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1) Integrate $2x^2 \ln x$

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

$\frac{du}{dx} = \frac{1}{x}, \; du = \frac{1}{x} dx$

$v = \frac{2x^3}{3}$

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

$= \ln x \cdot \frac{2x^3}{3} - \int \frac{2x^3}{3} \cdot \frac{dx}{x}$

$= \frac{2x^3}{3} \ln x - \int \frac{2x^2}{3} dx$

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

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

$= \frac{2x^3}{3}\left(\ln x - \frac{1}{3}\right) + c$

2) $\int 3te^{2t} dt$

$u = 3t \quad dv = e^{2t}$

$du = 3dx \quad v = \frac{1}{2}e^{2t}$

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

$\int 3te^{2t} dt = 3t \cdot \frac{1}{2}e^{2t} - \int \frac{1}{2}e^{2t} \cdot 3dx$

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

$= \frac{3te^{2t}}{2} - \frac{1}{2} \cdot \frac{3}{2} e^{2t} + c$

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

3). $\int x^2 \sin x dx$

Let $u = x^2 \qquad dv = \sin x$

$du = 2x dx \qquad v = -\cos x$

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

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

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

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

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

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

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

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

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

Let $A = 5x \qquad B = 6x$

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

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

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

$\therefore \int \cos 5x \cos 6x dx = \frac{\sin 11x}{22} + \frac{\sin x}{2} + c$

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

$A = 7x \quad B = 2x$

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

$$\int \sin 7x \cos 2x \, dx = \frac{1}{2}\int \sin 9x + \sin 5x$$

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

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

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