1. Let \( \mathbf{a} = 2\mathbf{i} + \mathbf{j} - \mathbf{k} \) and \( \mathbf{b} = \mathbf{i} + \mathbf{k} \).
   (a) Determine the angle between \( \mathbf{a} \) and \( \mathbf{b} \).
   (b) Find a unit vector orthogonal to both \( \mathbf{a} \) and \( \mathbf{b} \).
   (c) Find parametric equations for the line in \( \mathbb{R}^3 \) that passes through the point \((3, -5, 6)\) and is perpendicular to the plane containing \( \mathbf{a} \) and \( \mathbf{b} \).

2. Find the equation of the plane containing the triangle with vertices \( P = (1, 0, 2) \), \( Q = (3, 1, -2) \), and \( R = (1, -1, 3) \).

3. The position of a particle in space at time \( t \) is given by the vector function:
   \[ r(t) = \sin(t^2) \mathbf{i} + \cos(t^2) \mathbf{j} + 3t^2 \mathbf{k}, \quad t \geq 4. \]
   (a) Find the velocity and acceleration at time \( t \).
   (b) Find the initial speed at time \( t = 4 \).

4. A curve is described by the parametric equations
   \[ x = \ln t, \quad y = 2t, \quad z = t^2, \quad t \geq 1. \]
   (a) Find the parametric equations of the tangent line at the point \((0, 2, 1)\); that is, when \( t = 1 \).
   (b) Find the length of the curve for \( 1 \leq t \leq e \).

5. A constant force with magnitude 20 N acts directly upward from the \( xy \)-plane on an object with mass 4 kg. The object starts at the origin with initial velocity \( \mathbf{v}(0) = \mathbf{i} + \mathbf{j} \). Find its position function at time \( t \). [Recall Newton’s Second Law of Motion: \( \mathbf{F} = m\mathbf{a} \).]

(This exam is worth 50 points.)