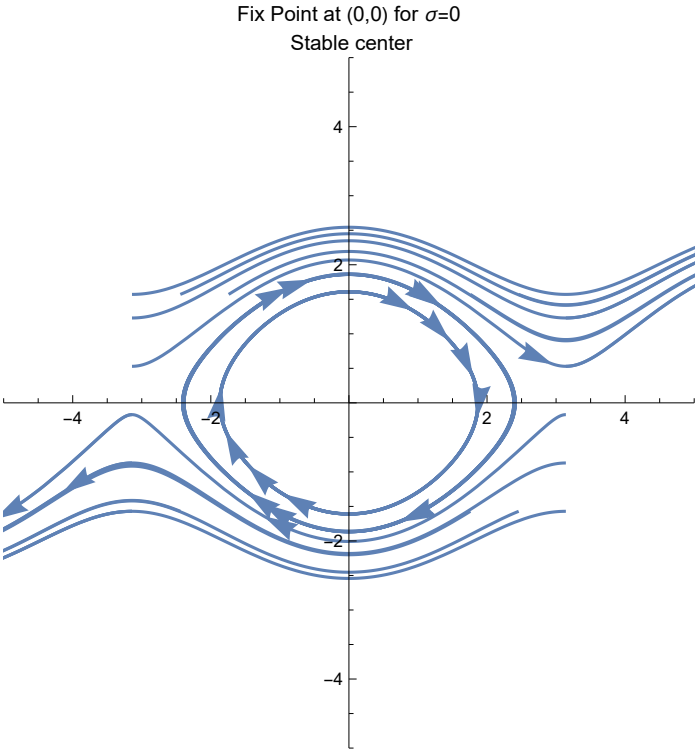
e)

In[ ]:=
```
Solve[{y == 0, -Sin[x] - σ * y == 0} ]
```

Out[ ]=
$$\left\{\left\{y \to 0,\ x \to 2\,\pi\,c_1 \text{ if } c_1 \in \mathbb{Z}\right\},\ \left\{y \to 0,\ x \to \pi + 2\,\pi\,c_1 \text{ if } c_1 \in \mathbb{Z}\right\}\right\}$$

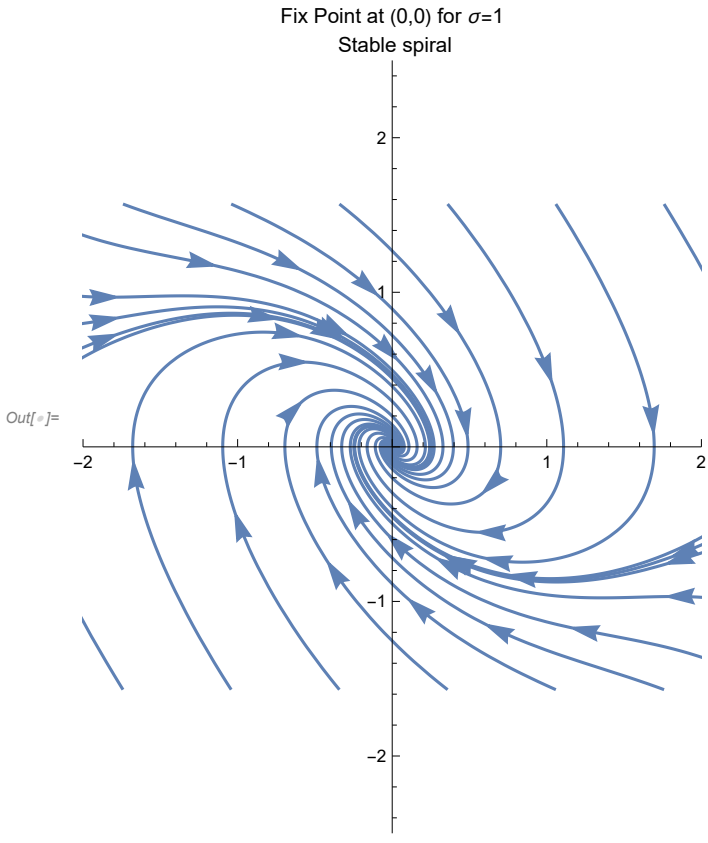
In[ ]:=
```
xmin = -π;
xmax = π;
ymin = -π / 2;
ymax = π / 2;
solution[x0_, y0_] :=
  Table[NDSolve[{D[x[t], t] == y[t], D[y[t], t] == -Sin[x[t]] - σ y[t],
     x[0] == x0, y[0] == y0}, {x[t], y[t]}, {t, 0, 15}], {σ, {0}}];
IC1 = Table[{xmin, y}, {y, ymin, ymax, 0.7}];
IC2 = Table[{xmax, y}, {y, ymin, ymax, 0.7}];
IC3 = Table[{x, ymin}, {x, xmin, xmax, 0.7}];
IC4 = Table[{x, ymax}, {x, xmin, xmax, 0.7}];
ICs = Join[IC1, IC2, IC3, IC4];
plot =
  Table[ParametricPlot[
    Evaluate[{x[t], y[t]} /. solution[ICs[[i, 1]], ICs[[i, 2]]]],
    {t, 0, 15}, PlotRange → {{-5, 5}, {-5, 5}},
    PlotLabel → "Fix Point at (0,0) for σ=0\n Stable center"] /.
   Line[x_] :→ {Arrowheads[{0, 0.0375, 0.0375, 0}], Arrow[x]}, {i, Length[ICs]}];
Show[{plot}]
```

Out[ ]=



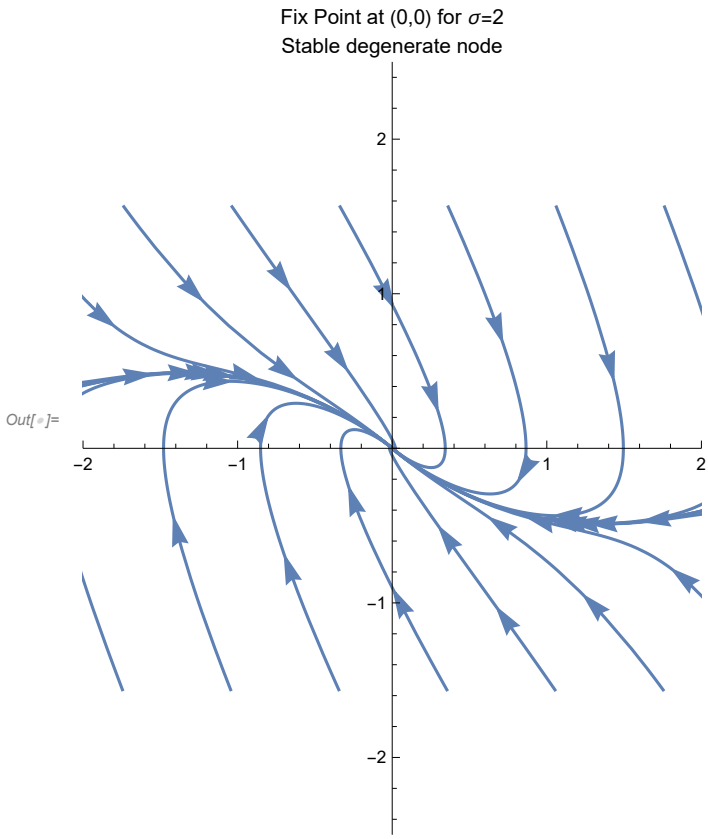
In[ ]:=
```
xmin = -π;
xmax = π;
ymin = -π / 2;
ymax = π / 2;
solution[x0_, y0_] :=
  Table[NDSolve[{D[x[t], t] == y[t], D[y[t], t] == -Sin[x[t]] - σ y[t],
     x[0] == x0, y[0] == y0}, {x[t], y[t]}, {t, 0, 15}], {σ, {1}}];
IC1 = Table[{xmin, y}, {y, ymin, ymax, 0.7}];
IC2 = Table[{xmax, y}, {y, ymin, ymax, 0.7}];
IC3 = Table[{x, ymin}, {x, xmin, xmax, 0.7}];
IC4 = Table[{x, ymax}, {x, xmin, xmax, 0.7}];
ICs = Join[IC1, IC2, IC3, IC4];
plot =
  Table[ParametricPlot[
     Evaluate[{x[t], y[t]} /. solution[ICs[[i, 1]], ICs[[i, 2]]]],
     {t, 0, 15}, PlotRange → {{-2, 2}, {-2.5, 2.5}},
     PlotLabel → "Fix Point at (0,0) for σ=1\n Stable spiral"] /.
    Line[x_] :↦ {Arrowheads[{0, 0.0375, 0.0375, 0}], Arrow[x]}, {i, Length[ICs]}];
Show[{plot}]
```

Out[ ]=



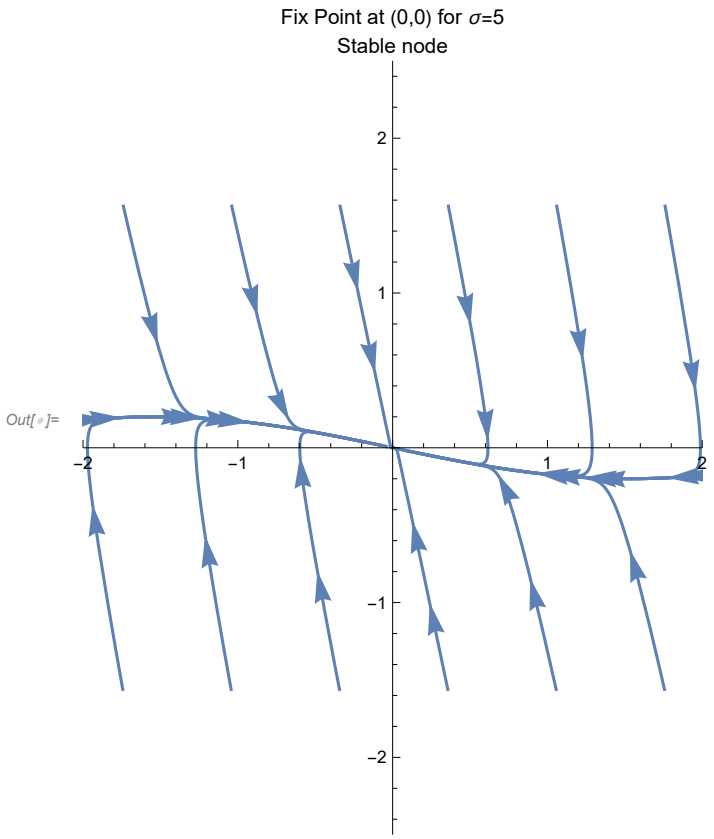
In[ ]:=
```
xmin = -π;
xmax = π;
ymin = -π / 2;
ymax = π / 2;
solution[x0_, y0_] :=
  Table[NDSolve[{D[x[t], t] == y[t], D[y[t], t] == -Sin[x[t]] - σ y[t],
     x[0] == x0, y[0] == y0}, {x[t], y[t]}, {t, 0, 15}], {σ, {2}}];
IC1 = Table[{xmin, y}, {y, ymin, ymax, 0.7}];
IC2 = Table[{xmax, y}, {y, ymin, ymax, 0.7}];
IC3 = Table[{x, ymin}, {x, xmin, xmax, 0.7}];
IC4 = Table[{x, ymax}, {x, xmin, xmax, 0.7}];
ICs = Join[IC1, IC2, IC3, IC4];
plot =
  Table[ParametricPlot[
     Evaluate[{x[t], y[t]} /. solution[ICs[[i, 1]], ICs[[i, 2]]]],
     {t, 0, 15}, PlotRange → {{-2, 2}, {-2.5, 2.5}},
     PlotLabel → "Fix Point at (0,0) for σ=2\n Stable degenerate node "] /.
    Line[x_] :↦ {Arrowheads[{0, 0.0375, 0.0375, 0}], Arrow[x]}, {i, Length[ICs]}];
Show[{plot}]
```

Out[ ]=



In[ ]:=
```
xmin = -π;
xmax = π;
ymin = -π / 2;
ymax = π / 2;
solution[x0_, y0_] :=
  Table[NDSolve[{D[x[t], t] == y[t], D[y[t], t] == -Sin[x[t]] - σ y[t],
     x[0] == x0, y[0] == y0}, {x[t], y[t]}, {t, 0, 15}], {σ, {5}}];
IC1 = Table[{xmin, y}, {y, ymin, ymax, 0.7}];
IC2 = Table[{xmax, y}, {y, ymin, ymax, 0.7}];
IC3 = Table[{x, ymin}, {x, xmin, xmax, 0.7}];
IC4 = Table[{x, ymax}, {x, xmin, xmax, 0.7}];
ICs = Join[IC1, IC2, IC3, IC4];
plot =
  Table[ParametricPlot[
     Evaluate[{x[t], y[t]} /. solution[ICs[[i, 1]], ICs[[i, 2]]]],
     {t, 0, 15}, PlotRange → {{-2, 2}, {-2.5, 2.5}},
     PlotLabel → "Fix Point at (0,0) for σ=5\n Stable node "] /.
    Line[x_] :↦ {Arrowheads[{0, 0.0375, 0.0375, 0}], Arrow[x]}, {i, Length[ICs]}];
Show[{plot}]
```

Out[ ]=



In[ ]:=
```
textgrid = TextGrid[{{"Fixed point @", "(0,0)"}, {"(σ=0)", "Stable center"},
    {"(σ=1)", "Stable spiral"},
    {"(σ=2)", "Stable degenerate node"}, {"(σ=5)", "Stable node"}}, Frame → All]
Export["C:/Users/maxim/OneDrive/Dokument/Wolfram
    Mathematica/TIF155/TIF155-Problems/Problem set 2table.png", textgrid];
```

Out[ ]=

Fixed point @	(0,0)
(σ=0)	Stable center
(σ=1)	Stable spiral
(σ=2)	Stable degenerate node
(σ=5)	Stable node