```
libname := "/u/ma/gustafson/bin/laylinalg.mla",
    "/usr/local/sys/maple/maple2016/lib"
```
(1)

```
> # Exercises 4,5,6,7 in Section 6.3
  # Solve for the equil points and find linearized DE for the
  system below
  # x'=60x-4x^2-3xy, y'=42y-2y^2-3xy
  # Then classify as spiral, center, node, saddle and comment on
  stability.
  # Construct a phase portrait for each equil point within the
  biological domain x>0, y>0.
```

```
> F1:=(x,y)->60*x-4*x^2-3*x*y; F2:=(x,y)->42*y-2*y^2-3*x*y; solve(
  {F1(x,y)=0,F2(x,y)=0},{x,y});
```

$$F1 := (x, y) \to 60\,x - 4\,x^2 - 3\,x\,y$$

$$F2 := (x, y) \to 42\,y - 2\,y^2 - 3\,x\,y$$

$$\{x = 0, y = 0\}, \{x = 0, y = 21\}, \{x = 15, y = 0\}, \{x = 6, y = 12\}$$
(2)

```
> F:=unapply(<F1(x,y),F2(x,y)>,(x,y)):F(x,y);
```

$$\begin{bmatrix} -4\,x^2 - 3\,x\,y + 60\,x \\ -3\,x\,y - 2\,y^2 + 42\,y \end{bmatrix}$$
(3)

```
> J:=unapply(<diff(F1(x,y),x),diff(F2(x,y),x)|diff(F1(x,y),y),diff
  (F2(x,y),y)>,(x,y)):J(x,y);
```

$$\begin{bmatrix} -8\,x - 3\,y + 60 & -3\,x \\ -3\,y & -3\,x - 4\,y + 42 \end{bmatrix}$$
(4)

```
> with(LinearAlgebra):X:=[0,0,15,6]:Y:=[0,21,0,12]:
> for i from 1 to 4 do 'J'(X[i],Y[i]) =J(X[i],Y[i]); od;
```

$$J(0, 0) = \begin{bmatrix} 60 & 0 \\ 0 & 42 \end{bmatrix}$$

$$J(0, 21) = \begin{bmatrix} -3 & 0 \\ -63 & -42 \end{bmatrix}$$

$$J(15, 0) = \begin{bmatrix} -60 & -45 \\ 0 & -3 \end{bmatrix}$$

$$J(6, 12) = \begin{bmatrix} -24 & -18 \\ -36 & -24 \end{bmatrix}$$
(5)

```
> ss:='ss':for i from 1 to 4 do ss[i]:=Eigenvalues(J(X[i],Y[i]))
  :od:eval(ss);
```

$$table\left(\left[1=\begin{bmatrix}60\\42\end{bmatrix},2=\begin{bmatrix}-3\\-42\end{bmatrix},3=\begin{bmatrix}-3\\-60\end{bmatrix},4=\begin{bmatrix}-24+18\sqrt{2}\\-24-18\sqrt{2}\end{bmatrix}\right]\right) \quad (6)$$

```
> for i from 1 to 4 do printf("Eigenvalues J(%a,%a) = %g, %g\n",X
  [i],Y[i],ss[i][1],ss[i][2]) od:
Eigenvalues J(0,0) = 60, 42
Eigenvalues J(0,21) = -3, -42
Eigenvalues J(15,0) = -3, -60
Eigenvalues J(6,12) = 1.45584, -49.4558
```

```
> for i from 1 to 4 do <dx,dy> = J(X[i],Y[i]).<x,y> od;
```

$$\begin{bmatrix}dx\\dy\end{bmatrix}=\begin{bmatrix}60\,x\\42\,y\end{bmatrix}$$

$$\begin{bmatrix}dx\\dy\end{bmatrix}=\begin{bmatrix}-3\,x\\-63\,x-42\,y\end{bmatrix}$$

$$\begin{bmatrix}dx\\dy\end{bmatrix}=\begin{bmatrix}-60\,x-45\,y\\-3\,y\end{bmatrix}$$

$$\begin{bmatrix}dx\\dy\end{bmatrix}=\begin{bmatrix}-24\,x-18\,y\\-36\,x-24\,y\end{bmatrix} \quad (7)$$

```
> # Classifications done from Caley-Hamilton-Zeibur examples for x
  (t), y(t)
> # unstable node, stable node, stable node,
  saddle
> # Phase portraits are done from maple as follows:
  # Tools ==> Tasks (Browse) ==> Differential Equations ==> ODEs ==
  > Phase Portrait
  # Then click on INSERT DEFAULT CONTENT, followed by editing the
  data boxes.
> # Alternative launch into the program: ?Task,phaseportrait
  # Then click on INSERT DEFAULT CONTENT at the top of the help
  file.
```