1. (10) For the functions $f$ and $g$ whose graphs are given below
   a) What are the domains of $f(x + 2)$ and $f(2x)$?
   b) Draw a graph of $f(x + 2)$ and $f(2x)$
   c) Find $f(g(2))$. 
2. (20) Let \( k \) be a constant and set

\[
f(x) = \begin{cases} 
2x + 1 & \text{if } x \leq 2; \\
\frac{x^2}{2} + k & \text{if } x > 2 
\end{cases}
\]

a) For which values of \( k \) is \( f(x) \) continuous at \( x = 2 \)?

b) Using a value of \( k \) from part a), is \( f(x) \) differentiable at \( x = 2 \)? Explain your answer.
3. (30) Find the derivatives of each of the following functions:
   a) \( f(x) = x^3 + 2x - 1 \)
   b) \( f(x) = \frac{3x - 1}{x^2 - 2x + 3} \)
   c) \( f(x) = \sqrt[3]{4 - x^3} \)
   d) \( f(x) = \sin^2 x \)
   e) \( f(x) = \int_1^{2x^2} \frac{\sin t}{t} \, dt \)
   f) Let \( f(x) \) be any function which is differentiable for all real numbers \( x \). Let \( g(x) = x^2 f(x) \). Find \( g'(0) \).
4. (15) Find the equation of the tangent line to the curve

\[ x^2 - xy + y^2 = 1 \]

at the point \((1, 1)\).
5. (15) A particle is moving on a vertical line so that its coordinate at time $t$ is

$$y = t^3 - 12t + 3.$$ 

a) Find the velocity and acceleration functions.

b) When is the particle moving upward and when is it moving downward?
6. (20) Consider the function \( f \) whose formula and derivatives are given as:

\[
f(x) = \frac{2x^2 - 5x + 5}{x - 2}, \quad f'(x) = \frac{2x^2 - 8x + 5}{(x - 2)^2}, \quad f''(x) = \frac{6}{(x - 2)^3}.
\]

a) Find and describe all asymptotes (vertical, horizontal and slant) of \( f \).
b) Find and classify all local extrema of \( f \).
c) Find all of the inflection points of \( f \).
d) Sketch the graph of \( f \).
7. (15) The radius of a sphere is increasing at a constant rate of .04 centimeters per second.
(Note the volume of a sphere of radius \( r \) is given by the formula \( V = \frac{4}{3} \pi r^3 \).)
At the time when the radius of the sphere is 10 centimeters, what is the rate of increase of its volume?
8. (20) In parts a-b find the antiderivatives of the given functions:

a) \[ \frac{1}{\sqrt{x - 2}} \]

b) \[ x^2 \cos x^3 \]

In parts d-e evaluate each of the integrals:

d) \[ \int_0^1 x^3 \, dx \]

e) \[ \int_0^{\frac{\pi}{8}} \cos 2x \, dx \]
9. (20) At time $t = 0$ a jogger is running at a velocity of 300 meters per minute. The jogger is slowing down with a negative acceleration that is proportional to time $t$ (that is $a = -kt$ where $k > 0$). This brings the jogger to a stop in 10 minutes.

a) Write an expression for the velocity of the jogger at time $t$.

b) What is the total distance traveled by the jogger in the 10 minute interval?
10. (20) Find the dimensions of the rectangle of largest area that has its base on the $x$-axis and its two other vertices above the $x$-axis and lying on the parabola $y = 8 - x^2$. 
11. (15) a) Let \( f(x) = x^3 - a \). Use Newton's Method for solving \( f(x) = 0 \) to write down a formula for \( x_{n+1} \) in terms of \( x_n \).
b) Using \( x_1 = 3 \) as your initial guess, use Newton's Method to find \( x_2 \) in the approximation of \( 29^{1/3} \). You may (or may not) be interested to know that if you carry out Newton's Method to \( x_4 \) the approximation is accurate to 26 decimal places.