

## Section 7.3

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### Problem 9

$$\int_2^3 \frac{dx}{(x^2 - 1)^{\frac{3}{2}}}$$

$$\text{Let : } x = \sec(t)$$

$$dx = \tan(t) \sec(t) dt$$

Solve as an indefinite integral:

$$\int \frac{1}{(\sec^2(t) - 1)^{\frac{3}{2}}} \tan(t) \sec(t) dt$$

$$\int \frac{\tan(t) \sec(t)}{(\tan^2(t))^{\frac{3}{2}}} dt$$

$$\int \frac{\tan(t) \sec(t)}{\tan^3(t)} dt$$

$$\int \frac{\sec(t)}{\tan^2(t)} dt$$

$$\int \frac{1}{\cos(t)} \frac{\cos^2(t)}{\sin^2(t)} dt$$

$$\int \cos(t) \sin^{-2}(t) dt$$

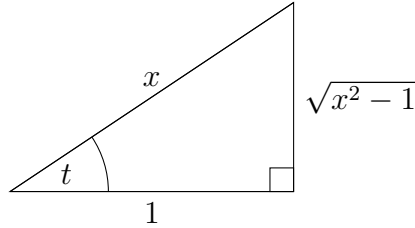
$$f(g(x)) = f'(g(x))g'(x)$$

$$f'(x) = x^{-2} \quad g(x) = \sin(t) \quad g'(x) = \cos(t)$$

$$\text{Therefore : } f(x) = \frac{-1}{x} \quad f(g(x)) = \frac{-1}{\sin(t)}$$

$$\int \cos(t) \sin^{-2}(t) dt = \frac{-1}{\sin(t)} + C$$

Recall that we substituted  $x = \sec(t)$ , which can be rewritten as  $\sec(t) = \frac{x}{1} = \frac{\text{hyp}}{\text{adj}}$ . If we imagine a triangle where the hypotenuse is  $x$  and the adjacent side is 1, then the opposite side must be  $\sqrt{x^2 - 1}$ .



Therefore:  $\sin(t) = \frac{\text{opp}}{\text{hyp}} = \frac{\sqrt{x^2-1}}{x}$

$$\frac{-1}{\sin(t)} + C = \frac{-x}{\sqrt{x^2-1}} + C$$

Now we integrate using the original limits:

$$\begin{aligned} & \left[ \frac{-x}{\sqrt{x^2-1}} \right]_2^3 \\ & \left( \frac{-3}{\sqrt{9-1}} \right) - \left( \frac{-2}{\sqrt{4-1}} \right) \\ & \frac{-3}{2\sqrt{2}} + \frac{2}{\sqrt{3}} \\ & = \frac{2}{\sqrt{3}} - \frac{3}{2\sqrt{2}} \end{aligned}$$

## Problem 19

$$\int \frac{\sqrt{1+x^2}}{x} dx$$

$$\text{Let : } x = \tan(t)$$

$$dx = \sec^2(t) dt$$

$$\int \frac{\sqrt{1+\tan^2(t)}}{\tan(t)} \sec^2(t) dt$$

$$\int \frac{\sqrt{\sec^2(t)}}{\tan(t)} \sec^2(t) dt$$

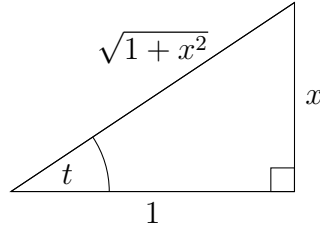
$$\int \frac{\sec(t)}{\tan(t)} (\tan^2(t) + 1) dt$$

$$\int \sec(t) \tan(t) dt + \int \frac{\sec(t)}{\tan(t)} dt$$

$$\int \sec(t) \tan(t) dt + \int \csc(t) dt$$

$$\sec^2(t) + \ln | \csc(t) - \cot(x) | + C$$

Recall that we substituted  $x = \tan(t)$ , which can be rewritten as  $\tan(t) = \frac{x}{1} = \frac{\text{opp}}{\text{adj}}$ . If we imagine a triangle where the opposite side is  $x$  and the adjacent side is  $1$ , then the hypotenuse must be  $\sqrt{1+x^2}$ .



Therefore:

$$\sec(t) = \frac{\text{hyp}}{\text{adj}} = \sqrt{1+x^2}$$

$$\csc(t) = \frac{\text{hyp}}{\text{opp}} = \frac{\sqrt{1+x^2}}{x}$$

$$\cot(t) = \frac{\text{adj}}{\text{opp}} = \frac{1}{x}$$

$$\begin{aligned} \sec^2(t) + \ln |\csc(t) - \cot(x)| + C &= (\sqrt{1+x^2})^2 + \ln \left| \frac{\sqrt{1+x^2}}{x} - \frac{1}{x} \right| + C \\ &= 1+x^2 + \ln \left| \frac{\sqrt{1+x^2}-1}{x} \right| + C \end{aligned}$$

## Problem 21

$$\int_0^{0.6} \frac{x^2}{\sqrt{9-25x^2}} dx$$

$$\text{Let } x = \frac{3}{5} \sin(t)$$

$$dx = \frac{3}{5} \cos(t) dt$$

Solve as an indefinite integral:

$$\int \frac{\frac{9}{25} \sin^2(t)}{\sqrt{9-25\left(\frac{3}{5} \sin(t)\right)^2}} \frac{3}{5} \cos(t) dt$$

$$\frac{27}{125} \int \frac{\sin^2(t)}{\sqrt{9}\sqrt{1-\sin^2(t)}} \cos(t) dt$$

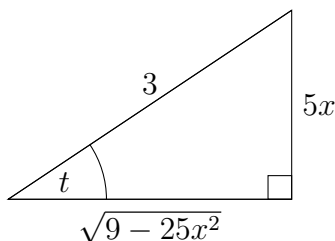
$$\frac{9}{125} \int \frac{\sin^2(t)}{\sqrt{\cos^2(t)}} \cos(t) dt$$

$$\frac{9}{125} \int \sin^2(t) dt$$

$$\frac{9}{125} \int \frac{1-\cos(2t)}{2} dt$$

$$\begin{aligned}
& \frac{9}{250} \int 1 - \cos(2t) dt \\
& \frac{9}{250} \left( \int 1 dt - \int \cos(2t) dt \right) \\
& \frac{9}{250} \left( t - \frac{1}{2} \sin(2t) \right) + C \\
& \frac{9}{250} \left( t - \frac{1}{2} 2 \sin(t) \cos(t) \right) + C \\
& \frac{9}{250} \left( t - \sin(t) \cos(t) \right) + C
\end{aligned}$$

Recall that we substituted  $x = \frac{3}{5} \sin(t)$ , which can be rewritten as  $\sin(t) = \frac{5x}{3} = \frac{\text{opp}}{\text{hyp}}$ . If we imagine a triangle where the opposite side is  $5x$  and the hypotenuse is  $3$ , then the adjacent side must be  $\sqrt{9 - 25x^2}$ .



Therefore:

$$\begin{aligned}
\cos(t) &= \frac{\sqrt{9 - 25x^2}}{3} \\
t &= \sin^{-1}\left(\frac{5x}{3}\right) \\
\frac{9}{250} \left( t - \sin(t) \cos(t) \right) + C &= \frac{9}{250} \left( \sin^{-1}\left(\frac{5x}{3}\right) - \frac{5x}{3} \frac{\sqrt{9 - 25x^2}}{3} \right) + C \\
&= \frac{9 \sin^{-1}\left(\frac{5x}{3}\right)}{250} - \frac{5x \sqrt{9 - 25x^2}}{250} + C
\end{aligned}$$

Now we integrate using the original limits:

$$\begin{aligned}
& \left[ \frac{9 \sin^{-1}\left(\frac{5x}{3}\right)}{250} - \frac{5x \sqrt{9 - 25x^2}}{250} \right]_0^{0.6} \\
& \left[ \frac{9 \sin^{-1}\left(\frac{3}{3}\right)}{250} - \frac{3\sqrt{9 - 9}}{250} \right] - \left[ \frac{9 \sin^{-1}\left(\frac{0}{3}\right)}{250} - \frac{0\sqrt{9 - 0}}{250} \right] \\
& \left[ \frac{9\pi}{250} - 0 \right] - 0 \\
& = \frac{9\pi}{250}
\end{aligned}$$

## Problem 23

$$\int \frac{dx}{x^2 + 2x + 5}$$

$$\int \frac{dx}{x^2 + 2x + 1 + 4}$$

$$\int \frac{dx}{(x+1)^2 + 4}$$

$$\text{Let : } x + 1 = 2 \tan(t)$$

$$dx = 2 \sec^2(t) dt$$

$$\int \frac{2 \sec^2(t)}{(2 \tan(t))^2 + 4} dt$$

$$\int \frac{2 \sec^2(t)}{4 \tan^2(t) + 4} dt$$

$$\frac{1}{2} \int \frac{\sec^2(t)}{\tan^2(t) + 1} dt$$

$$\frac{1}{2} \int \frac{\sec^2(t)}{\sec^2(t)} dt$$

$$\frac{1}{2} \int 1 dt$$

$$\frac{1}{2} t + C$$

Given our original substitution  $x + 1 = 2 \tan(t)$ , we can rewrite this as  $\tan(t) = \frac{x+1}{2}$  and get the equation  $\tan^{-1}\left(\frac{x+1}{2}\right) = t$ . Therefore:

$$\frac{1}{2} t + C = \frac{\tan^{-1}\left(\frac{x+1}{2}\right)}{2} + C$$

If any errors are found, please contact me at [alvin.lin.dev@gmail.com](mailto:alvin.lin.dev@gmail.com)