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Integrate the following functions

$$1) \int 2x^2 \ln x \, dx = \int u \, dv = UV - \int V \, du$$

$$u = \ln x$$

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

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

$$dv = 2x^2$$

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

$$\int u \, dv = UV - \int V \, du$$

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

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

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

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

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

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

$$u = 3t$$

$$\frac{du}{dt} = 3$$

$$du = 3dt$$

$$dv = e^{2t}$$

$$v = \frac{1}{2} e^{2t}$$

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

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

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

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

$$\int 3te^{2t} dt = \frac{3t}{2} e^{2t} - \frac{3}{4} e^{2t} + c$$

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

$$u = x^2$$

$$\frac{du}{dx} = 2x$$

$$du = 2x dx$$

$$dv = \sin x$$

$$v = -\cos x$$

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

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

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

$$= -x^2 \cos x + \begin{cases} u = x & , dv = \cos x \\ \frac{du}{dx} = 1 & v = \sin x \\ du = dx & \end{cases}$$

$$\rightarrow x \sin x - \int \sin x dx$$

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

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

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

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

$$\textcircled{4} \int \cos 5x \cos 6x dx$$

$$A = 5x$$

$$B = 6x$$

$$A+B = 5x+6x = 11x$$

$$A-B = 5x-6x = -x$$

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

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

$$= \frac{1}{2} \left[\frac{\sin 11x}{11} - \sin x \right]$$

$$= \frac{\sin 11x}{22} - \frac{\sin x}{2} + C$$

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

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

$$A + B = 7x + 2x \\ = 9x$$

$$A - B = 7x - 2x \\ = 5x$$

$$\text{Ex. } \sin A \cos B = \frac{1}{2} [\sin(A+B) + \sin(A-B)]$$

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

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

$$= \frac{-\cos 9x}{18} - \frac{\cos 5x}{10} + C$$