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In[625]:= matrix = -{-k1m X0 - k2 Y0, k2m Y0}, {k2 Y0, -k2m Y0 - k3}
Print["Eigenvalues are"]
lambda = Eigenvalues[matrix]
pp = First[lambda] Last[lambda]
Simplify[%]
"First data set"
k1 = 0.0002; k2 = 0.0001; k3 = 0.01; k1m = 0; k2m = 0; k3m = 0; k4 = 0;
A0 = 800; X0 = 340; Y0 = 50; Z0 = 0
sol = NDSolve[{
  X'[t] == k1 A0 X[t] - k1m X[t]^2 - k2 X[t] Y[t] + k2m Y[t]^2,
  Y'[t] == k2 X[t] Y[t] - k2m Y[t]^2 - k3 Y[t] + k3m Z[t],
  Z'[t] == k3 Y[t] - k3m Z[t] - k4 Z[t],
  X[0] == X0, Y[0] == Y0, Z[0] == Z0},
  {X, Y, Z}, {t, 0, 20}]

Plot[Evaluate[{X[t], Y[t], Z[t]} /. sol], {t, 0, 20}, PlotRange -> All,
  PlotStyle -> {{RGBColor[1, 0, 0]}, {RGBColor[0, 1, 0]}, {RGBColor[0, 0, 1]}},
  PlotLabel -> StyleForm[StyleForm["x[t]", FontColor -> RGBColor[1, 0, 0]]
  StyleForm["y[t]", FontColor -> RGBColor[0, 1, 0]] StyleForm["z[t]",
  FontColor -> RGBColor[0, 0, 1]], FontSize -> 12, FontWeight -> "Bold"]]
ParametricPlot[Evaluate[{X[t], Y[t]} /. sol], {t, 0, 20},
  PlotRange -> All, AxesLabel -> {"X", "Y"}]
PageBreakAbove
"Second data set"
k1 = 0.002; k2 = 0.001; k3 = 0.1; k1m = 0; k2m = 0; k3m = 0; k4 = 0;
A0 = 800;
sol = NDSolve[{
  X'[t] == k1 A0 X[t] - k1m X[t]^2 - k2 X[t] Y[t] + k2m Y[t]^2,
  Y'[t] == k2 X[t] Y[t] - k2m Y[t]^2 - k3 Y[t] + k3m Z[t],
  Z'[t] == k3 Y[t] - k3m Z[t] - k4 Z[t],
  X[0] == X0, Y[0] == Y0, Z[0] == Z0},
  {X, Y, Z}, {t, 0, 20}]
Plot[Evaluate[{X[t], Y[t]} /. sol], {t, 0, 20}, PlotRange -> All,
  PlotStyle -> {{RGBColor[1, 0, 0]}, {RGBColor[0, 0, 1]}},
  PlotLabel ->
  StyleForm[StyleForm["x[t]", FontColor -> RGBColor[1, 0, 0]] StyleForm["y[t]",
  FontColor -> RGBColor[0, 0, 1]], FontSize -> 12, FontWeight -> "Bold"]]
ParametricPlot[Evaluate[{X[t], Y[t]} /. sol], {t, 0, 20},
  PlotRange -> All, AxesLabel -> {"X", "Y"}]
PageBreakAbove
"Third data set"
k1 = 0.002; k2 = 0.001; k3 = 0.1; k1m = 0.004; k2m = 0.002; k3m = 0.2; k4 = 0;
A0 = 800;

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sol = NDSolve[{
  X'[t] == k1 A0 X[t] - k1m X[t]^2 - k2 X[t] Y[t] + k2m Y[t]^2,
  Y'[t] == k2 X[t] Y[t] - k2m Y[t]^2 - k3 Y[t] + k3m Z[t],
  Z'[t] == k3 Y[t] - k3m Z[t] - k4 Z[t],
  X[0] == X0, Y[0] == Y0, Z[0] == Z0},
  {X, Y, Z}, {t, 0, 20}]
Plot[Evaluate[{X[t], Y[t]} /. sol], {t, 0, 20}, PlotRange -> All,
  PlotStyle -> {{RGBColor[1, 0, 0]}, {RGBColor[0, 0, 1]}},
  PlotLabel ->
  StyleForm[StyleForm["x[t]", FontColor -> RGBColor[1, 0, 0]] StyleForm["y[t]",
    FontColor -> RGBColor[0, 0, 1]], FontSize -> 12, FontWeight -> "Bold"]]
ParametricPlot[Evaluate[{X[t], Y[t]} /. sol], {t, 0, 20},
  PlotRange -> All, AxesLabel -> {"X", "Y"}]
PageBreakAbove
"Fourth data set"
k1 = 0.0015; k2 = 0.001; k3 = 0.11; k1m = 0; k2m = 0; k3m = 0; k4 = 0;
A0 = 800;

sol = NDSolve[{
  X'[t] == k1 A0 X[t] - k1m X[t]^2 - k2 X[t] Y[t] + k2m Y[t]^2,
  Y'[t] == k2 X[t] Y[t] - k2m Y[t]^2 - k3 Y[t] + k3m Z[t],
  Z'[t] == k3 Y[t] - k3m Z[t] - k4 Z[t],
  X[0] == X0, Y[0] == Y0, Z[0] == Z0},
  {X, Y, Z}, {t, 0, 20}]
Plot[Evaluate[{X[t], Y[t]} /. sol], {t, 0, 20}, PlotRange -> All,
  PlotStyle -> {{RGBColor[1, 0, 0]}, {RGBColor[0, 0, 1]}},
  PlotLabel ->
  StyleForm[StyleForm["x[t]", FontColor -> RGBColor[1, 0, 0]] StyleForm["y[t]",
    FontColor -> RGBColor[0, 0, 1]], FontSize -> 12, FontWeight -> "Bold"]]
ParametricPlot[Evaluate[{X[t], Y[t]} /. sol], {t, 0, 20},
  PlotRange -> All, AxesLabel -> {"X", "Y"}]
PageBreakAbove
"Part B"
k1 = 0.003; k2 = 0.0045; k3 = 0.85; k1m = 0; k2m = 0; k3m = 0; k4 = 1;
A0 = 800;

sol = NDSolve[{
  X'[t] == k1 A0 X[t] - k1m X[t]^2 - k2 X[t] Y[t] + k2m Y[t]^2,
  Y'[t] == k2 X[t] Y[t] - k2m Y[t]^2 - k3 Y[t] + k3m Z[t],
  Z'[t] == k3 Y[t] - k3m Z[t] - k4 Z[t],
  X[0] == X0, Y[0] == Y0, Z[0] == Z0},
  {X, Y, Z}, {t, 0, 20}]
Plot[Evaluate[{X[t], Y[t]} /. sol], {t, 0, 20}, PlotRange -> All,
  PlotStyle -> {{RGBColor[1, 0, 0]}, {RGBColor[0, 0, 1]}},

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PlotLabel →
  StyleForm[StyleForm["x[t]", FontColor → RGBColor[1, 0, 0]] StyleForm["y[t]",
    FontColor → RGBColor[0, 0, 1]], FontSize → 12, FontWeight → "Bold"]
ParametricPlot[Evaluate[{X[t], Y[t]} /. sol], {t, 0, 20},
  PlotRange → All, AxesLabel → {"X", "Y"}]
PageBreakAbove
"Part C"
sol = NDSolve[{
  X'[t] == k1 A[t] X[t] - k1m X[t]^2 - k2 X[t] Y[t] + k2m Y[t]^2,
  Y'[t] == k2 X[t] Y[t] - k2m Y[t]^2 - k3 Y[t] + k3m Z[t],
  Z'[t] == k3 Y[t] - k3m Z[t] - k4 Z[t],
  A'[t] == -k1 A[t] X[t] + k1m X[t]^2 + k4 Z[t],
  X[0] == X0, Y[0] == Y0, Z[0] == Z0, A[0] == A0},
  {A, X, Y, Z}, {t, 0, 20}]
Plot[Evaluate[{X[t], Y[t]} /. sol], {t, 0, 20}, PlotRange → All,
  PlotStyle → {{RGBColor[1, 0, 0]}, {RGBColor[0, 0, 1]}},
  PlotLabel →
    StyleForm[StyleForm["x[t]", FontColor → RGBColor[1, 0, 0]] StyleForm["y[t]",
      FontColor → RGBColor[0, 0, 1]], FontSize → 12, FontWeight → "Bold"]
ParametricPlot[Evaluate[{X[t], Y[t]} /. sol], {t, 0, 20},
  PlotRange → All, AxesLabel → {"X", "Y"}]

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Out[625]= {{0.225, 0}, {-0.225, 0.85}}

Eigenvalues are

Out[627]= {0.85, 0.225}

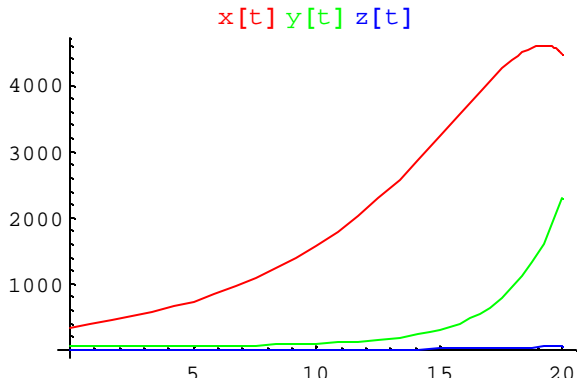
Out[628]= 0.19125

Out[629]= 0.19125

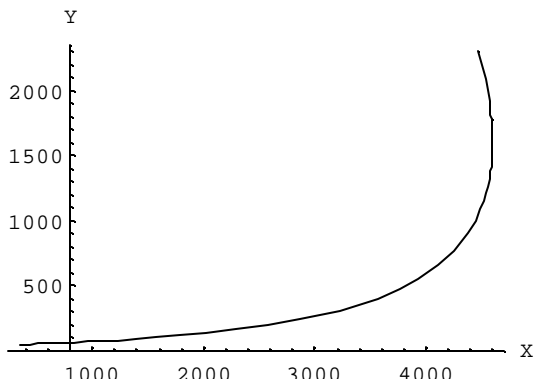
Out[630]= First data set

Out[632]= 0

Out[633]= {X → InterpolatingFunction[{{0., 20.}}, <>],
 Y → InterpolatingFunction[{{0., 20.}}, <>],
 Z → InterpolatingFunction[{{0., 20.}}, <>]}



Out[634]= - Graphics -

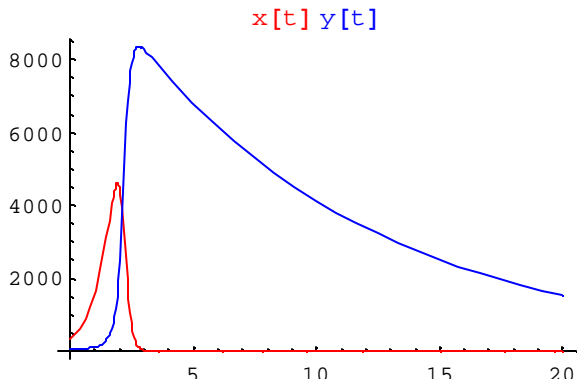


Out[635]= - Graphics -

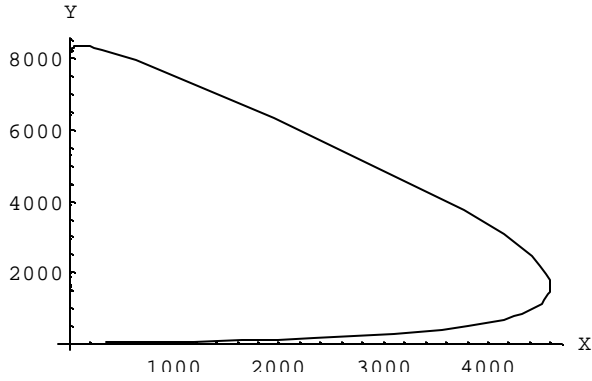
Out[636]= PageBreakAbove

Out[637]= Second data set

```
Out[640]= {{X -> InterpolatingFunction[{{0., 20.}}, <>],
           Y -> InterpolatingFunction[{{0., 20.}}, <>],
           Z -> InterpolatingFunction[{{0., 20.}}, <>]}}
```



Out[641]= - Graphics -

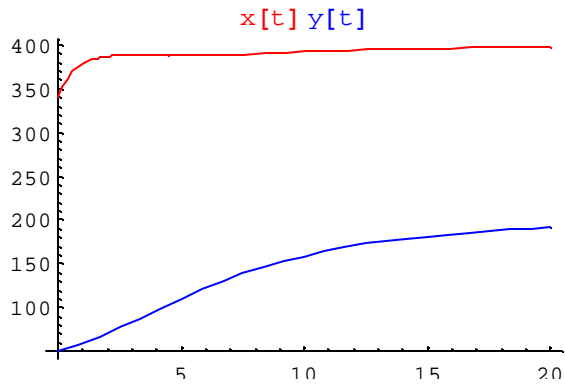


Out[642]= - Graphics -

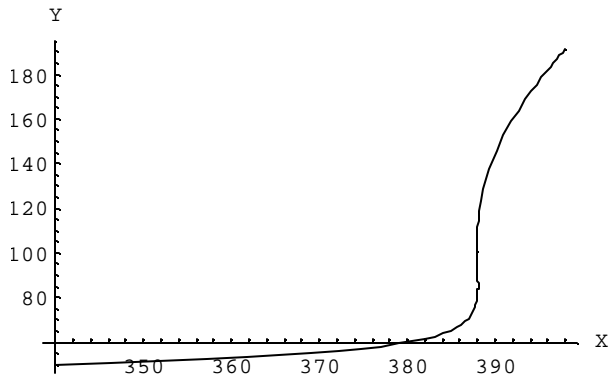
Out[643]= PageBreakAbove

Out[644]= Third data set

```
Out[647]= {{X → InterpolatingFunction[{{0., 20.}}, <>],
            Y → InterpolatingFunction[{{0., 20.}}, <>],
            Z → InterpolatingFunction[{{0., 20.}}, <>]}}
```



Out[648]= - Graphics -

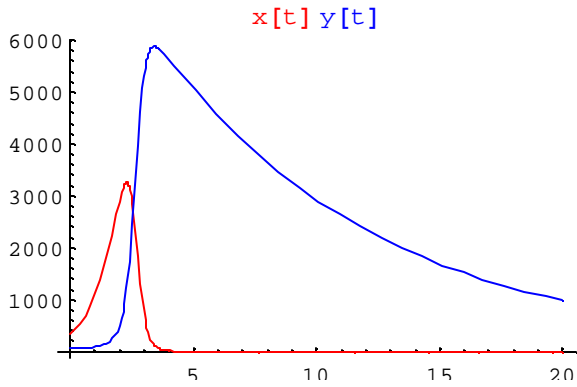


Out[649]= - Graphics -

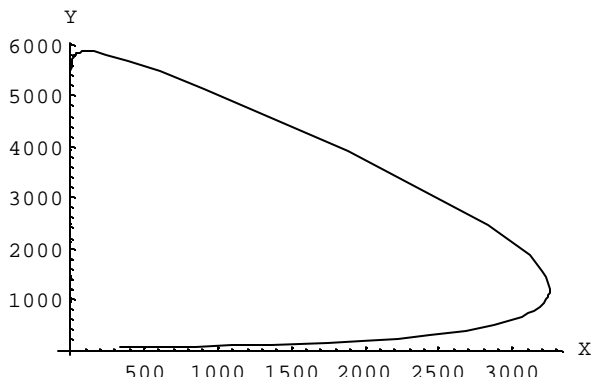
Out[650]= PageBreakAbove

Out[651]= Fourth data set

```
Out[654]= {{X → InterpolatingFunction[{{0., 20.}}, <>],
           Y → InterpolatingFunction[{{0., 20.}}, <>],
           Z → InterpolatingFunction[{{0., 20.}}, <>]}}
```



Out[655]= - Graphics -

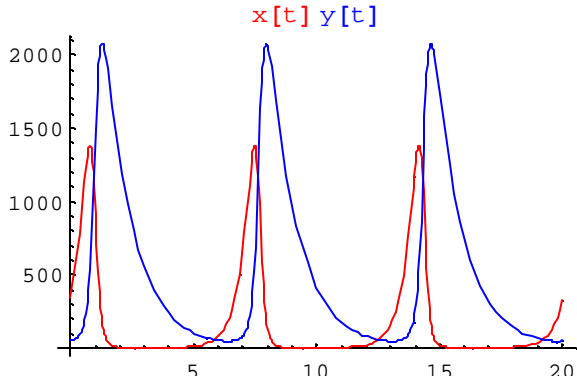


Out[656]= - Graphics -

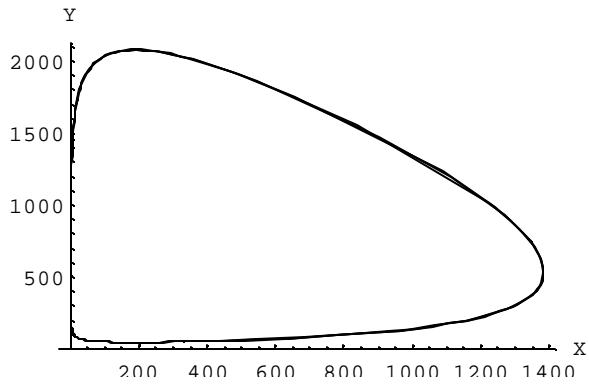
Out[657]= PageBreakAbove

Out[658]= Part B

```
Out[661]= {{X → InterpolatingFunction[{{0., 20.}}, <>],
           Y → InterpolatingFunction[{{0., 20.}}, <>],
           Z → InterpolatingFunction[{{0., 20.}}, <>]}}
```



Out[662]= - Graphics -

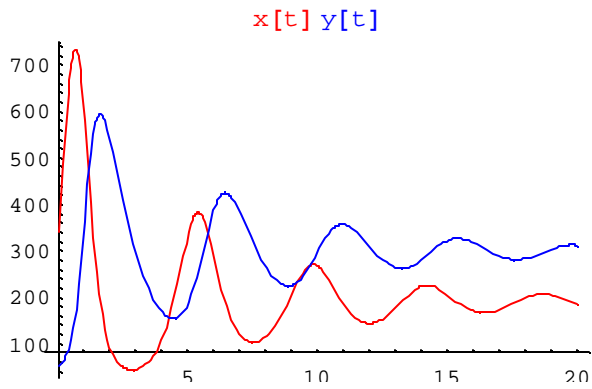


Out[663]= - Graphics -

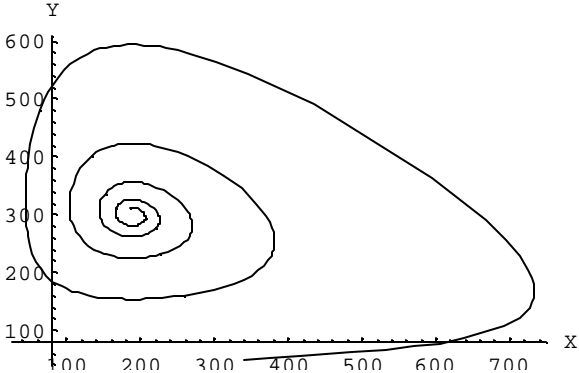
Out[664]= PageBreakAbove

Out[665]= Part C

```
Out[666]= {{A → InterpolatingFunction[{{0., 20.}}, <>],
            X → InterpolatingFunction[{{0., 20.}}, <>],
            Y → InterpolatingFunction[{{0., 20.}}, <>],
            Z → InterpolatingFunction[{{0., 20.}}, <>]}}
```



Out[667]= - Graphics -



Out[668]= - Graphics -