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:**

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. \[ \int x^2 e^x \, dx \] (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!)