Name:

You must show all of your work to get full credit.

1. Consider the system: $\begin{aligned} & \frac{d x}{d t}=x^{2}-2 x y+2 x \\ & \frac{d y}{d t}=y^{2}+x y+8 y\end{aligned}$
a. Find all equilibrium points
b. Using the Jacobian matrix, classify all equilibrium points.
c. For each equilibrium point sketch the phase portrait of the system near that point. Sketch each of these graphs separately.
2. Consider the same system from problem (1):

$$
\frac{d x}{d t}=x^{2}-2 x y+2 x
$$

$$
\frac{d y}{d t}=y^{2}+x y+8 y
$$

a. On the entire xy-plane, sketch the $x$ and $y$ nullclines and indicate the direction of the vector field along each nullcline.
b. From the nullclines find all the equilibrium points
c. What is the behavior of the solution with initial condition $\bar{Y}(0)=(-2,-3)$ ?
3. Consider the system $\frac{d x}{d t}=\left(x^{2}-2 x\right)\left(x^{2}+y^{2}-9\right)$

$$
\frac{d y}{d t}=y^{2}-2 y
$$

a. Sketch the x and y nullclines and indicate the direction of the vector field along each nullcline. Restrict your graph to the first quadrant $(x \geq 0, y \geq 0)$.
b. From the nullclines find the equilibrium points in the first quadrant.
c. What is the behavior of the solution with initial condition $\bar{Y}(0)=(1,1)$ ?
d. What is the behavior of the solution with the initial condition
$\vec{Y}(0)=\left(\frac{5}{2}, 1\right)$ ?
e. What is the behavior of the solution with the initial condition $\vec{Y}(0)=(3,3)$ ?

