Show work and write clearly.

1. (10 pts.) Derive the formula for the derivative of $\cos^{-1}(x)$.

2. (30 pts.) Find the derivatives of the following:
   a. $y = \cos^{-1}(\sin x)$
   b. $y = \sec^{-1}(e^x)$
   c. $y = x^3\sqrt{1 + x^2}$
   d. $y = (\ln x)^{\tan x}$
   e. $y = x^{(e^x)}$

3. (10 pts.) One hundred fruit flies are placed in a breeding container that can support a population of at most 5000 flies. If the population grows with a constant relative growth rate of 2% per day, how long will it take for the container to reach capacity?

4. (40 pts.) Find the following limits:
   a. $\lim_{x \to 2} \frac{\sqrt{x^2 + 5} - 3}{x^2 - 4}$
   b. $\lim_{x \to 0^+} x \ln x$
   c. $\lim_{x \to 0} \frac{1 - \cos x}{x + x^2}$
   d. $\lim_{x \to \infty} \left(x - \sqrt{x^2 + x}\right)$
   e. $\lim_{x \to 0} \frac{\sqrt{1 + x} - 1 - x}{x^2}$

5. (10 pts.) Forty percent of a radioactive substance decays in 5 years. How long would it take the sample to decay to 1% of its original amount?