Problem A. Graphing rational functions.

(1) Defined for $x \neq 0$; continuous for $x \neq 0$; differentiable for all $x \neq 0$; increasing nowhere; decreasing for all $x \neq 0$; concave up for $x > 0$; concave down for $x < 0$; critical point at $x = 0$; no point of inflection; asymptote $y = 0$ as $x \to 0$; asymptote $x = 0$ as $x \to \pm \infty$.

(2) Defined for $x \neq 0$; continuous for $x \neq 0$; differentiable for all $x \neq 0$; increasing for $x > 0$; decreasing for all $x < 0$; concave up nowhere; concave down for $x \neq 0$; critical points at $x = 0$; no points of inflection; asymptote $y = 0$ as $x \to 0$.

(3) Defined for $x \neq 0$; continuous for $x \neq 0$; differentiable for all $x \neq 0$; increasing for $x < -1, x > 1$; decreasing for all $-1 < x < 0, 0 < x < 1$; concave up for $x > 0$; concave down for $x < 0$; critical points at $x = 0, \pm 1$; no points of inflection; asymptote $x = 0$ as $x \to 0$; asymptote $y = x$ as $x \to \pm \infty$.

(4) Defined for $x \neq 4$; continuous for $x \neq 4$; differentiable for all $x \neq 4$; increasing for $x < 2, x > 6$; decreasing for all $2 < x < 4, 4 < x < 6$; concave up for $x > 4$; concave down for $x < 4$; critical points at $x = 2, 4, 6$; no points of inflection; asymptote $x = 4$ as $x \to 4$; asymptote $y = x$ as $x \to \pm \infty$.

(5) Defined for all $x$; continuous for all $x$; differentiable for all $x$; increasing for $x < 0$; decreasing for all $x > 0$; concave up for $x < -1/\sqrt{3}, x > 1/\sqrt{3}$; concave down for $-1/\sqrt{3} < x < \sqrt{3}$; critical point at $x = 0$; points of inflection at $x = \pm 1/\sqrt{3}$; asymptote $y = 0$ as $x \to \pm \infty$.

Problem B. Graphing functions with square roots.

(1-5) Circles.

(6-8) Ellipses.

(9-10) Hyperbolas.

(11-16) Parabolas.

(18) This problem appeared before on this homework assignment (almost).

(19) Make this one into problem (B18).
Problem C. Graphing other functions.

(1) Defined for all $x \neq 0, \pm 1, \pm 2, \ldots$; differentiable for all $x \neq 0, \pm 1, \pm 2, \ldots$; increasing nowhere; decreasing nowhere; concave up nowhere; concave down nowhere; all points are critical points; no points of inflection; no asymptotes;

(2) Defined for all $x$; continuous for all $x$; differentiable for $x \neq 0$; increasing for $x > 0$; decreasing for $x < 0$; concave up nowhere; concave down nowhere; critical point at $x = 0$; no points of inflection; asymptote $y = x$ as $x \to \infty$; asymptote $y = -x$ as $x \to -\infty$;

(3) Defined for all $x$; continuous for all $x$; differentiable for $x \neq 5$; increasing for $x > 5$; decreasing for $x < 5$; concave up nowhere; concave down nowhere; critical point at $x = 5$; no points of inflection; asymptote $y = x$ as $x \to \infty$; asymptote $y = -x$ as $x \to -\infty$;

(4) Defined for all $x$; continuous for all $x$; differentiable for $x \neq \pm 1$; increasing for $-1 < x < 0$, $x > 1$; decreasing for $x < -1$, $0 < x < 1$; concave up for $x < -1$, $x > 1$; concave down for $-1 < x < 1$; critical points at $x = \pm 1, 0$; no points of inflection; no asymptotes;

(5) Defined for all $x$; continuous for all $x$; differentiable for $x \neq 0$; increasing nowhere; decreasing nowhere; concave up nowhere; concave down nowhere; critical point at $x = 0$; no points of inflection; asymptotes $y = 1$ as $x \to \infty$; asymptotes $y = -1$ as $x \to -\infty$;

(6) Defined for all $x$; continuous for all $x$; differentiable for $x \neq 1$; increasing for all $x$; decreasing nowhere; concave up for $x < 1$; concave down for $x > 1$; critical point at $x = 1$; point of inflection at $x = 1$; no asymptotes;

(7) Defined for all $x$; continuous for all $x$; differentiable for $x \neq 0$; increasing for $x > 0$; decreasing for $x < 0$; concave up nowhere; concave down everywhere; critical point at $x = 0$; no points of inflection; no asymptotes;

(8) Defined for $x \neq 1$; continuous for all $x \neq 1$; differentiable for $x \neq 1$; increasing for $x < 1$; decreasing for $x > 1$; concave up everywhere; concave down nowhere; critical point at $x = 1$; no points of inflection; no asymptotes;

(12) See page 153 in the text.

(13) Make this one into problem (C12).

(14) Defined for all $x$; continuous for all $x$; differentiable for $x$; increasing for $2k\pi + \pi/2 < x < 2k\pi + \pi/2$, where $k$ is an integer; decreasing for $2k\pi + \pi/2 < x < 2k\pi + 3\pi/2$, where $k$ is an integer; concave up for $2k\pi - \pi < x < 2k\pi$, where $k$ is an integer; concave down
for \( 2k\pi < x < 2k\pi + \pi \), where \( k \) is an integer; critical points at \( x = k\pi + \pi/2 \), where \( k \) is an integer; points of inflection at \( x = k\pi \), where \( k \) is an integer; no asymptotes;

(15) Compare the graphs of \( y = \sin 2x \) and \( y = x \).

**Problem D. Rolle’s theorem and the mean value theorem.**

(4) \( c = 2 \pm \sqrt{3}/3 \)  
(5) \( c = 9/4 \)  
(6) \( c = 3\pi/2 \)

(7) \( c = \pi/4 \)  
(8) \( c = 2 \pm \sqrt{3}/3 \)  
(11) \( f(1) \neq f(3) \)

(12) \( f'(1) \) does not exist  
(13) \( f(x) \) is discontinuous at \( x = 0 \)

(14) \((3,6)\)  
(17) \( c = 8/27 \)  
(18) \( c = e - 1 \)  
(20) \( c = (a + b)/2 \)

(21) \( f'(0) \) does not exist  
(22) \( f(x) \) is discontinuous at \( x = 0 \)

(23) \((\sqrt{7}/3, (−2/3)(\sqrt{7}/3)), (−\sqrt{7}/3, (2/3)(\sqrt{7}/3))\)

**Problem E. Tangents and Normals.**

(1) 11  
(2) −12

(3) \( x - y + 5 = 0, \ x + y - 7 = 0 \)

(4) \( x - 4y + 3 = 0, \ 4x + y - 5 = 0 \)

(5) \( 14x - y - 10 = 0, \ x + 14y - 254 = 0 \)

(6) \( m^2x - my + a = 0, \ m^2x + m^3y - 2am^2 - a = 0 \)

(7) \( bx \cos \theta + ay \sin \theta = ab, \ ax \sec \theta - by \csc \theta = (a^2 - b^2) \)

(8) \( bx \sec \theta - ay \tan \theta = ab, \ x \sin \theta - y \cos \theta = (a/4) \sin 4\theta \)

(9) \( x \cos^3 \theta + y \sin^3 \theta = c, \ x \sin^3 \theta - y \cos^3 \theta + 2c \cot 2\theta = 0 \)

(10) \( x - ty + at^2 = 0, \ tx + y = at^3 + 2at \)

(11) \( 2x + 3my - 18m^2 - 27m^4 = 0 \)