1. (10 pts) Find the equation of the trajectories in the xy plane for the system
   \[ x' = 4y, \quad y' = 2x - 2. \]

2. (15 pts) Consider the population model governed by the autonomous equation
   \[ p' = \sqrt{2}p - \frac{4p^2}{1 + p^2}. \]
   (a) Sketch a graph of the growth rate \( p' \) versus the population \( p \), and sketch the phase line.
   (b) Find the equilibrium populations and determine their stability.

3. (10 pts) For the following system, for which values of the constant \( b \) is the origin an unstable spiral?
   \[
   \begin{align*}
   x' &= x - (b + 1)y \\
   y' &= -x + y
   \end{align*}
   \]

4. (15 pts) Consider the nonlinear system
   \[
   \begin{align*}
   x' &= x(1 - xy), \\
   y' &= 1 - x^2 + xy.
   \end{align*}
   \]
   (a) Find all the critical points (equilibrium solutions).
   (b) In the xy plane plot the x-nullcline(s) (vertical nullcline(s)).

5. (10 pts) Showing all your work, find a linear trajectory for the three dimensional system
   \[
   \bar{x}' = \begin{pmatrix} 1 & 2 & 0 \\ 0 & 0 & -1 \\ 0 & 1 & 2 \end{pmatrix} \bar{x}.
   \]

6. (10 pts) Classify the critical point as to type and stability for the system
   \[ x' = x + 13y, \quad y' = -2x - y. \]

7. (15 pts) A two-dimensional system \( \bar{x}' = A\bar{x} \) has eigenpairs
   \[ -2, \begin{pmatrix} 1 \\ 2 \end{pmatrix}, \quad 1, \begin{pmatrix} 1 \\ 0 \end{pmatrix}. \]
   (a) If \( \bar{x}(0) = \begin{pmatrix} 1 \\ 3 \end{pmatrix} \), find a formula for \( y(t) \). (where \( \bar{x}(t) = \begin{pmatrix} x(t) \\ y(t) \end{pmatrix} \)).
   (b) Sketch a rough, but accurate, phase portrait.
8. (15 pts) Consider the IVP

\[ \begin{align*}
x' &= -2x + 2y \\
y' &= 2x - 5y, \\
x(0) &= 3, \quad y(0) = -3.
\end{align*} \]

(a) Use your calculator’s graphical solver to plot the solution for \( t > 0 \) in the \( xy \) phase plane. (reproduce on the axes below).

(b) Using your plot in (a), sketch \( y(t) \) versus \( t \) for \( t > 0 \).