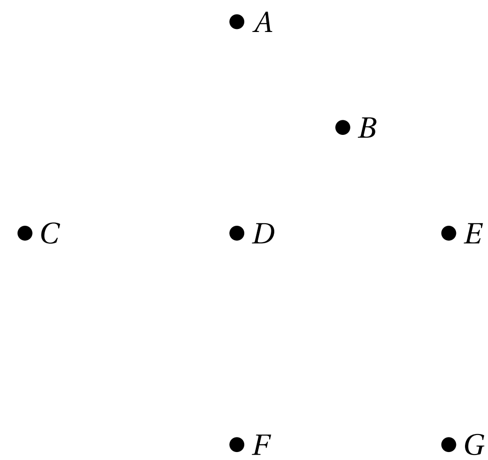
1. Give a vector **v** perpendicular to the plane that contains the line $x = 1 + t,\ y = 2 - 3t,\ z = 2 + 4t$ and the line $x = 2,\ y = -1 + 2t,\ z = 6 - t$. **(5 points)**

$\mathbf{v} = \langle \quad , \quad , \quad \rangle$

2. Find the angle θ between the planes $x = z + 8$ and $2y = 1 - 2x + z$. **(5 points)**

$\theta =$

3. Consider the points in the plane shown at right:



(a) Circle the vector that is equal to $2\overrightarrow{DE} - \overrightarrow{CA}$:

$\overrightarrow{DA}$	$\overrightarrow{DB}$	$\overrightarrow{DE}$	$\overrightarrow{DF}$	$\overrightarrow{DG}$

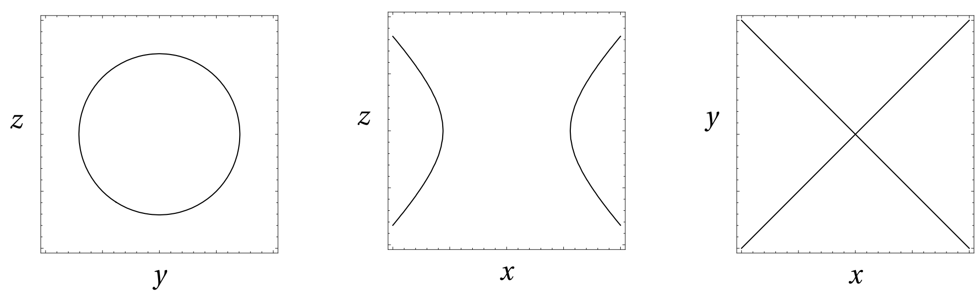
(2 points)

(b) Circle the vector that is equal to $\text{proj}_{\overrightarrow{CA}} \overrightarrow{DE}$:

$\overrightarrow{DA}$	$\overrightarrow{DB}$	$\overrightarrow{DE}$	$\overrightarrow{DF}$	$\overrightarrow{DG}$

(2 points)

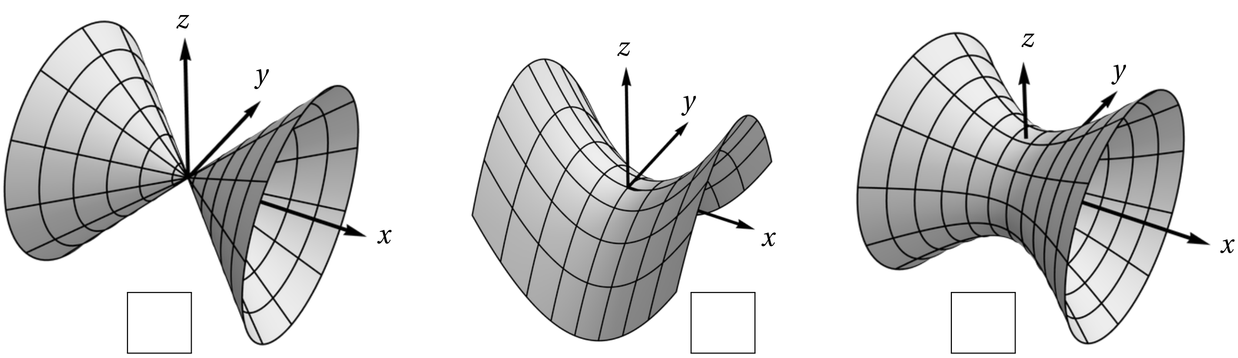
4. Suppose S is a quadric surface whose intersections with the following three planes are:



Plane $\{x = 1\}$ Plane $\{y = -1.5\}$ Plane $\{z = 1\}$

(a) Mark the box next to the picture of the portion of S where $-2 \le x \le 2$, $-2 \le y \le 2$, and $-2 \le z \le 2$:

(2 points)



(b) Circle the equation that S satisfies:

$x^2 + y^2 - z = 0$	$y^2 + z^2 - x^2 = 1$	$y^2 + z^2 = x^2$

(2 points)

5. Consider the limit $\lim_{(x,y)\to(0,0)} \frac{y^4 \cos^2 x}{x^4 + y^4}$. Does this limit exist? If so, what is its value? Justify your answer. **(5 points)**

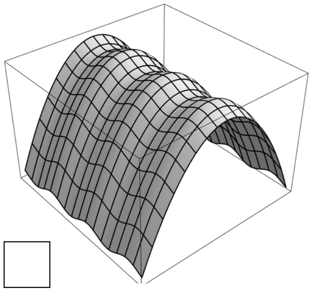
6. Find the equation of the tangent plane to the graph of g at the point $(1,0,4)$ based on the data in the table at right. **(4 points)**

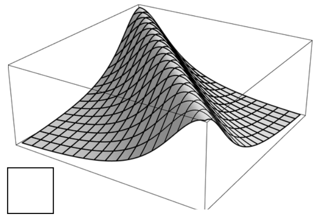
(x,y)	$g(x,y)$	$g_x(x,y)$	$g_y(x,y)$	$g_{xx}(x,y)$	$g_{yy}(x,y)$
$(0,4)$	1	2	4	2	-2
$(1,0)$	4	3	-1	0	0
$(1,4)$	3	-6	5	1	-3

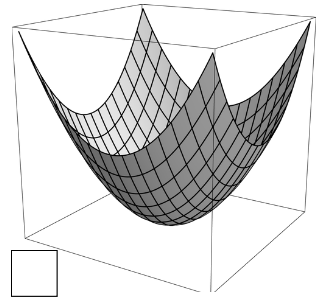
Equation: $\square\, x + \square\, y + \square\, z = \square$

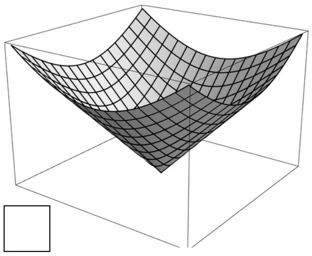
7. For each function, label its graph from among the options below by writing the corresponding letter in the box next to the graph. **(2 points each)**

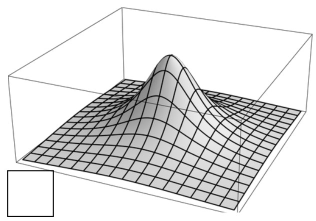
(A) $-y^2 + \sin(x)$ (B) $\sqrt{x^2 + y^2}$

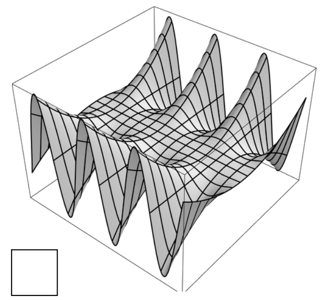




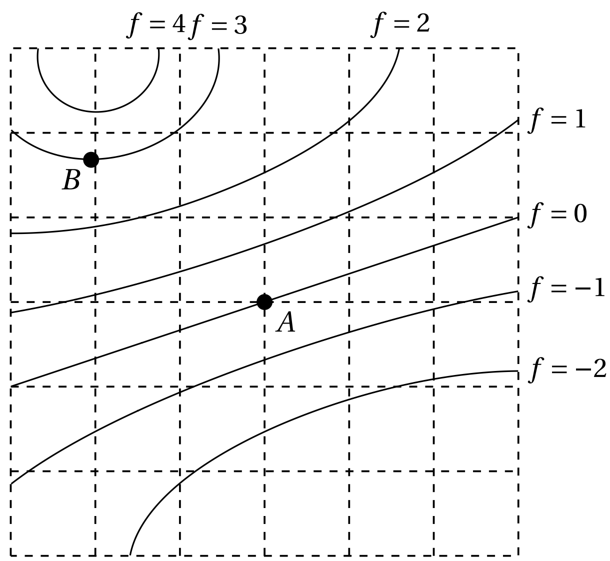








8. Consider the contour plot of $f(x, y)$ shown at right, where the dotted grid is made of unit squares.



(a) At the point B, is the derivative $\dfrac{\partial f}{\partial x}$ is:

negative zero positive

(1 point)

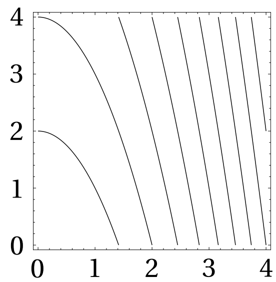
(b) Estimate the partial derivatives $\dfrac{\partial f}{\partial x}$ and $\dfrac{\partial f}{\partial y}$ at the point A. For each, circle the number below that is closest to your estimate.

(3 points)

$\dfrac{\partial f}{\partial x}$:	−3	−2.5	−2	−1.5	−1	−0.5	0	0.5	1	1.5	2	2.5	3
$\dfrac{\partial f}{\partial y}$:	−3	−2.5	−2	−1.5	−1	−0.5	0	0.5	1	1.5	2	2.5	3

9. Suppose the temperature, measured in °C, on a tabletop is given by $F(x, y) = 40 - x^2 - y$, where x and y have units of centimeters.

(a) Mark the box below the contour plot that best matches the function F. **(1 point)**



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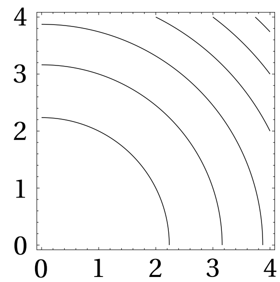

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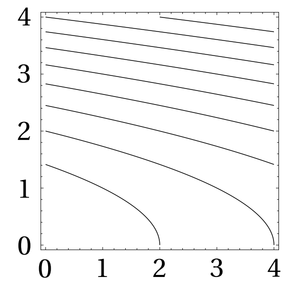

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(b) Suppose a small bug positioned at $(3, 1)$ is travelling so that its x-coordinate is **decreasing** at a rate of 1 cm/s and its y-coordinate is **increasing** at a rate of 2 cm/s. Use the Chain Rule to calculate the rate at which the temperature is changing from the bug's perspective. **(5 points)**

rate =	°C/s