1. (10 points) Compute the partial derivatives $g_{xx}$, $g_{xy}$, and $g_{yy}$ for $g(x, y) = e^{-xy}$.

2. (15 points) Let $f(r, s, t) = r^3s - s^2t^2$ and $a = i - 2j + 2k$.
   a. Compute the directional derivative of $f$ in the direction of $a$ at the point $Q(-2, 1, 3)$.
   b. What is the maximum value of any directional derivative of $f$ at $Q$?
   c. If, further, $r = y \sin x$, $s = \arctan(xy)$, and $t = \ln(x^2 + y^2)$, compute $\frac{\partial f}{\partial x}$.
3. (10 points) Let \( A = \begin{bmatrix} -1 & 1 \\ 2 & 0 \end{bmatrix} \). Show how \( A \) transforms the unit square \( \{(x, y) | 0 \leq x \leq 1, \ 0 \leq y \leq 1\} \). What is the area of the transformed region? Is the transformation orientation-preserving or orientation-reversing? Show computations or give explanation!

4. (15 points) Let \( w = 4x^2 + 3y^2 - 12z \) and \( P \) be the point \( (1, -1, 1/2) \).
   a. Sketch the level surfaces (and clearly label which is which!) \( w = -12 \), \( w = 0 \), and \( w = 36 \).
   b. The point \( P \) is on what level surface for \( w \)? Give an equation for the tangent plane to that surface at the point \( P \).
5. (12 points) Suppose \( u = f(x - ct) \), where \( c \) is a positive constant, and \( f \) is a differentiable function.
   
   a. Show that \( u_{tt} = c^2 u_{xx} \), that is, \( \frac{\partial^2 u}{\partial t^2} = c^2 \frac{\partial^2 u}{\partial x^2} \).

   b. The graph \( y = f(x) \) is shown below. Sketch the trace of the graph of \( u \) for each of \( t = -1, 1, 2 \); label which graph is which. Then sketch the graph of \( u \) as a function of \( x \) and \( t \) for \(-2c \leq x \leq 3c \) and \(-1 \leq t \leq 2\).
6. (13 points) Let \( g(x, y) = x^3 + y^3 - 6xy \). Find all critical points for \( g \) and indicate whether each is a local max, local min, or saddle point.

7. (12 points) The temperature on a circular disk \( \{(x, y) \mid 0 \leq x^2 + y^2 \leq 1 \} \) is \( T = 2x^2 + y^2 - y \). Find the hottest and coldest spots on the disk.
8. (13 points) The formula $1/R = 1/R_1 + 1/R_2$ determines the combined resistance $R$ when resistors of resistance $R_1$ and $R_2$ are combined in parallel.

a. Suppose $R_1 = 100$ and $R_2 = 25$, each with a possible error in measurement of 0.5. Use differentials, or the microscope approximation, to determine the maximum possible error in the computation of $R$.

b. In general what is the percent error in $R$ if there is a 2% error in the measurement of $R_1$, a 5% error in the measurement of $R_2$, and $R_1 = 4R_2$?