3.2

d)

SYSTEM1

In[ ]:=
```
ClearAll["Global`*"]
(*{μ*x-3*y-1*x^3,3*x+μ*y+2*y^3}*)
(*Define systems*)
mu = 1;
eq1 = x'[t] == mu * x[t] - 3 * y[t] - 1 * x[t]^3;
eq2 = y'[t] == 3 * x[t] + mu * y[t] + 2 * y[t]^3;
system = {eq1, eq2};

startPt = {{x[0] == -2, y[0] == 0.5}, {x[0] == 0.2, y[0] == 0},
    {x[0] == -0.1, y[0] == 0}, {x[0] == 2, y[0] == 0}, {x[0] == 0, y[0] == -0.5}};

t0 = 0;
tMax = 5;
sol = Table[NDSolve[{system, mu}, {x, y}, {t, t0, tMax}], {mu, startPt}];
sp = StreamPlot[{mu * x - 3 * y - 1 * x^3, 3 * x + mu * y + 2 * y^3},
    {x, -2, 2}, {y, -2, 2}, StreamColorFunction → None,
    StreamStyle → Pink, PlotRange → All, ImageSize → 700];
tp = ParametricPlot[Evaluate[{x[t], y[t]} /. #] & /@ sol, {t, t0, tMax}];
Show[sp, tp, FrameLabel → {"x", "y"}, PlotLabel → {"System 1 when μ = ", mu}]
```

NDSolve : At t == 0.4459972190136199`, step size is effectively zero; singularity or stiff system suspected.

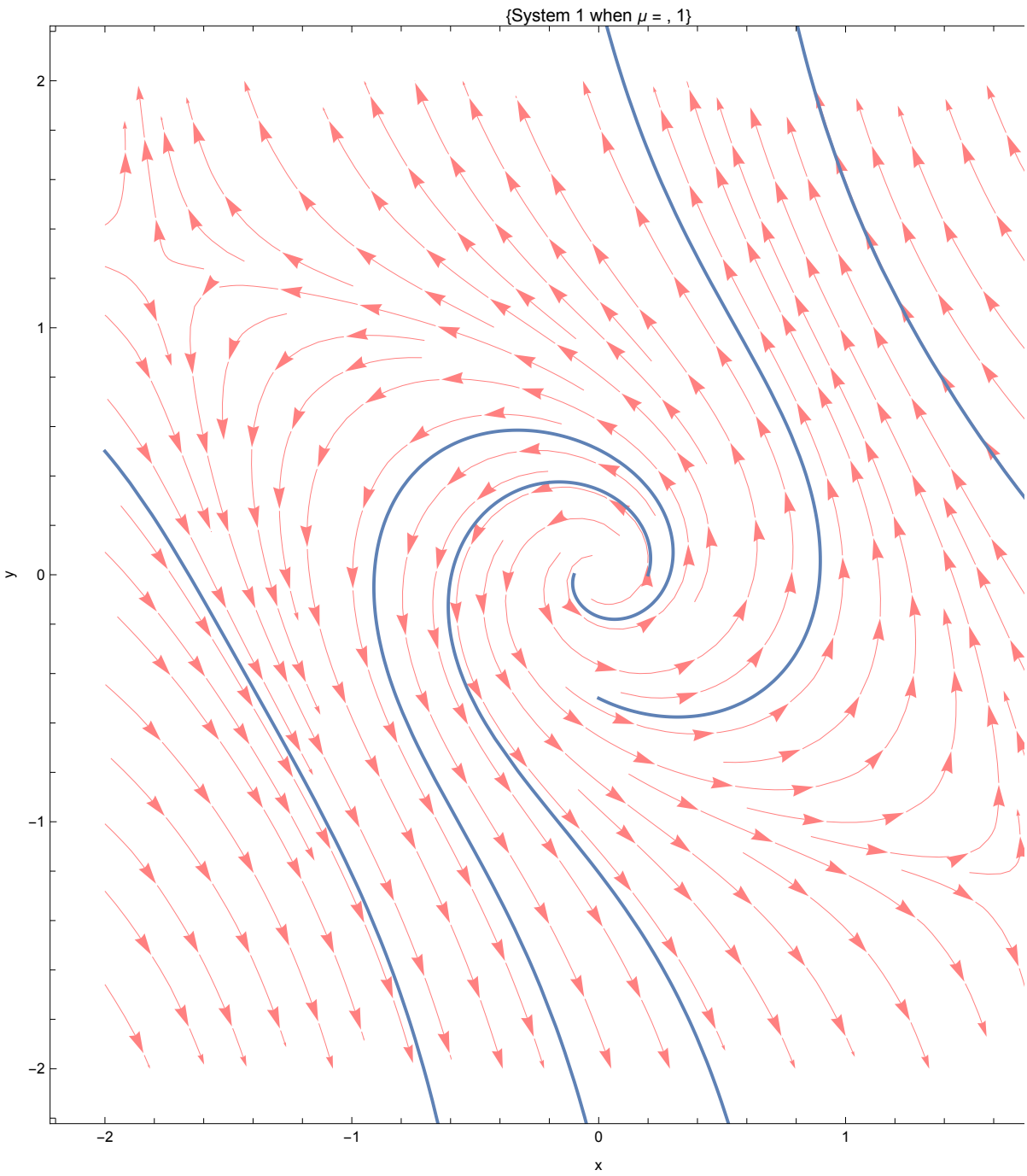
NDSolve : At t == 1.6955137738977624`, step size is effectively zero; singularity or stiff system suspected.

NDSolve : At t == 2.6168319771891846`, step size is effectively zero; singularity or stiff system suspected.

General : Further output of NDSolve::ndsz will be suppressed during this calculation.

ReplaceAll : {#1} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

Out[ ]=



In[•]:=
```
ClearAll["Global`*"]
(*{μ*x-3*y-1*x^3,3*x+μ*y+2*y^3}*)
(*Define systems*)
mu = -1;
eq1 = x'[t] == mu * x[t] - 3 * y[t] - 1 * x[t]^3;
eq2 = y'[t] == 3 * x[t] + mu * y[t] + 2 * y[t]^3;
system = {eq1, eq2};

startPt = {{x[0] == -2, y[0] == 0.6}, {x[0] == -2, y[0] == 0.3},
    {x[0] == -2, y[0] == -0.1}, {x[0] == 2, y[0] == -1}, {x[0] == 2, y[0] == 0.1}};

t0 = 0;
tMax = 5;
sol = Table[NDSolve[{system, mu}, {x, y}, {t, t0, tMax}], {mu, startPt}];
sp = StreamPlot[{mu * x - 3 * y - 1 * x^3, 3 * x + mu * y + 2 * y^3},
    {x, -2, 2}, {y, -2, 2}, StreamColorFunction → None,
    StreamStyle → Pink, PlotRange → All, ImageSize → 700];
tp = ParametricPlot[Evaluate[{x[t], y[t]} /. #] & /@ sol, {t, t0, tMax}];
Show[sp, tp, FrameLabel → {"x", "y"}, PlotLabel → {"System 1 when μ = ", mu}]
```

NDSolve : At t == 0.8298280447205103`, step size is effectively zero; singularity or stiff system suspected.

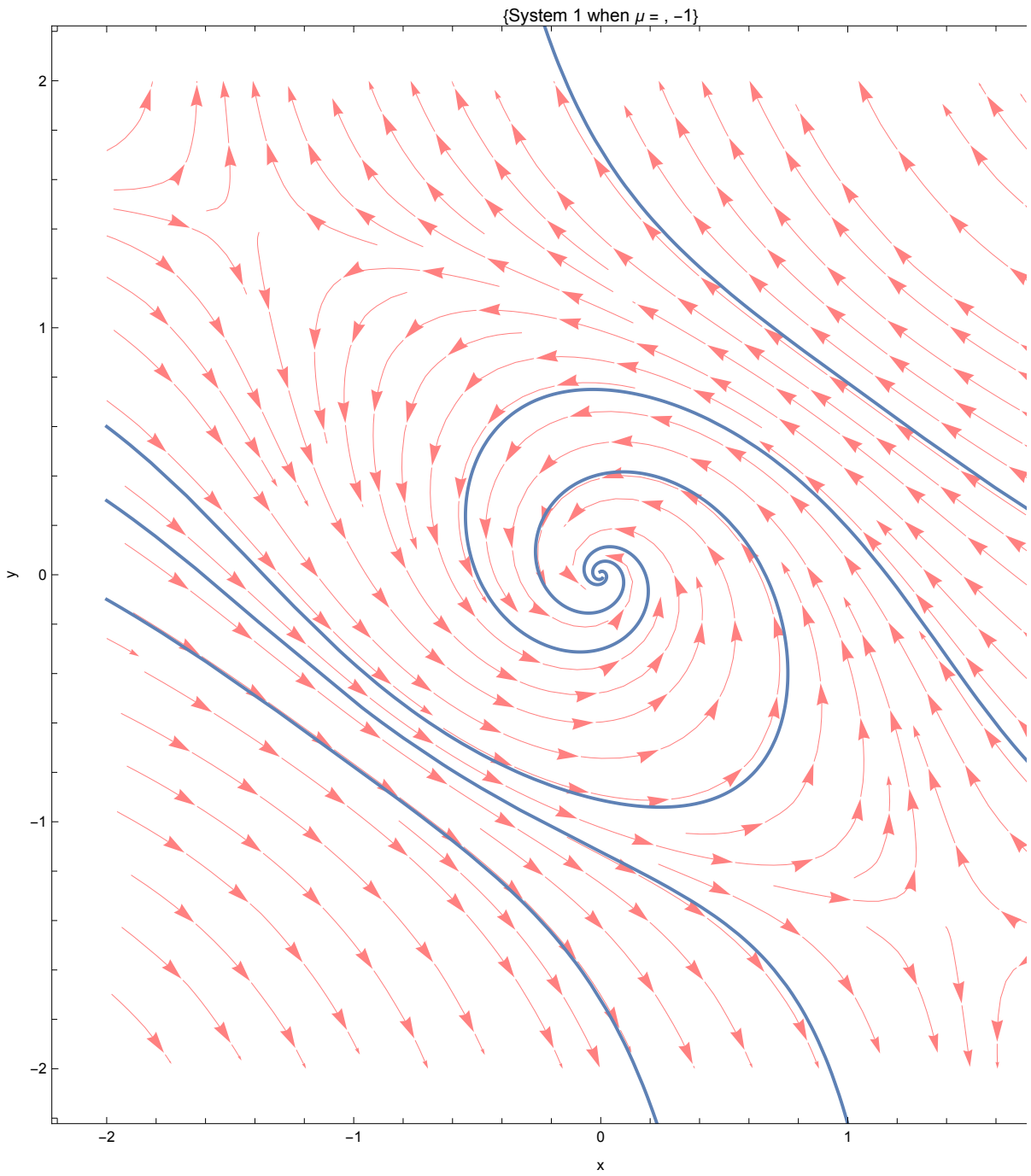
NDSolve : At t == 0.49145965056296`, step size is effectively zero; singularity or stiff system suspected.

NDSolve : At t == 0.49145965056296`, step size is effectively zero; singularity or stiff system suspected.

General : Further output of NDSolve::ndsz will be suppressed during this calculation.

ReplaceAll : {#1} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

Out[ ]=



System 1 is subcritical when mu =0

SYSTEM 2

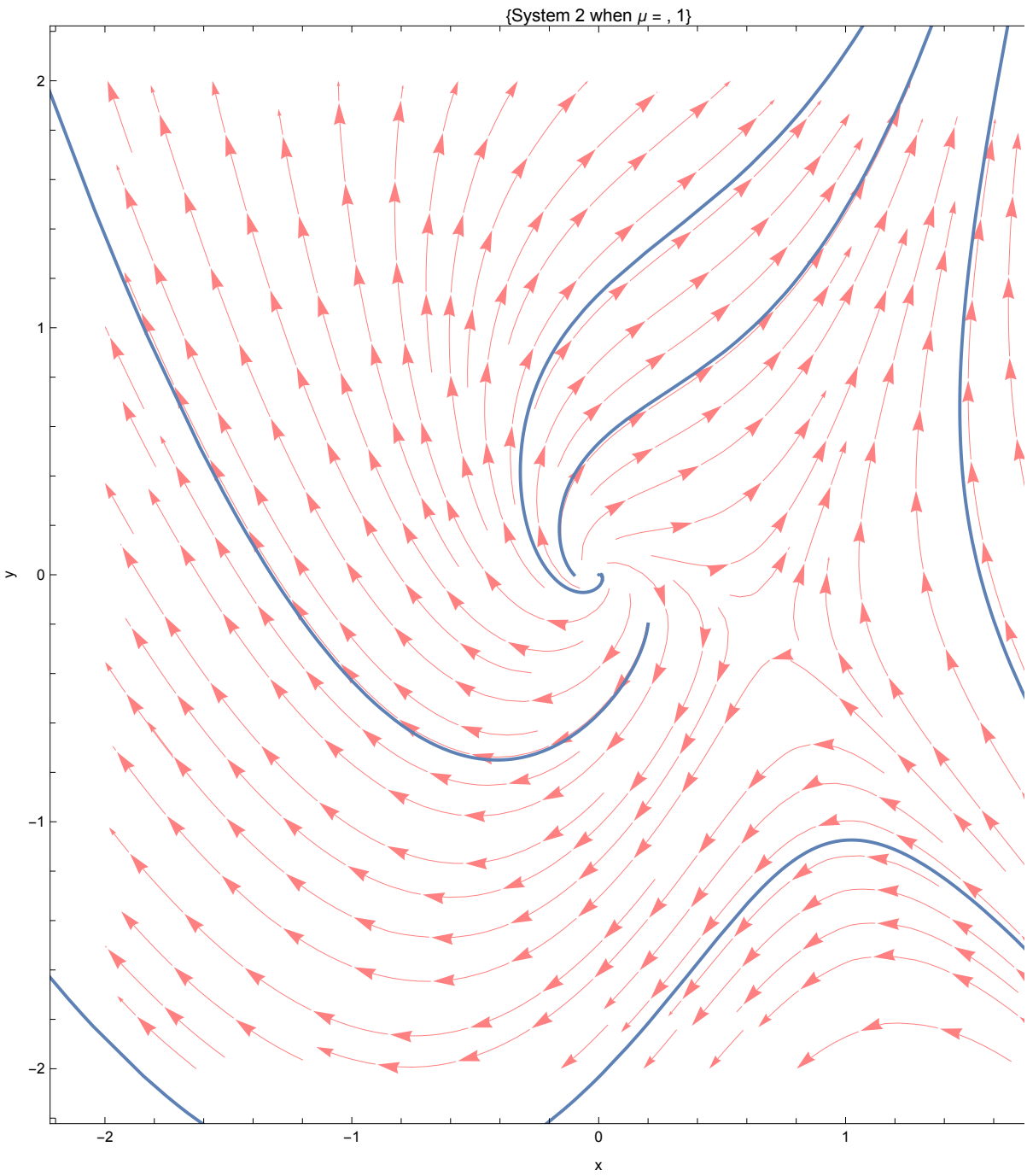
In[ ]:=
```
ClearAll["Global`*"]
(*{μ*x+y-x^2,        -x+μ*y+2*x^2}*)
(*Define systems*)
mu = 1;
eq1 = x'[t] == mu * x[t] + y[t] - x[t]^2;
eq2 = y'[t] == -x[t] + mu * y[t] + 2 * x[t]^2;
system = {eq1, eq2};

startPt = {{x[0] == 0, y[0] == 0}, {x[0] == 0.01, y[0] == 0}, {x[0] == -0.1, y[0] == 0},
    {x[0] == 2, y[0] == -1}, {x[0] == 0.2, y[0] == -0.2}, {x[0] == 2, y[0] == -1.8}};

t0 = 0;
tMax = 5;
sol = Table[NDSolve[{system, mu}, {x, y}, {t, t0, tMax}], {mu, startPt}];
sp = StreamPlot[{mu * x + y - x^2, -x + mu * y + 2 * x^2},
    {x, -2, 2}, {y, -2, 2}, StreamColorFunction → None,
    StreamStyle → Pink, PlotRange → All, ImageSize → 700];
tp = ParametricPlot[Evaluate[{x[t], y[t]} /. #] & /@ sol, {t, t0, tMax}];
Show[sp, tp, FrameLabel → {"x", "y"}, PlotLabel → {"System 2 when μ = ", mu}]
```

NDSolve : At t == 2.4530200668708932`, step size is effectively zero; singularity or stiff system suspected.

NDSolve : At t == 2.246107618300271`, step size is effectively zero; singularity or stiff system suspected.

ReplaceAll : {#1} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

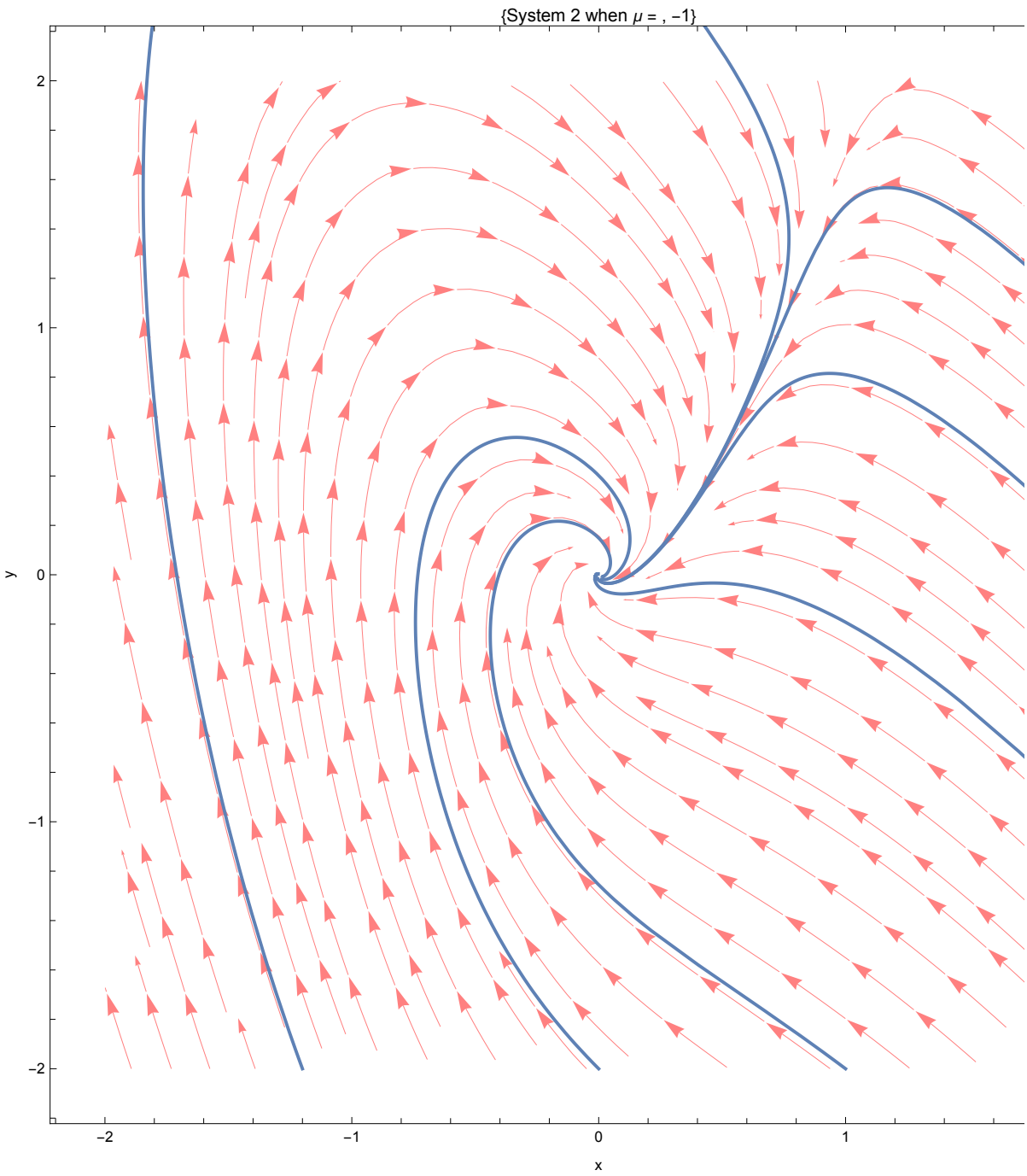
Out[ ]=



In[ ]:=
```
ClearAll["Global`*"]
(*{μ*x+y-x^2,        -x+μ*y+2*x^2}*)
(*Define systems*)
mu = -1;
eq1 = x'[t] == mu * x[t] + y[t] - x[t]^2;
eq2 = y'[t] == -x[t] + mu * y[t] + 2 * x[t]^2;
system = {eq1, eq2};

startPt = {{x[0] == 1, y[0] == -2}, {x[0] == 0, y[0] == -2}, {x[0] == -1.2, y[0] == -2},
    {x[0] == 2, y[0] == -1}, {x[0] == 2, y[0] == 0.1}, {x[0] == 2, y[0] == 1}};

t0 = 0;
tMax = 5;
sol = Table[NDSolve[{system, mu}, {x, y}, {t, t0, tMax}], {mu, startPt}];
sp = StreamPlot[{mu * x + y - x^2, -x + mu * y + 2 * x^2},
    {x, -2, 2}, {y, -2, 2}, StreamColorFunction → None,
    StreamStyle → Pink, PlotRange → All, ImageSize → 700];
tp = ParametricPlot[Evaluate[{x[t], y[t]} /. #] & /@ sol, {t, t0, tMax}];
Show[sp, tp, FrameLabel → {"x", "y"}, PlotLabel → {"System 2 when μ = ", mu}]
```

ReplaceAll : {#1} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

Out[ ]=



System 2 is supercritical when mu =0