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 \( \mathbf{0} \)

   

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

   

   f) calculate the volume of the parallelepiped determined by \( \mathbf{a}, \mathbf{b}, \) and \( \mathbf{c} \)

   

2. Identify the given surface and convert its equation to cylindrical coordinates \( x^2 + y^2 = 2z \)

   

   8 Points

   

   22 Points
3. The position of a projectile is given by \( \mathbf{r}(t) = 3 \sin(t) \mathbf{i} + 4t \mathbf{j} + 3 \cos(t) \mathbf{k} \). 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.

4 Points

18 Points
4. Find an equation for the plane consisting of all points that are equidistant from the points 
(-4, 2, 1) and (2, -4, 3).

5. Find $AC \times AD$ and $AB \cdot (AC \times AD)$ given the points $A(1,0,1)$, $B(2,3,0)$, $C(-1,1,4)$, and $D(0,3,2)$.

6. Find parametric equations for the line tangent to $r(t)$ at $t = 1$ if $r(t) = 6t i - 2t^3 j + \frac{1}{14} k$
and $r(0) = 2i - j + 4k$. 

30 Points
7. Convert the following equation in spherical coordinates to one in rectangular coordinates and sketch its graph: \( \rho^2 \sin^2 \phi \sin^2 \theta + \cos^2 \theta = 9. \)

10 Points

8. Find the distance between the parallel planes \( 10x + 2y - 2z = 5 \) and \( 5x + y - 1 = 1. \)

10 Points

9. A projectile is fired horizontally with initial speed of 500 m/s from a position 200 m above the ground. Determine the speed of the projectile when it hits the ground.

30 Points