

```
> #John Hermitt hw18
read "/John/Rutgers/Senior Fall/Dynamic Models/M18.txt";
with(LinearAlgebra) :
```

```
> #1
C := proc(a, b, c, d, e)
```

```
local x, y :
```

$$x := \frac{a}{\begin{pmatrix} b \\ c \end{pmatrix}} :$$

$$y := \frac{d}{x} \cdot e :$$

```
end:
```

$$C\left(\frac{3}{2}, \frac{3}{2}, \frac{3}{2}, 3, 3\right);$$

6

(1)

```
> #2
```

```
W := proc(a, b, k)
```

```
local x, y, z :
```

$$z = 1 / (1/a - 1/b) / (k - 1) :$$

```
end:
```

```
W(4, 5, 2);
```

z = 20

(2)

```
> #3
```

```
#i
```

$$\#F(x, y) = 0 = (x \cdot (1 - x - y) = (0, 0), (2, -1)$$

$$\#G(x, y) = 0 = x \cdot (3 - 2x - y) \rightarrow (x, y) = (0, 0), (2, -1)$$

```
#ii
```

$$\#J = \begin{bmatrix} 1 - x - y & \\ & 3 - 2 \cdot x - y, x \end{bmatrix};$$

$$J1 := \text{Matrix}(\begin{bmatrix} 1, 0 \\ 3, 0 \end{bmatrix}) :$$

$$x := \text{Eigenvalues}(J1);$$

```
# (0, 0)
```

```
#unstable
```

$$J2 := \text{Matrix}(\begin{bmatrix} 0, 2 \\ 0, 2 \end{bmatrix}) :$$

$$y := \text{Eigenvalues}(J2);$$

```
# (2, -1)
```

```
#unstable
```

$$x := \begin{bmatrix} 0 \\ 1 \end{bmatrix}$$

$$y := \begin{bmatrix} 0 \\ 2 \end{bmatrix}$$

(3)

```
> #4
```

$$F := [x \cdot (1 - x - y), x \cdot (3 - 2 \cdot x - y)];$$

$$\text{Dis2}(F, x, y, [2.1, -0.9], 0.1, 10);$$

$Dis2(F, x, y, [0.1, 0.1], 0.1, 10);$

Error, a constant cannot be added to a Vector; use +~ for
elementwise addition instead of +

$[[0.1, [2.1, -0.9]], [0.2, [0.1 F_1 + 2.1, 0.1 F_2 - 0.9]], [0.3, [0.2 F_1 + 2.1, 0.2 F_2 - 0.9]], [0.4, [0.3 F_1 + 2.1, 0.3 F_2 - 0.9]], [0.5, [0.4 F_1 + 2.1, 0.4 F_2 - 0.9]], [0.6, [0.5 F_1 + 2.1, 0.5 F_2 - 0.9]], [0.7, [0.6 F_1 + 2.1, 0.6 F_2 - 0.9]], [0.8, [0.7 F_1 + 2.1, 0.7 F_2 - 0.9]], [0.9, [0.8 F_1 + 2.1, 0.8 F_2 - 0.9]], [1.0, [0.9 F_1 + 2.1, 0.9 F_2 - 0.9]], [1.1, [1.0 F_1 + 2.1, 1.0 F_2 - 0.9]], [1.2, [1.1 F_1 + 2.1, 1.1 F_2 - 0.9]], [1.3, [1.2 F_1 + 2.1, 1.2 F_2 - 0.9]], [1.4, [1.3 F_1 + 2.1, 1.3 F_2 - 0.9]], [1.5, [1.4 F_1 + 2.1, 1.4 F_2 - 0.9]], [1.6, [1.5 F_1 + 2.1, 1.5 F_2 - 0.9]], [1.7, [1.6 F_1 + 2.1, 1.6 F_2 - 0.9]], [1.8, [1.7 F_1 + 2.1, 1.7 F_2 - 0.9]], [1.9, [1.8 F_1 + 2.1, 1.8 F_2 - 0.9]], [2.0, [1.9 F_1 + 2.1, 1.9 F_2 - 0.9]], [2.1, [2.0 F_1 + 2.1, 2.0 F_2 - 0.9]], [2.2, [2.1 F_1 + 2.1, 2.1 F_2 - 0.9]], [2.3, [2.2 F_1 + 2.1, 2.2 F_2 - 0.9]], [2.4, [2.3 F_1 + 2.1, 2.3 F_2 - 0.9]], [2.5, [2.4 F_1 + 2.1, 2.4 F_2 - 0.9]], [2.6, [2.5 F_1 + 2.1, 2.5 F_2 - 0.9]], [2.7, [2.6 F_1 + 2.1, 2.6 F_2 - 0.9]], [2.8, [2.7 F_1 + 2.1, 2.7 F_2 - 0.9]], [2.9, [2.8 F_1 + 2.1, 2.8 F_2 - 0.9]], [3.0, [2.9 F_1 + 2.1, 2.9 F_2 - 0.9]], [3.1, [3.0 F_1 + 2.1, 3.0 F_2 - 0.9]], [3.2, [3.1 F_1 + 2.1, 3.1 F_2 - 0.9]], [3.3, [3.2 F_1 + 2.1, 3.2 F_2 - 0.9]], [3.4, [3.3 F_1 + 2.1, 3.3 F_2 - 0.9]], [3.5, [3.4 F_1 + 2.1, 3.4 F_2 - 0.9]], [3.6, [3.5 F_1 + 2.1, 3.5 F_2 - 0.9]], [3.7, [3.6 F_1 + 2.1, 3.6 F_2 - 0.9]], [3.8, [3.7 F_1 + 2.1, 3.7 F_2 - 0.9]], [3.9, [3.8 F_1 + 2.1, 3.8 F_2 - 0.9]], [4.0, [3.9 F_1 + 2.1, 3.9 F_2 - 0.9]], [4.1, [4.0 F_1 + 2.1, 4.0 F_2 - 0.9]], [4.2, [4.1 F_1 + 2.1, 4.1 F_2 - 0.9]], [4.3, [4.2 F_1 + 2.1, 4.2 F_2 - 0.9]], [4.4, [4.3 F_1 + 2.1, 4.3 F_2 - 0.9]], [4.5, [4.4 F_1 + 2.1, 4.4 F_2 - 0.9]], [4.6, [4.5 F_1 + 2.1, 4.5 F_2 - 0.9]], [4.7, [4.6 F_1 + 2.1, 4.6 F_2 - 0.9]], [4.8, [4.7 F_1 + 2.1, 4.7 F_2 - 0.9]], [4.9, [4.8 F_1 + 2.1, 4.8 F_2 - 0.9]], [5.0, [4.9 F_1 + 2.1, 4.9 F_2 - 0.9]], [5.1, [5.0 F_1 + 2.1, 5.0 F_2 - 0.9]], [5.2, [5.1 F_1 + 2.1, 5.1 F_2 - 0.9]], [5.3, [5.2 F_1 + 2.1, 5.2 F_2 - 0.9]], [5.4, [5.3 F_1 + 2.1, 5.3 F_2 - 0.9]], [5.5, [5.4 F_1 + 2.1, 5.4 F_2 - 0.9]], [5.6, [5.5 F_1 + 2.1, 5.5 F_2 - 0.9]], [5.7, [5.6 F_1 + 2.1, 5.6 F_2 - 0.9]], [5.8, [5.7 F_1 + 2.1, 5.7 F_2 - 0.9]], [5.9, [5.8 F_1 + 2.1, 5.8 F_2 - 0.9]], [6.0, [5.9 F_1 + 2.1, 5.9 F_2 - 0.9]], [6.1, [6.0 F_1 + 2.1, 6.0 F_2 - 0.9]], [6.2, [6.1 F_1 + 2.1, 6.1 F_2 - 0.9]], [6.3, [6.2 F_1 + 2.1, 6.2 F_2 - 0.9]], [6.4, [6.3 F_1 + 2.1, 6.3 F_2 - 0.9]], [6.5, [6.4 F_1 + 2.1, 6.4 F_2 - 0.9]], [6.6, [6.5 F_1 + 2.1, 6.5 F_2 - 0.9]], [6.7, [6.6 F_1 + 2.1, 6.6 F_2 - 0.9]], [6.8, [6.7 F_1 + 2.1, 6.7 F_2 - 0.9]], [6.9, [6.8 F_1 + 2.1, 6.8 F_2 - 0.9]], [7.0, [6.9 F_1 + 2.1, 6.9 F_2 - 0.9]], [7.1, [7.0 F_1 + 2.1, 7.0 F_2 - 0.9]], [7.2, [7.1 F_1 + 2.1, 7.1 F_2 - 0.9]], [7.3, [7.2 F_1 + 2.1, 7.2 F_2 - 0.9]], [7.4, [7.3 F_1 + 2.1, 7.3 F_2 - 0.9]], [7.5, [7.4 F_1 + 2.1, 7.4 F_2 - 0.9]], [7.6, [7.5 F_1 + 2.1, 7.5 F_2 - 0.9]],$

$$\begin{aligned}
& [7.7, [7.6 F_1 + 2.1, 7.6 F_2 - 0.9]], [7.8, [7.7 F_1 + 2.1, 7.7 F_2 - 0.9]], [7.9, [7.8 F_1 + 2.1, \\
& 7.8 F_2 - 0.9]], [8.0, [7.9 F_1 + 2.1, 7.9 F_2 - 0.9]], [8.1, [8.0 F_1 + 2.1, 8.0 F_2 - 0.9]], [8.2, \\
& [8.1 F_1 + 2.1, 8.1 F_2 - 0.9]], [8.3, [8.2 F_1 + 2.1, 8.2 F_2 - 0.9]], [8.4, [8.3 F_1 + 2.1, 8.3 F_2 \\
& - 0.9]], [8.5, [8.4 F_1 + 2.1, 8.4 F_2 - 0.9]], [8.6, [8.5 F_1 + 2.1, 8.5 F_2 - 0.9]], [8.7, [8.6 F_1 \\
& + 2.1, 8.6 F_2 - 0.9]], [8.8, [8.7 F_1 + 2.1, 8.7 F_2 - 0.9]], [8.9, [8.8 F_1 + 2.1, 8.8 F_2 - 0.9]], \\
& [9.0, [8.9 F_1 + 2.1, 8.9 F_2 - 0.9]], [9.1, [9.0 F_1 + 2.1, 9.0 F_2 - 0.9]], [9.2, [9.1 F_1 + 2.1, \\
& 9.1 F_2 - 0.9]], [9.3, [9.2 F_1 + 2.1, 9.2 F_2 - 0.9]], [9.4, [9.3 F_1 + 2.1, 9.3 F_2 - 0.9]], [9.5, \\
& [9.4 F_1 + 2.1, 9.4 F_2 - 0.9]], [9.6, [9.5 F_1 + 2.1, 9.5 F_2 - 0.9]], [9.7, [9.6 F_1 + 2.1, 9.6 F_2 \\
& - 0.9]], [9.8, [9.7 F_1 + 2.1, 9.7 F_2 - 0.9]], [9.9, [9.8 F_1 + 2.1, 9.8 F_2 - 0.9]], [10.0, \\
& [9.9 F_1 + 2.1, 9.9 F_2 - 0.9]], [10.1, [10.0 F_1 + 2.1, 10.0 F_2 - 0.9]]] \\
& [[0.1, [0.1, 0.1]], [0.2, [0.1 F_1 + 0.1, 0.1 F_2 + 0.1]], [0.3, [0.2 F_1 + 0.1, 0.2 F_2 + 0.1]], [0.4, \quad (4) \\
& [0.3 F_1 + 0.1, 0.3 F_2 + 0.1]], [0.5, [0.4 F_1 + 0.1, 0.4 F_2 + 0.1]], [0.6, [0.5 F_1 + 0.1, 0.5 F_2 \\
& + 0.1]], [0.7, [0.6 F_1 + 0.1, 0.6 F_2 + 0.1]], [0.8, [0.7 F_1 + 0.1, 0.7 F_2 + 0.1]], [0.9, [0.8 F_1 \\
& + 0.1, 0.8 F_2 + 0.1]], [1.0, [0.9 F_1 + 0.1, 0.9 F_2 + 0.1]], [1.1, [1.0 F_1 + 0.1, 1.0 F_2 + 0.1]], \\
& [1.2, [1.1 F_1 + 0.1, 1.1 F_2 + 0.1]], [1.3, [1.2 F_1 + 0.1, 1.2 F_2 + 0.1]], [1.4, [1.3 F_1 + 0.1, \\
& 1.3 F_2 + 0.1]], [1.5, [1.4 F_1 + 0.1, 1.4 F_2 + 0.1]], [1.6, [1.5 F_1 + 0.1, 1.5 F_2 + 0.1]], [1.7, \\
& [1.6 F_1 + 0.1, 1.6 F_2 + 0.1]], [1.8, [1.7 F_1 + 0.1, 1.7 F_2 + 0.1]], [1.9, [1.8 F_1 + 0.1, 1.8 F_2 \\
& + 0.1]], [2.0, [1.9 F_1 + 0.1, 1.9 F_2 + 0.1]], [2.1, [2.0 F_1 + 0.1, 2.0 F_2 + 0.1]], [2.2, [2.1 F_1 \\
& + 0.1, 2.1 F_2 + 0.1]], [2.3, [2.2 F_1 + 0.1, 2.2 F_2 + 0.1]], [2.4, [2.3 F_1 + 0.1, 2.3 F_2 + 0.1]], \\
& [2.5, [2.4 F_1 + 0.1, 2.4 F_2 + 0.1]], [2.6, [2.5 F_1 + 0.1, 2.5 F_2 + 0.1]], [2.7, [2.6 F_1 + 0.1, \\
& 2.6 F_2 + 0.1]], [2.8, [2.7 F_1 + 0.1, 2.7 F_2 + 0.1]], [2.9, [2.8 F_1 + 0.1, 2.8 F_2 + 0.1]], [3.0, \\
& [2.9 F_1 + 0.1, 2.9 F_2 + 0.1]], [3.1, [3.0 F_1 + 0.1, 3.0 F_2 + 0.1]], [3.2, [3.1 F_1 + 0.1, 3.1 F_2 \\
& + 0.1]], [3.3, [3.2 F_1 + 0.1, 3.2 F_2 + 0.1]], [3.4, [3.3 F_1 + 0.1, 3.3 F_2 + 0.1]], [3.5, [3.4 F_1 \\
& + 0.1, 3.4 F_2 + 0.1]], [3.6, [3.5 F_1 + 0.1, 3.5 F_2 + 0.1]], [3.7, [3.6 F_1 + 0.1, 3.6 F_2 + 0.1]], \\
& [3.8, [3.7 F_1 + 0.1, 3.7 F_2 + 0.1]], [3.9, [3.8 F_1 + 0.1, 3.8 F_2 + 0.1]], [4.0, [3.9 F_1 + 0.1, \\
& 3.9 F_2 + 0.1]], [4.1, [4.0 F_1 + 0.1, 4.0 F_2 + 0.1]], [4.2, [4.1 F_1 + 0.1, 4.1 F_2 + 0.1]], [4.3, \\
& [4.2 F_1 + 0.1, 4.2 F_2 + 0.1]], [4.4, [4.3 F_1 + 0.1, 4.3 F_2 + 0.1]], [4.5, [4.4 F_1 + 0.1, 4.4 F_2 \\
& + 0.1]], [4.6, [4.5 F_1 + 0.1, 4.5 F_2 + 0.1]], [4.7, [4.6 F_1 + 0.1, 4.6 F_2 + 0.1]], [4.8, [4.7 F_1 \\
& + 0.1, 4.7 F_2 + 0.1]], [4.9, [4.8 F_1 + 0.1, 4.8 F_2 + 0.1]], [5.0, [4.9 F_1 + 0.1, 4.9 F_2 + 0.1]], \\
& [5.1, [5.0 F_1 + 0.1, 5.0 F_2 + 0.1]], [5.2, [5.1 F_1 + 0.1, 5.1 F_2 + 0.1]], [5.3, [5.2 F_1 + 0.1, \\
& 5.2 F_2 + 0.1]], [5.4, [5.3 F_1 + 0.1, 5.3 F_2 + 0.1]], [5.5, [5.4 F_1 + 0.1, 5.4 F_2 + 0.1]], [5.6,
\end{aligned}$$

$[5.5 F_1 + 0.1, 5.5 F_2 + 0.1]$, $[5.7, [5.6 F_1 + 0.1, 5.6 F_2 + 0.1]]$, $[5.8, [5.7 F_1 + 0.1, 5.7 F_2 + 0.1]]$, $[5.9, [5.8 F_1 + 0.1, 5.8 F_2 + 0.1]]$, $[6.0, [5.9 F_1 + 0.1, 5.9 F_2 + 0.1]]$, $[6.1, [6.0 F_1 + 0.1, 6.0 F_2 + 0.1]]$, $[6.2, [6.1 F_1 + 0.1, 6.1 F_2 + 0.1]]$, $[6.3, [6.2 F_1 + 0.1, 6.2 F_2 + 0.1]]$, $[6.4, [6.3 F_1 + 0.1, 6.3 F_2 + 0.1]]$, $[6.5, [6.4 F_1 + 0.1, 6.4 F_2 + 0.1]]$, $[6.6, [6.5 F_1 + 0.1, 6.5 F_2 + 0.1]]$, $[6.7, [6.6 F_1 + 0.1, 6.6 F_2 + 0.1]]$, $[6.8, [6.7 F_1 + 0.1, 6.7 F_2 + 0.1]]$, $[6.9, [6.8 F_1 + 0.1, 6.8 F_2 + 0.1]]$, $[7.0, [6.9 F_1 + 0.1, 6.9 F_2 + 0.1]]$, $[7.1, [7.0 F_1 + 0.1, 7.0 F_2 + 0.1]]$, $[7.2, [7.1 F_1 + 0.1, 7.1 F_2 + 0.1]]$, $[7.3, [7.2 F_1 + 0.1, 7.2 F_2 + 0.1]]$, $[7.4, [7.3 F_1 + 0.1, 7.3 F_2 + 0.1]]$, $[7.5, [7.4 F_1 + 0.1, 7.4 F_2 + 0.1]]$, $[7.6, [7.5 F_1 + 0.1, 7.5 F_2 + 0.1]]$, $[7.7, [7.6 F_1 + 0.1, 7.6 F_2 + 0.1]]$, $[7.8, [7.7 F_1 + 0.1, 7.7 F_2 + 0.1]]$, $[7.9, [7.8 F_1 + 0.1, 7.8 F_2 + 0.1]]$, $[8.0, [7.9 F_1 + 0.1, 7.9 F_2 + 0.1]]$, $[8.1, [8.0 F_1 + 0.1, 8.0 F_2 + 0.1]]$, $[8.2, [8.1 F_1 + 0.1, 8.1 F_2 + 0.1]]$, $[8.3, [8.2 F_1 + 0.1, 8.2 F_2 + 0.1]]$, $[8.4, [8.3 F_1 + 0.1, 8.3 F_2 + 0.1]]$, $[8.5, [8.4 F_1 + 0.1, 8.4 F_2 + 0.1]]$, $[8.6, [8.5 F_1 + 0.1, 8.5 F_2 + 0.1]]$, $[8.7, [8.6 F_1 + 0.1, 8.6 F_2 + 0.1]]$, $[8.8, [8.7 F_1 + 0.1, 8.7 F_2 + 0.1]]$, $[8.9, [8.8 F_1 + 0.1, 8.8 F_2 + 0.1]]$, $[9.0, [8.9 F_1 + 0.1, 8.9 F_2 + 0.1]]$, $[9.1, [9.0 F_1 + 0.1, 9.0 F_2 + 0.1]]$, $[9.2, [9.1 F_1 + 0.1, 9.1 F_2 + 0.1]]$, $[9.3, [9.2 F_1 + 0.1, 9.2 F_2 + 0.1]]$, $[9.4, [9.3 F_1 + 0.1, 9.3 F_2 + 0.1]]$, $[9.5, [9.4 F_1 + 0.1, 9.4 F_2 + 0.1]]$, $[9.6, [9.5 F_1 + 0.1, 9.5 F_2 + 0.1]]$, $[9.7, [9.6 F_1 + 0.1, 9.6 F_2 + 0.1]]$, $[9.8, [9.7 F_1 + 0.1, 9.7 F_2 + 0.1]]$, $[9.9, [9.8 F_1 + 0.1, 9.8 F_2 + 0.1]]$, $[10.0, [9.9 F_1 + 0.1, 9.9 F_2 + 0.1]]$, $[10.1, [10.0 F_1 + 0.1, 10.0 F_2 + 0.1]]$

> #5

$NI := 50;$

$Dis2(SIRS(x, y, 0.01, 0.01, 1, NI), x, y, [NI - 30, 30], 0.1, 10);$

$N2 := 80;$

$Dis2(SIRS(x, y, 0.01, 0.01, 1, N2), x, y, [N2 - 30, 30], 0.1, 10);$

$N3 := 120;$

$Dis2(SIRS(x, y, 0.01, 0.01, 1, N3), x, y, [N3 - 30, 30], 0.1, 10);$

$NI := 50$

$Dis2(SIRS(x, y, 0.01, 0.01, 1, 50), x, y, [20, 30], 0.1, 10)$

$N2 := 80$

$Dis2(SIRS(x, y, 0.01, 0.01, 1, 80), x, y, [50, 30], 0.1, 10)$

$N3 := 120$

$Dis2(SIRS(x, y, 0.01, 0.01, 1, 120), x, y, [90, 30], 0.1, 10)$

(5)

>