln x$, $dv = 2x^2$

$du = \frac{1}{x} dx$, $v = \frac{2x^3}{3}$

$\int u dv = uv - \int v du$

$= \ln x \left(\frac{2x^3}{3}\right) - \int \frac{2x^3}{3} \cdot \frac{1}{x} dx$

then; $\frac{2x^3}{3} \ln x - \frac{2x^2}{3} dx$

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

2. $\int 3te^{2t}$; let $u = 3t$, $dv = e^{2t}$, $du = 3dx$, $v = e^{2t}$

$\int u dv = uv - \int v du$

$= 3t(e^{2t}) - \int e^{2t} \cdot 3dx$

$= 3t(e^{2t}) - \int 2e^{2t} \cdot 3 \, dx$

$= 3te^{2t} - 3 \cdot 2e^{2t} + c$

$v = e^{2t}$

(3) $\int x^2 \sin x \, dx$

let $u = x^2$, $dv = \cancel{\cos x}\ \sin x$

$\frac{du}{dx} = 2x$, $v = \cancel{+}\cos x$

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

$= x^2(\cos x) - \int \cos x \; 2x\,dx$

$= x^2 \cos x - \int \cos x \left[\frac{du}{2x} \times \frac{2x}{1}\right]$

$\int u\,dv = \cancel{x^2 \cos x - \int \cos}\ \ x^2 \cos x - \cos x + c$

(4) $\int \cos 5x \cos 6x \, dx$

let $A = 5x$, $B = 6x$

$\cos A \cos B = \frac{1}{2}\left[\cos(5x+6x) + \cos(5x-6x)\right]$

$\cos A \cos B = \frac{1}{2}\left[\cos 11x + \cos(-x)\right]$

$= \frac{1}{2}\left[\frac{\cos 11x}{11} + \frac{\cos(-x)}{1}\right]$

$\int \cos 5x \cos 6x \, dx = \frac{\cos 11x}{22} + \frac{\cos(-x)}{2} + C$

(5) $\int \sin 7x \cos 2x \, dx$

let $A = 7x$ and $B = 2x$

$\sin A \cos B = \frac{1}{2}\left[\sin 9x + \sin 5x\right]$

$= \frac{1}{2}\left[\frac{\sin 9x}{9} + \frac{\sin 5x}{5}\right]$

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