1. (20 Points) Consider the differential equation \( \dot{x} = a^2 x - x^3 \) with \( a > 0 \).
   (a) Find the fixed points and classify their stability type.
   (b) Draw the phase portrait.

2. (20 Points) Consider the system of linear differential equations
   \[
   \begin{pmatrix}
   \dot{x} \\
   \dot{y}
   \end{pmatrix}
   = \begin{pmatrix}
   -8 & -3 \\
   3 & -2
   \end{pmatrix}
   \begin{pmatrix}
   x \\
   y
   \end{pmatrix}
   \]
   which has a repeated eigenvalue \(-5\).
   (a) Find the general real solution.
   (b) Classify the type of linear system.
   (c) Draw the phase portrait.

3. (30 Points) Consider the equations
   \[
   \begin{pmatrix}
   \dot{x} \\
   \dot{y}
   \end{pmatrix}
   = \begin{pmatrix}
   -2x + y \\
   4 - 2xy
   \end{pmatrix}.
   \]
   (a) Find the (two) fixed points and classify them.
   (b) Draw the phase portraits using the null clines and the answer to part (a).

4. (30 Points) Consider the conservative system of differential equations
   \[
   \begin{pmatrix}
   \dot{x} \\
   \dot{y}
   \end{pmatrix}
   = \begin{pmatrix}
   y \\
   -x + x^2
   \end{pmatrix}.
   \]
   (a) Find the fixed points.
   (b) Find the potential function \( V(x) \) and draw its graph.
   (c) Draw the phase portrait for the system of differential equations.