Show all work for full credit.

Here is a list of some identities and formulas.

\[
\begin{align*}
\sin^2(u) &= \frac{1}{2} (1 - \cos(2u)) \\
\cos^2(u) &= \frac{1}{2} (1 + \cos(2u)) \\
2 \sin(u) \cos(u) &= \sin(2u)
\end{align*}
\]

\[
\text{proj}_a \vec{b} = \left( \frac{\vec{a} \cdot \vec{b}}{|\vec{a}|^2} \right) \vec{a}
\]

\[
\text{comp}_a \vec{b} = \left( \frac{\vec{a} \cdot \vec{b}}{|\vec{a}|} \right) \vec{a}
\]

<table>
<thead>
<tr>
<th>(\theta)</th>
<th>(\cos(\theta))</th>
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1. Consider the curve \( x = 3 \sin t, \ y = 4 \cos t \) for \( 0 \leq t \leq \frac{3\pi}{2} \).
   (a) Graph the curve, indicating initial and terminal points, and the direction of the curve.
   (b) Find the equation of the tangent line at the point where \( t = \pi \).
   (c) Set up the equation (do not evaluate) indicating the length of the given curve.

2. Let \( x = \sin(\pi t) \) and \( y = t^2 + t \). Find the equation of the tangent lines to the curve at \( (0, 2) \).

3. Find the length of the parametric curve
   \[
   x = t \sin(t) \\
   y = t \cos(t) \\
   0 \leq t \leq 1
   \]

4. Find \( \frac{\partial^2 y}{\partial x^2} \) for the parametric curve
   \[
   x = t^2 + 1 \\
   y = e^t - 1
   \]

5. Sketch \( r = 3 - 3 \sin(\theta) \).

6. Let \( r_1 = 1 - \sin(\theta) \) and \( r_2 = 1 \).
   (a) Sketch the given functions on the same graph.
   (b) Set up an integral to find the arc length of \( r_1 \) when \( 0 \leq \theta \leq \pi/2 \). Do not evaluate.
   (c) Set up an integral to find the area inside \( r_1 \) and outside \( r_2 \). Evaluate to find the area.

7. Let \( r_1 = 4 \sin(\theta) \) and \( r_2 = 2 \).
   (a) Sketch the given functions on the same graph.
   (b) Set up an integral to find the arc length of \( r_1 \) when \( 0 \leq \theta \leq \pi/2 \). Do not evaluate.
   (c) Set up an integral to find the area inside \( r_1 \) and outside \( r_2 \). Evaluate to find the area.

8. Consider the curve \( r = \sin(3\theta) \).
   (a) Sketch the curve \( r \).
   (b) Evaluate the slope of the tangent line at \( \theta = \pi/6 \).
   (c) Find the equation of the tangent line at \( \theta = \pi/6 \).

9. Find the area of the region inside both the curve \( r = \cos \theta \) and \( r = \sin \theta \).

10. Determine whether the vectors are parallel, orthogonal, or neither.
    (a) \( \mathbf{a} = \langle -3, 5, 11 \rangle, \quad \mathbf{b} = \langle 10, -5, 5 \rangle \)
    (b) \( \mathbf{a} = \mathbf{i} + 2\mathbf{j} - \mathbf{k}, \quad \mathbf{b} = 3\mathbf{i} + 6\mathbf{j} + 3\mathbf{k} \)
(c) \( \vec{a} = \langle 2, -3, 8 \rangle \) and \( \vec{b} = \langle -6, 9, -24 \rangle \).

11. Given that \( \vec{a} = \langle 3, -4, -5 \rangle \), \( \vec{b} = \langle -2, 1, 2 \rangle \), and \( \vec{c} = \langle -6, -3, 2 \rangle \). Answer the following questions.

(a) Evaluate \( 2\vec{a} - 3\vec{b} + 2\vec{c} \)

(b) Evaluate \( \frac{|\vec{a}| \vec{b}}{|\vec{c}|} \)

(c) Find the angle between \( \vec{b} \) and \( \vec{c} \).

(d) Are the vectors \( \vec{a} \) and \( \vec{b} \) orthogonal to each other? Why or why not.

(e) Find \( \vec{b} \times \vec{c} \)

(f) Find \( |\vec{b} \times \vec{c}| \)

(g) Find the vector projection of \( \vec{b} \) onto \( \vec{c} \).

(h) Find the direction cosines and the direction angles of the vector \( \vec{a} \). Round your answer to nearest degrees.

12. Given three points \( P(2, 1, 2) \), \( Q(3, 8, -6) \), and \( R(-2, -3, 1) \), find

(a) Find the vector equation of the line that passes through the points \( P(2, 1, 2) \) and \( Q(3, 8, -6) \).

(b) Find the parametric equations of the line that passes through the points \( P(2, 1, 2) \) and \( R(-2, -3, 1) \).

(c) Are the lines \( PQ \) and \( PR \) parallel, orthogonal, or neither.

(d) Find the equation of the plane that passes through the points \( P(2, 1, 2) \), \( Q(3, 8, -6) \), and \( R(-2, -3, 1) \).