

Berechne für jede Funktion in Aufgabe **A)** und **B)**:

- a) Berechne die mittlere Änderungsrate  $m_S$  zwischen Punkt  $A(a|f(a))$  und Punkt  $B(b|f(b))$  der Funktion  $f(x)$ .
- b) Berechne die Ableitungsfunktion  $f'(x)$ .
- c) Berechne die momentane Änderungsrate  $m_T$  am Punkt  $A$  der Funktion  $f(x)$ .

**A) Mittlere und momentane Änderungsrate: Polynom**

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| <ol style="list-style-type: none"> <li>1. <math>f(x) = -\frac{x}{30}(30x^4 + 103x^3 - 240)</math><br/><math>a = -1, b = 2</math></li> <li>2. <math>f(x) = -\frac{x^2}{99}(36x^2 + 25)</math><br/><math>a = 1, b = 3</math></li> <li>3. <math>f(x) = \frac{9}{2}</math><br/><math>a = -3, b = 1</math></li> <li>4. <math>f(x) = \frac{x^4}{4}(x^2 - 20)^2</math><br/><math>a = -4, b = 3</math></li> <li>5. <math>f(x) = \frac{x^4}{9}(x - 100)</math><br/><math>a = -4, b = -3</math></li> <li>6. <math>f(x) = \frac{1}{81}(7x^5 - 9)^2</math><br/><math>a = -3, b = 3</math></li> <li>7. <math>f(x) = \frac{3x^4}{7}</math><br/><math>a = -2, b = 2</math></li> <li>8. <math>f(x) = 7x^5</math><br/><math>a = 1, b = 2</math></li> <li>9. <math>f(x) = \frac{x^3}{9}(7x + 18)</math><br/><math>a = -2, b = -1</math></li> <li>10. <math>f(x) = \frac{6x^2}{7}</math><br/><math>a = -4, b = -1</math></li> <li>11. <math>f(x) = -\frac{1}{30}(20x^5 - 10x^4 - 30x^2 - 3)</math><br/><math>a = 1, b = 2</math></li> </ol> | <ol style="list-style-type: none"> <li>12. <math>f(x) = -\frac{x^3}{6}(7x + 15)</math><br/><math>a = 1, b = 2</math></li> <li>13. <math>f(x) = \frac{1}{140}(80x^5 - 180x + 63)</math><br/><math>a = -4, b = 2</math></li> <li>14. <math>f(x) = \frac{x}{30}(25x + 66)</math><br/><math>a = 1, b = 2</math></li> <li>15. <math>f(x) = -\frac{1}{315}(486x^4 + 350x^2 + 315)</math><br/><math>a = 1, b = 3</math></li> <li>16. <math>f(x) = -x(3x + 11)</math><br/><math>a = -4, b = -1</math></li> <li>17. <math>f(x) = \frac{x^2}{42}(35x^3 + 21x^2 + 98x - 30)</math><br/><math>a = -3, b = -2</math></li> <li>18. <math>f(x) = \frac{5x^3}{3}</math><br/><math>a = -3, b = 1</math></li> <li>19. <math>f(x) = \frac{1}{3}(3x - 1)</math><br/><math>a = -4, b = -3</math></li> <li>20. <math>f(x) = \frac{10}{7}</math><br/><math>a = -2, b = 1</math></li> <li>21. <math>f(x) = \frac{4x^2}{7}</math><br/><math>a = -2, b = 2</math></li> <li>22. <math>f(x) = \frac{9x^4}{1600}(12x^2 + 5)^2</math><br/><math>a = 1, b = 3</math></li> </ol> |
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**B) Mittlere und momentane Änderungsrate: allgemeine Potenzfunktion**

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| <ol style="list-style-type: none"> <li>1. <math>f(x) = \frac{4\sqrt[4]{x^5}}{3} + \frac{9}{7\sqrt[5]{x^6}} + \frac{1}{8\sqrt[6]{x^3}}</math><br/><math>a = 6, b = 7</math></li> <li>2. <math>f(x) = -\frac{8\sqrt[5]{x^5}}{3} + \frac{23}{15x^2} + \frac{10}{x^5}</math><br/><math>a = 7, b = 9</math></li> <li>3. <math>f(x) = -\frac{x^4}{9} - \frac{5\sqrt[3]{x^4}}{2} - \frac{1}{\sqrt[5]{x^3}} + \frac{3}{2x^6}</math><br/><math>a = 2, b = 8</math></li> <li>4. <math>f(x) = \frac{1}{2\sqrt[3]{x^3}} - \frac{4}{9x^4} - \frac{4}{9\sqrt[3]{x}}</math><br/><math>a = 3, b = 8</math></li> <li>5. <math>f(x) = -\frac{3x}{5} - \frac{2}{9\sqrt[4]{x^3}}</math><br/><math>a = 1, b = 3</math></li> <li>6. <math>f(x) = 3x^4 - \frac{95}{8x^6}</math><br/><math>a = 1, b = 8</math></li> <li>7. <math>f(x) = -\frac{8x^5}{5} - \frac{3\sqrt[3]{x^4}}{7} + \frac{5}{3}</math><br/><math>a = 5, b = 6</math></li> <li>8. <math>f(x) = \left(6\sqrt[3]{x^6} + \frac{2}{3\sqrt[5]{x}}\right)^2</math><br/><math>a = 4, b = 8</math></li> <li>9. <math>f(x) = \left(\frac{7x}{10} - \frac{\sqrt[5]{x^6}}{2}\right)^2</math><br/><math>a = 1, b = 2</math></li> <li>10. <math>f(x) = -\frac{3}{7x^6}</math><br/><math>a = 2, b = 3</math></li> <li>11. <math>f(x) = -3x^3 - \frac{4}{5\sqrt{x^6}} + \frac{3}{\sqrt[3]{x^3}} - \frac{5}{9x^6}</math><br/><math>a = 5, b = 9</math></li> </ol> | <ol style="list-style-type: none"> <li>12. <math>f(x) = -\frac{5}{7x^4}</math><br/><math>a = 1, b = 2</math></li> <li>13. <math>f(x) = \frac{11x^3}{9}</math><br/><math>a = 2, b = 5</math></li> <li>14. <math>f(x) = \frac{5x^5}{2}</math><br/><math>a = 1, b = 3</math></li> <li>15. <math>f(x) = \frac{x^5}{3} - \frac{6\sqrt{x^3}}{5} + \frac{2}{3\sqrt[5]{x^4}} + \frac{9}{7\sqrt[6]{x^2}}</math><br/><math>a = 1, b = 5</math></li> <li>16. <math>f(x) = \frac{2\sqrt{x^4}}{7} + 4\sqrt[3]{x^5} - \frac{1}{\sqrt[6]{x}}</math><br/><math>a = 1, b = 3</math></li> <li>17. <math>f(x) = \frac{6x^2}{5} + \frac{4}{3}</math><br/><math>a = 2, b = 9</math></li> <li>18. <math>f(x) = -\frac{2}{5\sqrt[3]{x^4}} - \frac{1}{2\sqrt{x^2}} + \frac{1}{3x^2}</math><br/><math>a = 7, b = 8</math></li> <li>19. <math>f(x) = \frac{8x^3}{7} - \frac{10\sqrt[5]{x^2}}{9} - \frac{5}{3x^2} - \frac{7}{9x^3}</math><br/><math>a = 5, b = 7</math></li> <li>20. <math>f(x) = -\frac{3}{5\sqrt{x^6}} + \frac{1}{3x^3} - \frac{5}{9x^5} - \frac{9}{\sqrt{x}}</math><br/><math>a = 2, b = 9</math></li> <li>21. <math>f(x) = -4x^6 + \frac{2}{x^4}</math><br/><math>a = 1, b = 9</math></li> <li>22. <math>f(x) = -\frac{8\sqrt{x}}{3} + \frac{x^5}{9} + 7x^4</math><br/><math>a = 7, b = 9</math></li> </ol> |
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**A) Lösung: Mittlere und momentane Änderungsrate: Polynom**

1.  $f(x) = -x^5 - \frac{103x^4}{30} + 8x$ ,  $m_S \approx -20.17$   
 $f'(x) = -5x^4 - \frac{206x^3}{15} + 8$ ,  $m_T \approx 16.73$
2.  $f(x) = -\frac{4x^4}{11} - \frac{25x^2}{99}$ ,  $m_S \approx -15.56$   
 $f'(x) = -\frac{16x^3}{11} - \frac{50x}{99}$ ,  $m_T \approx -1.96$
3.  $f(x) = \frac{9}{2}$ ,  $m_S = 0.00$   
 $f'(x) = 0$ ,  $m_T = 0.00$
4.  $f(x) = \frac{x^8}{4} - 10x^6 + 100x^4$ ,  $m_S = 2.50$   
 $f'(x) = 2x^7 - 60x^5 + 400x^3$ ,  $m_T = 48.00$
5.  $f(x) = \frac{x^5}{9} - \frac{100x^4}{9}$ ,  $m_S \approx 2031.22$   
 $f'(x) = \frac{5x^4}{9} - \frac{400x^3}{9}$ ,  $m_T \approx 2986.67$
6.  $f(x) = \frac{49x^{10}}{81} - \frac{14x^5}{9} + 1$ ,  $m_S = 63.00$   
 $f'(x) = \frac{490x^9}{81} - \frac{70x^4}{9}$ ,  $m_T = 315.00$
7.  $f(x) = \frac{3x^4}{7}$ ,  $m_S = 0.00$   
 $f'(x) = \frac{12x^3}{7}$ ,  $m_T \approx -13.71$
8.  $f(x) = 7x^5$ ,  $m_S = 217.00$   
 $f'(x) = 35x^4$ ,  $m_T = 35.00$
9.  $f(x) = \frac{7x^4}{9} + 2x^3$ ,  $m_S \approx 2.33$   
 $f'(x) = \frac{28x^3}{9} + 6x^2$ ,  $m_T \approx -0.89$
10.  $f(x) = \frac{6x^2}{7}$ ,  $m_S \approx -4.29$   
 $f'(x) = \frac{12x}{7}$ ,  $m_T \approx -6.86$
11.  $f(x) = -\frac{2x^5}{3} + \frac{x^4}{3} + x^2 + \frac{1}{10}$ ,  $m_S \approx -12.67$   
 $f'(x) = -\frac{10x^4}{3} + \frac{4x^3}{3} + 2x$ ,  $m_T = 0.00$
12.  $f(x) = -\frac{7x^4}{6} - \frac{5x^3}{2}$ ,  $m_S \approx -35.00$   
 $f'(x) = -\frac{14x^3}{3} - \frac{15x^2}{2}$ ,  $m_T \approx -12.17$
13.  $f(x) = \frac{4x^5}{7} - \frac{9x}{7} + \frac{9}{20}$ ,  $m_S \approx 99.29$   
 $f'(x) = \frac{20x^4}{7} - \frac{9}{7}$ ,  $m_T \approx 730.14$
14.  $f(x) = \frac{5x^2}{6} + \frac{11x}{5}$ ,  $m_S \approx 4.70$   
 $f'(x) = \frac{5x}{3} + \frac{11}{5}$ ,  $m_T \approx 3.87$
15.  $f(x) = -\frac{54x^4}{35} - \frac{10x^2}{9} - 1$ ,  $m_S \approx -66.16$   
 $f'(x) = -\frac{216x^3}{35} - \frac{20x}{9}$ ,  $m_T \approx -8.39$
16.  $f(x) = -3x^2 - 11x$ ,  $m_S = 4.00$   
 $f'(x) = -6x - 11$ ,  $m_T = 13.00$
17.  $f(x) = \frac{5x^5}{6} + \frac{x^4}{2} + \frac{7x^3}{3} - \frac{5x^2}{7}$ ,  $m_S \approx 191.24$   
 $f'(x) = \frac{25x^4}{6} + 2x^3 + 7x^2 - \frac{10x}{7}$ ,  $m_T \approx 350.79$
18.  $f(x) = \frac{5x^3}{3}$ ,  $m_S \approx 11.67$   
 $f'(x) = 5x^2$ ,  $m_T = 45.00$
19.  $f(x) = x - \frac{1}{3}$ ,  $m_S \approx 1.00$   
 $f'(x) = 1$ ,  $m_T = 1.00$
20.  $f(x) = \frac{10}{7}$ ,  $m_S = 0.00$   
 $f'(x) = 0$ ,  $m_T = 0.00$
21.  $f(x) = \frac{4x^2}{7}$ ,  $m_S = 0.00$   
 $f'(x) = \frac{8x}{7}$ ,  $m_T \approx -2.29$
22.  $f(x) = \frac{81x^8}{100} + \frac{27x^6}{40} + \frac{9x^4}{64}$ ,  $m_S = -37.50$   
 $f'(x) = \frac{162x^7}{25} + \frac{81x^5}{20} + \frac{9x^3}{16}$ ,  $m_T = -4.35$

**B) Lösung: Mittlere und momentane Änderungsrate: allgemeine Potenzfunktion**

1.  $f(x) = \frac{4x^{\frac{5}{4}}}{3} + \frac{1}{8\sqrt{x}} + \frac{9}{7x^{\frac{9}{5}}}$ ,  $m_S \approx 2.63$   
 $f'(x) = \frac{5\sqrt[4]{x}}{3} - \frac{1}{16x^{\frac{3}{2}}} - \frac{54}{35x^{\frac{14}{5}}}$ ,  $m_T \approx 2.57$
2.  $f(x) = -\frac{8x}{3} + \frac{23}{15x^2} + \frac{10}{x^5}$ ,  $m_S \approx -2.67$   
 $f'(x) = -\frac{8}{3} - \frac{46}{15x^3} - \frac{50}{x^6}$ ,  $m_T \approx -2.68$
3.  $f(x) = -\frac{5x^{\frac{4}{3}}}{2} - \frac{x^4}{9} + \frac{3}{2x^6} - \frac{1}{x^{\frac{3}{5}}}$ ,  $m_S \approx -81.11$   
 $f'(x) = -\frac{10\sqrt[3]{x}}{3} - \frac{4x^3}{9} - \frac{9}{x^7} + \frac{3}{5x^{\frac{8}{5}}}$ ,  $m_T \approx -7.63$
4.  $f(x) = \frac{1}{2x} - \frac{4}{9x^4} - \frac{4}{9\sqrt[3]{x}}$ ,  $m_S \approx -0.00$   
 $f'(x) = -\frac{1}{2x^2} + \frac{16}{9x^5} + \frac{4}{27x^{\frac{4}{3}}}$ ,  $m_T \approx -0.01$
5.  $f(x) = -\frac{3x}{5} - \frac{2}{9x^{\frac{3}{4}}}$ ,  $m_S \approx -0.54$   
 $f'(x) = -\frac{3}{5} + \frac{1}{x^{\frac{7}{4}}}$ ,  $m_T \approx -0.43$
6.  $f(x) = 3x^4 - \frac{95}{8x^6}$ ,  $m_S \approx 1756.70$   
 $f'(x) = 12x^3 + \frac{285}{4x^7}$ ,  $m_T = 83.25$
7.  $f(x) = -\frac{3x^{\frac{4}{3}}}{7} - \frac{8x^5}{5} + \frac{5}{3}$ ,  $m_S \approx -7442.61$   
 $f'(x) = -\frac{4\sqrt[3]{x}}{7} - 8x^4$ ,  $m_T \approx -5000.98$
8.  $f(x) = 8x^{\frac{9}{5}} + 36x^4 + \frac{4}{9x^{\frac{5}{3}}}$ ,  $m_S \approx 71.98$   
 $f'(x) = \frac{72x^{\frac{4}{5}}}{5} + 144x^3 - \frac{8}{45x^{\frac{8}{3}}}$ ,  $m_T \approx 47.97$
9.  $f(x) = \frac{x^{\frac{12}{5}}}{4} - \frac{7x^{\frac{11}{10}}}{10} + \frac{49x^2}{100}$ ,  $m_S \approx 0.05$   
 $f'(x) = \frac{3x^{\frac{7}{5}}}{5} - \frac{77x^{\frac{6}{10}}}{50} + \frac{49x}{50}$ ,  $m_T \approx 0.10$
10.  $f(x) = -\frac{3}{7x^6}$ ,  $m_S \approx 0.01$   
 $f'(x) = \frac{18}{7x^7}$ ,  $m_T \approx 0.02$
11.  $f(x) = -3x^3 + \frac{3}{x} - \frac{4}{5x^3} - \frac{5}{9x^6}$ ,  $m_S \approx -453.07$   
 $f'(x) = -9x^2 - \frac{3}{x^2} + \frac{12}{5x^4} + \frac{10}{3x^7}$ ,  $m_T \approx -225.12$
12.  $f(x) = -\frac{5}{7x^4}$ ,  $m_S \approx 0.67$   
 $f'(x) = \frac{20}{7x^5}$ ,  $m_T \approx 2.86$
13.  $f(x) = \frac{11x^3}{9}$ ,  $m_S \approx 47.67$   
 $f'(x) = \frac{11x^2}{3}$ ,  $m_T \approx 14.67$
14.  $f(x) = \frac{5x^5}{2}$ ,  $m_S = 302.50$   
 $f'(x) = \frac{25x^4}{2}$ ,  $m_T = 12.50$
15.  $f(x) = -\frac{6x^{\frac{3}{2}}}{5} + \frac{x^5}{3} + \frac{9}{7\sqrt[3]{x}} + \frac{2}{3x^{\frac{4}{5}}}$ ,  $m_S \approx 257.03$   
 $f'(x) = -\frac{9\sqrt{x}}{5} + \frac{5x^4}{3} - \frac{3}{7x^{\frac{4}{3}}} - \frac{8}{15x^{\frac{9}{5}}}$ ,  $m_T \approx -1.10$
16.  $f(x) = 4x^{\frac{5}{3}} + \frac{2x^2}{7} - \frac{1}{6\sqrt{x}}$ ,  $m_S \approx 11.71$   
 $f'(x) = \frac{20x^{\frac{2}{3}}}{3} + \frac{4x}{7} + \frac{1}{6x^{\frac{3}{2}}}$ ,  $m_T \approx 7.40$
17.  $f(x) = \frac{6x^2}{5} + \frac{4}{3}$ ,  $m_S \approx 13.20$   
 $f'(x) = \frac{12x}{5}$ ,  $m_T \approx 4.80$
18.  $f(x) = -\frac{1}{2x} + \frac{1}{3x^2} - \frac{2}{5x^{\frac{4}{3}}}$ ,  $m_S \approx 0.01$   
 $f'(x) = \frac{1}{2x^2} - \frac{2}{3x^3} + \frac{8}{15x^{\frac{7}{3}}}$ ,  $m_T \approx 0.01$
19.  $f(x) = -\frac{10x^{\frac{2}{5}}}{9} + \frac{8x^3}{7} - \frac{5}{3x^2} - \frac{7}{9x^3}$ ,  $m_S \approx 124.44$   
 $f'(x) = \frac{24x^{\frac{2}{5}}}{7} + \frac{10}{3x^3} + \frac{7}{3x^4} - \frac{4}{9x^{\frac{8}{5}}}$ ,  $m_T \approx 85.58$
20.  $f(x) = -\frac{4}{15x^3} - \frac{5}{9x^5} - \frac{9}{\sqrt{x}}$ ,  $m_S \approx 0.49$   
 $f'(x) = \frac{4}{5x^4} + \frac{25}{9x^6} + \frac{9}{2x^{\frac{3}{2}}}$ ,  $m_T \approx 1.68$
21.  $f(x) = -4x^6 + \frac{2}{x^4}$ ,  $m_S \approx -265720.25$   
 $f'(x) = -24x^5 - \frac{8}{x^5}$ ,  $m_T = -32.00$
22.  $f(x) = -\frac{8\sqrt{x}}{3} + \frac{x^5}{9} + 7x^4$ ,  $m_S \approx 16906.31$   
 $f'(x) = \frac{5x^4}{9} + 28x^3 - \frac{4}{3\sqrt{x}}$ ,  $m_T \approx 10937.38$

**A) Ableitungsfunktion von einer allgemeinen Potenzfunktion**

Berechne die Ableitungsfunktion von  $f$  und achte dabei auf die Variable.

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| 1. $f(t) = \frac{5}{11x^2z}$  | 12. $f(t) = -9t^6z^6 + \frac{3x^2}{5}z^2 - \frac{1}{5\sqrt[6]{t^4x^4z^4}} - \frac{5}{\sqrt{tx^3z}}$                    |
| 2. $f(z) = -\frac{5t^4z^2}{2x^2} - t^3x^2z^5 - \frac{9}{4}\sqrt[3]{t^6x^2z^2} - \frac{10}{t^2z^3}$    | 13. $f(z) = \left(-\frac{11x}{z^6} - 2\sqrt[3]{t^2xz}\right)^2$  |
| 3. $f(x) = \frac{4t^2}{z^4}x^6 - \frac{1}{\sqrt[6]{t^2}} - \frac{7}{10\sqrt[5]{t^6x^3z^3}}$           | 14. $f(t) = \left(-\frac{7x^3}{5} - \frac{7}{6t^5x}\right)^2$  |
| 4. $f(t) = \left(-\frac{7\sqrt[3]{x}}{2} + \frac{3}{5\sqrt[6]{tz^6}}\right)^2$                        | 15. $f(x) = \frac{5}{8}\sqrt{tx^5z^5} + \frac{7\sqrt[3]{t^2}}{5} + 3$  |
| 5. $f(x) = \frac{3x^3}{2z^6}$   | 16. $f(x) = -10\sqrt[4]{tx^4}$   |
| 6. $f(t) = \left(\frac{2}{3}\sqrt[4]{xz^3} + \frac{6}{7\sqrt[4]{txz^4}}\right)^2$                     | 17. $f(x) = t^5x^4z^5 + \frac{10t}{3z^4} - \frac{8}{\sqrt{x^3z^2}} - \frac{3}{2x^5}$                                   |
| 7. $f(x) = -\frac{3}{2\sqrt{t^6x^2z^3}} + \frac{3}{4\sqrt[6]{tx^3z^4}} + \frac{10x^6}{3t^3z^2}$       | 18. $f(z) = 4\sqrt[4]{t^3x^3z^3} + \frac{5}{8\sqrt[3]{t^3x^6z^5}} - \frac{1}{10\sqrt[3]{x^5z^4}} + \frac{x^3z^5}{t^5}$ |
| 8. $f(z) = \frac{t^6x^2}{2z^3}$   | 19. $f(z) = -\frac{tx^5}{8}z^5 - \frac{4t}{11}z^5 - \frac{1}{3} + \frac{7z^2}{6t^2x^4}$                                |
| 9. $f(x) = -\frac{11t^2}{3}x^4z^2 + 3\sqrt{x^5} + \frac{1}{4\sqrt[3]{x^3z^6}} + \frac{5}{8t^4x^5z^5}$ | 20. $f(t) = \frac{8x^6}{t^3}$  |
| 10. $f(x) = -\frac{4\sqrt{z^4}}{7}$   | 21. $f(z) = \frac{10t^6}{9}x^2z^3 - \frac{8t}{5}x^3z^5 - 5x^4 + \frac{11}{2\sqrt[4]{t^4x^2z^2}}$                       |
| 11. $f(z) = \left(-\frac{8x}{7}z^4 + \frac{1}{3}\sqrt[4]{t^6x^2z^3}\right)^2$                         | 22. $f(x) = \left(\frac{t^4x^5}{2} + \frac{10x^2}{9t^4}\right)^2$  |

**B) Tangentensteigung eines Polynoms**

Berechne alle Stellen, an denen die Funktion die gegebene Tangentensteigung  $m_T$  hat.

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| 1. $c(x) = -\frac{x^5}{5} + \frac{5x^4}{4} - 2x^3, m_T = 0$                       | 19. $w(x) = \frac{x^5}{5} + \frac{x^4}{4} - 14x^3, m_T = 0$                     |
| 2. $r(x) = \frac{x^4}{8} - \frac{4x^3}{3} + 3x^2 - 6x, m_T = -6$                  | 20. $p(x) = -\frac{x^5}{5} - \frac{x^4}{4} + 4x^3 + 2x, m_T = 2$                |
| 3. $p(x) = \frac{x^3}{2} - 3x^2 + 4x, m_T = -2$                                   | 21. $s(x) = -\frac{x^4}{2} - \frac{14x^3}{3} + 30x^2 - 2x, m_T = -2$            |
| 4. $r(x) = -\frac{2x^5}{7} - \frac{15x^4}{14} + \frac{100x^3}{3} + 7x, m_T = 7$   | 22. $s(x) = \frac{x^3}{9} - \frac{7x^2}{6} + \frac{13x}{3}, m_T = 7$            |
| 5. $b(x) = \frac{7x^5}{30} - \frac{7x^4}{8} - \frac{140x^3}{9} - 2x, m_T = -2$    | 23. $c(x) = -\frac{6x^5}{35} - \frac{15x^4}{14} - \frac{12x^3}{7}, m_T = 0$     |
| 6. $k(x) = \frac{x^4}{8} - \frac{17x^3}{6} + \frac{35x^2}{2}, m_T = 0$            | 24. $i(x) = \frac{x^5}{15} + \frac{x^4}{4} - \frac{28x^3}{9} + 5x, m_T = 5$     |
| 7. $q(x) = \frac{3x^3}{2} + \frac{27x^2}{4} - 10x, m_T = 8$                       | 25. $w(x) = \frac{4x^5}{45} - \frac{4x^4}{9} - \frac{28x^3}{9} - x, m_T = -1$   |
| 8. $q(x) = -\frac{x^3}{6} - \frac{3x^2}{2} + \frac{7x}{2}, m_T = 0$               | 26. $c(x) = -\frac{7x^3}{3} + \frac{35x^2}{2} - 20x, m_T = 8$                   |
| 9. $h(x) = -\frac{11x^4}{36} + \frac{110x^3}{27} - \frac{44x^2}{3} + 5x, m_T = 5$ | 27. $a(x) = -\frac{x^3}{7} - \frac{12x^2}{7} - \frac{36x}{7}, m_T = 0$          |
| 10. $e(x) = \frac{4x^3}{15} - \frac{8x^2}{5} - 57x, m_T = -9$                     | 28. $n(x) = -\frac{2x^5}{15} + \frac{11x^4}{6} - \frac{20x^3}{3} - x, m_T = -1$ |
| 11. $w(x) = \frac{4x^3}{15} + \frac{6x^2}{5} + \frac{13x}{5}, m_T = 1$            | 29. $y(x) = \frac{x^3}{6} - 5x^2 + 50x, m_T = 0$                                |
| 12. $b(x) = -\frac{11x^3}{9} - \frac{77x^2}{6} - 22x, m_T = 0$                    | 30. $r(x) = \frac{5x^4}{16} + \frac{5x^3}{6} + \frac{5x^2}{8} - 5x, m_T = -5$   |
| 13. $q(x) = 2x^3 - 42x^2 + 294x, m_T = 0$   | 31. $k(x) = -\frac{3x^5}{10} - \frac{9x^4}{8} + 14x^3 + 9x, m_T = 9$            |
| 14. $e(x) = -\frac{x^4}{2} - \frac{10x^3}{3} + 14x^2 + 9x, m_T = 9$               | 32. $l(x) = -\frac{11x^4}{4} - 11x^3 + 154x^2 - 2x, m_T = -2$                   |
| 15. $d(x) = -\frac{x^5}{10} + \frac{2x^3}{3} + x, m_T = 1$                        | 33. $p(x) = -\frac{8x^5}{5} + 6x^4 + \frac{32x^3}{3}, m_T = 0$                  |
| 16. $m(x) = \frac{11x^4}{40} - \frac{22x^3}{15} - \frac{33x^2}{5} + 8x, m_T = 8$  | 34. $m(x) = -3x^3 + 54x^2 - 315x, m_T = 0$                                      |
| 17. $a(x) = -\frac{x^4}{12} - \frac{x^3}{9} + 2x^2 - 9x, m_T = -9$                | 35. $a(x) = -\frac{2x^3}{7} - \frac{54x^2}{7} - \frac{486x}{7}, m_T = 0$        |
| 18. $r(x) = -\frac{x^3}{2} - \frac{3x^2}{4} + 133x, m_T = -2$                     | 36. $f(x) = \frac{11x^5}{25} - \frac{11x^4}{4} - \frac{132x^3}{5}, m_T = 0$     |

**A) Lösung: Ableitungsfunktion von einer allgemeinen Potenzfunktion**

1.  $f(t) = \frac{5}{11x^2z}$   
 $f'(t) = 0$
2.  $f(z) = -\frac{5t^4z^2}{2x^2} - t^3x^2z^5 - \frac{9t^2}{4}x^{\frac{2}{3}}z^{\frac{2}{3}} - \frac{10}{t^2z^3}$   
 $f'(z) = -\frac{5t^4}{x^2}z^4 - 5t^3x^2z^4 - \frac{3t^2x^{\frac{2}{3}}}{2\sqrt[3]{z}} + \frac{30}{t^2z^4}$
3.  $f(x) = \frac{4t^2}{z^4}x^6 - \frac{1}{\sqrt[3]{t}} - \frac{7}{10t^{\frac{6}{5}}x^{\frac{3}{5}}z^{\frac{3}{5}}}$   
 $f'(x) = \frac{24t^2}{z^4}x^5 + \frac{21}{50t^{\frac{6}{5}}x^{\frac{8}{5}}z^{\frac{3}{5}}}$
4.  $f(t) = \frac{49x^{\frac{2}{3}}}{4} + \frac{9}{25\sqrt[3]{tz^2}} - \frac{21\sqrt[3]{x}}{5\sqrt[6]{tz}}$   
 $f'(t) = -\frac{3}{25t^{\frac{4}{3}}z^2} + \frac{7\sqrt[3]{x}}{10t^{\frac{5}{6}}z}$
5.  $f(x) = \frac{3x^3}{2z^6}$   
 $f'(x) = \frac{9x^2}{2z^6}$
6.  $f(t) = \frac{4\sqrt{x}}{9}z^{\frac{3}{2}} + \frac{36}{49\sqrt{t}\sqrt{xz^2}} + \frac{8}{7\sqrt[4]{t}\sqrt[4]{z}}$   
 $f'(t) = -\frac{18}{49t^{\frac{3}{2}}\sqrt{xz^2}} - \frac{2}{7t^{\frac{5}{4}}\sqrt[4]{z}}$
7.  $f(x) = \frac{10x^6}{3t^3z^2} - \frac{3}{2t^3xz^{\frac{3}{2}}} + \frac{3}{4\sqrt[6]{t}\sqrt{xz^{\frac{3}{2}}}}$   
 $f'(x) = \frac{20x^5}{t^3z^2} + \frac{3}{2t^3xz^{\frac{3}{2}}} - \frac{3}{8\sqrt[6]{t}z^{\frac{3}{2}}z^{\frac{3}{2}}}$
8.  $f(z) = \frac{t^6x^2}{2z^3}$   
 $f'(z) = -\frac{3t^6x^2}{2z^4}$
9.  $f(x) = -\frac{11t^2}{3}x^4z^2 + 3x^{\frac{5}{2}} + \frac{1}{4x^{\frac{3}{4}}z^{\frac{3}{2}}} + \frac{5}{8t^4x^5z^5}$   
 $f'(x) = -\frac{44t^2}{3}x^3z^2 + \frac{15x^{\frac{3}{2}}}{2} - \frac{3}{16x^{\frac{7}{4}}z^{\frac{3}{2}}} - \frac{25}{8t^4x^6z^5}$
10.  $f(x) = -\frac{4z^2}{7}$   
 $f'(x) = 0$
11.  $f(z) = -\frac{16t^{\frac{3}{2}}}{21}x^{\frac{3}{2}}z^{\frac{19}{4}} + \frac{t^3x}{9}z^{\frac{3}{2}} + \frac{64x^2}{49}z^8$   
 $f'(z) = -\frac{76t^{\frac{3}{2}}}{21}x^{\frac{3}{2}}z^{\frac{15}{4}} + \frac{t^3x}{6}\sqrt{z} + \frac{512x^2}{49}z^7$
12.  $f(t) = -9t^6z^6 + \frac{3x^2}{5}z^2 - \frac{5}{\sqrt{tx^{\frac{3}{2}}}\sqrt{z}} - \frac{1}{5t^{\frac{2}{3}}x^{\frac{2}{3}}z^{\frac{2}{3}}}$   
 $f'(t) = -54t^5z^6 + \frac{5}{2t^{\frac{2}{3}}x^{\frac{2}{3}}\sqrt{z}} + \frac{2}{15t^{\frac{5}{3}}x^{\frac{2}{3}}z^{\frac{2}{3}}}$
13.  $f(z) = 4t^{\frac{4}{3}}x^{\frac{2}{3}}z^{\frac{2}{3}} + \frac{44t^{\frac{2}{3}}}{z^{\frac{17}{3}}}x^{\frac{4}{3}} + \frac{121x^2}{z^{12}}$   
 $f'(z) = \frac{8t^{\frac{4}{3}}x^{\frac{2}{3}}}{3\sqrt[3]{z}} - \frac{748t^{\frac{2}{3}}x^{\frac{4}{3}}}{3z^{\frac{20}{3}}} - \frac{1452x^2}{z^{13}}$
14.  $f(t) = \frac{49x^6}{25} + \frac{49x^2}{15t^5} + \frac{49}{36t^{10}x^2}$   
 $f'(t) = -\frac{49x^2}{3t^6} - \frac{245}{18t^{11}x^2}$
15.  $f(x) = \frac{7t^{\frac{3}{2}}}{5} + \frac{5\sqrt{t}}{8}x^{\frac{5}{2}}z^{\frac{5}{2}} + 3$   
 $f'(x) = \frac{25\sqrt{t}}{16}x^{\frac{3}{2}}z^{\frac{5}{2}}$
16.  $f(x) = -10\sqrt[4]{tx}$   
 $f'(x) = -10\sqrt[4]{t}$
17.  $f(x) = t^5x^4z^5 + \frac{10t}{3z^4} - \frac{3}{2x^5} - \frac{8}{x^{\frac{3}{2}}z}$   
 $f'(x) = 4t^5x^3z^5 + \frac{15}{2x^6} + \frac{12}{x^{\frac{5}{2}}z}$
18.  $f(z) = 4t^{\frac{3}{4}}x^{\frac{3}{4}}z^{\frac{3}{4}} - \frac{1}{10x^{\frac{5}{3}}z^{\frac{4}{3}}} + \frac{5}{8tx^2z^{\frac{5}{3}}} + \frac{x^3z^5}{t^5}$   
 $f'(z) = \frac{3t^{\frac{3}{4}}x^{\frac{3}{4}}}{4\sqrt[4]{z}} + \frac{2}{15x^{\frac{5}{3}}z^{\frac{7}{3}}} - \frac{25}{24tx^2z^{\frac{8}{3}}} + \frac{5x^3z^4}{t^5}$
19.  $f(z) = -\frac{tx^5}{8}z^5 - \frac{4t}{11}z^5 - \frac{1}{3} + \frac{7z^2}{6t^2x^4}$   
 $f'(z) = -\frac{5t}{8}x^5z^4 - \frac{20t}{11}z^4 + \frac{7z}{3t^2x^4}$
20.  $f(t) = \frac{8x^6}{t^3}$   
 $f'(t) = -\frac{24x^6}{t^4}$
21.  $f(z) = \frac{10t^6}{9}x^2z^3 - \frac{8t}{5}x^3z^5 - 5x^4 + \frac{11}{2t\sqrt{x}\sqrt{z}}$   
 $f'(z) = \frac{10t^6}{3}x^2z^2 - 8tx^3z^4 - \frac{11}{4t\sqrt{x}z^{\frac{3}{2}}}$
22.  $f(x) = \frac{t^8x^{10}}{4} + \frac{10x^7}{9} + \frac{100x^4}{81t^8}$   
 $f'(x) = \frac{5t^8}{2}x^9 + \frac{70x^6}{9} + \frac{400x^3}{81t^8}$

**B) Lösung: Tangentensteigung eines Polynoms**

1.  $c'(x) = -x^4 + 5x^3 - 6x^2$   
 $x_1 = 0, x_2 = 2, x_3 = 3$
2.  $r'(x) = \frac{x^3}{2} - 4x^2 + 6x - 6$   
 $x_1 = 0, x_2 = 2, x_3 = 6$
3.  $p'(x) = \frac{3x^2}{2} - 6x + 4$   
 $x_1 = 2$
4.  $r'(x) = -\frac{10x^4}{7} - \frac{30x^3}{7} + 100x^2 + 7$   
 $x_1 = -10, x_2 = 0, x_3 = 7$
5.  $b'(x) = \frac{7x^4}{6} - \frac{7x^3}{2} - \frac{140x^2}{3} - 2$   
 $x_1 = -5, x_2 = 0, x_3 = 8$
6.  $k'(x) = \frac{x^3}{2} - \frac{17x^2}{2} + 35x$   
 $x_1 = 0, x_2 = 7, x_3 = 10$
7.  $q'(x) = \frac{9x^2}{2} + \frac{27x}{2} - 10$   
 $x_1 = -4, x_2 = 1$
8.  $q'(x) = -\frac{x^2}{2} - 3x + \frac{7}{2}$   
 $x_1 = -7, x_2 = 1$
9.  $h'(x) = -\frac{11x^3}{9} + \frac{110x^2}{9} - \frac{88x}{3} + 5$   
 $x_1 = 0, x_2 = 4, x_3 = 6$
10.  $e'(x) = \frac{4x^2}{5} - \frac{16x}{5} - 57$   
 $x_1 = -6, x_2 = 10$
11.  $w'(x) = \frac{4x^2}{5} + \frac{12x}{5} + \frac{13}{5}$   
 $x_1 = -2, x_2 = -1$
12.  $b'(x) = -\frac{11x^2}{3} - \frac{77x}{3} - 22$   
 $x_1 = -6, x_2 = -1$
13.  $q'(x) = 6x^2 - 84x + 294$   
 $x_1 = 7$
14.  $e'(x) = -2x^3 - 10x^2 + 28x + 9$   
 $x_1 = -7, x_2 = 0, x_3 = 2$
15.  $d'(x) = -\frac{x^4}{2} + 2x^2 + 1$   
 $x_1 = -2, x_2 = 0, x_3 = 2$
16.  $m'(x) = \frac{11x^3}{10} - \frac{22x^2}{5} - \frac{66x}{5} + 8$   
 $x_1 = -2, x_2 = 0, x_3 = 6$
17.  $a'(x) = -\frac{x^3}{3} - \frac{x^2}{3} + 4x - 9$   
 $x_1 = -4, x_2 = 0, x_3 = 3$
18.  $r'(x) = -\frac{3x^4}{2} - \frac{3x}{2} + 133$   
 $x_1 = -10, x_2 = 9$
19.  $w'(x) = x^4 + x^3 - 42x^2$   
 $x_1 = -7, x_2 = 0, x_3 = 6$
20.  $p'(x) = -x^4 - x^3 + 12x^2 + 2$   
 $x_1 = -4, x_2 = 0, x_3 = 3$
21.  $s'(x) = -2x^3 - 14x^2 + 60x - 2$   
 $x_1 = -10, x_2 = 0, x_3 = 3$
22.  $s'(x) = \frac{x^2}{3} - \frac{7x}{3} + \frac{13}{3}$   
 $x_1 = -1, x_2 = 8$
23.  $c'(x) = -\frac{6x^4}{7} - \frac{30x^3}{7} - \frac{36x^2}{7}$   
 $x_1 = -3, x_2 = -2, x_3 = 0$
24.  $i'(x) = \frac{x^3}{3} + x^3 - \frac{28x^2}{3} + 5$   
 $x_1 = -7, x_2 = 0, x_3 = 4$
25.  $w'(x) = \frac{4x^4}{9} - \frac{16x^3}{9} - \frac{28x^2}{3} - 1$   
 $x_1 = -3, x_2 = 0, x_3 = 7$
26.  $c'(x) = -7x^2 + 35x - 20$   
 $x_1 = 1, x_2 = 4$
27.  $a'(x) = -\frac{3x^2}{7} - \frac{24x}{7} - \frac{36}{7}$   
 $x_1 = -6, x_2 = -2$
28.  $n'(x) = -\frac{2x^4}{3} + \frac{22x^3}{3} - 20x^2 - 1$   
 $x_1 = 0, x_2 = 5, x_3 = 6$
29.  $y'(x) = \frac{x^2}{2} - 10x + 50$   
 $x_1 = 10$
30.  $r'(x) = \frac{5x^3}{4} + \frac{5x^2}{2} + \frac{5x}{4} - 5$   
 $x_1 = -1, x_2 = 0$
31.  $k'(x) = -\frac{3x^4}{2} - \frac{9x^3}{2} + 42x^2 + 9$   
 $x_1 = -7, x_2 = 0, x_3 = 4$
32.  $l'(x) = -11x^3 - 33x^2 + 308x - 2$   
 $x_1 = -7, x_2 = 0, x_3 = 4$
33.  $p'(x) = -8x^4 + 24x^3 + 32x^2$   
 $x_1 = -1, x_2 = 0, x_3 = 4$
34.  $m'(x) = -9x^2 + 108x - 315$   
 $x_1 = 5, x_2 = 7$
35.  $a'(x) = -\frac{6x^4}{7} - \frac{108x}{7} - \frac{486}{7}$   
 $x_1 = -9$
36.  $f'(x) = \frac{11x^4}{5} - 11x^3 - \frac{396x^2}{5}$   
 $x_1 = -4, x_2 = 0, x_3 = 9$

**A) Tangentengleichung**

Berechne die Tangentengleichung  $y_T$  von  $f(x)$  an der Stelle  $x_0$ .

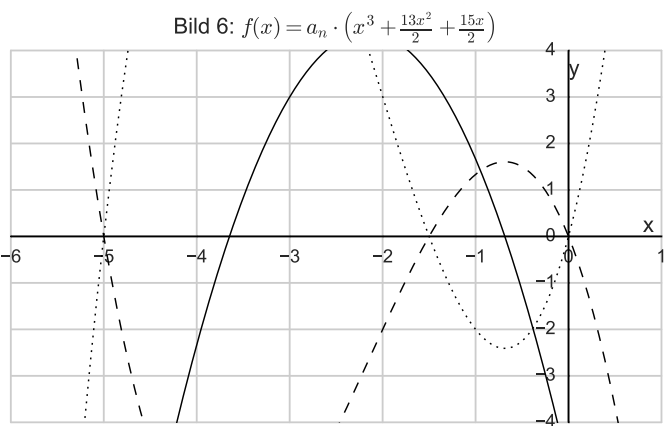
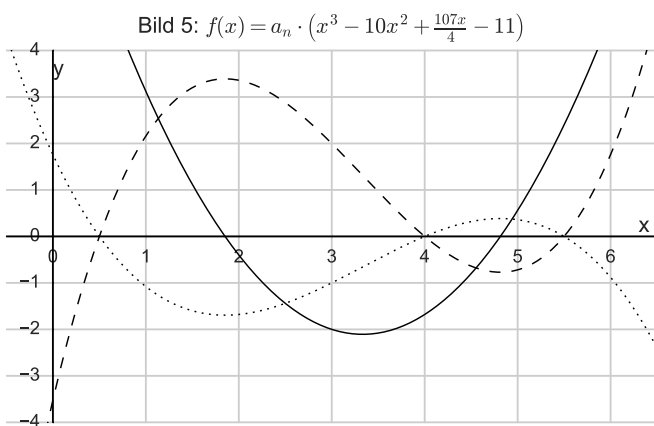
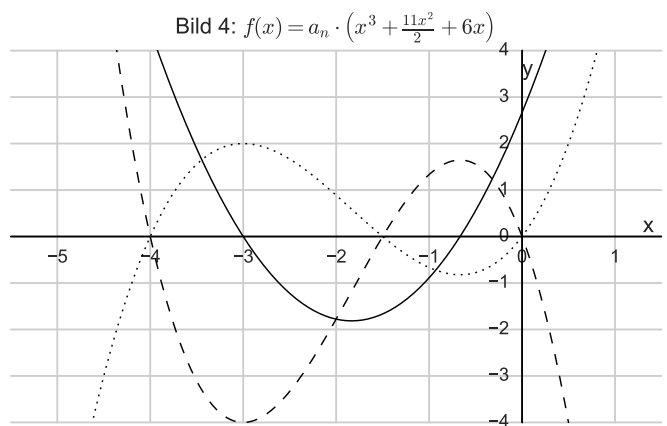
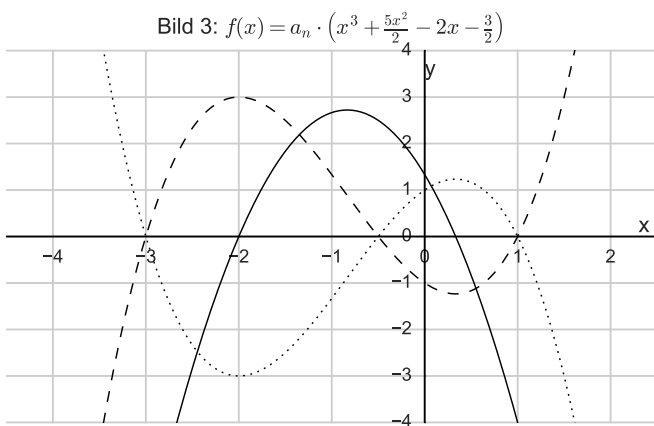
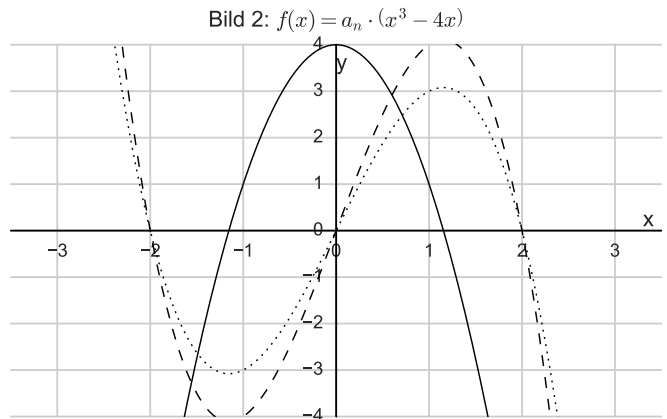
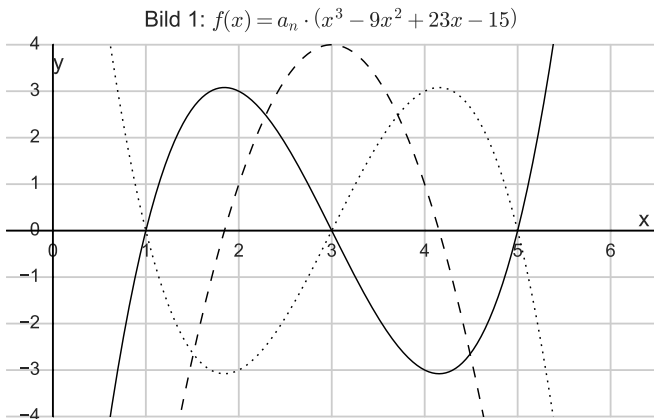
1.  $f(x) = 5x, x_0 = 2$
2.  $f(x) = -\frac{5x}{2}, x_0 = -2$
3.  $f(x) = -\frac{x^3}{4} + \frac{5x^2}{2} - 4x, x_0 = -2$
4.  $f(x) = \left(\frac{x^3}{3} + 4x^2\right)^2, x_0 = 1$
5.  $f(x) = -\frac{5x^3}{3}, x_0 = 2$
6.  $f(x) = \frac{2x}{3}, x_0 = 3$
7.  $f(x) = -\frac{2x^2}{3}, x_0 = 1$
8.  $f(x) = -\frac{x^2}{5}, x_0 = -1$
9.  $f(x) = \left(-x^2 + \frac{x}{3}\right)^2, x_0 = 3$
10.  $f(x) = -\frac{23x^3}{15} + x^2, x_0 = -2$
11.  $f(x) = \frac{576x^2}{25}, x_0 = -1$
12.  $f(x) = \frac{5x}{4}, x_0 = -1$
13.  $f(x) = -\frac{x^3}{4} - \frac{7x^2}{5} + \frac{2x}{3}, x_0 = 3$
14.  $f(x) = \frac{11x^2}{6}, x_0 = 0$
15.  $f(x) = \left(-\frac{3x^3}{2} - \frac{x}{3}\right)^2, x_0 = -1$
16.  $f(x) = \left(-6x^2 - \frac{x}{3}\right)^2, x_0 = 3$
17.  $f(x) = \frac{4x^2}{3} - \frac{11x}{4}, x_0 = -3$
18.  $f(x) = \left(\frac{4x^2}{5} - 2x\right)^2, x_0 = 2$
19.  $f(x) = -\frac{4x^3}{5} + 3x^2, x_0 = 2$
20.  $f(x) = -\frac{52x^3}{15} + \frac{x^2}{3}, x_0 = -2$
21.  $f(x) = x^3 - \frac{x^2}{2}, x_0 = -2$
22.  $f(x) = \left(-\frac{6x^3}{5} - 3x^2\right)^2, x_0 = 2$
23.  $f(x) = -6x, x_0 = -1$
24.  $f(x) = -\frac{x^3}{2}, x_0 = 0$

1.  $f(x) = 5x, y_T = 5x$
2.  $f(x) = -\frac{5x}{2}, y_T = -\frac{5}{2}x + 5$
3.  $f(x) = -\frac{x^3}{4} + \frac{5x^2}{2} - 4x, y_T = -\frac{4}{5}x^3 + \frac{7}{2}x^2 - 4x + 4$
4.  $f(x) = \frac{6}{x^6} + \frac{3}{8x^5} + \frac{3}{40x^4} + \frac{3}{16x^3} + 64x^3, y_T = -17x - 14$
5.  $f(x) = -\frac{5x^3}{3}, y_T = -5x^2 + \frac{3}{80}$
6.  $f(x) = \frac{3}{2x}, y_T = \frac{3}{2x}$
7.  $f(x) = -\frac{3}{2x^2}, y_T = -\frac{3}{4x} + \frac{3}{2}$
8.  $f(x) = \frac{5}{x^2} + \frac{5}{3}, y_T = \frac{5}{x^2} + \frac{5}{3}$
9.  $f(x) = x^4 - \frac{2x^3}{5} + \frac{3}{2x^2}, y_T = 4x^3 - \frac{6x^2}{5} - \frac{3}{x^3} + \frac{3}{2}$
10.  $f(x) = -\frac{23x^3}{3} + x^2, y_T = -\frac{23}{3}x^2 + 2x$
11.  $f(x) = \frac{576x^2}{25}, y_T = \frac{1152x}{25}$
12.  $f(x) = \frac{5x}{4}, y_T = \frac{5}{4}$
13.  $f(x) = -\frac{x^3}{4} - \frac{7x^2}{5} + \frac{2x}{3}, y_T = -\frac{3}{4}x^2 - \frac{14}{5}x + \frac{2}{3}$
14.  $f(x) = \frac{11x^2}{6}, y_T = \frac{11}{3}x$
15.  $f(x) = \frac{9x^4}{6} + x^4 + \frac{9}{x^2}, y_T = \frac{4}{9}x^3 + 4x^3 + \frac{9}{x^3}$
16.  $f(x) = 36x^4 + 4x^3 + \frac{9}{x^2} + \frac{9}{2x}, y_T = 144x^3 + 12x^2 + \frac{9}{2x^2} - \frac{9}{1990x}$
17.  $f(x) = \frac{4x^2}{3} - \frac{11x}{4}, y_T = \frac{8}{3}x - \frac{11}{4}$
18.  $f(x) = \left(\frac{4x^2}{5} - 2x\right)^2, y_T = \frac{16x^4}{25} - \frac{16x^3}{5} + 4x^2$
19.  $f(x) = -\frac{4x^3}{5} + 3x^2, y_T = -\frac{4}{5}x^2 + 6x$
20.  $f(x) = -\frac{52x^3}{15} + \frac{x^2}{3}, y_T = -\frac{52}{5}x^2 + \frac{2}{3}x$
21.  $f(x) = x^3 - \frac{x^2}{2}, y_T = 3x^2 - \frac{x}{2} + 18$
22.  $f(x) = \frac{36x^5}{5} + \frac{5}{36x^5} + 9x^4, y_T = \frac{216x^4}{5} + 36x^4 + \frac{28512x}{9072} - \frac{25}{5}$
23.  $f(x) = -6x, y_T = -6x$
24.  $f(x) = -\frac{x^3}{2}, y_T = -\frac{3}{2}x^2$

**B) Tangentengleichung, Schaubilder von Funktionen und ihre Ableitungen**

Ordne die Schaubilder A, B und C den Funktionen  $f(x)$ ,  $f'(x)$  und  $g(x)$  zu und bestimme den Funktionsterm von  $f(x)$ . Gib außerdem die Tangentengleichung  $y_T$  an der kleinsten Nullstelle von  $f(x)$  an.

— A    - - - B    ····· C



5. A:  $f'(x)$ , B:  $f(x)$ , C:  $g(x)$   
 $f(x) = \frac{8x^3}{25} - \frac{16x^2}{214} + \frac{5}{25} - \frac{25}{88}$   
 $f'(x) = \frac{24x^2}{25} - \frac{32x}{214} + \frac{5}{25}$   
 $y_T = -\frac{25}{168} + \frac{25}{168}$  bei  $x_0 = 0.5$

3. A:  $f'(x)$ , B:  $g(x)$ , C:  $f(x)$   
 $f(x) = -\frac{2x^3}{3} - \frac{5x^2}{2} + \frac{3}{4} + 1$   
 $f'(x) = -2x^2 - 5x + \frac{3}{4}$   
 $y_T = -4x + 4$  bei  $x_0 = -3.0$

1. A:  $g(x)$ , B:  $f'(x)$ , C:  $f(x)$   
 $f(x) = -x^3 + 9x^2 - 23x + 15$   
 $f'(x) = -3x^2 + 18x - 23$   
 $y_T = 4x - 12$  bei  $x_0 = 1.0$

6. A:  $f'(x)$ , B:  $f(x)$ , C:  $g(x)$   
 $f(x) = -\frac{2x^3}{3} - \frac{13x^2}{2} - 5x$   
 $f'(x) = -2x^2 - \frac{13x}{2} - 5$   
 $y_T = -5x$  bei  $x_0 = -5.0$

4. A:  $f'(x)$ , B:  $g(x)$ , C:  $f(x)$   
 $f(x) = \frac{6x^3}{8} + \frac{22x^2}{8} + \frac{3}{8}$   
 $f'(x) = \frac{3}{4} + \frac{44x}{4} + \frac{3}{8}$   
 $y_T = \frac{3}{8}x$  bei  $x_0 = -4.0$

2. A:  $f'(x)$ , B:  $g(x)$ , C:  $f(x)$   
 $f(x) = -x^3 + 4x$   
 $f'(x) = -3x^2 + 4$   
 $y_T = -8x - 16$  bei  $x_0 = -2.0$