**Directions:** Show **ALL** work for credit; Give **EXACT** answers when possible; Start each problem on a **SEPARATE** page; Use only **ONE** side of each page; Be neat; Leave margins on the left and top for the **STAPLE**; Calculators can be used for graphing and calculating only; Nothing written on this page will be graded.

1. Find the equation of the tangent plane to \( F(x, y, z) = 0 \) at the point \((9, 5, 7)\) where the function \( F(x, y, z) \) is given by \( x^3 + 3y^2 + xz - 867 \).

2. Use the chain rule (as shown in class) to find \( \frac{\partial z}{\partial u} \) and \( \frac{\partial z}{\partial v} \) when \( z = (x + y) \ln(xy), \quad x = \sin(uv) \) and \( y = \sqrt{u/v} \).

3. Use the pictures below to determine if the various derivatives are positive, negative or zero. The unit vector \( \vec{u} \) is given by \( \langle -\frac{1}{\sqrt{2}}, -\frac{1}{\sqrt{2}} \rangle \).

   (a) Use the graph (below left) to determine \( f_x(P), \ f_y(P), \ f_{xx}(P), \ f_{yy}(P) \) and \( f_{\vec{u}}(P) \).

   (b) Use the graph (below right) to determine \( g_x(Q), \ g_y(Q), \ g_{xx}(Q), \ g_{yy}(Q) \) and \( g_{\vec{u}}(Q) \).

4. The values of various derivatives of \( f \) at the point \((e, 1)\) have been found to be:
   \( f(e, 1) = 5, \ f_x(e, 1) = e^{-1}, \ f_y(e, 1) = e, \ f_{xx}(e, 1) = 1 + e, \ f_{xy}(e, 1) = 1 + e^{-1} \) and \( f_{yy}(e, 1) = 1 - e \).

   (a) Find \( Q(x, y) \), the quadratic Taylor polynomial for \( f \) at the point \((e, 1)\).

   (b) Find parametric equations of the normal line to the surface of \( z = f(x, y) \) at the point \((e, 1)\).

   (c) Find a direction \( \vec{u} \) (unit vector) so that \( f_{\vec{u}}(e, 1) = 0 \).

5. The relative density of the earth (centered at the origin with radius 1) is given by \( \sqrt{1 - \sqrt{x^2 + y^2 + z^2}} \).

   Find the directional derivative as you leave \( P(5/26, 12/26, 0) \) heading away from the center of the earth. Do your derivatives by hand and simplify your exact answer. Use the calculator to check.