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Class Exercise

$$\int x^3 \ln x \, dx$$

$$u = \ln x \quad u' = \frac{1}{x}$$

$$v' = x^3 \quad v = \frac{x^4}{4}$$

Integration By Parts

$$\int u v' \, dx = u \cdot v - \int u' v \, dx$$

$$\int x^3 \ln x \, dx = \ln x \cdot \frac{x^4}{4} - \int \frac{1}{x} \cdot \frac{x^4}{4} \, dx$$

$$= \ln x \cdot \frac{1}{4} x^4 - \frac{1}{4} \int \frac{1}{x} \cdot x^4 \, dx$$

$$= \ln x \cdot \frac{1}{4} x^4 - \frac{1}{4} \int \frac{x^4}{x} \, dx$$

$$= \ln x \cdot \frac{1}{4} x^4 - \frac{1}{4} \int x^3 \, dx$$

$$= \ln x \cdot \frac{1}{4} x^4 - \frac{1}{4} \left(\frac{1}{4} x^4 \right)$$

$$= \ln x \cdot \frac{1}{4} x^4 - \frac{1}{16} x^4$$

$$= \boxed{\frac{1}{4} x^4 \left(\ln x - \frac{1}{4} \right)}$$