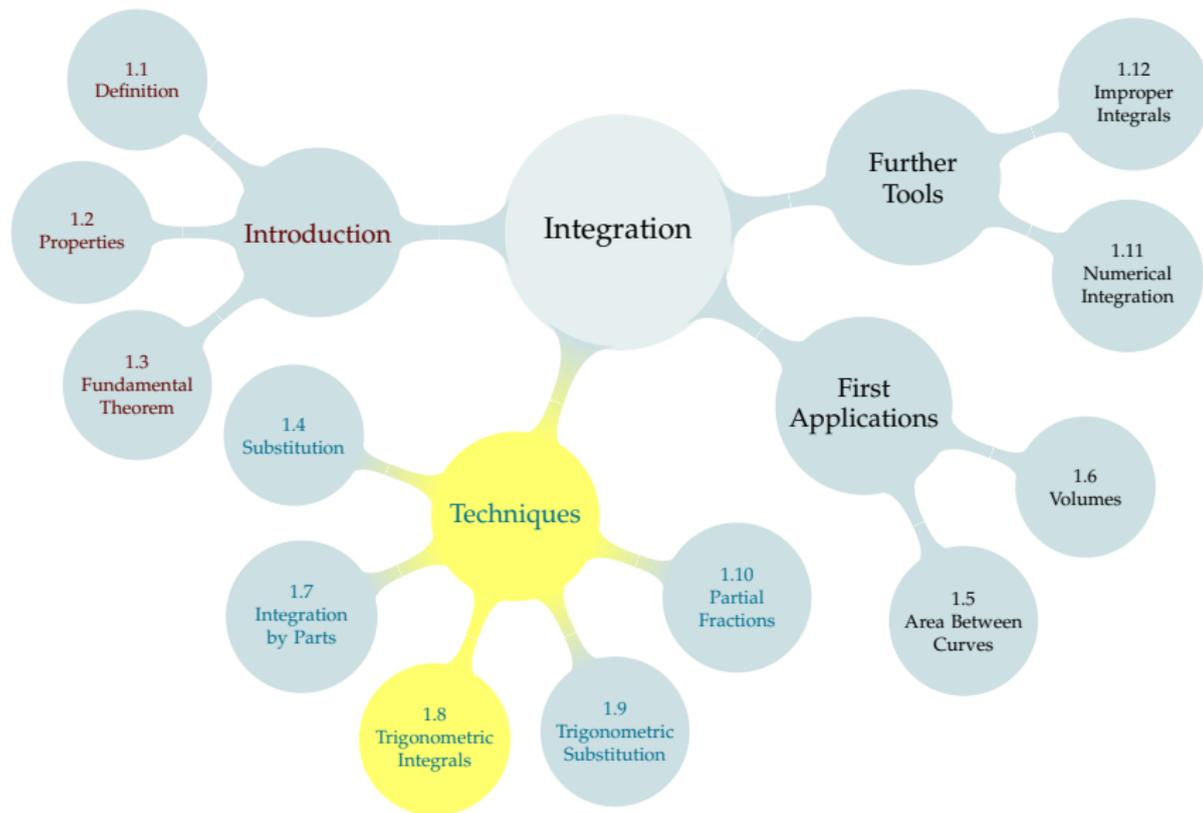


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## Evaluating $\int \tan^m x \sec^n x \, dx$

To evaluate  $\int \tan^m x \sec^n x \, dx$ , we can use:

- ▶  $u = \sec x$  if  $m$  is odd and  $n \geq 1$
- ▶  $u = \tan x$  if  $n$  is even and  $n \geq 2$
- ▶  $u = \cos x$  if  $m$  is odd
- ▶  $u = \tan x$  if  $m$  is even and  $n = 0$   
(after using  $\tan^2 x = \sec^2 x - 1$ , maybe several times)

Remaining case:  $n$  odd and  $m$  is even.

The general remaining case is known, but complicated. Instead of treating it exhaustively, we'll show examples of two methods.

$\int \sec x \, dx$ 

We saw a way of integrating secant with the following trick:

$$\begin{aligned}\int \sec x \, dx &= \int \sec x \left( \frac{\sec x + \tan x}{\sec x + \tan x} \right) dx = \int \frac{\sec^2 x + \sec x \tan x}{\sec x + \tan x} dx \\ &= \int \frac{1}{u} du \quad \text{with } u = \sec x + \tan x\end{aligned}$$

Another trick: this time let  $u = \sin x$ ,  $du = \cos x \, dx$ :

$$\begin{aligned}\int \sec x \, dx &= \int \frac{1}{\cos x} dx = \int \frac{\cos x}{\cos^2 x} dx \\ &= \int \frac{1}{1 - \sin^2 x} \cos x \, dx = \int \frac{1}{1 - u^2} du\end{aligned}$$

The integrand  $\frac{1}{1-u^2}$  is a rational function of  $u$  (i.e. a ratio of two polynomials). There is a procedure, called Partial Fractions, that can be used to evaluate all integrals of rational functions. We will learn it in Section 1.10.



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

We can integrate around in a circle (with integration by parts) to evaluate  $\int \sec^3 x \, dx$ . Let  $u = \sec x$ ,  $dv = \sec^2 x \, dx$ . Then  $du = \sec x \tan x \, dx$  and  $v = \tan x$ .

$$\begin{aligned}\int \sec^3 x \, dx &= \sec x \tan x - \int \sec x \tan^2 x \, dx \\ &= \sec x \tan x - \int \sec x (\sec^2 x - 1) \, dx \\ &= \sec x \tan x - \int \sec^3 x \, dx + \int \sec x \, dx \\ &= \sec x \tan x - \int \sec^3 x \, dx + \log |\sec x + \tan x| + C'\end{aligned}$$

$$2 \int \sec^3 x \, dx = \sec x \tan x + \log |\sec x + \tan x| + C'$$

$$\int \sec^3 x \, dx = \frac{1}{2} (\sec x \tan x + \log |\sec x + \tan x|) + C$$

with  $C = C'/2$ .