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 points)**

$\mathbf{v} = \Big\langle \quad , \quad , \quad \Big\rangle$ $\qquad$ $\mathbf{w} = \Big\langle \quad , \quad , \quad \Big\rangle$

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

$\mathbf{v} \times \mathbf{w} = \Big\langle \quad , \quad , \quad \Big\rangle$

(c) Find the area of the triangle $\triangle ABC$. **(2 points)**

Area($\triangle$) =

2. Suppose that two planes have (non-zero) normal vectors $\mathbf{n}_1$ and $\mathbf{n}_2$ respectively, and that $\mathbf{n}_1 \times \mathbf{n}_2 = \mathbf{0}$. 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 $\text{proj}_{\mathbf{v}}\mathbf{w}$, the vector projection of $\mathbf{w}$ onto $\mathbf{v}$. **(3 points)**

$\text{proj}_{\mathbf{v}}\mathbf{w} = \langle \quad , \quad , \quad \rangle$

(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 $0 \le \theta \le \frac{\pi}{2}$ 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: $z =$ [ ] x + [ ] y + [ ]

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.

	g	f	f_x	f_y	f_{xx}	f_{xy}
$(0,0)$	5	1	4	6	4	5
$(5,1)$	0	4	7	2	1	9

(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)**

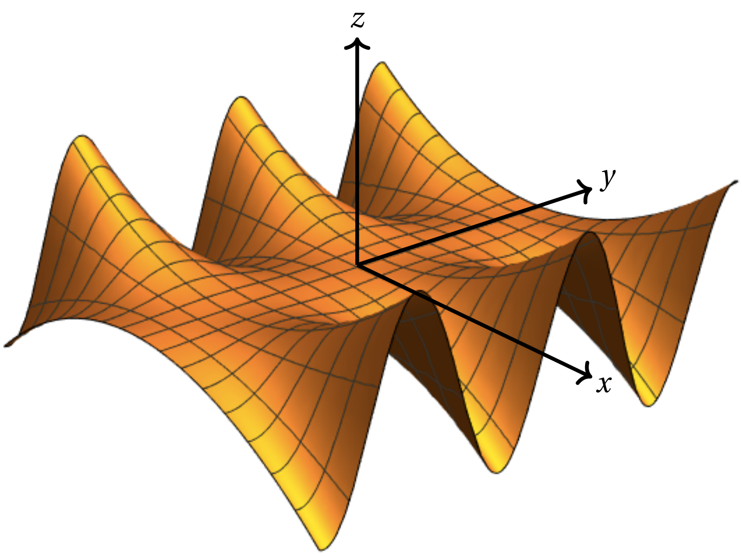
A. $f(x, y) = x^2 + y^2 - 2$

B. $f(x, y) = x^2 \cos(y)$

C. $f(x, y) = x^2 \sin(y)$

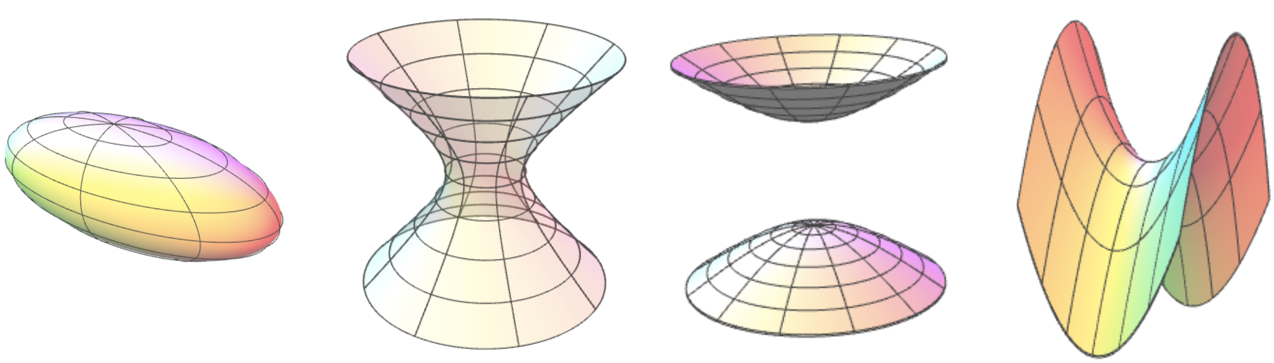
D. $f(x, y) = xye^{xy}$

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 *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.

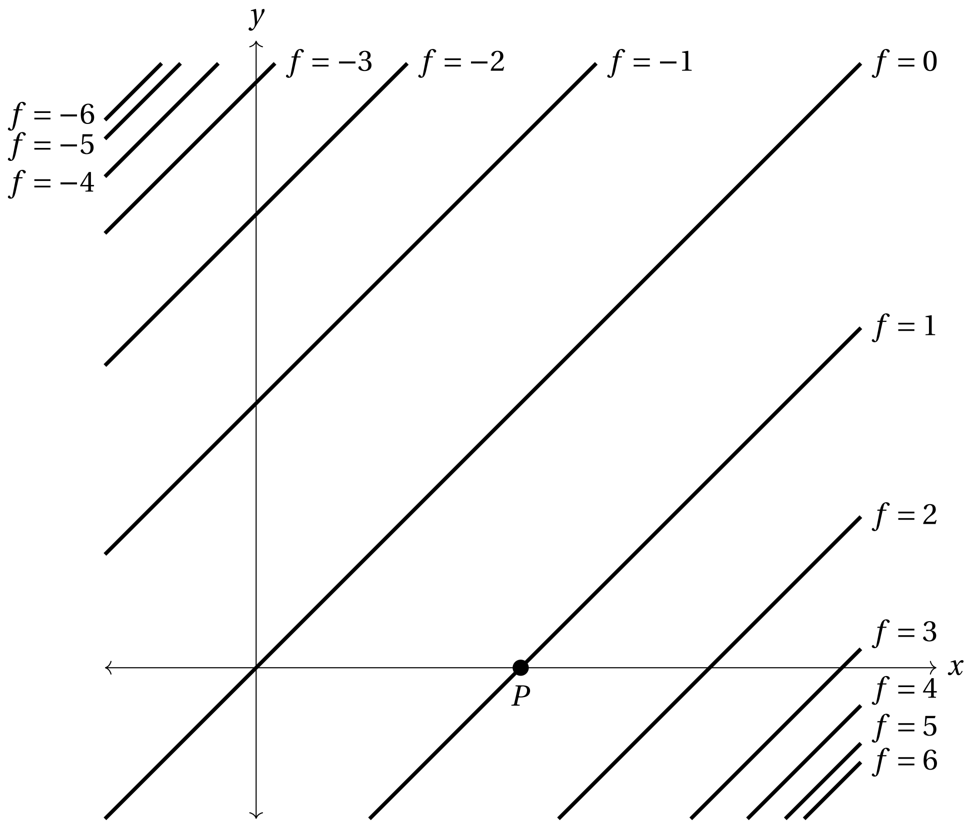
C. $f(x,y) \to 0$ as $(x,y) \to (0,0)$ along the lines $x = 0$ and $y = 0$, and $\lim_{(x,y)\to(0,0)} f(x,y) = 1$.

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)**



(a) $f_x(P)$ is | negative zero positive |

(b) $f_{xx}(P)$ is | negative zero positive |

(c) $f_{xy}(P)$ is | negative zero positive |.