1) Use the limit definition of the derivative to explore why $x^2|x|$ is differentiable at the point $(0,0)$ and why $|x|$ is not differentiable at the point $(0,0)$. How can you generalize this?

2) Differentiate the following functions.
   a) $f(x) = x\sqrt{x^2 - 3}$
   b) $g(x) = \frac{x^3 + 2}{x^2 + 1}$
   c) $h(x) = (3x^2 - 1)\left(x^2 - \frac{1}{x}\right)$
   d) $r(x) = \frac{x^3 + 2x^2 + x - 1}{\sqrt{x}}$

3) Differentiate the following functions:
   a) $h(x) = \frac{x^2 - x + 1}{(x-1)^{1/3}}$
   b) $k(x) = \begin{cases} \frac{x^2 - 1}{x+2}, & x > -1 \\ x + 2, & x \leq -1 \end{cases}$
   c) $n(x) = \sin^2(\cos(4x))$

4) Find...

5) Given $f(x) = 3x^2 \sqrt{4 - x^2}$
   a) Find $\frac{df}{dx}$
   b) Where are the horizontal and vertical tangents?

6) For the following equation:
   \[ 5x^2y - y^3 = 1 + x^2 \]
   a) Find $\frac{dy}{dx}$.
   b) Find the equation of the tangent line to the curve at the point $(1,2)$.

7) Find the derivatives of the following functions by using the limit definition.
   a) $f(x) = \frac{x}{x+3}$
   b) $g(x) = \sin(x)$

8) For what values of $x$ does the function $g(x) = x + 2\sin x$ have horizontal tangent lines?

9) Suppose $f(x) = ax^2 + bx + c$ and that the tangent lines at $x = 1$ and $x = -1$ have slopes $-8$ and $-1$ respectively, and that the point $(2,15)$ is a point on the graph. What are the values of $a, b,$ and $c$?
10) Find the values of $a$ so that the tangent line to $y = x^2 - 2\sqrt{x} + 1$ is perpendicular to the line $ay + 2x = 2$ at $x = 4$.

11) The position, in meters, of a particle at time $t$ is given by

$$s(t) = t^3 - 9t^2 + 15t - 12$$

where $t$ is measured in seconds.

a) Find the particles average rate of change from 2 to 4 seconds.

b) Find a function for the velocity at time $t$.

c) What is the particle's instantaneous rate of change at 2 seconds?

d) At which time(s) does the particle come to a stop?

e) What is its position at the time the particle first comes to a stop?

12) Given the graph below:

Identify where the function...

a) is increasing,

b) is decreasing,

c) has horizontal tangents,

d) has vertical tangents,

e) is not differentiable. Can you classify the types of non-differentiability.

f) Now use the answers above to sketch a graph of the derivative.

13) Take the derivatives of the following functions [using logarithms]:

a) $f(x) = 5\tan^2(x)$

b) $g(x) = x^\sin(x)$

c) $h(x) = \frac{e^{3x+1}(x^2+3)^3}{\sqrt{2x-1}}$

14) Gravel is being dumped from a conveyor belt at a rate of 30 ft$^3$/min. As it falls from the conveyor belt, it forms a pile in the shape of a cone whose base diameter and height are always equal. How fast is the height of the pile increasing when the pile is 10 ft high?

15) Approximate $1.976$ using differentials.

16) Use the linearization of the function $\sqrt{3x - 4}$ at $a = 4$ to approximate the value of $\sqrt{8.012}$.

17) The radius of a sphere is given as 24 cm with a maximum error in measurement of 0.2 cm.

a) Use differentials to estimate the maximum error in the calculated volume of the sphere.

b) What is the relative error? What is the percentage error?

18) Find the $x$ values where the curve represented by the following equation has horizontal tangent lines.

$$x^2 + xy + y^2 = 6$$