Answer each of the following questions. Show all work, as partial credit may be given.

1. Consider the quadric surface given by the equation \( \frac{x^2}{9} + \frac{y^2}{16} - \frac{z^2}{4} = 1 \).

   (a) (12 pts.) Find the equation of the trace of this surface in the \( xy \), \( xz \) and \( yz \) planes. You do not need to sketch the traces.

   (b) (4 pts.) Identify the surface as an ellipsoid, elliptic paraboloid, hyperbolic paraboloid, hyperboloid of one sheet, or a hyperboloid of two sheets.

2. (8 pts.) Set up but do not evaluate an integral giving the length of the curve given by the vector-valued function \( \mathbf{r}(t) = 3t^2 \mathbf{i} + t^3 \mathbf{j} + 6t \mathbf{k} \), \( 0 \leq t \leq 1 \).

3. (16 pts.) Find the arclength function for the curve given by the vector-valued function \( \mathbf{r}(t) = 5t^2 \mathbf{i} + 4t^2 \mathbf{j} + (3 - 3t^2) \mathbf{k} \) for \( t \geq 0 \). You must fully evaluate any integrals you set up.

4. A projectile is fired horizontally with a velocity of 1800 feet per second from an altitude of 1000 feet above level ground.

   (a) (16 pts.) Find a vector-valued function giving the position of the projectile \( t \) seconds after it has been fired. (Hint: The equation for the position of a projectile \( t \) seconds after it has been fired is \( \mathbf{r}(t) = -16t^2 \mathbf{j} + v_0 t + \mathbf{r}_0 \) where \( v_0 \) is the initial velocity and \( \mathbf{r}_0 \) the initial position of the projectile.)

   (b) (8 pts.) How far downrange does the projectile strike the ground? Be sure to express your answer in correct units.

   (c) (8 pts.) What is its speed when it strikes the ground? Be sure to express your answer in correct units.

5. Consider the curve determined by \( \mathbf{r}(t) = 2 \sin(2t) \mathbf{i} + 3 \mathbf{j} + 2 \cos(2t) \mathbf{k} \).

   (a) (12 pts.) Find the unit tangent vector \( \mathbf{T}(t) \) and the unit normal vector \( \mathbf{N}(t) \) for the curve. (Hint: The unit normal vector is given by \( \mathbf{N}(t) = \mathbf{T}'(t)/|\mathbf{T}'(t)| \).)

   (b) (8 pts.) Verify that the unit tangent and unit normal vectors are orthogonal for every value of \( t \).

6. (12 pts.) Show that the limit \( \lim_{(x,y)\to(0,0)} \frac{2x^2 - y^2}{x^2 + 2y^2} \) does not exist.