1. Decide if the following statements are TRUE or FALSE and circle your answer. **You do NOT need to justify your answers.**

   (a) (1 point) If \( u \) and \( v \) are vectors in \( \mathbb{R}^3 \) then \( (u \times v) \cdot u = 0 \).

   (b) (1 point) If \( r(t) = (r_1(t), r_2(t), r_3(t)) \) is a vector-valued function and \( |r(t)| = 4 \) for all \( t \in \mathbb{R} \) then \( r \cdot r' = 0 \) for all \( t \).

   (c) (1 point) Let \( u \) and \( v \) be vectors in \( \mathbb{R}^3 \). Then \( u \cdot (u - v) \) is a vector in \( \mathbb{R}^3 \).

   (d) (1 point) Let \( f = f(x, y) \) be a function of two variables which is continuous at \( (a, b) \) and \( g = g(t) \) be a function which is continuous at \( f(a, b) \). Let \( h(t) = f(g(t), g(t)) \). Then \( h \) is continuous at \( f(a, b) \).

2. Give examples of the following. Be as explicit as possible. **You do NOT need to justify your answers.**

   (a) (2 points) Give an example of a continuous vector-valued function \( r(t) \) which is not differentiable at \( t = 2 \).

   (b) (2 points) Give an example of a vector-valued function which has constant curvature \( \kappa \neq 0 \).

   (c) (2 points) Give equations for two different planes in \( \mathbb{R}^3 \) which are parallel to the plane \( z = 2x - 5y \).

   (d) (2 points) Give an example of a vector \( u \in \mathbb{R}^2 \) for which \( u \cdot \langle \cos \frac{\pi}{5}, \sin \frac{\pi}{5} \rangle = 0 \).

3. Let \( u = \langle 3, 2, 2 \rangle \) and \( v = \langle 1, -4, 6 \rangle \).

   (a) (2 points) Compute \( 2u - v \).

   (b) (2 points) Compute \( u \cdot v \).

   (c) (2 points) Compute \( u \times v \).

   (d) (2 points) Compute the angle between \( u \) and \( v \).

   (e) (2 points) Compute \( \text{proj}_u v \).

4. A ball is thrown from an initial height of 20 m above with an initial speed of 10 m/s and initial angle of \( \frac{\pi}{3} \) radians with the ground.

   (a) (3 points) Give the position vector of the ball \( r(t) \) at time \( t \).

   (b) (2 points) Set up but do not evaluate an integral which gives the length of the path traveled by the ball. This is not the distance traveled by the ball along the ground, but the length of the path that the ball traces in the air.

5. (5 points) A weight of 5 N is tied to two strings, both fastened to the ceiling. The first string is tied to the weight at position \( \langle 0, 0 \rangle \) and is fastened to the ceiling at position \( \langle 3, 2 \rangle \). The second string is tied to the weight at position \( \langle 0, 0 \rangle \) and is fastened to the ceiling at position \( \langle -1, 2 \rangle \). Compute the force vectors which give the forces that the strings exert on the weight.

6. (5 points) Compute the maximum and minimum curvature for the ellipse

   \[ \frac{x^2}{4} + \frac{y^2}{9} = 1. \]

7. (5 points) Give an equation for the plane containing the line \( r(t) = \langle 3 + t, 2, 1 - t \rangle \) and the point \( \langle 2, -3, 1 \rangle \).

8. (5 points) Compute the normal and tangential components of acceleration \( (a_N, a_T) \) for a particle whose position at time \( t \) is given by the vector-valued function

   \[ r(t) = \langle t^2, t + 2 \rangle. \]