1. (a) (10 points) A particle traveling in a straight line is located at the point $(1, -1, 2)$ and has speed 2 at time $t = 0$. The particle moves toward the point $(3, 0, 3)$ with constant acceleration $2\,\mathbf{i} + \mathbf{j} + \mathbf{k}$. Find the particle's position vector $\mathbf{r}(t)$ at time t and the time that it takes to get to the point $(3, 0, 3)$.

   (b) (10 points) Let the trajectory of a projectile be given in parametric form as $x(t) = \cos t$, $y(t) = \sin t$, $z(t) = t$. Find the curve's unit tangent vector and the total length of the trajectory curve from $t = 0$ to $t = \pi$.

2. (a) (15 points) For the function $f(x, y) = \sqrt{y - x^2 + 3}$, find and sketch the domain. Find an equation for and sketch the graph of the level curve of $f(x, y)$ passing through $(2, 5)$.

   (b) (10 points) Find all the second order partial derivatives of $g(x, y) = xe^{xy} + x^2 - 3y$.

   (c) (10 points) Find $\partial f/\partial r$ and $\partial f/\partial s$ for $f(x, y, z) = x^2 + y^2 + e^z$ where $x = r\sin s$, $y = r\cos s$, and $z = rs$ by using the chain rule for partial derivatives.

3. (a) (10 points) Find the directional derivative of $f(x, y, z) = \cos(xy) + e^{yz} + \ln(zx)$ at $P_0(1, 0, 1)$ in the direction of $\mathbf{v} =< 1, 2, 2 >$. What are the directions for which f increases the most and decreases the most at P_0?

   (b) (10 points) Write the equations for the tangent plane and the normal line to the level surface $f = 2$ at P_0 in part (**a**).

4. (a) (10 points) Let $f(x, y) = x^2 + y^2 - 2x - 4y$ and the region R be bounded by $y = x, y = 0$ and $x = 1$. Find the absolute maximum and minimum values of f over R.

   (b) (5 points) Suppose we know that $f_{xx}(x, y) = 6x, f_{xy}(x, y) = 6y, f_{yy}(x, y) = 6x + 6y$. Suppose we also know that points $(0, \sqrt{5}), (0, -\sqrt{5}), (2, 1), (-2, -1)$ are critical points of $f(x, y)$. Classify each critical point.

   (c) (10 points) Find the maximum and minimum values of the temperature $T(x, y, z) = x - 2y + 5z$ on the sphere $x^2 + y^2 + z^2 = 30$.