1. Let $\mathbf{u} = \langle 1,\ 0,\ 2\rangle$, $\mathbf{v} = \langle -3,\ 1,\ 1\rangle$, and $\mathbf{w} = \langle 2,\ -1,\ 1\rangle$ be vectors in $\mathbb{R}^3$.

(a) Let θ be the angle between **u** and **v**. Circle the value of θ below. **(2 points)**

$\theta = 0$	$0 < \theta < \pi/2$	$\theta = \pi/2$	$\pi/2 < \theta < \pi$	$\theta = \pi$

(b) Circle the value of $|2\mathbf{u} - \mathbf{v}|$. **(2 points)**

$\sqrt{10}$	$\sqrt{11}$	$\sqrt{30}$	$\sqrt{34}$	$\sqrt{35}$

(c) Mark the answer that best describes the meaning of the expression $\left|\mathbf{u} \cdot (\mathbf{v} \times \mathbf{w})\right|$. **(1 point)**

☐ It is the sum of the areas of the two parallelograms determined by the two pairs $\{\mathbf{u}, \mathbf{v}\}$ and $\{\mathbf{u}, \mathbf{w}\}$.

☐ It is the area of the parallelogram with vertices determined by 0, $\mathbf{u}, \mathbf{v}$, and $\mathbf{w}$.

☐ It is the volume of the parallelepiped determined by the vectors $\mathbf{u}, \mathbf{v}$, and $\mathbf{w}$.

☐ It has no meaning, but it is always defined and sometimes it is zero.

☐ It is undefined.

Scratch Space

2. Find a parametric equation for the line passing through the points $A(2,0,3)$ and $B(3,1,6)$. **(2 points)**

$$\big(x(t), y(t), z(t)\big) = \big(\qquad , \qquad , \qquad \big)$$

3. Find an equation of the plane that contains the line L parameterized by $\mathbf{r}(t) = \langle 1+t,\ 1,\ 2t\rangle$ and the point $P(2,\ 4,\ 0)$. **(5 points)**

Equation: $\square\, x + \square\, y + \square\, z = \square$

4. Let **a** and **b** be two vectors in $\mathbb{R}^3$ such that $\left|\text{proj}_{\mathbf{a}}\mathbf{b}\right| = 2$. **(1 point each)**

(a) Determine the value of $\left|\text{proj}_{3\mathbf{a}}\mathbf{b}\right|$. Circle your answer:

$\frac{2}{3}$	2	3	5	6

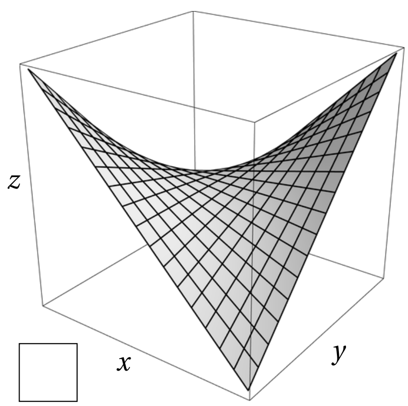
(b) Determine the value of $\left|\text{proj}_{\mathbf{a}}5\mathbf{b}\right|$. Circle your answer:

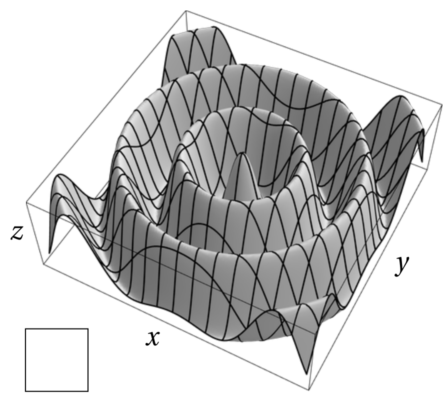
$\frac{2}{5}$	2	5	7	10

5. Find the value of m such that the vector $\mathbf{u} = \langle -9,\ m,\ 6\rangle$ is perpendicular to the plane $3x + y - 2z = 15$. Circle your answer. **(2 points)**

$m = -3$	$m = -1$	$m = 0$	$m = 1$	$m = 39$

6. For each graph below, find the corresponding function from the options at right and write the corresponding letter in the box next to the graph. **(2 points each)**





(A) $\sin(x+y)$

(B) $x^2 - y^2$

(C) $\cos\left(\sqrt{x^2+y^2}\right)$

(D) $\cos(x)\cos(y)$

(E) $(x-y)^2$

(F) xy

Scratch Space

7. Let $f(x, y) = x^3 y + 2xy^2 + y$.

(a) Find the equation of the tangent plane to the surface $z = f(x, y)$ at the point $(0, 1, 1)$. **(4 points)**

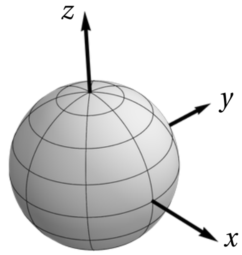
Equation: $\square\, x + \square\, y + \square\, z = \square$

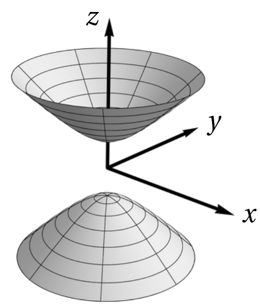
(b) Use linear approximation to estimate the value of $f(0.2, 0.9)$. **(2 points)**

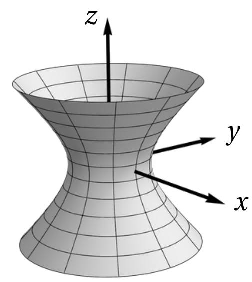
$f(0.2, 0.9) \approx$

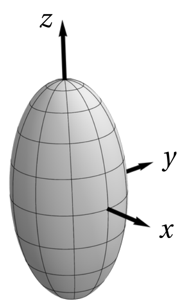
8. For each equation below, write the corresponding letter in the box next to the picture of the surface it describes. **(2 points each)**

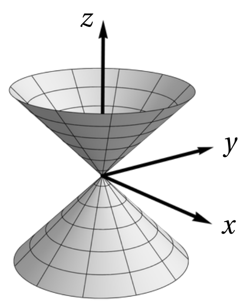
(A) $x^2 + y^2 - z^2 + 1 = 0$ (B) $4x^2 + y^2 + 4z^2 - 1 = 0$

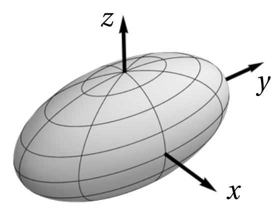




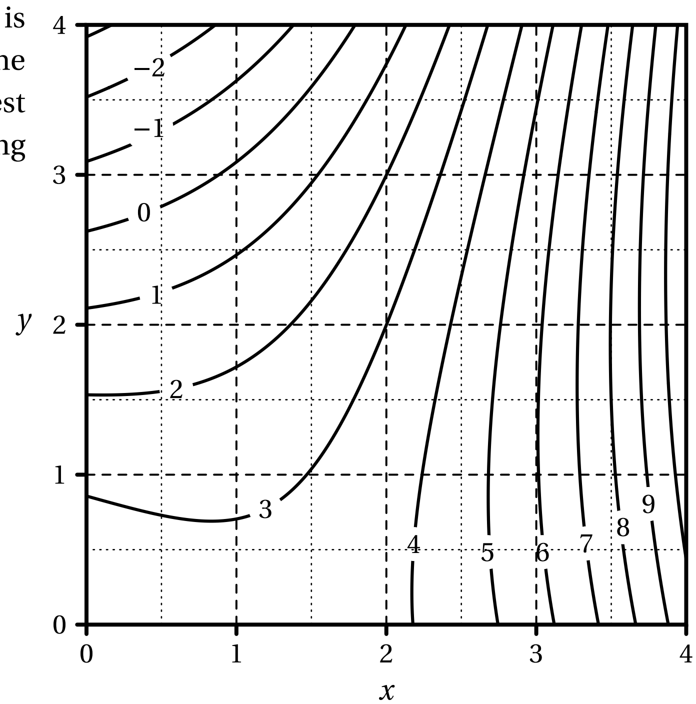








9. The contour map of a differentiable function $f(x, y)$ is shown at right, where each level curve is labeled by the corresponding value of f. For each part, circle the best possible answer. **2 points** for part (a) and the remaining parts are **1 point each**.



(a) $\dfrac{\partial f}{\partial x}(2,2)$ is

-4 -2 -1 0 1 2 4

(b) $\dfrac{\partial f}{\partial y}(2,2)$ is negative zero positive

(c) $\dfrac{\partial^2 f}{\partial x^2}(2,2)$ is negative zero positive

(d) $\dfrac{\partial^2 f}{\partial y \partial x}(2,2)$ is negative zero positive

10. Let $f(x,y) = \dfrac{xy^2}{3x^2 + y^4}$. Determine the limits in the problems below. Be sure to *explain your reasoning.* If a limit does not exist, write "DNE" in the box provided.

(a) Determine $\lim_{y \to 0} f(y^2, y)$. **(2 points)**

$\lim_{y \to 0} f(y^2, y) =$

(b) Determine $\lim_{(x,y) \to (0,0)} f(x,y)$. **(2 points)**

$\lim_{(x,y) \to (0,0)} f(x,y) =$

(c) Determine $\lim_{(x,y) \to (1,0)} f(x,y)$. **(1 point)**

$\lim_{(x,y) \to (1,0)} f(x,y) =$

11. Let $f\colon \mathbb{R}^2 \to \mathbb{R}$ be a differentiable function of two variables. Let $x(u,v) = u^2 v$ and $y(u,v) = u\cos(v)$. Consider the function $g(u,v) = f\big(x(u,v), y(u,v)\big)$. Use the table of values for f and g below to compute $g_u(1,0)$. **(4 points)**

	g	f	f_x	f_y	f_{xx}	f_{xy}
(1,0)	5	1	2	-1	0	5
(0,1)	0	5	3	-2	10	-11

$g_u(1,0) =$

Scratch Space