1. Explain why \((x - x_0)^2 + (y - y_0)^2 + (z - z_0)^2 = r^2\) is the equation of the sphere of radius \(r\) centered at the point \((x_0, y_0, z_0)\). (9 points)

2. Consider the surface given by the quadratic equation \(4x^2 - y^2 - 9z^2 = 1\).
   (a) Sketch the cross-sections of the surface for \(x = -1\), \(x = 0\), and \(x = 1\). (9 points)
   (b) Sketch the cross-section of the surface for \(y = 0\). (3 points)
   (c) Sketch the cross-section of the surface for \(z = 0\). (3 points)
   (d) Use pictures and/or words to describe the surface given by this quadratic equation. (6 points)

3. Find the standard form for the equation of the plane containing the points \((5, -2, 1)\), \((5, 2, 7)\), and \((10, 2, 2)\). (12 points)

4. Consider the function \(f(x, y) = \sqrt{16 - x^2 - y^2}\).
   (a) Determine the domain of this function. (4 points)
   (b) Determine the range of this function. (3 points)
   (c) Sketch representative level curves for this function. (6 points)
   (d) Sketch and/or describe the graph of this function. (4 points)

5. Show that \(\lim_{(x,y) \to (0,0)} \frac{x^3y}{x^4 + 5y^4}\) does not exist. (8 points)

There is more on the flip side.
6. (a) For $f(x, y, z)$, state the **definition** of partial derivative of $f$ with respect to $z$. (4 points)
(b) For $f(x, y, z)$, state an **interpretation** of partial derivative of $f$ with respect to $z$. (4 points)

7. Compute the second partial derivatives of $f(x, y) = y \sin(xy)$. (15 points)

8. The ideal gas law relates pressure $p$, volume $V$, temperature $T$, and number of gas particles $n$ as $pV = nRT$ where $R = 0.082$ L·atm/(mol·K) is a constant. Suppose we are doing an experiment with $n = 1$ mol of gas held constant. During the experiment, there is a particular time at which the pressure has the value 1.4 atm and is changing at the rate of 0.3 atmospheres per hour while the volume has value 0.8 L and is changing at the rate of −0.1 liters per hour. For this particular time, what is the rate at which the temperature is changing with respect to time? (10 points)