Name: _____

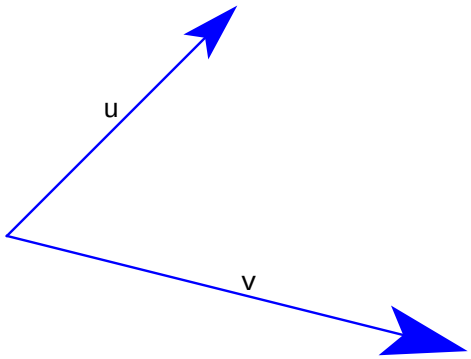
- **READ THE FOLLOWING DIRECTIONS!**
- **Do NOT open the exam until instructed to do so.**
- You have until 12:50 to complete this exam. When you are told to stop writing, do it or you will lose all points on the page you write on.
- You may not communicate with other students during this test.
- No written materials of any kind are allowed. No scratch paper is allowed except as given by the proctors.
- No phones, calculators, or any other electronic devices are allowed for any reason, including checking the time (a simple wristwatch is fine).
- Any case of cheating will be taken extremely seriously.
- Show all your work and explain your answers.
- Before turning in your exam, check to make certain you've answered all the questions.
- You do not need to simplify algebraic expressions.

Question:	1	2	3	4	5	6	7	Total
Points:	17	15	22	6	10	14	16	100
Score:								

1. Quickies:

   (a) (5 points) Parametrize the line segment joining $(1, 3, 2)$ to $(-1, 2, 4)$.

   (b) (4 points) Here are two vectors $\vec{u}$ and $\vec{v}$ living in the plane of this paper. Describe the direction of $\vec{u} \times \vec{v}$.



   (c) (3 points) Describe the magnitude of the same $\vec{u} \times \vec{v}$ in terms of some geometry.

   (d) (4 points) Is the cross product is commutative? That is, does $\vec{a} \times \vec{b} = \vec{b} \times \vec{a}$ for every $\vec{a}, \vec{b}$? Explain briefly.

   (e) (1 point) Is the cross product associative? That is, does $\vec{a} \times (\vec{b} \times \vec{c}) = (\vec{a} \times \vec{b}) \times \vec{c}$ for all $\vec{a}, \vec{b}, \vec{c}$? Explain briefly.

2. Consider the planes $x - y + 2z = 4$ and $2x - 3y + z = 6$.

   (a) (3 points) Explain why, at a glance, you know these planes are not parallel.

   (b) (6 points) Find a vector that is parallel to both planes.

   (c) (6 points) Give an equation for the line that is the intersection of the two planes.

3. Suppose a particle moves in space, with position $(\sin t,\ \cos t,\ t - t^2)$ at time t.

(a) (4 points) Find the velocity at time $t = \pi/2$.

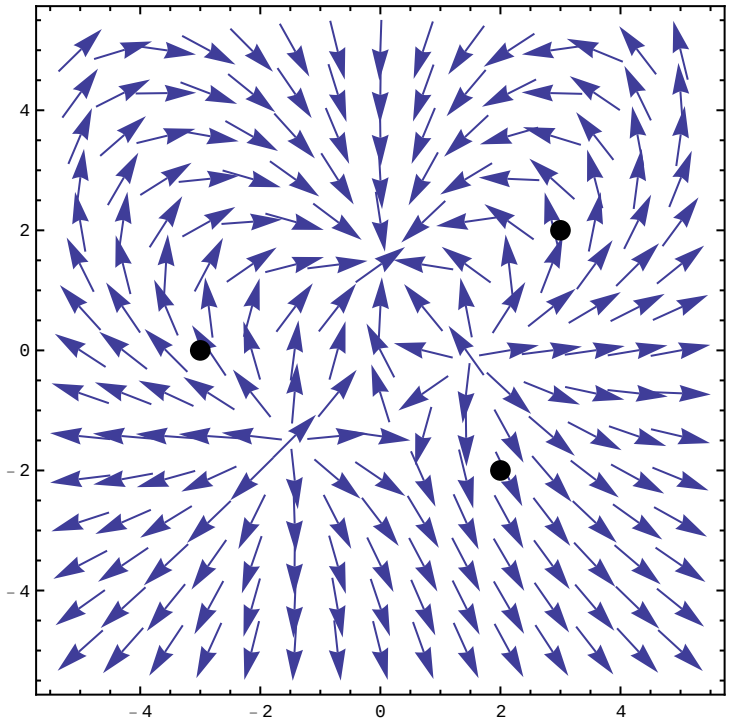
(b) (4 points) Find the acceleration at time $t = \pi/2$.

(c) (6 points) Find the tangential component of acceleration at time $t = \pi/2$.

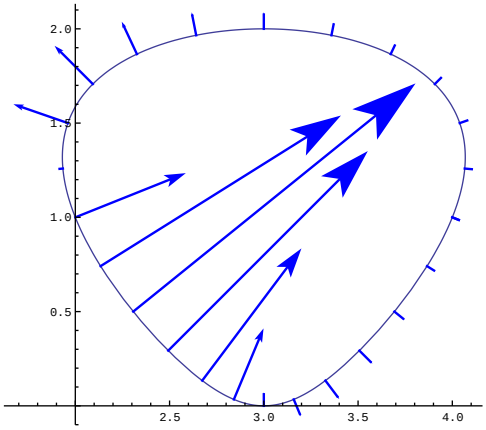
(d) (4 points) Find the normal component of acceleration at time $t = \pi/2$.

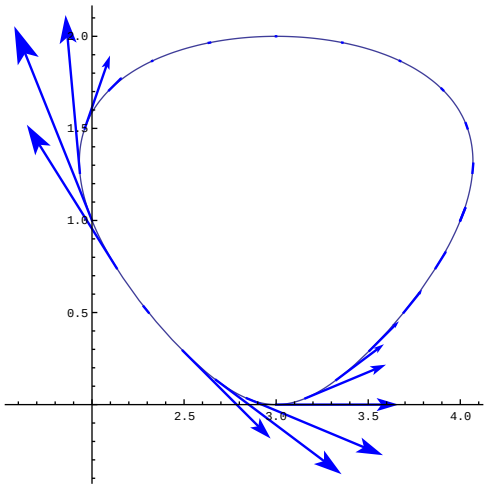
(e) (4 points) What do you know about how the speed of the particle is changing at $t = \pi/2$? How do you know?

4. (6 points) Here's a (scaled) plot of a certain vector field $\vec{F}(x, y)$. Throw in the trajectories that pass through the indicated points.



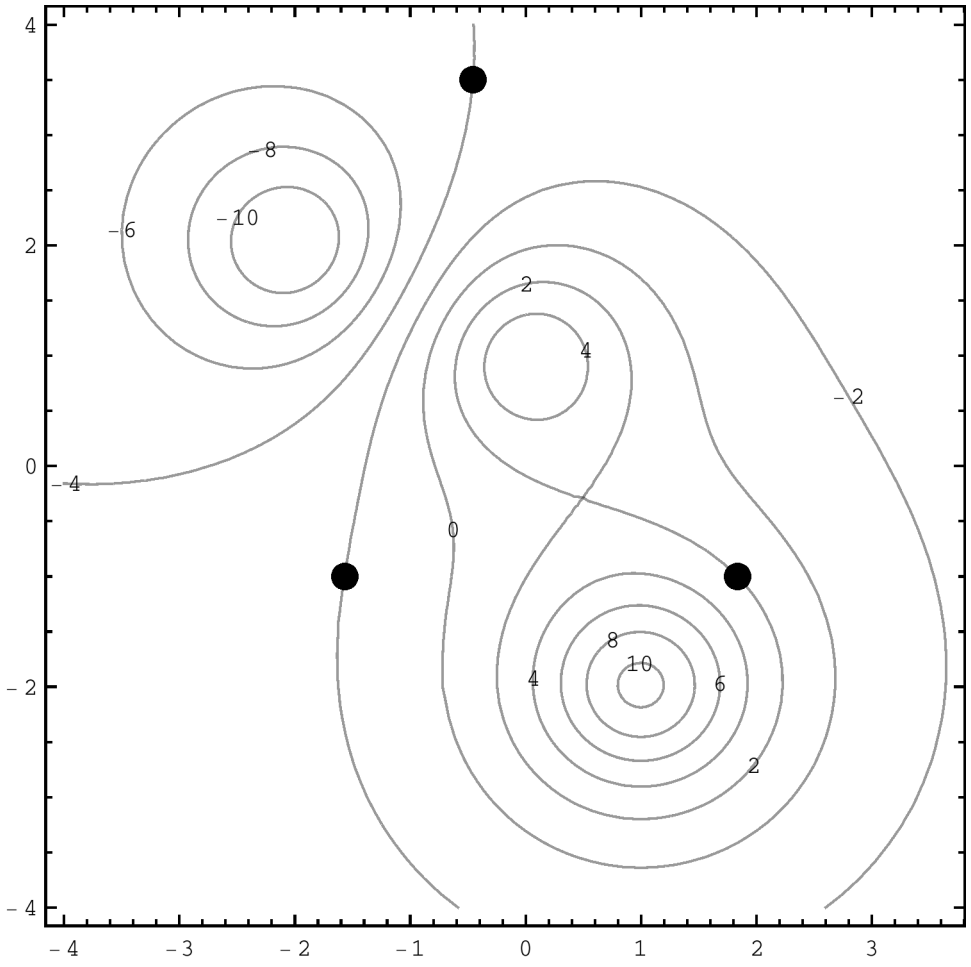
5. (10 points) Now we'll just look at $\vec{F}$ on a curve C. Shown below are the tangential and normal components of $\vec{F}$ on C. What do each of them tell you about the net flow of $\vec{F}$ along/across C?





6. (14 points) Find the maximum and minimum values of $f(x, y) = x^3y$ on the disk $x^2 + y^2 \leq 4$. Then sketch the region together with the level curves for f corresponding to your maximum and minimum.

7. Below is a plot of several level curves of a function $f(x, y)$ inside the rectangle R.



(a) (9 points) At the indicated points, sketch in the gradient vectors.

(b) (7 points) Mark the (approximate) locations of any critical points of f in R, and classify them as local max, min, or saddle points.

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