1. Let \( A = (0, -1, 1), B = (1, -1, 3), C = (2, 0, 0) \) be three points.

   (a) Find \( \mathbf{v} = \overrightarrow{AB} \) and \( \mathbf{w} = \overrightarrow{BC}. \) \( (2 \text{ points}) \)

   \[ \mathbf{v} = \langle \ , \ , \ \rangle \]

   \[ \mathbf{w} = \langle \ , \ , \ \rangle \]

   (b) Calculate the cross-product \( \mathbf{v} \times \mathbf{w}. \) \( (3 \text{ points}) \)

   \[ \mathbf{v} \times \mathbf{w} = \langle \ , \ , \ \rangle \]

   (c) Find the area of the triangle \( \triangle ABC. \) \( (2 \text{ points}) \)

   \[ \text{Area}(\triangle) = \]
2. Suppose that two planes have (non-zero) normal vectors \( \mathbf{n}_1 \) and \( \mathbf{n}_2 \) respectively, and that \( \mathbf{n}_1 \times \mathbf{n}_2 = 0 \). Which of the following could possibly be true? List the letters in the box. (4 points)

A. The planes intersect in a line.

B. The planes are orthogonal to each other.

C. The planes are parallel to each other.

D. The planes are equal to each other.

The possibly true statements are

3. (a) Let \( \mathbf{v} = \langle 1, 0, 2 \rangle \), and let \( \mathbf{w} = \langle -1, 3, 0 \rangle \). Find \( \text{proj}_v \mathbf{w} \), the vector projection of \( \mathbf{w} \) onto \( \mathbf{v} \). (3 points)

\( \text{proj}_v \mathbf{w} = \langle \quad , \quad , \quad \rangle \)

(b) Let \( \mathbf{P} \) be the plane with equation \( x + 2z = 0 \). Find the distance from the point \( (-1, 3, 0) \) to the plane \( \mathbf{P} \). (2 points)

The distance is
4. Find the angle $0 \leq \theta \leq \frac{\pi}{2}$ between the planes $z = x + \sqrt{2}y$ and $x - z = 5$. Express your answer in radians. (4 points)

$\theta =$ 

5. Find the tangent plane to the surface $z = x^2 e^y$ at the point $(3, 0, 9)$. (5 points)

Equation: $z =$ 


6. Suppose $f$ is a differentiable function of $x$ and $y$ with continuous second partial derivatives. Let $g(u, v) = f(e^u + (v + 2)^2, e^{3u} + v^3)$. You are given the following table of values.

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$g$</td>
<td>$f$</td>
<td>$f_x$</td>
<td>$f_y$</td>
<td>$f_{xx}$</td>
<td>$f_{xy}$</td>
</tr>
<tr>
<td>(0,0)</td>
<td>5</td>
<td>1</td>
<td>4</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>(5,1)</td>
<td>0</td>
<td>4</td>
<td>7</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

(a) Use the table to calculate $g_{u}(0, 0)$, if possible. Otherwise, write “Insufficient information”. (4 points)

$$g_{u}(0, 0) =$$

(b) Use the table to calculate $f_{yx}(5, 1)$, if possible. Otherwise, write “Insufficient information”. (1 point)

$$f_{yx}(5, 1) =$$
7. The picture below is the graph of a function \( z = f(x, y) \) illustrated relative to the coordinate axes. Pick the correct function \( f \). (2 points)

A. \( f(x, y) = x^2 + y^2 - 2 \)
B. \( f(x, y) = x^2 \cos(y) \)
C. \( f(x, y) = x^2 \sin(y) \)
D. \( f(x, y) = x y e^{xy} \)
E. \( f(x, y) = \sin(x) \cos(y) \)

The correct function is

8. Let \( f(x, y, z) = ax^2 + by^2 + cz^2 \) for some real numbers \( a, b, \) and \( c \). Which of the following \textit{could not} be a level set of \( f \)? Circle the letter corresponding to yours answer. (2 points)

A. Ellipsoid
B. Hyperboloid of 1 sheet
C. Hyperboloid of 2 sheets
D. Hyperbolic paraboloid
9. Let $f$ be a function of $x$ and $y$. Consider the following statements.

A. $f(x, y) \to 0$ as $(x, y) \to (0, 0)$ along every straight line through $(0,0)$, but $\lim_{(x,y)\to(0,0)} f(x,y)$ does not exist.

B. $f(x, y) \to 0$ as $(x, y) \to (0, 0)$ along the lines $x = 0$ and $y = 0$, but $\lim_{(x,y)\to(0,0)} f(x,y)$ does not exist.

C. $f(x, y) \to 0$ as $(x, y) \to (0, 0)$ along the lines $x = 0$ and $y = 0$, and $\lim_{(x,y)\to(0,0)} f(x,y) = 1$.

Which statements could possibly be true?
List the letter(s) for those statement(s) in the box, or write “none”. (3 points)

The possibly true statements are
10. A contour map for a function $f$ of $x$ and $y$ and a point $P$ in the plane are given below.

Use the contour map to determine if the following quantities are negative, zero, or positive. (2 points each)

![Contour Map]

(a) $f_x(P)$ is __________
(b) $f_{xx}(P)$ is __________
(c) $f_{xy}(P)$ is __________