1. Given vectors \( \mathbf{a}, \mathbf{b}, \) and \( \mathbf{c} \), show using magnitudes and/or the dot product and/or the cross product how you would:

a) decide if \( \mathbf{a} \) and \( \mathbf{b} \) are parallel

b) decide if \( \mathbf{a} \) and \( \mathbf{b} \) are orthogonal

c) calculate the area of the triangle determined by \( \mathbf{a} \) and \( \mathbf{c} \)

d) calculate the angle \( \theta \)

e) find the vector \( \mathbf{d} \)

f) determine a vector parallel to \( \mathbf{a} \) which is 5 units long.

2. Identify the given surface and convert its equation to cylindrical coordinates: \( x^2 + y^2 + z^2 = 2x \)
3. The position of a projectile is given by \( \mathbf{r}(t) = 4 \mathbf{j} + \ln(\cos(t)) \mathbf{k}, \cos(t) > 0 \). Find the following:

a) The projectile's velocity, \( \mathbf{v} \)

2 Points

b) The speed of the projectile

2 Points

c) The unit tangent vector, \( \mathbf{T} \)

2 Points

d) The unit normal vector, \( \mathbf{N} \)

3 Points

e) The curvature, \( \kappa \)

3 Points

f) The acceleration of the projectile written in terms of \( \mathbf{T} \) and \( \mathbf{N} \). You do not have to write out \( \mathbf{T} \) and \( \mathbf{N} \) in your answer.

6 Points

18 Points
4. Find an equation for the plane through the point (−4, 6, 1) and containing the line 
   \[ x = 3 - t, \ y = 2 - 3t, \ z = 1 + 2t. \]

10 Points

5. Write \( \mathbf{u} = \mathbf{i} - \mathbf{j} + 2\mathbf{k} \) as the sum of a vector parallel to and a vector orthogonal to \( \mathbf{v} = 3\mathbf{i} + \mathbf{k} \).

10 Points

6. At time \( t = 0 \) a particle has the velocity \( 4 \mathbf{k} \). At time \( t = 3 \) the particle is located at the point \((13, -9, 25)\). If the particle’s acceleration is given by \( \mathbf{a}(t) = -2 \mathbf{j} + 6t \mathbf{k} \), find parametric equations for the line tangent to the particle’s curve of motion at \( t = 3 \).

30 Points
7. Convert the following equation in spherical coordinates to one in rectangular coordinates and sketch its graph. $\rho^2 \sin^2 \phi \cos^2 \theta + \cos^2 \phi = 16$.

8. Find the angle between AB and AC given the points A(1, 0, 1), B(3, 2, 0), and C(0, -3, 3).

9. A projectile is fired horizontally with initial speed of 2 ft/s from a position 9 ft above the ground. Where does the projectile hit the ground?