1. The variables $x$ and $y$ are related as follows: 

$$(x^2 + y^2 - x)^2 = x^2 + y^2.$$ 

Find the slope of the tangent lines at the points $(0, 1)$ and $(0, -1)$.

2. Graph the following function using information gained from the first and second derivatives $f(x) = xe^{-x}$.

3. Let $g(x) = \sin(\arctan x)$ and let $h(x) = x(1 + x^2)^{-1/2}$. Find $g'(x)$ and $h'(x)$ Show that $g(x)/g'(x) = h(x)/h'(x)$. What can you conclude from this?

4. A conical ice cube, whose radius $r$ is equal to its height $h$, is put on a hot plate and begins to melt. The hot plate’s heating element is getting warmer, and the rate at which the ice melts ($dV/dt$, where $t$ is measured in seconds) is equal to $-\sqrt{\pi}A$ where $A$ is the area of the base. Find $V$ in terms of $h$ and find $dh/dt$ in terms of $h$.

5. Let $g(x) = (1 - \cos x)/x$ if $x \neq 0$ and let $g(x) = 0$ if $x = 0$. Is $g$ continuous at $x = 0$? Why or why not?

6. Note that $[x \sin x]' = \sin x + x \cos x$. Using your knowledge of differentiation, find an antiderivative for $x \cos x$.

7. Graph the function $f$ where $f(x) = 2x^3 + 3x^2 - 36x - 10$ using the first and second derivatives. Your work must be consistent with your final answer. A correct graph with incorrect computations will receive no credit. You should also label any relative maximums, any relative minimums, any points of inflection, and any asymptotes.

8. A piece of wire 10 meters long is cut into two pieces. One piece is bent into a square and the other into an equilateral triangle. How should the wire be cut so that the total area (of the square and triangle) is a maximum? a minimum?

9. A stone is dropped from a cliff and its velocity at time $t$ is observed to be $v(t) = -32t$ (ft/sec), that is, until it hits the ground at time $t = 5$ (seconds). What does the position function $s(t)$ look like and how high is the cliff?
10. Find the absolute maximum and the absolute minimum value of the function \( g(x) = \sqrt{x(3-x)} \) on the interval \([0, 3]\) (which, in fact, is its domain). Your work must justify your answer.

11. The function \( h \) is differentiable everywhere and the following three values are known: \( h(1) = 1, h(2) = 3, \) and \( h(3) = 0 \). A professor claims in addition that \(-2 < h'(x) < 2\) for all real numbers \( x \). Is this possible? Why or why not?

12. Find the linear function which best \emph{approximates} the function \( \sqrt{x} \) at \( x = 9 \).

13. Find

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\lim_{x \to \infty} \frac{\ln x}{x^{1.0001}}
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