

## Phase portraits of 2-D linear systems

Sketch the phase portrait and identify the type of the equilibrium:

$$[1] \quad \frac{dx_1}{dt} = 2x_1 + x_2, \quad \frac{dx_2}{dt} = x_2$$

$$[2] \quad \frac{dx_1}{dt} = -2x_1, \quad \frac{dx_2}{dt} = -2x_2$$

$$[3] \quad \frac{dx_1}{dt} = -7x_1 + 10x_2, \quad \frac{dx_2}{dt} = -5x_1 + 8x_2$$

$$[4] \quad \frac{dx_1}{dt} = -2x_1 - 3x_2, \quad \frac{dx_2}{dt} = x_1 - 6x_2$$

$$[5] \quad \frac{dx_1}{dt} = -7x_1 + 9x_2, \quad \frac{dx_2}{dt} = -x_1 - x_2$$

$$[6] \quad \frac{dx_1}{dt} = 3x_1 + 5x_2, \quad \frac{dx_2}{dt} = -2x_1 + x_2$$

$$[7] \quad \frac{dx_1}{dt} = x_1 + 5x_2, \quad \frac{dx_2}{dt} = -2x_1 - x_2$$

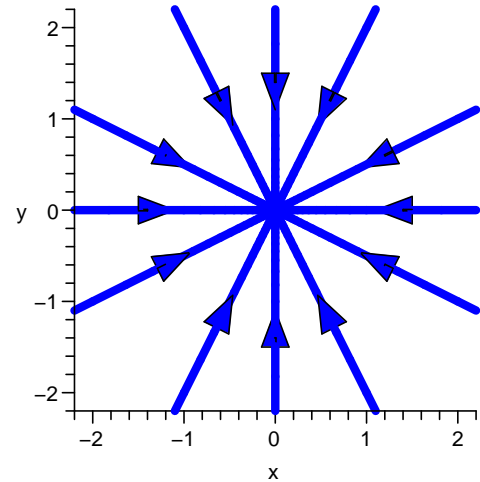
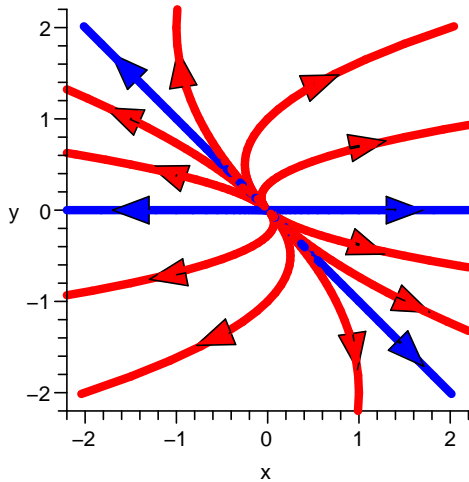
$$[8] \quad \frac{dx_1}{dt} = 5x_2, \quad \frac{dx_2}{dt} = -2x_1 - 2x_2$$

**Answers:**

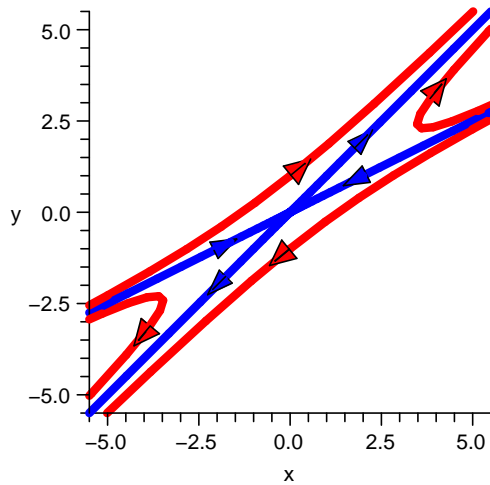
- [1] Unstable improper node   [2] Stable proper node   [3] Saddle   [4] Stable improper node  
[5] Stable degenerate node   [6] Unstable focus   [7] Center   [8] Stable focus

In the pictures below, the blue directions are the directions of eigenvectors.

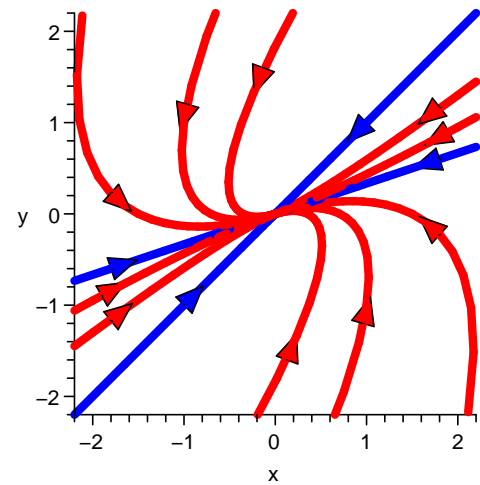
**[1] Repulsive Improper Node   [2] Attractive Proper Node**



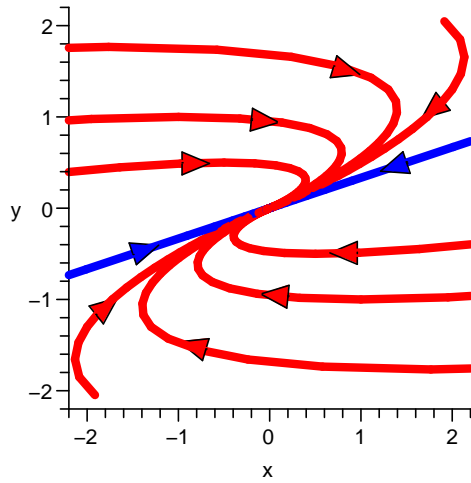
**[3] Saddle**



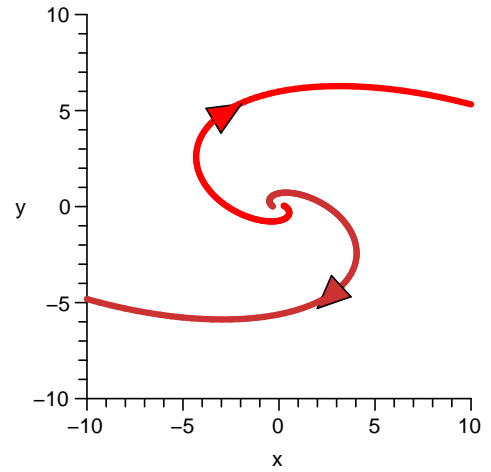
**[4] Attractive Improper Node**



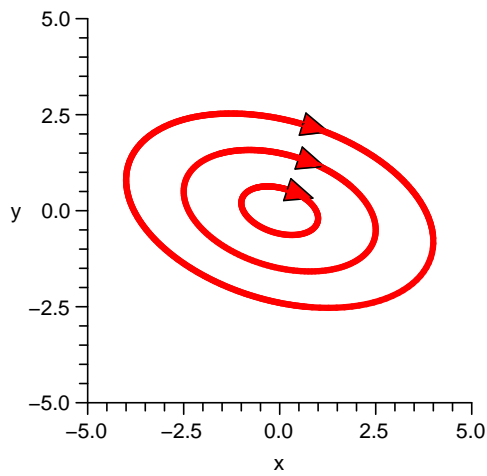
**[5] Attractive Degenerate Node**



**[6] Repulsive focus**



**[7] Center**



**[8] Attractive focus**

