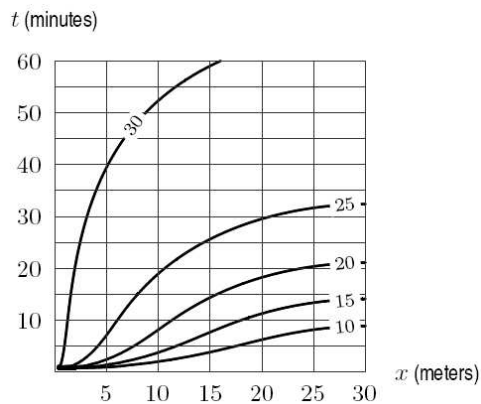# Classroom Voting Questions: Multivariable Calculus

## 14.4 Gradients and Directional Derivatives in the Plane

1. The figure shows the temperature T $°C$ in a heated room as a function of distance $x$ in meters along a wall and time $t$ in minutes. Which of the following is larger?



   (a) $||\nabla T(15, 15)||$

   (b) $||\nabla T(25, 25)||$

2. The table below gives values of the function $f(x, y)$ which is smoothly varying around the point (3, 5). Estimate the vector $\nabla(f(3,5))$. If the gradient vector is placed with its tail at the origin, into which quadrant does the vector point?

|     |     | $y$   |       |       |
| --- | --- | ----- | ----- | ----- |
|     |     | 4.9   | 5     | 5.1   |
|     | 2.9 | 18.12 | 17.42 | 16.73 |
| $x$ | 3   | 18.42 | 17.74 | 17.04 |
|     | 3.1 | 18.71 | 18.04 | 17.35 |

   (a) I

   (b) II

   (c) III

   (d) IV

   (e) Can't tell without more information

3. Let $\nabla f(1, 1) = 3\hat{i} - 5\hat{j}$. What is the sign of the directional derivative of f in the direction of the vector $\nwarrow$ and in the direction of the vector $\uparrow$?

   (a) positive and positive
   (b) positive and negative
   (c) negative and positive
   (d) negative and negative


4. Let $\nabla f(1, 1) = 3\hat{i} - 5\hat{j}$. What is the sign of the directional derivative of f in the direction of the vector $\leftarrow$ and in the direction of the vector $\searrow$?

   (a) positive and positive
   (b) positive and negative
   (c) negative and positive
   (d) negative and negative


5. In which direction is the directional derivative of $z = x^2 + y^2$ at the point (2,3) most positive?

   (a) $\hat{i}$
   (b) $-\hat{i} - \hat{j}$
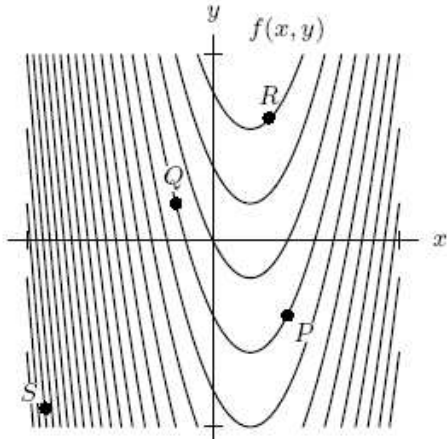   (c) $-\hat{i} + \hat{j}$
   (d) $\hat{i} + \hat{j}$


6. Which of the vectors shown on the contour diagram of $f(x, y)$ in the figure below could be $\nabla f$ at the point at which the tail is attached?



   (a) A
   (b) B

2
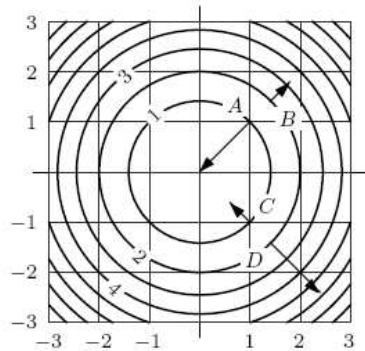
(c) C

(d) D

7. At which of the points P, Q,R, S in the figure below does the gradient have the largest magnitude?
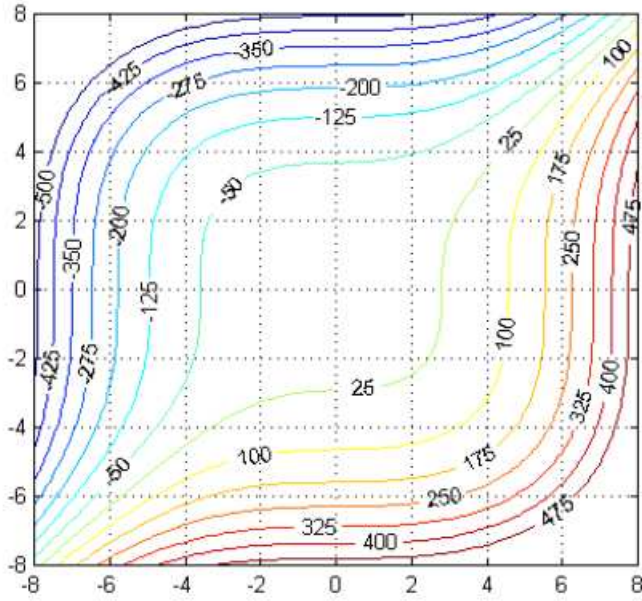


(a) P

(b) Q

(c) R

(d) S

8. The surface of a hill is modeled by $z = 25 - 2x^2 - 4y^2$. When a hiker reaches the point (1, 1, 19), it begins to rain. She decides to descend the hill by the most rapid way. Which of the following vectors points in the direction in which she starts her descent?
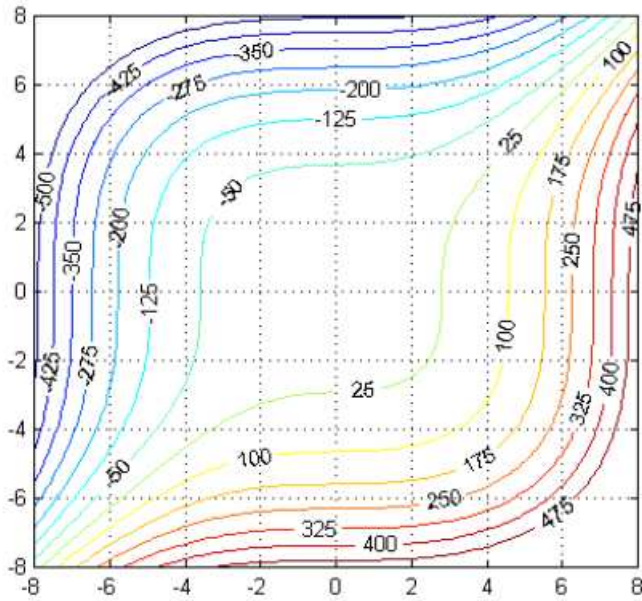
(a) $-4x\hat{i} - 8y\hat{j}$

(b) $4x\hat{i} + 8y\hat{j}$

(c) $-4\hat{i} - 8\hat{j}$

(d) $4\hat{i} + 8\hat{j}$

(e) None of the above

9. At which point will the gradient vector have the largest magnitude?

(a) (0,2)

(b) (-4,-4)

(c) (0,0)

(d) (6,-2)

10. At which point will the gradient vector be most parallel to $\hat{j}$?



(a) (0,4)

(b) (-4,-4)

(c) (0,0)

(d) (6,-2)

11. $\nabla f(1,1) = 3\hat{i} - 5\hat{j}$. What is the sign of the directional derivative of $f$ in the direction $\vec{v} = 4\hat{i} + 2\hat{j}$?

(a) Positive

(b) Negative

12. Suppose that the temperature at a point $(x, y)$ on the floor of a room is given by $T(x, y)$. Suppose heat is being radiated out from a hot spot at the origin. Which of the following could be $\nabla T(a, b)$, where $a, b > 0$?

(a) $2\hat{i} + 2\hat{j}$

(b) $-2\hat{i} - 2\hat{j}$

(c) $-2\hat{i} + 2\hat{j}$

(d) $2\hat{i} - 2\hat{j}$