1. (a) Let $a$ and $b$ be constants. Find the derivative of $F(x) = x^a \sec(b^x)$.

   (b) Show that $\arctan(x) + \arctan(1/x) = C$. For some constant $C$.

2. Consider the function $f(x) = x^3 e^{-3x^2}$.

   (a) (3 points) Compute any horizontal asymptotes of $f$, or show none exist.

   (b) (4 points) For what values of $x$ is $f$ increasing? *Justify.*

   (c) At what $x$ values does $f$ have local extrema? *Justify.*

3. The class flag is being raised up a pole with height function $H(t) = 5t^2 + 2$ (in meters). Matt is 2 meters tall, and is walking away from the flagpole with position $x(t) = 5t - 1$. When he is 4 meters from the flagpole what is the rate at which the distance between the top of Matt's head and the flag changing?

4. Albert has $4\pi$ $\text{m}^3$ of clay and must make **both** a solid sphere and a solid cube. If Albert shapes the clay so that the product $P =$ (surface area of sphere) $\cdot$ (volume of cube) is maximized, what is the radius of the sphere? Justify your answer coincides with a max. ($V_{sphere} = \frac{4}{3}\pi r^3$, $V_{cube} = w^3$, $SA_{sphere} = 4\pi r^2$.)

5. Let $C$ be the curve given by the relation $\sin(\pi xy) = 0$.

   (a) Find the equation of the tangent line at the point $(x, y) = (\pi, \frac{1}{\pi})$.

   (b) Using linear approximation, approximate the value of $b$ for which $(\frac{3}{2}\pi, b)$ lies on $C$. *Give an exact answer.*

6. Using the **limit definition** of the derivative find $g'(0)$ if $g(x) = \begin{cases} x^3 \ln\left(\frac{1}{x^2}\right), & x > 0 \\ 0, & x \leq 0 \end{cases}$