The Product Rule: The Product Rule states that:

\[ \frac{d}{dx} [u(x)v(x)] = \]

Thus, we can apply the Fundamental Theorem of Calculus and obtain

\[ u(x)v(x) = \int + \int . \]

Rearranging the terms, we get the Integration by Parts Formula:

**Integration by Parts Formula:**

How do we pick \( u \) and \( dv \)? Well, to start with, \( dv \) should be easy to integrate!

**Examples:**

1. \( \int xe^x \, dx \)
   
   \[ u = \quad dv = \]
   \[ du = \quad v = \]

2. \( \int_1^2 \ln x \, dx \)
   
   \[ u = \quad dv = \]
   \[ du = \quad v = \]
3. $\int x \ln x \, dx$

4. $\int_{0}^{\pi} x \sin x \, dx$

5. $\int_{0}^{1} x\sqrt{x+1} \, dx$
6. $\int x^2e^x \, dx$ (Hint: Integrate by parts twice)

7. $\int \arctan x \, dx$ (Hint: Let $u = \arctan x$.)
8. $\int e^x \cos x \, dx$ (Hint: Integrate by parts twice.)

9. $\int x(\ln x)^3 \, dx$ (Hint: Integrate by parts three times.)

10. $\int xe^{x^2} \, dx$ (Hint: Don’t work too hard!)