Show **ALL** work for credit; be neat; and use only **ONE** side of each page of paper. Do **NOT** write on this page. Calculators can be used for graphing and calculating only. Give exact answers when possible.

1. Show the limit below does not exist.
\[
\lim_{(x,y) \to (0,0)} \frac{y^2}{x^2 + y^2}
\]

2. Use the Chain Rule to find \( \partial z / \partial u \) and \( \partial z / \partial v \) when \( z = \ln(x^2 + xy + y^2) \), \( x = v/u \) and \( y = u\sqrt{v} \).

3. Fixing Maple errors. Each of the following produced an error or an empty graph, explain how to fix each.
(Assume “with(plots);” has already been done.)
   a. \texttt{gradplot(x^2+xy+y^2,x=0..2,y=0..2)};
   b. \texttt{plot3d(exp(x+y),x:=0..1,y=-1..1)};
   c. \texttt{contourplot(x*y,x=-10..10,y=-10..10,contours=1, 4, 9, 25, 36)};
   d. \texttt{plot3d(x*y,x=-1..1,y=-1..1,axes=boxed,title=my graph)};
   e. \texttt{contourploot(sin(x)*sin(y),x=0..Pi,y=0..Pi)};

4. Find the directional derivative of \( f(x,y,z) = x^3 y^2 z \) as you leave the point \( P(-1,2,1) \) heading in the direction of the point \( Q(1,0,2) \).

5. The point \( P \) is on the contour graph of the function \( f \) with a local maximum at \( M \) (below left) and the point \( Q \) is on the gradplot of the graph of the function \( g \) (below right). Let \( u \) be the unit vector \( u = (i+j)/\sqrt{2} \) and let \( v \) be the unit vector \( v = (i-j)/\sqrt{2} \).

   Find the sign (positive, negative or zero) of the partials of \( f \): \( f_x(P), f_y(P), f_{xx}(P), f_{yy}(P) \) and the partials of \( g \): \( g_x(Q), g_y(Q) \) and the four directional derivatives \( f_u(P), f_v(P), g_u(Q) \) and \( g_v(Q) \).

6. A differentiable function \( f(x,y) \) has the property that \( f(1,2) = 7 \) and \( \nabla f(1,2) = 2i - 5j \).
   a. Find the equation of the tangent PLANE to the SURFACE \( z = f(x,y) \) at the point \( (1,2,7) \).
   b. Find the equation of the tangent LINE to the level CURVE of \( f \) through the point \( (1,2) \).

There is more test on the back.
7. Change the cylindrical coordinate equation $z = r$ into rectangular and spherical coordinates (simplify). Sketch the graph and describe the graph in words.

8. Use Lagrange multipliers to find the minimum and maximum VALUES of $x^2 - 2x + y^2 - 2y$ subject to the constraint $x^2 + y^2 = 2$.

9. Find critical points of the function $f(x, y) = x^3 + 3xy^2 - 12x$. Classify these local extrema by filling out a table like the one below, with a separate line for each critical point. [Hint: Use your TI-89 to check that you got the correct collection of critical points.]

<table>
<thead>
<tr>
<th>$(x, y)$</th>
<th>$f_{xx}$</th>
<th>$f_{yy}$</th>
<th>$f_{xy}$</th>
<th>big D</th>
<th>Classification</th>
</tr>
</thead>
</table>

10. Find the coordinates of the POINT closest to the point $P(1, 1, 0)$ which is both on the surface $z^2 = x^2 + y^2$ AND is in the first octant.