

Integral Indefinida – Aula 1

- 01. $\int \partial x = x + c$
- 02. $\int x^p \partial x = \frac{x^{p+1}}{p+1} + c \rightarrow p \neq -1$
- 03. $\int e^x \partial x = e^x + c$
- 04. $\int \frac{\partial x}{x} = \ln|x| + c$
- 05. $\int u^p \partial u = \frac{u^{p+1}}{p+1} + c \rightarrow p \neq -1$
- 06. $\int e^u \partial u = e^u + c$
- 07. $\int \frac{\partial u}{u} = \ln|u| + c$
- 08. $\int a^u \partial u = \frac{a^u}{\ln|a|} + c$

Exercício I

$$\begin{aligned}\int \partial x &= x + c \\ \int x^3 \partial x &= \frac{x^4}{4} + c\end{aligned}\tag{1}$$

Exercício II

$$\int 3x^4 \partial x = 3 \int x^4 \partial x = 3 \frac{x^5}{5} + c = \frac{3x^5}{5} + c\tag{2}$$

Exercício III

$$\int (4x^5 + 7) \partial x = \int 4x^5 \partial x + \int 7 \partial x = 4 \int x^5 \partial x + 7 \int \partial x = 4 \frac{x^6}{6} + 7x + c = \frac{2x^6}{3} + 7x + c\tag{3}$$

Exercício IV

$$\int 3 \partial x = 3 \int \partial x = 3x + c\tag{4}$$

Exercício V

$$\int 5x^7 \partial x = 5 \int x^7 \partial x = \frac{5x^8}{8} + c\tag{5}$$

Exercício VI

$$\int (5+3x^2-7x^3) \partial x = 5 \int \partial x + 3 \int x^2 \partial x - 7 \int x^3 \partial x = 5x + \frac{3x^3}{3} - \frac{7x^4}{4} + c = \frac{-7x^4}{4} + x^3 + 5x + c \quad (6)$$

Integral Indefinida – [Aula 2](#)

Exercício I

$$\int \frac{\partial x}{x^4} = \int x^{-4} \partial x = \frac{x^{-3}}{-3} + c = \frac{-1}{3x^3} + c \quad (7)$$

Exercício II

$$\int \sqrt{x^3} \partial x = \int x^{\frac{3}{2}} \partial x = \frac{x^{\frac{5}{2}}}{\left(\frac{5}{2}\right)} + c = \sqrt{x^5} \cdot \frac{2}{5} = \frac{2\sqrt{x^5}}{5} + c \quad (8)$$

Exercício II

$$\int \left(7\sqrt[5]{x^2} + \frac{3}{x^3} \right) \partial x = \int \left(7x^{\frac{2}{5}} + 3x^{-3} \right) \partial x = 7 \int x^{\frac{2}{5}} \partial x + 3 \int x^{-3} \partial x = 7 \frac{x^{\frac{7}{5}}}{\left(\frac{7}{5}\right)} + 3 \frac{x^{-2}}{-2} + c = 5\sqrt[5]{x^7} - \frac{3}{2x^2} + c \quad (9)$$

Integral indefinida – [Aula 3](#)

Exercício I

$$\int (3x^{-4} - 3x + 4) \partial x = 3 \int x^{-4} \partial x - 3 \int x \partial x + 4 \int \partial x = 3 \frac{x^{-3}}{(-3)} - 3 \frac{x^2}{2} + 4x + c = \frac{-1}{x^3} - \frac{3x^2}{2} + 4x + c \quad (10)$$

Exercício II

$$\int \frac{2}{3} \sqrt{x} \partial x = \frac{2}{3} \int x^{\frac{1}{2}} \partial x = \frac{2}{3} \frac{x^{\frac{3}{2}}}{\left(\frac{3}{2}\right)} + c = \frac{4\sqrt{x^3}}{9} + c \quad (11)$$

Integral de uma função Potência – [Aula 4](#)

Exercício I

$$\int \frac{\sqrt{x} x^3}{\sqrt[3]{x^2}} \partial x = \int \frac{x^{\frac{1}{2}} x^3}{x^{\frac{2}{3}}} \partial x = \int x^{\frac{1}{2}+3-\frac{2}{3}} \partial x = \int x^{\frac{3+18-4}{6}} \partial x = \int x^{\frac{17}{6}} \partial x = \frac{x^{\frac{23}{6}}}{\left(\frac{23}{6}\right)} + c = \frac{6\sqrt[6]{x^{23}}}{23} + c \quad (12)$$

Integral Indefinida – [Aula 5](#)

Exercício I

$$\int \frac{\partial x}{x^3} = \int x^{-3} \partial x = \frac{x^{-2}}{-2} + c = \frac{-1}{2x^2} + c \quad (13)$$

Exercício II

$$\int \frac{\partial x}{x} = \ln x + c \quad (14)$$

Exercício III

$$\int \sqrt{2x+1} \partial x = \int \sqrt{u} \frac{\partial u}{2} = \frac{1}{2} \int u^{\frac{1}{2}} \partial u = \frac{1}{2} \frac{u^{\frac{3}{2}}}{\left(\frac{3}{2}\right)} + c = \frac{1}{2} \frac{2}{3} \sqrt{u^3} + c = \frac{\sqrt{u^3}}{3} + c = \frac{\sqrt{(2x+1)^3}}{3} + c$$

$$u = 2x+1, \frac{\partial u}{\partial x} = 2 \rightarrow \partial x = \frac{\partial u}{2} \quad (15)$$

$$\frac{\partial \left(\frac{\sqrt{(2x+1)^3}}{3} + c \right)}{\partial x} = \frac{\partial \left(\frac{1}{3} (2x+1)^{\frac{3}{2}} + c \right)}{\partial x} = \frac{1}{3} \frac{3}{2} (2x+1)^{\frac{3}{2}-1} \cdot 2 + 0 = (2x+1)^{\frac{1}{2}} = \sqrt{2x+1}$$

Exercício IV

$$\int \frac{5x^3+2x+3}{x} \partial x = \int \left(\frac{5x^3}{x} + \frac{2x}{x} + \frac{3}{x} \right) \partial x = \int \left(5x^2 + 2 + \frac{3}{x} \right) \partial x =$$

$$5 \int x^2 \partial x + 2 \int \partial x + 3 \int \frac{\partial x}{x} = 5 \frac{x^3}{3} + 2x + 3 \ln|x| + c = \frac{5x^3}{3} + 2x + 3 \ln|x| + c \quad (16)$$

$$\frac{\partial \left(\frac{5x^3}{3} + 2x + 3 \ln|x| + c \right)}{\partial x} = \frac{5}{3} 3x^2 + 2 + 3 \frac{1}{x} + 0 = 5x^2 + 2 + \frac{3}{x} = \frac{5x^3+2x+3}{x}$$

Exercício V

$$\int \left(2x^4 + 3 + 5e^x + \frac{7}{x} \right) \partial x = 2 \int x^4 \partial x + 3 \int \partial x + 5 \int e^x \partial x + 7 \int \frac{\partial x}{x} =$$

$$2 \frac{x^5}{5} + 3x + 5e^x + 7 \ln|x| + c = \frac{2x^5}{5} + 3x + 5e^x + 7 \ln|x| + c$$

(17)

$$\frac{\partial \left(\frac{2x^5}{5} + 3x + 5e^x + 7 \ln|x| + c \right)}{\partial x} = \frac{2}{5} 5x^4 + 3 + 5e^x + 7 \frac{1}{x} + 0 = 2x^4 + 3 + 5e^x + \frac{7}{x}$$

Integral Indefinida – [Aula 6](#)

Exercício I

$$\int \frac{5t^2 + 7}{\sqrt[3]{t^4}} \partial t = \int \frac{5t^2 + 7}{t^{\frac{4}{3}}} \partial t = \int t^{\frac{-4}{3}} (5t^2 + 7) \partial t = \int 5t^{2 - \frac{4}{3}} + 7t^{\frac{-4}{3}} \partial t = \int 5t^{\frac{2}{3}} + 7t^{\frac{-4}{3}} \partial t =$$

$$5 \int t^{\frac{2}{3}} \partial t + 7 \int t^{\frac{-4}{3}} \partial t = 5 \frac{t^{\frac{5}{3}}}{\left(\frac{5}{3}\right)} + 7 \frac{t^{\frac{-1}{3}}}{\left(\frac{-1}{3}\right)} + c = 5 \frac{3}{5} \sqrt[3]{t^5} - 7 \cdot 3 \frac{1}{\sqrt[3]{t}} + c = 3\sqrt[3]{t^5} - \frac{21}{\sqrt[3]{t}} + c$$

(18)

$$\frac{\partial \left(3\sqrt[3]{t^5} - \frac{21}{\sqrt[3]{t}} + c \right)}{\partial t} = \frac{\partial \left(3t^{\frac{5}{3}} - 21t^{\frac{-1}{3}} + c \right)}{\partial t} = 3 \frac{5}{3} t^{\frac{2}{3}} - 21 \left(\frac{-1}{3} \right) t^{\frac{-4}{3}} + 0 = 5\sqrt[3]{t^2} + \frac{7}{\sqrt[3]{t^4}} =$$

$$\frac{5t^{\frac{2}{3}} t^{\frac{4}{3}} + 7}{\sqrt[3]{t^4}} = \frac{5t^{\frac{2}{3} + \frac{4}{3}} + 7}{\sqrt[3]{t^4}} = \frac{5t^{\frac{6}{3}} + 7}{\sqrt[3]{t^4}} = \frac{5t^2 + 7}{\sqrt[3]{t^4}}$$

Integral Indefinida e Composta – [Aula 7](#)

Exercício I

$$\int \frac{\partial x}{\sqrt{x}} = \int \frac{\partial x}{x^{\frac{1}{2}}} = \int x^{\frac{-1}{2}} \partial x = \frac{x^{\frac{1}{2}}}{\left(\frac{1}{2}\right)} + c = 2\sqrt{x} + c$$

(19)

Exercício II

$$\int \left(3e^x + \frac{2}{x} \right) \partial x = 3 \int e^x \partial x + 2 \int \frac{\partial x}{x} = 3e^x + 2 \ln|x| + c$$

(20)

Exercício III

$$\begin{aligned}
 \int x^3 \partial x &= \frac{x^4}{4} + c \\
 \int (2x^2+1)^3 x \partial x &= \int u^3 \times \frac{\partial u}{4x} = \frac{1}{4} \int u^3 \partial u = \frac{1}{4} \frac{u^4}{4} + c = \frac{u^4}{16} + c = \frac{(2x^2+1)^4}{16} + c = \\
 &= \frac{(2x^2+1)^4}{2^4} + c = \left(\frac{2x^2+1}{2} \right)^4 + c = \left(x^2 + \frac{1}{2} \right)^4 + c \\
 u &= 2x^2+1, \frac{\partial u}{\partial x} = 4x \rightarrow \partial x = \frac{\partial u}{4x} \\
 &\frac{\partial \left[\left(x^2 + \frac{1}{2} \right)^4 + c \right]}{\partial x} = 4 \left(x^2 + \frac{1}{2} \right)^3 \cdot 2x + 0 = 8x \left(x^2 + \frac{1}{2} \right)^3 = 8x \left(x^2 + \frac{1}{2} \right) \left(x^2 + \frac{1}{2} \right)^2 = \\
 &= (8x^3 + 4x) \left(x^4 + x^2 + \frac{1}{4} \right) = 8x^7 + 8x^5 + 2x^3 + 4x^5 + 4x^3 + x = 8x^7 + 12x^5 + 6x^3 + x \\
 (2x^2+1)^3 x &= (2x^2+1)^2 (2x^2+1) x = (4x^4 + 4x^2 + 1) (2x^3 + x) = 8x^7 + 4x^5 + 8x^5 + 4x^3 + 2x^3 + x = \\
 &= 8x^7 + 12x^5 + 6x^3 + x
 \end{aligned}
 \tag{21}$$

Integral indefinida e composta – [Aula 8](#)

Exercício I

$$\begin{aligned}
 \int 3e^x \partial x &= 3 \int e^x \partial x = 3e^x + c \\
 \int e^{x^2+1} x \partial x &= \int e^u \times \frac{\partial u}{2x} = \frac{1}{2} \int e^u \partial u = \frac{1}{2} e^u + c = \frac{e^{x^2+1}}{2} + c \\
 u &= x^2+1, \frac{\partial u}{\partial x} = 2x \rightarrow \partial x = \frac{\partial u}{2x} \\
 &\frac{\partial \left(\frac{e^{x^2+1}}{2} + c \right)}{\partial x} = \frac{1}{2} e^{x^2+1} 2x + 0 = e^{x^2+1} x
 \end{aligned}
 \tag{22}$$

Exercício II

$$\begin{aligned}
 \int e^{x^4+1} x^3 \partial x &= \int e^u \times \frac{\partial u}{4x^3} = \frac{1}{4} \int e^u \partial u = \frac{1}{4} e^u + c = \frac{e^{x^4+1}}{4} + c \\
 u &= x^4+1, \frac{\partial u}{\partial x} = 4x^3 \rightarrow \partial x = \frac{\partial u}{4x^3} \\
 &\frac{\partial \left(\frac{e^{x^4+1}}{4} + c \right)}{\partial x} = \frac{1}{4} e^{x^4+1} 4x^3 + 0 = e^{x^4+1} x^3
 \end{aligned}
 \tag{23}$$

Exercício III

$$\begin{aligned}
 \int \frac{x}{(2x^2-1)^3} \partial x &= \int (2x^2-1)^{-3} x \partial x = \int u^{-3} \frac{\partial u}{4x} = \frac{1}{4} \int u^{-3} \partial u = \frac{1}{4} \frac{u^{-2}}{(-2)} + c = \frac{-1}{8u^2} + c = \\
 &\quad \frac{-1}{8(2x^2-1)^2} + c \\
 u &= 2x^2-1, \frac{\partial u}{\partial x} = 4x \rightarrow \partial x = \frac{\partial u}{4x} \\
 \frac{\partial \left(\frac{-1}{8(2x^2-1)^2} + c \right)}{\partial x} &= \frac{\partial \left(\frac{-(2x^2-1)^{-2}}{8} + c \right)}{\partial x} = \frac{-1}{8} (-2) (2x^2-1)^{-3} 4x + 0 = (2x^2-1)^{-3} x = \\
 &\quad \frac{x}{(2x^2-1)^3}
 \end{aligned} \tag{24}$$

Exercício IV

$$\begin{aligned}
 \int \frac{x}{2x^2-1} \partial x &= \int (2x^2-1)^{-1} x \partial x = \int u^{-1} \frac{\partial u}{4x} = \frac{1}{4} \int u^{-1} \partial u = \frac{1}{4} \ln|u| + c = \frac{\ln|2x^2-1|}{4} + c \\
 u &= 2x^2-1, \frac{\partial u}{\partial x} = 4x \rightarrow \partial x = \frac{\partial u}{4x} \\
 \frac{\partial \left(\frac{\ln|2x^2-1|}{4} + c \right)}{\partial x} &= \frac{1}{4} \frac{1}{2x^2-1} 4x + 0 = \frac{x}{2x^2-1}
 \end{aligned} \tag{25}$$

Integral pelo Método da Substituição não tão evidente – [Aula 9](#)

Exercício I

$$\begin{aligned} \int x^2 \sqrt{1+x} \partial x &\rightarrow \int (u-1)^2 \sqrt{u} \partial u = \int (u-1)^2 u^{\frac{1}{2}} \partial u = \int (u^2 - 2u + 1) u^{\frac{1}{2}} \partial u = \\ &\int \left(u^{2+\frac{1}{2}} - 2u^{1+\frac{1}{2}} + u^{\frac{1}{2}} \right) \partial u = \int \left(u^{\frac{5}{2}} - 2u^{\frac{3}{2}} + u^{\frac{1}{2}} \right) \partial u = \int u^{\frac{5}{2}} \partial u - 2 \int u^{\frac{3}{2}} \partial u + \int u^{\frac{1}{2}} \partial u = \\ \frac{u^{\frac{7}{2}}}{\left(\frac{7}{2}\right)} - 2 \frac{u^{\frac{5}{2}}}{\left(\frac{5}{2}\right)} + \frac{u^{\frac{3}{2}}}{\left(\frac{3}{2}\right)} + c &= \frac{2\sqrt{u^7}}{7} - \frac{4\sqrt{u^5}}{5} + \frac{2\sqrt{u^3}}{3} + c = \frac{2\sqrt{(1+x)^7}}{7} - \frac{4\sqrt{(1+x)^5}}{5} + \frac{2\sqrt{(1+x)^3}}{3} + c \end{aligned}$$

$$u = 1+x \rightarrow x = u-1, \frac{\partial x}{\partial u} = 1 \rightarrow \partial x = \partial u$$

(26)

$$\begin{aligned} \frac{\partial \left(\frac{2\sqrt{(1+x)^7}}{7} - \frac{4\sqrt{(1+x)^5}}{5} + \frac{2\sqrt{(1+x)^3}}{3} + c \right)}{\partial x} &= \frac{\partial \left(\frac{2(1+x)^{\frac{7}{2}}}{7} - \frac{4(1+x)^{\frac{5}{2}}}{5} + \frac{2(1+x)^{\frac{3}{2}}}{3} + c \right)}{\partial x} = \\ \frac{2}{7} \frac{7}{2} (1+x)^{\frac{5}{2}} - \frac{4}{5} \frac{5}{2} (1+x)^{\frac{3}{2}} + \frac{2}{3} \frac{3}{2} (1+x)^{\frac{1}{2}} + 0 &= (1+x)^{\frac{5}{2}} - 2(1+x)^{\frac{3}{2}} + (1+x)^{\frac{1}{2}} = \\ (1+x)^{\frac{1}{2}} \left((1+x)^{\frac{5}{2}-\frac{1}{2}} - 2(1+x)^{\frac{3}{2}-\frac{1}{2}} + 1 \right) &= (1+x)^{\frac{1}{2}} \left((1+x)^2 - 2(1+x) + 1 \right) = \\ (1+x)^{\frac{1}{2}} \left((1+x)^2 - 2(1+x) + 1 \right) &= (1+x)^{\frac{1}{2}} (1+2x+x^2-2-2x+1) = (1+x)^{\frac{1}{2}} x^2 = x^2 \sqrt{1+x} \end{aligned}$$

Exercício II

$$\begin{aligned} \int x^2 \sqrt{1+x} \partial x &\rightarrow \int (u^2-1)^2 u 2u \partial u = 2 \int (u^2-1)^2 u^2 \partial u = 2 \int (u^4 - 2u^2 + 1) u^2 \partial u = \\ 2 \int (u^6 - 2u^4 + u^2) \partial u &= 2 \int u^6 \partial u - 4 \int u^4 \partial u + 2 \int u^2 \partial u = 2 \frac{u^7}{7} - 4 \frac{u^5}{5} + 2 \frac{u^3}{3} + c = \\ \frac{2\sqrt{(1+x)^7}}{7} - \frac{4\sqrt{(1+x)^5}}{5} + \frac{2\sqrt{(1+x)^3}}{3} + c & \end{aligned} \quad (27)$$

$$u = \sqrt{1+x} \rightarrow u^2 = 1+x \rightarrow x = u^2 - 1, \frac{\partial x}{\partial u} = 2u \rightarrow \partial x = 2u \partial u$$

O que é uma Integral Definida – [Aula 10](#)

Exercício I

$$\int_1^2 x^3 \partial x = \left. \frac{x^4}{4} \right|_1^2 = \frac{(2)^4}{4} - \frac{(1)^4}{4} = \frac{16}{4} - \frac{1}{4} = \frac{16-1}{4} = \frac{15}{4} = 3,75 \quad (28)$$

Integral Definida – [Aula 10a](#)

Exercício I

$$\int_0^2 (6x^2 - 4x + 5) \partial x = 6 \int_0^2 x^2 \partial x - 4 \int_0^2 x \partial x + 5 \int_0^2 \partial x = 6 \left[\frac{x^3}{3} - 4 \frac{x^2}{2} + 5x \right]_0^2 = 2x^3 - 2x^2 + 5x \Big|_0^2 = x(2x^2 - 2x + 5) \Big|_0^2 = [(2)(2(2)^2 - 2(2) + 5)] - [(0)(2(0)^2 - 2(0) + 5)] = 2(8 - 4 + 5) = 2 \cdot 9 = 18 \quad (29)$$

Exercício II

$$\int_{-1}^0 (2x - e^x) \partial x = 2 \int_{-1}^0 x \partial x - \int_{-1}^0 e^x \partial x = 2 \left[\frac{x^2}{2} - e^x \right]_{-1}^0 = x^2 - e^x \Big|_{-1}^0 = ((0)^2 - e^{(0)}) - ((-1)^2 - e^{(-1)}) = -1 - \left(1 - \frac{1}{e}\right) = -1 - 1 + \frac{1}{e} = -2 + \frac{1}{e} \quad (30)$$

Integral definida – [Aula 11](#)

Exercício I

$$\begin{aligned} \frac{5\pi}{4} \int_0^2 \frac{r \partial r}{1+r^2} &= \frac{5\pi}{4} \int_0^2 (1+r^2)^{-1} r \partial r = \frac{5\pi}{4} \int_0^2 u^{-1} \frac{\partial u}{2r} = \frac{5\pi}{4} \frac{1}{2} \int_0^2 u^{-1} \partial u = \frac{5\pi}{8} \int_0^2 u^{-1} \partial u = \\ \frac{5\pi}{8} \ln|u| \Big|_0^2 &= \frac{5\pi}{8} \ln|1+r^2| \Big|_0^2 = \left[\frac{5\pi}{8} \ln|1+(2)^2| \right] - \left[\frac{5\pi}{8} \ln|1+(0)^2| \right] = \frac{5\pi}{8} \ln|5| - \frac{5\pi}{8} \ln|1| = \\ \frac{5\pi}{8} (\ln|5| - \ln|1|) &= \frac{5\pi}{8} (\ln|5| - 0) = \frac{5\pi}{8} \ln|5| \quad (31) \\ u &= 1+r^2, \frac{\partial u}{\partial r} = 2r \rightarrow \partial x = \frac{\partial u}{2r} \\ \ln|1| &= x \rightarrow e^x = 1 = e^0 \rightarrow x = 0 \\ \ln|5| &= x \rightarrow e^x = 5 \end{aligned}$$

Exercício II

$$2\pi \int_0^2 r^2 \partial r = 2\pi \left[\frac{r^3}{3} \right]_0^2 = \frac{2\pi r^3}{3} \Big|_0^2 = \left(\frac{2\pi(2)^3}{3} \right) - \left(\frac{2\pi(0)^3}{3} \right) = \frac{16\pi}{3} \quad (32)$$

Exercício II

$$\begin{aligned} 2\pi \int_0^{\sqrt{2}} (4r - 2r^3) \partial r &= 8\pi \int_0^{\sqrt{2}} r \partial r - 4\pi \int_0^{\sqrt{2}} r^3 \partial r = 8\pi \left[\frac{r^2}{2} - 4\pi \frac{r^4}{4} \right]_0^{\sqrt{2}} = 4\pi r^2 - \pi r^4 \Big|_0^{\sqrt{2}} = \\ \pi r^2 (4 - r^2) \Big|_0^{\sqrt{2}} &= \left[\pi (\sqrt{2})^2 (4 - (\sqrt{2})^2) \right] - \left[\pi (0)^2 (4 - (0)^2) \right] = 2\pi (4 - 2) = 4\pi \quad (33) \end{aligned}$$

Exercício III

$$\pi \int_0^2 x^2 \partial x = \pi \left[\frac{x^3}{3} \right]_0^2 = \frac{\pi x^3}{3} \Big|_0^2 = \left(\frac{\pi(2)^3}{3} \right) - \left(\frac{\pi(0)^3}{3} \right) = \frac{8\pi}{3} \quad (34)$$

Exercício IV

$$\frac{\pi}{16} \int_1^4 x^4 \partial x = \frac{\pi}{16} \left[\frac{x^5}{5} \right]_1^4 = \frac{\pi x^5}{80} \Big|_1^4 = \left(\frac{\pi(4)^5}{80} \right) - \left(\frac{\pi(1)^5}{80} \right) = \frac{4^5 \pi}{80} - \frac{\pi}{80} = \frac{1024\pi - \pi}{80} = \frac{1023\pi}{80} \quad (35)$$

Exercício V

$$\pi \int_1^2 (x^2)^2 \partial x = \pi \int_1^2 x^4 \partial x = \pi \left[\frac{x^5}{5} \right]_1^2 = \frac{\pi x^5}{5} \Big|_1^2 = \left(\frac{\pi(2)^5}{5} \right) - \left(\frac{\pi(1)^5}{5} \right) = \frac{32\pi}{5} - \frac{\pi}{5} = \frac{32\pi - \pi}{5} = \frac{31\pi}{5} \quad (36)$$

Exercício VI

$$\begin{aligned} \pi \int_{-1}^2 (-x^4 - x^2 + 6x + 8) \partial x &= -\pi \int_{-1}^2 x^4 \partial x - \pi \int_{-1}^2 x^2 \partial x + 6\pi \int_{-1}^2 x \partial x + 8\pi \int_{-1}^2 \partial x = \\ &= -\pi \left[\frac{x^5}{5} - \pi \frac{x^3}{3} + 6\pi \frac{x^2}{2} + 8\pi x \right]_{-1}^2 = \left[-\frac{\pi x^5}{5} - \frac{\pi x^3}{3} + 3\pi x^2 + 8\pi x \right]_{-1}^2 = -\pi x \left(\frac{x^4}{5} + \frac{x^2}{3} - 3x - 8 \right) \Big|_{-1}^2 \\ &= \left[-\pi(2) \left(\frac{(2)^4}{5} + \frac{(2)^2}{3} - 3(2) - 8 \right) \right] - \left[-\pi(-1) \left(\frac{(-1)^4}{5} + \frac{(-1)^2}{3} - 3(-1) - 8 \right) \right] = \\ &= -2\pi \left(\frac{16}{5} + \frac{4}{3} - 6 - 8 \right) - \pi \left(\frac{1}{5} + \frac{1}{3} + 3 - 8 \right) = -2\pi \left(\frac{48 + 20 - 210}{15} \right) - \pi \left(\frac{3 + 5 - 75}{15} \right) = \\ &= 2\pi \left(\frac{142}{15} \right) + \pi \left(\frac{67}{15} \right) = \pi \left(\frac{284}{15} + \frac{67}{15} \right) = \frac{351\pi}{15} = \frac{3^3 \cdot 13\pi}{3 \cdot 5} = \frac{3^2 \cdot 13\pi}{5} = \frac{117\pi}{5} \end{aligned} \quad (37)$$

Exercício VII

$$\begin{aligned} \pi \int_0^8 (\sqrt[3]{y})^2 \partial y &= \pi \int_0^8 \left(y^{\frac{1}{3}} \right)^2 \partial y = \pi \int_0^8 y^{\frac{2}{3}} \partial y = \pi \left[\frac{y^{\frac{5}{3}}}{\frac{5}{3}} \right]_0^8 = \frac{3\pi \sqrt[3]{y^5}}{5} \Big|_0^8 = \\ &= \left(\frac{3\pi \sqrt[3]{(8)^5}}{5} \right) - \left(\frac{3\pi \sqrt[3]{(0)^5}}{5} \right) = \frac{3\pi \sqrt[3]{8^3 \cdot 8^2}}{5} = \frac{3\pi 2^3 \sqrt[3]{(2^3)^2}}{5} = \frac{3\pi 2^3 2^2}{5} = \frac{3\pi 2^5}{5} = \frac{96\pi}{5} \end{aligned} \quad (38)$$

Integral definida – [Aula 12](#)

Exercício I

$$\int_1^2 2x \partial x = 2 \int_1^2 x \partial x = 2 \left[\frac{x^2}{2} \right]_1^2 = x^2 \Big|_1^2 = ((2)^2) - ((1)^2) = 4 - 1 = 4 - 1 = 3 \quad (39)$$

Exercício II

$$\int_1^4 2\sqrt{x} \partial x = \int_1^4 2x^{\frac{1}{2}} \partial x = 2 \int_1^4 x^{\frac{1}{2}} \partial x = 2 \left[\frac{x^{\frac{3}{2}}}{\frac{3}{2}} \right]_1^4 = \frac{4\sqrt{x^3}}{3} \Big|_1^4 = \left(\frac{4\sqrt{(4)^3}}{3} \right) - \left(\frac{4\sqrt{(1)^3}}{3} \right) =$$

$$\frac{4\sqrt{4^2 \cdot 2^2}}{3} - \frac{4}{3} = \frac{32}{3} - \frac{4}{3} = \frac{32-4}{3} = \frac{28}{3}$$
(40)

Exercício III

$$\int_1^2 4x^2 \partial x = 4 \int_1^2 x^2 \partial x = 4 \left[\frac{x^3}{3} \right]_1^2 = \frac{4}{3} x^3 \Big|_1^2 = \frac{4}{3} (2^3 - 1^3) = \frac{4}{3} 7 = \frac{28}{3}$$
(41)

Integrais definidas e indefinidas – [Aula 13](#)

Exercício I

$$\int \left(\frac{3}{x^4} + \frac{2x^2}{3} - 2x + 7 \right) \partial x = \int \left(3x^{-4} + \frac{2}{3}x^2 - 2x + 7 \right) \partial x =$$

$$3 \int x^{-4} \partial x + \frac{2}{3} \int x^2 \partial x - 2 \int x \partial x + 7 \int \partial x = 3 \frac{x^{-3}}{-3} + \frac{2}{3} \frac{x^3}{3} - 2 \frac{x^2}{2} + 7x + c =$$

$$\frac{-1}{x^3} + \frac{2x^3}{9} - x^2 + 7x + c$$
(42)

$$\frac{\partial \left(\frac{-1}{x^3} + \frac{2x^3}{9} - x^2 + 7x + c \right)}{\partial x} = \frac{\partial \left(-x^{-3} + \frac{2}{9}x^3 - x^2 + 7x + c \right)}{\partial x} = 3x^{-4} + \frac{2}{9}3x^2 - 2x + 7 + 0 =$$

$$\frac{3}{x^4} + \frac{2x^2}{3} - 2x + 7$$

Exercício II

$$\int 5\sqrt[3]{x^2} \partial x = \int 5x^{\frac{2}{3}} \partial x = 5 \int x^{\frac{2}{3}} \partial x = 5 \left[\frac{x^{\frac{5}{3}}}{\frac{5}{3}} \right] + c = 3\sqrt[3]{x^5} + c$$
(43)

$$\frac{\partial (3\sqrt[3]{x^5} + c)}{\partial x} = \frac{\partial (3x^{\frac{5}{3}} + c)}{\partial x} = 3 \frac{5}{3} x^{\frac{2}{3}} + 0 = 5\sqrt[3]{x^2}$$

Exercício III

$$\int_2^4 2x^3 \partial x = 2 \int_2^4 x^3 \partial x = 2 \left[\frac{x^4}{4} \right]_2^4 = \frac{1}{2} x^4 \Big|_2^4 = \frac{1}{2} (4^4 - 2^4) = \frac{1}{2} ((2 \cdot 2)^4 - 2^4) = \frac{1}{2} (2^4 \cdot 2^4 - 2^4) = \frac{2^4}{2} (2^4 - 1) = 2^3 (16 - 1) = 8 \cdot 15 = 120 \quad (44)$$

Exercício IV

$$\int_1^2 (3x^2 - 2x) \partial x = 3 \int_1^2 x^2 \partial x - 2 \int_1^2 x \partial x = 3 \left[\frac{x^3}{3} \right]_1^2 - 2 \left[\frac{x^2}{2} \right]_1^2 = x^3 - x^2 \Big|_1^2 = x^2(x-1) \Big|_1^2 = [2^2(2-1)] - [1^2(1-1)] = 4 \quad (45)$$

Integral definida pelo método da substituição – U du – [Aula 14](#)

Exercício I

$$\int_0^2 \sqrt{2x^2+1} x \partial x = \int_0^2 \sqrt{u} \frac{\partial u}{4x} = \frac{1}{4} \int_0^2 u^{\frac{1}{2}} \partial u = \frac{1}{4} \left[\frac{u^{\frac{3}{2}}}{\frac{3}{2}} \right]_0^2 = \frac{1}{4} \frac{2}{3} \sqrt{u^3} \Big|_0^2 = \frac{1}{6} \sqrt{u^3} \Big|_0^2 = \frac{1}{6} \sqrt{(2x^2+1)^3} \Big|_0^2$$

$$\frac{1}{6} [\sqrt{(2 \cdot 2^2+1)^3} - \sqrt{(2 \cdot 0^2+1)^3}] = \frac{1}{6} (\sqrt{9^3} - \sqrt{1^3}) = \frac{1}{6} (\sqrt{9^2 \cdot 3} - 1) = \frac{1}{6} (27 - 1) = \frac{1}{6} 26 = \frac{13}{3}$$

$$u = 2x^2 + 1, \frac{\partial u}{\partial x} = 4x \rightarrow \partial x = \frac{\partial u}{4x} \quad (46)$$

Integral Método da Substituição – [Aula 15](#)

Exercício I

$$\int (x^3-1)^4 x^2 \partial x = \int u^4 \frac{\partial u}{3x^2} = \frac{1}{3} \int u^4 \partial u = \frac{1}{3} \frac{u^5}{5} + c = \frac{(x^3-1)^5}{15} + c$$

$$u = x^3 - 1, \frac{\partial u}{\partial x} = 3x^2 \rightarrow \partial x = \frac{\partial u}{3x^2} \quad (47)$$

Exercício II

$$\int \frac{x}{(x^2-1)^3} \partial x = \int (x^2-1)^{-3} x \partial x = \int u^{-3} \frac{\partial u}{2} = \frac{1}{2} \int u^{-3} \partial u = \frac{1}{2} \frac{u^{-2}}{(-2)} + c = \frac{-1}{4u^2} + c$$

$$= \frac{-1}{4(x^2-1)^2} + c$$

$$u = x^2 - 1, \partial u = 2x \partial x \rightarrow \frac{\partial u}{2} = x \partial x \quad (48)$$

Exercício III

$$\int \frac{x}{(x^2-1)} \partial x = \int (x^2-1)^{-1} x \partial x = \int u^{-1} \frac{\partial u}{2} = \frac{1}{2} \int u^{-1} \partial u = \frac{1}{2} \ln|u| + c = \frac{\ln|x^2-1|}{2} + c$$

$$u = x^2 - 1, \partial u = 2x \partial x \rightarrow \frac{\partial u}{2} = x \partial x$$
(49)

Exercício IV

$$\int e^{x^2-1} x \partial x = \int e^u \frac{\partial u}{2} = \frac{1}{2} e^u \partial u = \frac{1}{2} e^u + c = \frac{e^{x^2-1}}{2} + c$$

$$u = x^2 - 1, \partial u = 2x \partial x \rightarrow \frac{\partial u}{2} = x \partial x$$
(50)

Exercício V

$$\int \sqrt{x^3-4} x^2 \partial x = \int u^{\frac{1}{2}} \frac{\partial u}{3} = \frac{1}{3} \int u^{\frac{1}{2}} \partial u = \frac{1}{3} \left(\frac{u^{\frac{3}{2}}}{\frac{3}{2}} \right) + c = \frac{1}{3} \frac{2}{3} \sqrt{u^3} + c = \frac{2\sqrt{u^3}}{9} + c =$$

$$\frac{2\sqrt{(x^3-4)^3}}{9} + c$$

$$u = x^3 - 4, \partial u = 3x^2 \partial x \rightarrow \frac{\partial u}{3} = x^2 \partial x$$
(51)

Exercício VI

$$\int e^{\sqrt{x}} \frac{\partial x}{\sqrt{x}} = \int e^{x^{\frac{1}{2}}} \frac{\partial x}{x^{\frac{1}{2}}} = \int e^{x^{\frac{1}{2}}} x^{-\frac{1}{2}} \partial x = \int e^u 2 \partial u = 2 \int e^u \partial u = 2e^u + c = 2e^{\sqrt{x}} + c$$

$$u = \sqrt{x} = x^{\frac{1}{2}}, \partial u = \frac{1}{2} x^{-\frac{1}{2}} \partial x = \frac{1}{2} \frac{\partial x}{\sqrt{x}} \rightarrow 2 \partial u = \frac{\partial x}{\sqrt{x}}$$
(52)

Exercício VII

$$\int \frac{x \partial x}{\sqrt[5]{x^2-1}} = \int \frac{x}{(x^2-1)^{\frac{1}{5}}} \partial x = \int (x^2-1)^{-\frac{1}{5}} x \partial x = \int u^{-\frac{1}{5}} \frac{\partial u}{2} = \frac{1}{2} \int u^{-\frac{1}{5}} \partial u = \frac{1}{2} \left(\frac{u^{\frac{4}{5}}}{\frac{4}{5}} \right) + c =$$

$$\frac{1}{2} \frac{5}{4} \sqrt[5]{u^4} + c = \frac{5\sqrt[5]{u^4}}{8} + c = \frac{5\sqrt[5]{(x^2-1)^4}}{8} + c$$

$$u = x^2 - 1, \partial u = 2x \partial x \rightarrow \frac{\partial u}{2} = x \partial x$$
(53)

Exercício VIII

$$\int \frac{e^t \partial t}{e^t + 4} = \int (e^t + 4)^{-1} e^t \partial t = \int u^{-1} \partial u = \ln|u| + c = \ln|e^t + 4| + c$$

$$u = e^t + 4, \partial u = e^t \partial t$$
(54)

Integral de uma Função Exponencial Qualquer – [Aula 16](#)

Exercício I

$$\int \sqrt{10^{3x}} \partial x = \int 10^{\frac{3x}{2}} \partial x = \int 10^u \frac{2}{3} \partial u = \frac{2}{3} \int 10^u \partial u = \frac{2}{3} \frac{10^u}{\ln|10|} + c = \frac{2 \cdot 10^{\frac{3x}{2}}}{3 \ln|10|} + c = \frac{2\sqrt{10^{3x}}}{3 \ln|10|} + c$$

$$u = \frac{3x}{2}, \partial u = \frac{3}{2} \partial x = \frac{2}{3} \partial u = \partial x$$

$$\frac{\partial \left(\frac{2\sqrt{10^{3x}}}{3 \ln|10|} + c \right)}{\partial x} = \frac{\partial \left(\frac{2}{3 \ln|10|} 10^{\frac{3x}{2}} + c \right)}{\partial x} = \frac{2}{3 \ln|10|} \frac{3 \ln|10| \sqrt{10^{3x}}}{2} + 0 = \sqrt{10^{3x}}$$

$$y = 10^{\frac{3x}{2}} \rightarrow \ln|y| = \ln|10^{\frac{3x}{2}}| = \frac{3x}{2} \ln|10| = \frac{3 \ln|10|}{2} x$$

$$\frac{\partial(\ln|y|)}{\partial y} = \frac{\partial \left(\frac{3 \ln|10|}{2} x \right)}{\partial x} \rightarrow \frac{1}{y} \partial y = \frac{3 \ln|10|}{2} \partial x \rightarrow \partial y = y \frac{3 \ln|10|}{2} \partial x \rightarrow \frac{\partial y}{\partial x} =$$

$$10^{\frac{3x}{2}} \frac{3 \ln|10|}{2} = \frac{3 \ln|10| \sqrt{10^{3x}}}{2}$$
(55)

Integral de função marginal – [Aula 17](#)

Exercício I

O custo marginal por unidade x é dado pela expressão $\frac{\partial c(x)}{\partial x} = 20 - \frac{4x^3}{5}$. Determine a função custo total $c(x)$ da produção, sabendo-se que o custo fixo para $x = 0$ é de R\$2000,00.

$$\frac{\partial c(x)}{\partial x} = 20 - \frac{4x^3}{5} \rightarrow \int \partial c(x) = \int \left(20 - \frac{4x^3}{5} \right) \partial x \rightarrow \int \left(20 - \frac{4x^3}{5} \right) \partial x = 20 \int \partial x - \frac{4}{5} \int x^3 \partial x =$$

$$20x - \frac{4}{5} \frac{x^4}{4} + c = 20x + \frac{x^4}{5} + c$$

$$20 \cdot 0 + \frac{0^4}{5} + c = 2000 \rightarrow c = 2000$$

$$c(x) = 20x + \frac{x^4}{5} + 2000$$
(56)

Exercício II

O rendimento marginal de um bem em quantidade (x) é dado pela expressão $Rm = 800 - 2x^2$. Ache o rendimento total para $x = 6$, sabendo que quando $x = 0$, $R = 0$.

$$\begin{aligned}
 \frac{\partial r(x)}{\partial x} &= 800 - 2x^2 \rightarrow \int \partial r(x) = \int (800 - 2x^2) \partial x \rightarrow \int (800 - 2x^2) \partial x = 800 \int \partial x - 2 \int x^2 \partial x \\
 800x - 2 \frac{x^3}{3} + c &= 800x - \frac{2x^3}{3} + c \\
 800 \cdot 0 - \frac{2 \cdot 0^3}{3} + c &= 0 \rightarrow c = 0 \\
 r(x) &= 800x - \frac{2x^3}{3} \\
 r(6) &= 800 \cdot 6 - \frac{2 \cdot 6^3}{3} = 4800 - \frac{2 \cdot 2^3 \cdot 3^3}{3} = 4800 - 2^4 \cdot 3^2 = 4800 - 16 \cdot 9 = 4800 - 144 = 4656
 \end{aligned}
 \tag{57}$$

Método da substituição com $\sin(x)$ e $\cos(x)$ – [Aula 18](#)

01. $\int \sin(u) \partial u = -\cos(u) + c$
02. $\int \cos(u) \partial u = \sin(u) + c$
03. $\int \operatorname{tg}(u) \partial u = \ln|\sec(u)| + c$
04. $\int \operatorname{cotg}(u) \partial u = \ln|\sin(u)| + c$
05. $\int \sec(u) \partial u = \ln|\sec(u) + \operatorname{tg}(u)| + c$
06. $\int \operatorname{cosec}(u) \partial u = \ln|\operatorname{cosec}(u) - \operatorname{cotg}(u)| + c$
07. $\int \sec^2(u) \partial u = \operatorname{tg}(u) + c$
08. $\int \operatorname{cosec}^2(u) \partial u = -\operatorname{cotg}(u) + c$
09. $\int \sec(u) \operatorname{tg}(u) \partial u = \sec(u) + c$
10. $\int \operatorname{cosec}(u) \operatorname{cotg}(u) \partial u = -\operatorname{cosec}(u) + c$

Exercício I

$$\begin{aligned}
 \int \sin(2x^2 - 1) x \partial x &= \int \sin(u) \frac{\partial u}{4} = \frac{1}{4} \sin(u) \partial u = \frac{1}{4} (-\cos(u)) + c = \frac{-\cos(u)}{4} + c = \\
 &\quad \frac{-\cos(2x^2 - 1)}{4} + c \\
 u &= 2x^2 - 1, \partial u = 4x \partial x \rightarrow \frac{\partial u}{4} = x \partial x
 \end{aligned}
 \tag{58}$$

$$\frac{\partial \left(\frac{-\cos(2x^2 - 1)}{4} + c \right)}{\partial x} = \frac{-1}{4} [-\sin(2x^2 - 1)] 4x + 0 = \sin(2x^2 - 1) x$$

Exercício II

$$\begin{aligned}
 \int \cos(3x^3+4) x^2 \partial x &= \int \cos(u) \frac{\partial u}{9} = \frac{1}{9} \int \cos(u) \partial u = \frac{1}{9} \text{sen}(u) + c = \frac{\text{sen}(3x^3+4)}{9} + c \\
 u &= 3x^3+4, \partial u = 9x^2 \partial x \rightarrow \frac{\partial u}{9} = x^2 \partial x \\
 \frac{\partial \left(\frac{\text{sen}(3x^3+4)}{9} + c \right)}{\partial x} &= \frac{1}{9} \cos(3x^3+4) 9x^2 + 0 = \cos(3x^3+4) x^2
 \end{aligned}
 \tag{59}$$

Exercício III

$$\begin{aligned}
 \int \text{sen}(\sqrt{x}) \frac{\partial x}{\sqrt{x}} &= \int \text{sen}\left(x^{\frac{1}{2}}\right) \frac{\partial x}{x^{\frac{1}{2}}} = \int \text{sen}\left(x^{\frac{1}{2}}\right) x^{-\frac{1}{2}} \partial x = \int \text{sen}(u) 2 \partial u = 2 \int \text{sen}(u) \partial u = \\
 &2(-\cos(u)) + c = -2 \cos \sqrt{x} + c \\
 u &= \sqrt{x} = x^{\frac{1}{2}}, \partial u = \frac{1}{2} x^{-\frac{1}{2}} \partial x \rightarrow 2 \partial u = x^{-\frac{1}{2}} \partial x
 \end{aligned}
 \tag{60}$$

Exercício IV

$$\begin{aligned}
 \int \text{sen}(x) \cos(x) \partial x &= \int u \partial u = \frac{u^2}{2} + c = \frac{\text{sen}^2(x)}{2} + c \\
 u &= \text{sen}(x), \partial u = \cos(x) \partial x \\
 \frac{\partial \left(\frac{\text{sen}^2(x)}{2} + c \right)}{\partial x} &= \frac{1}{2} 2 \text{sen}(x) \cos(x) + 0 = \text{sen}(x) \cos(x)
 \end{aligned}
 \tag{61}$$

Exercício V

$$\begin{aligned}
 \int \text{sen}(\cos(x)) \text{sen}(x) \partial x &= \int \text{sen}(u) (-\partial u) = - \int \text{sen}(u) \partial u = -(-\cos(u)) + c = \\
 &\cos(\cos(x)) + c \\
 u &= \cos(x), \partial u = -\text{sen}(x) \partial x \rightarrow -\partial u = \text{sen}(x) \partial x \\
 \frac{\partial [\cos(\cos(x)) + c]}{\partial x} &= -\text{sen}(\cos(x)) (-\text{sen}(x)) + 0 = \text{sen}(\cos(x)) \text{sen}(x)
 \end{aligned}
 \tag{62}$$

Exercício VI

$$\begin{aligned}
 \int \sqrt{\text{sen}(\theta)} \cos(\theta) \partial \theta &= \int u^{\frac{1}{2}} \partial u = \frac{u^{\frac{3}{2}}}{\left(\frac{3}{2}\right)} + c = \frac{2\sqrt{u^3}}{3} + c = \frac{2\sqrt{\text{sen}^3(\theta)}}{3} + c \\
 u &= \text{sen}(\theta), \partial u = \cos(\theta) \partial \theta
 \end{aligned}
 \tag{63}$$

Exercício VI

$$\begin{aligned}
 \int \ln|x| \frac{\partial x}{x} &= \int \ln|x| x^{-1} \partial x = \int u \partial u = \frac{u^2}{2} + c = \frac{\ln^2|x|}{2} + c \\
 u &= \ln|x|, \partial u = \frac{1}{x} \partial x \rightarrow \partial u = x^{-1} \partial x \\
 \frac{\partial \left(\frac{\ln^2|x|}{2} + c \right)}{\partial x} &= \frac{1}{2} 2 \ln|x| \frac{1}{x} + 0 = \frac{\ln|x|}{x}
 \end{aligned}
 \tag{64}$$

Exercício VII

$$\begin{aligned}
 \int \frac{\partial x}{x \ln^2|x|} &= \int (x \ln^2|x|)^{-1} \partial x = \int \ln^{-2}|x| x^{-1} \partial x = \int u^{-2} \partial u = \frac{u^{-1}}{(-1)} = \frac{-1}{u} + c = \frac{-1}{\ln|x|} + c \\
 u &= \ln|x|, \partial u = \frac{1}{x} \partial x \rightarrow \partial u = x^{-1} \partial x \\
 \frac{\partial \left(\frac{-1}{\ln|x|} + c \right)}{\partial x} &= \frac{\partial (-\ln^{-1}|x| + c)}{\partial x} = \ln^{-2} \frac{1}{x} + 0 = \frac{1}{x \ln^2|x|}
 \end{aligned}
 \tag{65}$$

Exercício VIII

$$\begin{aligned}
 \int \frac{\sin(\theta) \partial \theta}{(5 - \cos(\theta))^3} &= \int (5 - \cos(\theta))^{-3} \sin(\theta) \partial \theta = \int u^{-3} \partial u = \frac{u^{-2}}{(-2)} + c = \frac{-1}{2u^2} + c = \\
 &\quad \frac{-1}{2(5 - \cos(\theta))^2} + c \\
 u &= 5 - \cos(\theta), \partial u = -(-\sin(\theta)) \partial \theta \rightarrow \partial u = \sin(\theta) \partial \theta \\
 \frac{\partial \left(\frac{-1}{2(5 - \cos(\theta))^2} + c \right)}{\partial \theta} &= \frac{\partial \left(\frac{-1}{2} (5 - \cos(\theta))^{-2} + c \right)}{\partial \theta} = \frac{-1}{2} (-2) (5 - \cos(\theta))^{-3} (-(-\sin(\theta))) = \\
 &\quad (5 - \cos(\theta))^{-3} \sin(\theta) = \frac{\sin(\theta)}{(5 - \cos(\theta))^3}
 \end{aligned}
 \tag{66}$$

Integração de funções trigonométricas – Aula 19

Exercício I

$$\begin{aligned}
 \int \text{tg}(x) \partial x &= \int \frac{\text{sen}(x)}{\cos(x)} \partial x = \int \cos^{-1}(x) \text{sen}(x) \partial x = \int u^{-1} (-\partial u) = - \int u^{-1} \partial u = \\
 &= -\ln|u| + c = \ln|u^{-1}| + c = \ln\left|\frac{1}{u}\right| + c = \ln\left|\frac{1}{\cos(x)}\right| + c = \ln|\sec(x)| + c \\
 u &= \cos(x), \partial u = -\text{sen}(x) \partial x \rightarrow -\partial u = \text{sen}(x) \partial x
 \end{aligned}$$

(67)

$$\begin{aligned}
 \frac{\partial(\ln|\sec(x)| + c)}{\partial x} &= \frac{\partial\left(\ln\left|\frac{1}{\cos(x)}\right| + c\right)}{\partial x} = \frac{\partial(\ln|\cos^{-1}(x)| + c)}{\partial x} = \frac{\partial(-\ln|\cos(x)| + c)}{\partial x} = \\
 &= \frac{-\frac{1}{\cos(x)}(-\text{sen}(x)) + 0}{\cos(x)} = \frac{\text{sen}(x)}{\cos(x)} = \text{tg}(x)
 \end{aligned}$$

Exercício II

$$\begin{aligned}
 \int \text{cotg}(x) \partial x &= \int \frac{\cos(x)}{\text{sen}(x)} \partial x = \int \text{sen}^{-1}(x) \cos(x) \partial x = \int u^{-1} \partial u = \ln|u| + c = \ln|\text{sen}(x)| + c \\
 u &= \text{sen}(x), \partial u = \cos(x) \partial x
 \end{aligned}$$

(68)

$$\frac{\partial(\ln|\text{sen}(x)| + c)}{\partial x} = \frac{1}{\text{sen}(x)} \cos(x) + 0 = \frac{\cos(x)}{\text{sen}(x)} = \text{cotg}(x)$$

Exercício III

$$\begin{aligned}
 \int \sec(x) \partial x &= \int \sec(x) \left(\frac{\sec(x) + \text{tg}(x)}{\sec(x) + \text{tg}(x)} \right) \partial x = \int \frac{\sec^2(x) + \sec(x) \text{tg}(x)}{\sec(x) + \text{tg}(x)} \partial x = \\
 &= \int [\sec(x) + \text{tg}(x)]^{-1} [\sec(x) \text{tg}(x) + \sec^2(x)] \partial x = \int u^{-1} \partial u = \ln|u| + c = \ln|\sec(x) + \text{tg}(x)| + c \\
 u &= \sec(x) + \text{tg}(x), \partial u = [\sec(x) \text{tg}(x) + \sec^2(x)] \partial x
 \end{aligned}$$

(69)

$$\begin{aligned}
 \frac{\partial(\ln|\sec(x) + \text{tg}(x)| + c)}{\partial x} &= \frac{1}{\sec(x) + \text{tg}(x)} [\sec(x) \text{tg}(x) + \sec^2(x)] + 0 = \\
 &= \frac{\sec^2(x) + \sec(x) \text{tg}(x)}{\sec(x) + \text{tg}(x)} = \frac{\sec(x) [\sec(x) + \text{tg}(x)]}{\sec(x) + \text{tg}(x)} = \sec(x)
 \end{aligned}$$

Exercício IV

$$\begin{aligned}
 \int \text{cossec}(x) \partial x &= \int \text{cossec}(x) \left(\frac{\text{cossec}(x) - \cotg(x)}{\text{cossec}(x) - \cotg(x)} \right) \partial x = \\
 &= \int \frac{\text{cossec}^2(x) - \text{cossec}(x) \cotg(x)}{\text{cossec}(x) - \cotg(x)} \partial x = \\
 &= \int [\text{cossec}(x) - \cotg(x)]^{-1} [-\text{cossec}(x) \cotg(x) + \text{cossec}^2(x)] \partial x = \int u^{-1} \partial u = \\
 &= \ln|u| + c = \ln|\text{cossec}(x) - \cotg(x)| + c \\
 u &= \text{cossec}(x) - \cotg(x) \Rightarrow \partial u = [-\text{cossec}(x) \cotg(x) - (-\text{cossec}^2(x))] \partial x \rightarrow \\
 \partial u &= [-\text{cossec}(x) \cotg(x) + \text{cossec}^2(x)] \partial x \\
 \frac{\partial (\ln|\text{cossec}(x) - \cotg(x)| + c)}{\partial x} &= \\
 \frac{1}{\text{cossec}(x) - \cotg(x)} [-\text{cossec}(x) \cotg(x) - (-\text{cossec}^2(x))] + 0 &= \\
 \frac{\text{cossec}^2(x) - \text{cossec}(x) \cotg(x)}{\text{cossec}(x) - \cotg(x)} &= \frac{\text{cossec}(x) [\text{cossec}(x) - \cotg(x)]}{\text{cossec}(x) - \cotg(x)} = \text{cossec}(x)
 \end{aligned}
 \tag{70}$$

Exercício V

$$\begin{aligned}
 \int \text{tg}(3x) \partial x &= \int \text{tg}(u) \frac{\partial u}{3} = \frac{1}{3} \text{tg}(u) \partial u = \frac{1}{3} \ln|\sec(u)| + c = \frac{\ln|\sec(u)|}{3} + c = \frac{\ln|\sec(3x)|}{3} + c \\
 u &= 3x, \partial u = 3 \partial x \rightarrow \frac{\partial u}{3} = \partial x
 \end{aligned}
 \tag{71}$$

Exercício VI

$$\begin{aligned}
 \int \frac{\partial x}{\text{sen}(2x)} &= \int \text{sen}^{-1}(2x) \partial x = \int \text{cossec}(2x) \partial x = \int \text{cossec}(u) \frac{\partial u}{2} = \frac{1}{2} \int \text{cossec}(u) \partial u = \\
 \frac{1}{2} \ln|\text{cossec}(u) - \cotg(u)| + c &= \frac{\ln|\text{cossec}(u) - \cotg(u)|}{2} + c = \frac{\ln|\text{cossec}(2x) - \cotg(2x)|}{2} + c \\
 u &= 2x, \partial u = 2 \partial x \rightarrow \frac{\partial u}{2} = \partial x
 \end{aligned}
 \tag{72}$$

Integração de funções trigonométricas – [Aula 20](#)

Exercício I

$$\begin{aligned}
 \int \frac{\text{tg}(\sqrt{x}) \partial x}{\sqrt{x}} &= \int \frac{\text{tg}\left(x^{\frac{1}{2}}\right) \partial x}{x^{\frac{1}{2}}} = \int \text{tg}\left(x^{\frac{1}{2}}\right) x^{-\frac{1}{2}} \partial x = \int \text{tg}(u) 2 \partial u = 2 \int \text{tg}(u) \partial u = \\
 2 \ln|\sec(u)| + c &= 2 \ln|\sec(\sqrt{x})| + c \\
 u &= \sqrt{x} = x^{\frac{1}{2}}, \partial u = \frac{1}{2} x^{-\frac{1}{2}} \partial x \rightarrow 2 \partial u = x^{-\frac{1}{2}} \partial x
 \end{aligned}
 \tag{73}$$

Exercício II

$$\int \frac{\cotg(\ln|x|)\partial x}{x} = \int \cotg(\ln|x|)x^{-1}\partial x = \int \cotg(u)\partial u = \ln|\operatorname{sen}(u)| + c = \ln|\operatorname{sen}(\ln|x|)| + c$$

$$u = \ln|x|, \partial u = \frac{1}{x}\partial x \rightarrow \partial u = x^{-1}\partial x$$
(74)

Exercício III

$$\int \sec(5x - \pi)\partial x = \int \sec(u)\frac{\partial u}{5} = \frac{1}{5} \int \sec(u)\partial u = \frac{1}{5} \ln|\sec(u) + \tg(u)| + c =$$

$$\frac{\ln|\sec(5x - \pi) + \tg(5x - \pi)|}{5} + c$$

$$u = 5x - \pi, \partial u = 5\partial x \rightarrow \frac{\partial u}{5} = \partial x$$
(75)

Integral de potência $\operatorname{sen}(x)$ ou $\cos(x)$ – [Aula 21](#)

$$\int \cos^n(x)\partial x$$

$$\int \operatorname{sen}^n(x)\partial x$$

$$n \rightarrow \text{ímpar} \quad \operatorname{sen}^2(x) + \cos^2(x) = 1$$

$$\operatorname{sen}^2(x) = \frac{1 - \cos(2x)}{2}$$

$$n \rightarrow \text{par} \quad \cos^2(x) = \frac{1 + \cos(2x)}{2}$$

$$\int \operatorname{sen}^m(x)\cos^n(x)\partial x$$

$$n \vee m \rightarrow \text{ímpar} \quad \text{Separa o } \partial u \begin{cases} \operatorname{sen}(x)\partial x \\ \cos(x)\partial x \end{cases}$$

Transforma em $\operatorname{sen}^p(x)$ ou $\cos^p(x)$ através de $\operatorname{sen}^2(x) + \cos^2(x) = 1$

$$\operatorname{sen}^2(x) = \frac{1 - \cos(2x)}{2}$$

$$n \wedge m \rightarrow \text{par} \quad \cos^2(x) = \frac{1 + \cos(2x)}{2}$$

Exercício I

$$\begin{aligned}
 \int \cos^5(x) \partial x &= \int \cos^4(x) \cos(x) \partial x = \int (\cos^2(x))^2 \cos(x) \partial x = \int (1 - \sin^2(x))^2 \cos(x) \partial x = \\
 &= \int [1 - 2\sin^2(x) + \sin^4(x)] \cos(x) \partial x = \int [\cos(x) - 2\sin^2(x) \cos(x) + \sin^4(x) \cos(x)] \partial x = \\
 &= \int \cos(x) \partial x - 2 \int \sin^2(x) \cos(x) \partial x + \int \sin^4(x) \cos(x) \partial x = \int \partial u - 2 \int u^2 \partial u + \int u^4 \partial u = \\
 &= u - 2 \frac{u^3}{3} + \frac{u^5}{5} + c = \sin(x) - \frac{2\sin^3(x)}{3} + \frac{\sin^5(x)}{5} + c \\
 &\quad u = \sin(x), \partial u = \cos(x) \partial x
 \end{aligned}$$

$$\begin{aligned}
 \frac{\partial \left(\sin(x) - \frac{2\sin^3(x)}{3} + \frac{\sin^5(x)}{5} + c \right)}{\partial x} &= \frac{\partial \left(\sin(x) - \frac{2}{3} \sin^3(x) + \frac{1}{5} \sin^5(x) + c \right)}{\partial x} = \\
 \cos(x) - \frac{2}{3} 3 \sin^2(x) \cos(x) + \frac{1}{5} 5 \sin^4(x) \cos(x) + 0 &= \cos(x) [1 - 2\sin^2(x) + \sin^4(x)] = \\
 \cos(x) [1 - (\sin^2(x) + \sin^2(x)) + (\sin^2(x))^2] &= \\
 \cos(x) [(1 - \sin^2(x)) - \sin^2(x) + (1 - \cos^2(x))^2] &= \\
 \cos(x) [\cos^2(x) - \sin^2(x) + (1 - 2\cos^2(x) + \cos^4(x))] &= \\
 \cos(x) [\cos^2(x) - \sin^2(x) + 1 - (\cos^2(x) + \cos^2(x)) + \cos^4(x)] &= \\
 \cos(x) [\cos^2(x) + (1 - \sin^2(x)) - \cos^2(x) - \cos^2(x) + \cos^4(x)] &= \\
 \cos(x) [\cos^2(x) - \cos^2(x) + \cos^4(x)] = \cos(x) \cos^4(x) = \cos^5(x)
 \end{aligned} \tag{76}$$

Exercício II

$$\begin{aligned}
 \int \text{sen}^4(x) \partial x &= \int (\text{sen}^2(x))^2 \partial x = \int \left(\frac{1 - \cos(2x)}{2} \right)^2 \partial x = \int \frac{1 - 2\cos(2x) + \cos^2(2x)}{4} \partial x = \\
 \frac{1}{4} \int \left[1 - 2\cos(2x) + \frac{1 + \cos(2 \cdot 2x)}{2} \right] \partial x &= \frac{1}{4} \int \partial x - \frac{1}{2} \int \cos(2x) \partial x + \frac{1}{8} \int [1 + \cos(4x)] \partial x = \\
 \frac{1}{4} \int \partial x - \frac{1}{2} \int \cos(2x) \partial x + \frac{1}{8} \int \partial x + \frac{1}{8} \int \cos(4x) \partial x &= \\
 \frac{1}{4} \int \frac{\partial u}{2} - \frac{1}{2} \int \cos(u) \frac{\partial u}{2} + \frac{1}{8} \int \frac{\partial u}{2} + \frac{1}{8} \int \cos(2u) \frac{\partial u}{2} &= \\
 \frac{1}{8} \int \partial u - \frac{1}{4} \int \cos(u) \partial u + \frac{1}{16} \int \partial u + \frac{1}{16} \int \cos(2u) \partial u &= \\
 \frac{1}{8} \int \partial u - \frac{1}{4} \int \cos(u) \partial u + \frac{1}{16} \int \partial u + \frac{1}{16} \int \cos(v) \frac{\partial v}{2} &= \\
 \frac{1}{8} \int \partial u - \frac{1}{4} \int \cos(u) \partial u + \frac{1}{16} \int \partial u + \frac{1}{32} \int \cos(v) \partial v &= \\
 \frac{1}{8} u - \frac{1}{4} \text{sen}(u) + \frac{1}{16} u + \frac{1}{32} \text{sen}(v) + c &= \frac{2u+u}{16} - \frac{\text{sen}(u)}{4} + \frac{\text{sen}(2u)}{32} + c = \\
 \frac{3u}{16} - \frac{\text{sen}(u)}{4} + \frac{\text{sen}(2u)}{32} + c &= \frac{3 \cdot 2x}{16} - \frac{\text{sen}(2x)}{4} + \frac{\text{sen}(2 \cdot 2x)}{32} + c = \\
 \frac{3x}{8} - \frac{\text{sen}(2x)}{4} + \frac{\text{sen}(4x)}{32} + c &= \\
 u = 2x, \frac{\partial u}{2} = \partial x &= \\
 v = 2u, \frac{\partial v}{2} = \partial u &=
 \end{aligned}
 \tag{77}$$

Integral do produto de potência entre $\sin(x)$ e $\cos(x)$ – [Aula 22](#)

Exercício I

$$\begin{aligned}
 \int \sin^5(x) \cos^2(x) \partial x &= \int \sin^4(x) \cos^2(x) \sin(x) \partial x = \int (\sin^2(x))^2 \cos^2(x) \sin(x) \partial x = \\
 &= \int (1 - \cos^2(x))^2 \cos^2(x) \sin(x) \partial x = \int [1 - 2\cos^2(x) + \cos^4(x)] \cos^2(x) \sin(x) \partial x = \\
 &= \int [\cos^2(x) - 2\cos^4(x) + \cos^6(x)] \sin(x) \partial x = \\
 &= \int \cos^2(x) \sin(x) \partial x - 2 \int \cos^4(x) \sin(x) \partial x + \int \cos^6(x) \sin(x) \partial x = \\
 &= \int u^2 (-\partial u) - 2 \int u^4 (-\partial u) + \int u^6 (-\partial u) = - \int u^2 \partial u + 2 \int u^4 \partial u - \int u^6 \partial u = \\
 &= \frac{-u^3}{3} + 2 \frac{u^5}{5} - \frac{u^7}{7} + c = \frac{-\cos^3(x)}{3} + \frac{2\cos^5(x)}{5} - \frac{\cos^7(x)}{7} + c \\
 &\quad u = \cos(x), -\partial u = \sin(x) \partial x
 \end{aligned}$$

(78)

$$\begin{aligned}
 \frac{\partial \left(\frac{-\cos^3(x)}{3} + \frac{2\cos^5(x)}{5} - \frac{\cos^7(x)}{7} + c \right)}{\partial x} &= \frac{\partial \left(-\frac{1}{3} \cos^3(x) + \frac{2}{5} \cos^5(x) - \frac{1}{7} \cos^7(x) + c \right)}{\partial x} = \\
 &= -\frac{1}{3} 3 \cos^2(x) (-\sin(x)) + \frac{2}{5} 5 \cos^4(x) (-\sin(x)) - \frac{1}{7} 7 \cos^6(x) (-\sin(x)) + 0 = \\
 \cos^2(x) \sin(x) - 2 \cos^4(x) \sin(x) + \cos^6(x) \sin(x) &= \sin(x) [\cos^2(x) - 2 \cos^4(x) + \cos^6(x)] = \\
 \sin(x) \cos^2(x) [1 - 2 \cos^2(x) + \cos^4(x)] &= (1 - \cos^2(x))^2 \cos^2(x) \sin(x) = \\
 (\sin^2(x))^2 \cos^2(x) \sin(x) &= \sin^4(x) \cos^2(x) \sin(x) = \sin^5(x) \cos^2(x)
 \end{aligned}$$

Exercício II

$$\begin{aligned}
 \int \text{sen}^2(x) \cos^4(x) \partial x &= \int \frac{1 - \cos(2x)}{2} (\cos^2(x))^2 \partial x = \frac{1}{2} \int (1 - \cos(2x)) \left(\frac{1 + \cos(2x)}{2} \right)^2 \partial x \\
 &= \frac{1}{2} \int (1 - \cos(2x)) \left(\frac{1 + 2\cos(2x) + \cos^2(2x)}{4} \right) \partial x = \\
 &= \frac{1}{8} \int (1 - \cos(2x)) (1 + 2\cos(2x) + \cos^2(2x)) \partial x = \\
 &= \frac{1}{8} \int (1 + 2\cos(2x) + \cos^2(2x) - \cos(2x) - 2\cos^2(2x) - \cos^3(2x)) \partial x = \\
 &= \frac{1}{8} \int (\text{sen}^2(2x) + \cos(2x) - \cos^2(2x) \cos(2x)) \partial x = \\
 &= \frac{1}{8} \int \text{sen}^2(2x) \partial x + \frac{1}{8} \int \cos(2x) \partial x - \frac{1}{8} \int \cos^2(2x) \cos(2x) \partial x = \\
 &= \frac{1}{8} \int \frac{1 - \cos(4x)}{2} \partial x + \frac{1}{8} \int \cos(2x) \partial x - \frac{1}{8} \int (1 - \text{sen}^2(2x)) \cos(2x) \partial x = \quad (79) \\
 &= \frac{1}{16} \int (1 - \cos(4x)) \partial x + \frac{1}{8} \int \cos(2x) \partial x - \frac{1}{8} \int (\cos(2x) - \text{sen}^2(2x) \cos(2x)) \partial x = \\
 &= \frac{1}{16} \int \partial x - \frac{1}{16} \int \cos(4x) \partial x + \frac{1}{8} \int \cos(2x) \partial x - \frac{1}{8} \int \cos(2x) \partial x + \frac{1}{8} \int \text{sen}^2(2x) \cos(2x) \partial x \\
 &= \frac{1}{16} \int \partial x - \frac{1}{32} \int \cos(2y) \partial y + \frac{1}{16} \int \text{sen}^2(y) \cos(y) \partial y = \\
 &= \frac{1}{16} \int \partial x - \frac{1}{64} \int \cos(z) \partial z + \frac{1}{16} \int u^2 \partial u = \frac{1}{16} x - \frac{1}{64} \text{sen}(z) + \frac{1}{16} \frac{u^3}{3} + c = \\
 &= \frac{x}{16} - \frac{\text{sen}(2y)}{64} + \frac{\text{sen}^3(y)}{48} + c = \frac{x}{16} - \frac{\text{sen}(4x)}{64} + \frac{\text{sen}^3(2x)}{48} + c \\
 &= y = 2x, \frac{\partial y}{2} = \partial x; z = 2y, \frac{\partial z}{2} = \partial y; u = \text{sen}(y), \partial u = \cos(y) \partial y
 \end{aligned}$$

Integral de Funções Trigonométricas – [Aula 23](#)

$$\begin{aligned}
 \text{tg}(x) &= \frac{\text{sen}(x)}{\cos(x)}, \text{cotg}(x) = \frac{\cos(x)}{\text{sen}(x)} \\
 \sec(x) &= \frac{1}{\cos(x)}, \text{cosec}(x) = \frac{1}{\text{sen}(x)} \\
 \text{sen}^2(x) + \cos^2(x) &= 1
 \end{aligned}$$

$$\frac{\text{sen}^2(x)}{\text{sen}^2(x)} + \frac{\cos^2(x)}{\text{sen}^2(x)} = \frac{1}{\text{sen}^2(x)} \rightarrow 1 + \text{cotg}^2(x) = \text{cosec}^2(x) \rightarrow \text{cosec}^2(x) - \text{cotg}^2(x) = 1$$

$$\frac{\text{sen}^2(x)}{\cos^2(x)} + \frac{\cos^2(x)}{\cos^2(x)} = \frac{1}{\cos^2(x)} \rightarrow \text{tg}^2(x) + 1 = \sec^2(x) \rightarrow \sec^2(x) - \text{tg}^2(x) = 1$$

Exercício I

$$\begin{aligned}
 \int [tg(2x) + cotg(2x)]^2 \partial x &= \int [tg^2(2x) + 2tg(2x)cotg(2x) + cotg^2(2x)] \partial x = \\
 &= \int tg^2(2x) \partial x + 2 \int tg(2x)cotg(2x) \partial x + \int cotg^2(2x) \partial x = \\
 &= \int (\sec^2(2x) - 1) \partial x + 2 \int \frac{\cancel{\text{sen}(2x)}}{\cos(2x)} \frac{\cos(2x)}{\cancel{\text{sen}(2x)}} \partial x + \int (\csc^2(2x) - 1) \partial x = \\
 &= \int \sec^2(2x) \partial x - \int \partial x + 2 \int \partial x + \int \csc^2(2x) \partial x - \int \partial x = \\
 &= \frac{1}{2} \int \sec^2(u) \partial u - \int \partial x + 2 \int \partial x + \frac{1}{2} \int \csc^2(u) \partial u - \int \partial x = \\
 &= \frac{1}{2} tg(u) - x + 2x + \frac{1}{2} (-cotg(u)) - x + c = \frac{tg(2x)}{2} - \frac{cotg(2x)}{2} + c \\
 u &= 2x; \frac{\partial u}{2} = \partial x
 \end{aligned}
 \tag{80}$$