1. Is the curve $x = \cos t$, $y = 2\sin t$, $z = -1 - 3\sin^2 t$ on the surface $z = -x^2 - y^2$? Write the tangent line to the curve at $t = 0$.

2. Consider the saddle $f(x, y) = xy$.

   (a) Find the equation of the tangent plane to this saddle at the point $(x, y, z) = (3, 5, 15)$.

   (b) The tangent plane you just found intersects the saddle at many points. Find the set of all such points. (*Hint: set the z for the saddle equal to the z for the tangent plane, and solve for x, y. It helps to factor by grouping.*)

   (c) Repeat the above two problems for an arbitrary point (a, b, ab) on this saddle. Here, a, b are constants.

3. Let $f(x, y) = x^3 + y^2 \sin(x)$.

   (a) Calculate the gradient of f.

   (b) Find the equation of the plane tangent to the graph of f at the point $(x_0, y_0) = (1, 0)$.

   (c) What is the normal vector of the plane you found?

   (d) Using linear approximations of f, approximate $f(1.1, 0.1)$ and $f(0.1, 1.1)$. Should you use the same linear approximation formula for both of these points?

4. Let $f(x, y) = xye^{xy-1}$.

   (a) Consider the point $(1, 1)$. To which level set does this point belong?

   (b) Find a vector perpendicular to the level set above at $(1, 1)$.

   (c) Find an equation for the line tangent to this level set above at $(1, 1)$.

5. Match the following surfaces to their level sets.

(a) $f(x,y) = 2x^2 + y^2$ (b) $f(x,y) = \sqrt{x^2 + 2y^2}$ (c) $f(x,y) = x^2 + 2y^2$

(d) $f(x,y) = e^{x^2+2y^2}$