(10pts) 1. Convert the point \((2\sqrt{3}, -2, 4)\) which is in rectangular coordinates into

(a) Cylindrical coordinates \((r, \theta, z)\).

(b) Spherical coordinates \((\rho, \phi, \theta)\).

(10pts) 2. Describe the set of points \(\{(r, \theta, z) : 0 \leq r \leq 1, 0 \leq \theta \leq 2\pi, r^2 \leq z \leq 2 - r^2\}\) and sketch the graph. Include and label the axes in your sketch.
(24pts) 3. Let $\vec{F}(t) = (\sin t, \cos t, t)$ be a vector function. Find the following.

(a) The unit tangent vector $\vec{T}$, and the speed $\frac{ds}{dt}$.

(b) The curvature $\kappa$.

(c) The tangential and normal components of $\vec{a}$, i.e., $a_T$, $a_N$.

(d) Explain why $\vec{a} = \vec{N}$, and find $\vec{N}$, the unit normal vector.

(e) The unit binormal vector $\vec{B}$.

(f) The equation of the osculating plane at $t = 0$. 
(30pts) 4. Let \( z = f(x, y) = \sqrt{9 - x^2 - y^2} \). Do the following.

(a) Sketch the domain of the function \( f(x, y) \).

(b) Compute \( \partial f / \partial x \) and \( \partial f / \partial y \).

(c) Compute \( \partial^2 f / \partial x \partial y \).

(d) Find the tangent plane to this surface at the point \((2, -1, 2)\).

(e) Find \( D_{\vec{U}} f(2, -1) \) where \( \vec{U} = \left( \frac{1}{2}, -\frac{\sqrt{3}}{2} \right) \).

(f) Let \( x = 3 - t^2, \ y = -t^3 \). Use the Chain Rule to find \( \frac{dz}{dt} \) at \( t = 1 \).
5. A climber is at the point $(1, 1, 2)$ on the hill $z = 4y - x^2 - y^2$. The $z$ axis points up, $y$ axis north, $x$ axis east.

(a) What is the direction of steepest descent? What is the steepness of the hill in this direction?

(b) If the climber heads north, will he be going up the hill or down? At what rate (with respect to distance)?

(c) In what directions may the climber go in order to stay on the same altitude?
(8pts) 6. A bug at the point \((1, 1, 1)\) on the egg \(x^2/4 + y^2/4 + z^2/2 = 1\) flies off along the normal line. Does it reach a flower at \((5, 5, 10)\)?