1. (20 pts) (**QuAQ**'s) Quick answer questions. Answer the following True or False questions and **write at least one sentence to justify your answer**.

   (a) **T** or **F**: The vectors $\mathbf{T}(t)$ and $\mathbf{N}(t)$ are perpendicular for all values of t.

   (b) **T** or **F**: The domain of the function $g(x, y) = \sqrt{4 - x^2 - y^2}$ is a sphere.

   (c) **T** or **F**: The level curves of the function $h(x, y) = (x - y)^2$ are lines.

   (d) **T** or **F**: Suppose that for a function $f(x, y)$,

   $$\lim_{(x,0)\to(0,0)} f(x, y) = \lim_{(0,y)\to(0,0)} f(x, y) = L.$$

   (In other words, the limits taken along the x-axis and the y-axis exist and are equal.) We conclude that $\lim_{(x,y)\to(0,0)} f(x, y)$ exists.

2. (5 pts) For the function $F(x, y, z) = 2x^2 + 2y^2 - 2z + 6$,

   (a) **Calculate** at least three level surfaces.

   (b) **Describe** in words these level surfaces (using quadric surface terminology).

   (c) And try your best to **draw** these level surfaces.

3. (10 pts) For the curve defined by the vector function $\mathbf{r}(t) = \langle \sin(2t), \sin(3t), -1 \rangle$,

   (a) Find $\mathbf{r}'(t)$ and $\mathbf{T}(t)$.

   (b) Find the tangent line to the curve when $t = \pi/2$.

4. (20 pts) Consider the function $f(x, y) = 2\sqrt{x} \cdot y^2$.

   (a) Find the tangent plane to the graph of f above the point $(1, -1)$.

   (b) Find the gradient vector $\nabla f(x, y)$.

   (c) Find the directional derivative $D_{\mathbf{u}} f(1, -1)$ in the direction $3\mathbf{i} - 4\mathbf{j}$.

   (d) Give a real world interpretation of what the number that is your answer in part (c) means.