This taxing but fun fifty-minute test covers sections 2.5 through 3.4 of *Calculus: Early Transcendentals* (5ed) by James Stewart. Clearly indicate your answers. Unless otherwise indicated, all parts of problems are four points each.

1. Find the indicated limits.
   
   a. \( \lim_{x \to \infty} \left( \sqrt{9x^2 + x} - 3x \right) \)
   
   b. \( \lim_{x \to -\infty} \frac{\sqrt{9x^2 + x}}{x} \)
   
   c. \( \lim_{x \to 0} \frac{\sin 5x}{\tan 3x} \)
   
   d. \( \lim_{x \to 0} \frac{1 - \cos(5x)}{3x} \)

2. For what value of \( a \) is the function \( f(x) \) continuous \((-\infty, \infty)\)?

   \[
   f(x) = \begin{cases} 
   2x & \text{if } x > 5 \\
   3 - ax & \text{if } x < 5 
   \end{cases}
   \]

3. A calculus test is thrown in the air and its height in feet is given by \( s = 40t - 16t^2 \). Find its velocity when \( t = 2 \).
4. Use a limit definition of derivative to show the derivative of $1-3x^2$ is $6x$.  (6 points)

5. If $f$ is the focal length of a convex lens and an object is placed at a distance $p$ from the lens, then its image will be at a distance $q$ from the lens, where $f$, $p$, and $q$ are related by the lens equation:

\[
\frac{1}{f} = \frac{1}{p} + \frac{1}{q}
\]

For a fixed focal length $f$, find the rate of change of $q$ with respect to $p$.  (6 points)

6. Using the graphs on the right, find $u'(1)$ where $u(x) = f(x)g(x)$.  (6 points)
7. The curve \( y = 1/(1 + x^2) \) is called the witch of Agnesi. Find the equation of the tangent line to this curve at the point (2, 1/5).

8. Find the (first) derivative of the following

a) \( x^{51} - 3x^{32} - 23 \)

b) \( x \tan x \)

c) \( e^x \sin x \)

d) \( \frac{1 - x^2}{1 + x^2} \)

e) \( 4\pi^2 \)

f) \( \cos x \sec x \)

g) \( \sqrt[3]{t^2} + \sqrt{t^3} \)

h) \( \sqrt{x} (x - 1) \)