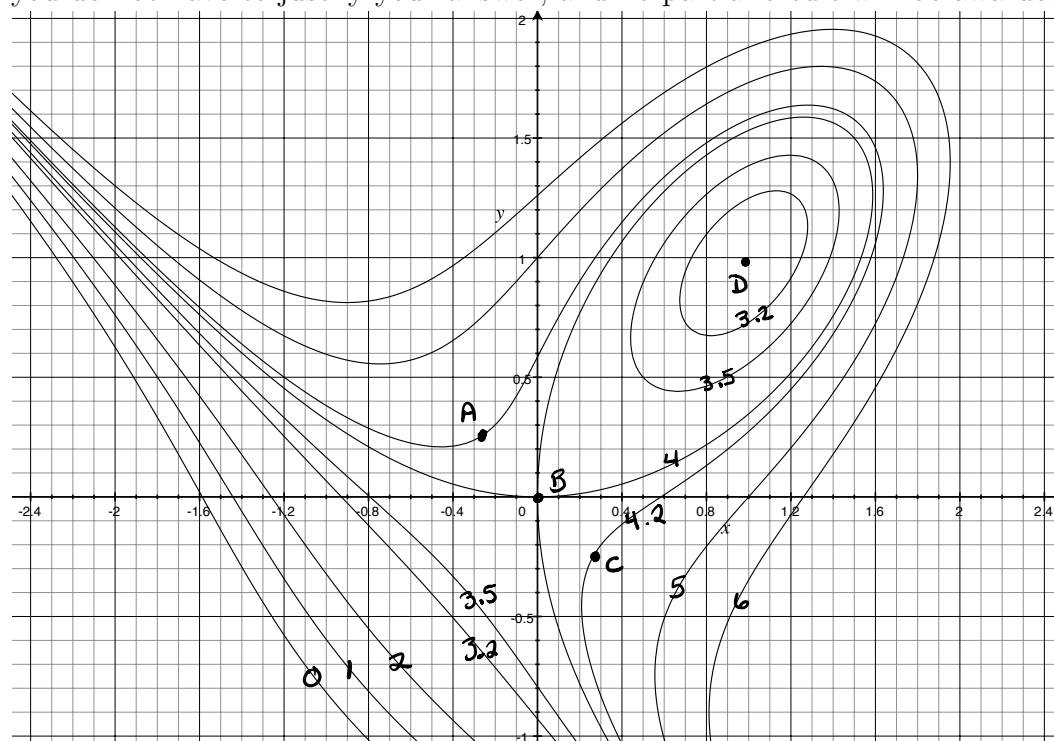


15. The following diagram shows the contour map of a function $f(x, y)$. The number written on each curve indicates the value of f on that curve. For this problem, you do not have to justify your answer, and no partial credit will be awarded.



- (a) (1 point each) For each marked point, circle (or write) the correct classification.

A : Not a critical point Local minimum Local maximum Saddle point

B : Not a critical point Local minimum Local maximum Saddle point

C : Not a critical point Local minimum Local maximum Saddle point

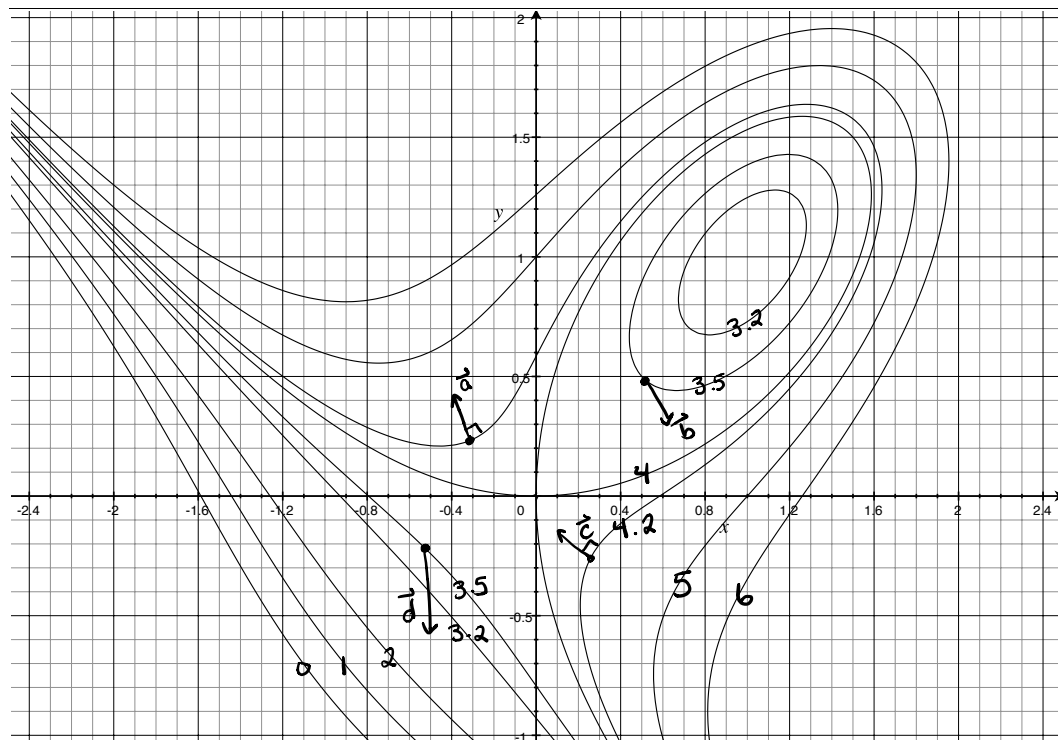
D : Not a critical point Local minimum Local maximum Saddle point

- (b) (2 points each) Determine the sign (positive or negative) of each of the following:

i. $\frac{\partial f}{\partial x}(0, 1)$: _____

ii. $\frac{\partial f}{\partial y}(0, 1)$: _____

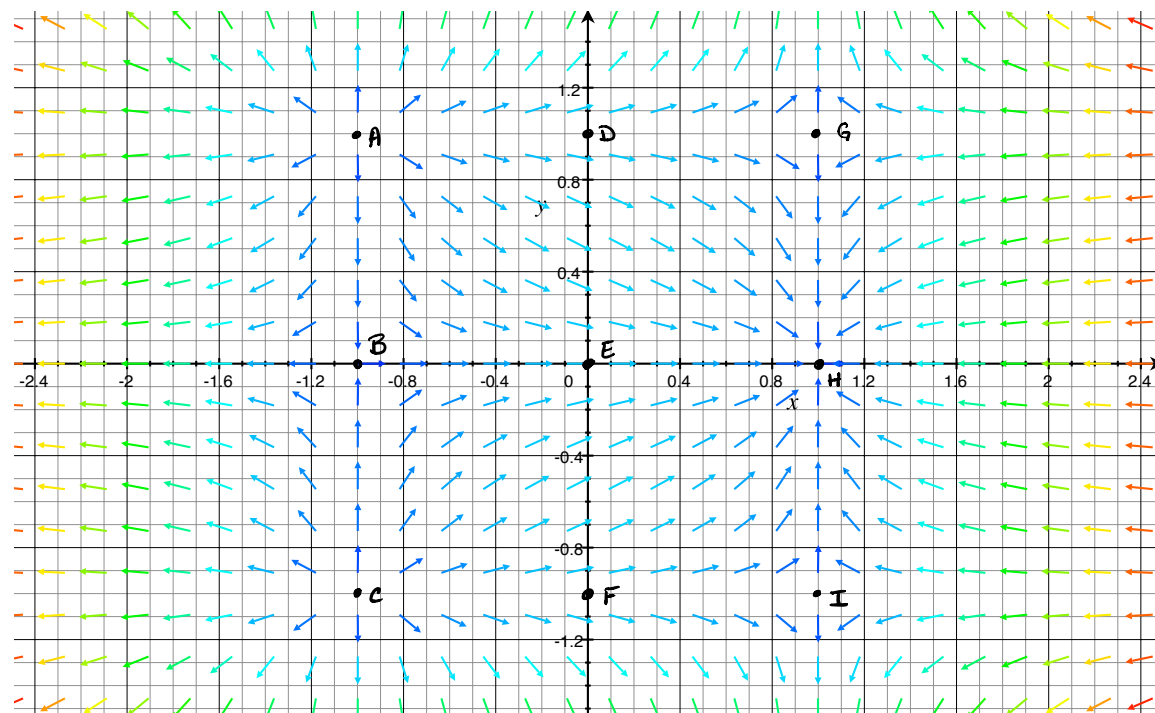
- (c) (2 points) The following diagram shows the contour map of the same function $f(x, y)$ with four vectors, $\vec{a}$, $\vec{b}$, $\vec{c}$, and $\vec{d}$, drawn. The number written on each curve indicates the value of f on that curve.



Circle (or write) all vectors which could be ∇f at that point.

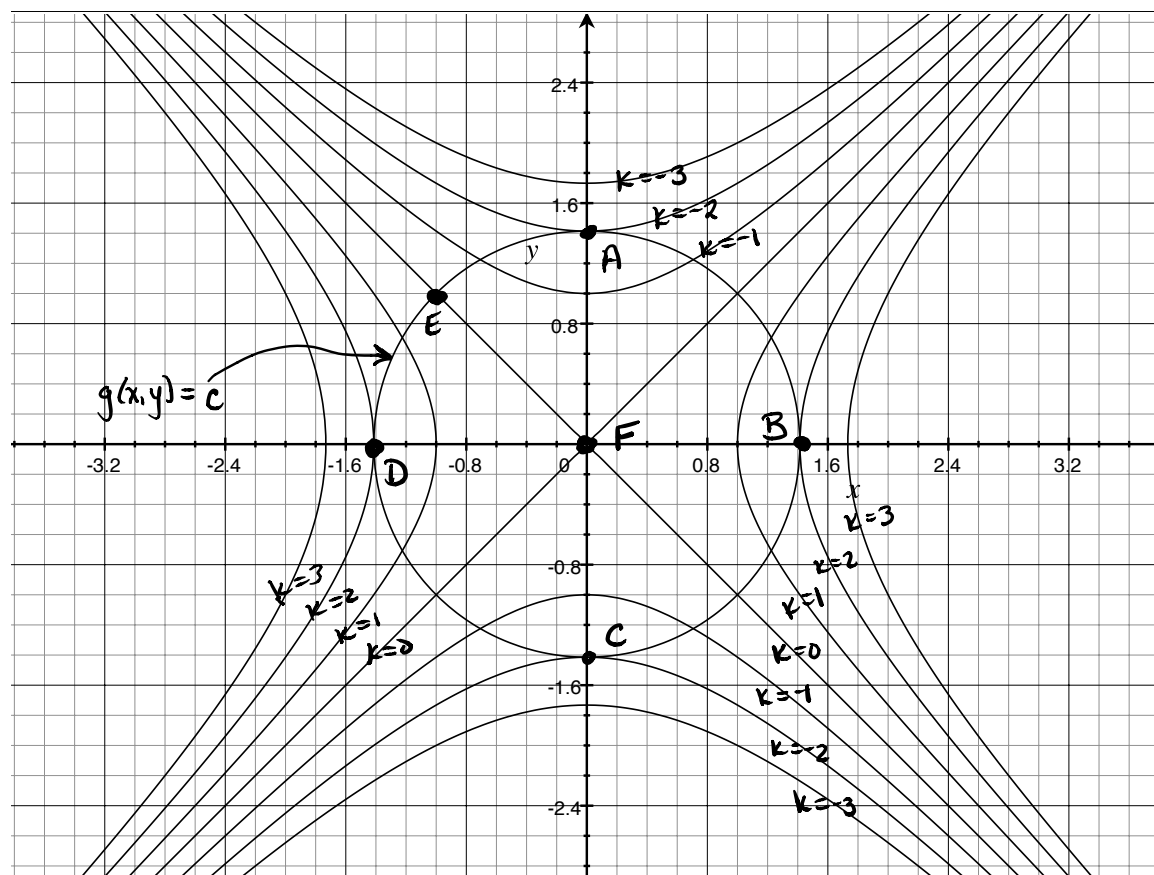
$\vec{a}$ $\vec{b}$ $\vec{c}$ $\vec{d}$

16. (1 point each) The following diagram shows the gradient vector field of a function $f(x, y)$. Circle the correct classification for each of the marked points. For this problem, you do not have to justify your answer, and no partial credit will be awarded.



- A : Not a critical point Local minimum Local maximum Saddle point
- B : Not a critical point Local minimum Local maximum Saddle point
- C : Not a critical point Local minimum Local maximum Saddle point
- D : Not a critical point Local minimum Local maximum Saddle point
- E : Not a critical point Local minimum Local maximum Saddle point
- F : Not a critical point Local minimum Local maximum Saddle point
- G : Not a critical point Local minimum Local maximum Saddle point
- H : Not a critical point Local minimum Local maximum Saddle point
- I : Not a critical point Local minimum Local maximum Saddle point

17. (3 points each) The following graph shows the level curves $f(x, y) = k$ of a function f and the graph of a function $g(x, y) = c$. For this problem, you do not have to justify your answer, and no partial credit will be awarded.



Use the graph to complete the following sentences:

- (a) Subject to the constraint $g(x, y) = c$, the function $f(x, y)$ has an absolute maximum of _____ which occurs at the point(s) _____.
- (b) Subject to the constraint $g(x, y) = c$, the function $f(x, y)$ has an absolute minimum of _____ which occurs at the point(s) _____.

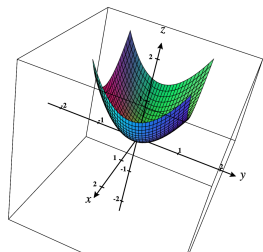
19. (2 points each) Match each graph with its corresponding contour map and gradient vector field. Write your answer in the space provided below. For this problem, you do not have to justify your answer, and no partial credit will be awarded.

Graph

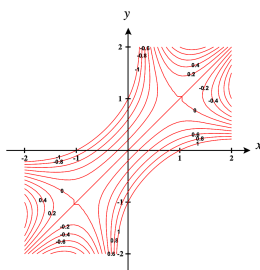
Contour map

Gradient vector field

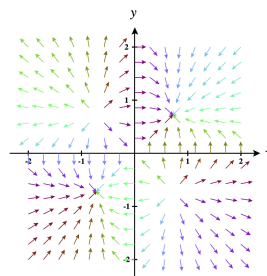
1.



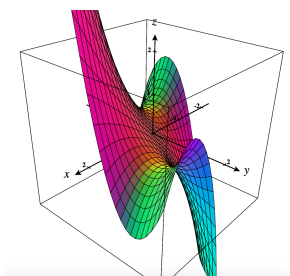
A.



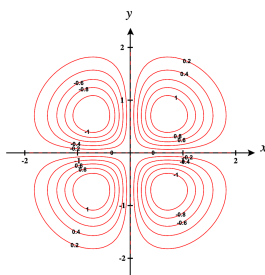
i.



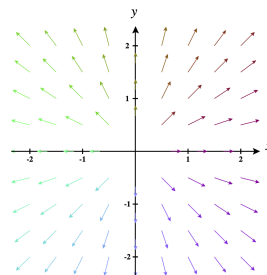
2.



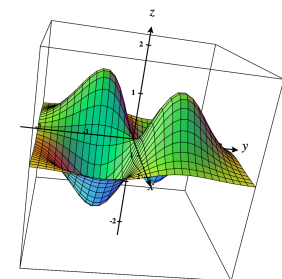
B.



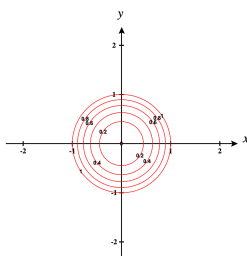
ii.



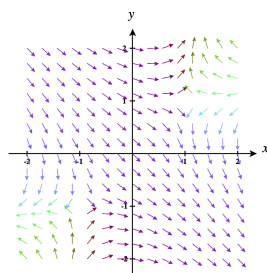
3.



C.



iii.



Graph 1 corresponds to contour map _____ and gradient vector field _____.
 Graph 2 corresponds to contour map _____ and gradient vector field _____.
 Graph 3 corresponds to contour map _____ and gradient vector field _____.

20. (2 points each) Determine if each statement is true or false, and write the (entire) word TRUE or FALSE in the space provided. You do not have to justify your answers, and no partial credit will be awarded.

(a) The function

$$f(x, y) = \begin{cases} \frac{1 - \cos(x^2 + y^2)}{x^2 + y^2} & \text{if } (x, y) \neq (0, 0) \\ 1 & \text{if } (x, y) = (0, 0) \end{cases}$$

is continuous.

(b) If two lines in $\mathbb{R}^3$ do not intersect, then they are parallel.

(c) Let $\vec{r}(t)$ be a curve in space. The binormal vector to the curve $\vec{B}$ lies on the osculating plane.

(d) A quadric surface whose vertical traces are all (non-degenerate) hyperbolas and whose horizontal traces are all (non-degenerate) ellipses is a hyperboloid of one sheet.

(e) The graph of the function with spherical equation $\rho = \pi/3$ is a cone which opens upwards.