1. (15 points) Find the following limits. If a limit does not exist write ‘DNE’.

   a) \( \lim_{{x \to 0}} \frac{x^2 - x}{x} \)

   b) \( \lim_{{x \to 3}} \frac{x^2 + 1}{x - 3} \)

   c) \( \lim_{{x \to \infty}} \frac{\sqrt{x^2 + x - 4}}{x + 3} \)
2. (24 points) Find the following derivatives. (Do not simplify.)

a) \( f(x) = 3e^{x^2} + x^4 + (2x + 1)^9 \)

b) \( f(x) = x^3e^{\sqrt{x}} \)

c) \( f(x) = \ln(x^3 + 8x + 1) \)

d) \( f(x) = \frac{(x^2 + 8x + 3)}{(2x + 1)} \)
3. (15 points) Given \( f(x) = \frac{4x + 8}{x - 3} \). Find (if any)
   a) The \( x \)-intercept(s) and the \( y \)-intercept(s).

   b) The vertical asymptotes (VA) and the horizontal asymptotes (HA).

   c) The derivative \( f'(x) \).

   d) Intervals where \( f(x) \) is increasing and decreasing.

   e) Put all this information on an accurate sketch of \( f(x) \).
4. (12 points) Find the intervals where \( f(x) = 2x^3 - 9x^2 + 27 \) is concave up and concave down, and find any inflection points. (Do not sketch.)

5. (12 points) Find the absolute minimum and absolute maximum of \( f(x) = xe^x \) on \([-2, 0]\). (Show all work.)

6. (12 points) Find the equation of the tangent line to the curve \( y = \sqrt{3 + 2x - x^2} \) at the point \((0, \sqrt{3})\). Write your answer in slope-intercept \( y = mx + b \) form.
7. (20 points) Evaluate the integrals

a) \( \int e^x + \sqrt{x} - 8 + 3x^2 \, dx \)

b) \( \int x^5 \ln x \, dx \) (Use integration by parts.)
8. (24 points) Evaluate the definite integrals

a) \[ \int_{0}^{2} x \sqrt{2x^2 + 1} \, dx \]

b) \[ \int_{1}^{e} \frac{(\ln x)^2}{x} \, dx \]

9. (10 points) The total profit (in dollars) from the sale of \( x \) watches is given by

\[ P(x) = 12x - 0.03x^2 - 300. \]

a) Find the marginal profit function.

b) What is the number of watches that the company must produce and sell in order to maximize total profit.
10. (12 points) Sketch the area bounded between the two curves

\[ f(x) = -x \quad \text{and} \quad g(x) = 2x - x^2 \]

and then find this area.

11. (12 points) \( S(x) \) is the price, in dollars per unit, that producers are willing to accept for \( x \) units of an item, and \( D(x) \) is the price, in dollars per unit, that consumers are willing to pay for \( x \) units. Find the equilibrium quantity and equilibrium price.

\[ S(x) = 60 - 2x^2 \quad D(x) = x^2 + 9x + 30 \]
12. (12 points) Given

\[ f(x, y) = x^2 y + 2x^2 + y^2 + 4. \]

The critical points of \( f(x, y) \) are \((0, 0), (2, -2) \) and \((-2, -2)\). Identify them as relative minimum, relative maximum or saddle point.
13. (20 points) Use Lagrange multipliers to find the minimum value of the function

\[ f(x, y) = 8xy + 4x^2 + 5y^2 \]

subject to the constraint

\[ 2x + y = 40. \]