```
> read `DMB.txt`
```

For a list of the Main procedures type: Help(); for help with a specific procedure type: Help (ProcedureName); for example Help(Feig);

For a list of the Continuous Dynamical Models procedures type: HelpC(); for help with a specific procedure type: Help(ProcedureName); for example Help(Feig);

(1)

```
> ExpGenLotka(2, 50);
```

The Equilibrium points are

$$\{[-2.683896620, 2.286282306], [0., 0.], [0., 0.5154639175], [2.777777778, 0.]\}$$

The stable Equilibrium points are

$$\{[-2.683896620, 2.286282306], [2.777777778, 0.]\}$$

at time t=, 50, *with initial conditions*, $[0.5, 0.5]$, *the ultimate behavior is*

$$[2.777777728, 1.149773525 \times 10^{-32}]$$

and with initial conditions, $[0.1, 0.1]$

$$[2.777777728, 6.166171822 \times 10^{-32}]$$

and with initial conditions, $\left[\frac{1}{2}, 1\right]$

$$[2.777777728, 3.559447327 \times 10^{-32}]$$

(2)

```
> ExpGenLotka(2, 50);
```

The Equilibrium points are

$$\{[0., 0.], [0., 0.5494505494], [0.5773361976, 0.4162191192], [0.6024096386, 0.]\}$$

The stable Equilibrium points are

$$\{[0.5773361976, 0.4162191192]\}$$

at time t=, 50, *with initial conditions*, $[0.5, 0.5]$, *the ultimate behavior is*

$$[0.5773353857, 0.4162269422]$$

and with initial conditions, $[0.1, 0.1]$

$$[0.5773441893, 0.4161420388]$$

and with initial conditions, $\left[\frac{1}{2}, 1\right]$

(3)

[0.5773337040, 0.4162431525] **(3)**

> *ExpGenLotka*(2, 50);

The Equilibrium points are

{[0., 0.], [0., 0.7575757576], [0.6088280061, 0.3424657534], [0.6944444444, 0.]}

The stable Equilibrium points are
{[0.6088280061, 0.3424657534]}
at time t=, 50, *with initial conditions*, [0.5, 0.5], *the ultimate behavior is*
[0.6083381214, 0.3438919093]

and with initial conditions, [0.1, 0.1]

[0.6090313958, 0.3418714132]
and with initial conditions, $\left[\frac{1}{2}, 1\right]$

[0.6079000622, 0.3451611023] **(4)**

> *ExpGenLotka*(2, 50);

The Equilibrium points are

{[0., 0.], [0., 3.846153846], [3.125000000, 0.], [5.693950178, −0.5338078292]}

The stable Equilibrium points are
{[0., 3.846153846], [5.693950178, −0.5338078292]}
at time t=, 50, *with initial conditions*, [0.5, 0.5], *the ultimate behavior is*
$[1.281369109 \times 10^{-14}, 3.846152340]$

and with initial conditions, [0.1, 0.1]

$[1.453868707 \times 10^{-13}, 3.846146901]$
and with initial conditions, $\left[\frac{1}{2}, 1\right]$

$[1.781552673 \times 10^{-15}, 3.846153251]$ **(5)**

> *ExpGenLotka*(2, 50);

The Equilibrium points are

$$\{[-0.3925417076, 1.054955839], [0., 0.], [0., 0.6097560976], [1., 0.]\}$$

The stable Equilibrium points are

$$\{[-0.3925417076, 1.054955839], [1., 0.]\}$$

at time t=, 50, *with initial conditions*, [0.5, 0.5], *the ultimate behavior is*

$$[0.9998105170, 2.330802373 \times 10^{-13}]$$

and with initial conditions, [0.1, 0.1]

$$[0.9872150245, 1.084685957 \times 10^{-6}]$$

and with initial conditions, $\left[\frac{1}{2}, 1\right]$

$$[0.9997372607, 7.560882067 \times 10^{-13}] \quad \textbf{(6)}$$

> *ExpGenLotka*(2, 50);

The Equilibrium points are

$$\{[0., 0.], [0., 2.083333333], [0.4256712508, 0.3274394237], [0.8474576271, 0.]\}$$

The stable Equilibrium points are

$$\{[0., 2.083333333], [0.8474576271, 0.]\}$$

at time t=, 50, *with initial conditions*, [0.5, 0.5], *the ultimate behavior is*

$$[1.961907983 \times 10^{-28}, 2.083333258]$$

and with initial conditions, [0.1, 0.1]

$$[1.060024740 \times 10^{-25}, 2.083333258]$$

and with initial conditions, $\left[\frac{1}{2}, 1\right]$

$$[3.086660984 \times 10^{-32}, 2.083333258] \quad \textbf{(7)}$$

> *ExpGenLotka*(2, 50);

The Equilibrium points are

$$\{[0., 0.], [0., 1.282051282], [0.4893238434, 0.8303677343], [0.5434782609, 0.]\}$$

The stable Equilibrium points are

$$\{[0.4893238434, 0.8303677343]\}$$

at time t=, 50, *with initial conditions*, [0.5, 0.5], *the ultimate behavior is*

[0.4893238506, 0.8303677165]

and with initial conditions, [0.1, 0.1]

[0.4893238506, 0.8303677165]

and with initial conditions, $\left[\frac{1}{2}, 1\right]$

[0.4893238362, 0.8303677521] **(8)**

> *ExpGenLotka*(2, 50);

The Equilibrium points are

{[0., 0.], [0., 2.380952381], [0.5154639175, 0.], [2.212389381, −5.309734513]}

The stable Equilibrium points are

{[0., 2.380952381], [2.212389381, −5.309734513]}

at time t=, 50, *with initial conditions*, [0.5, 0.5], *the ultimate behavior is*

[0.0002790072347, 2.326581452]

and with initial conditions, [0.1, 0.1]

[0.2033063029, 1.086983281]

and with initial conditions, $\left[\frac{1}{2}, 1\right]$

$[8.511188435 \times 10^{-7}, 2.376315130]$ **(9)**

> *ExpGenLotka*(2, 50);

The Equilibrium points are

{[0., 0.], [0., 0.7575757576], [0.4854368932, 0.3236245955], [0.7462686567, 0.]}

The stable Equilibrium points are

{[0.4854368932, 0.3236245955]}

at time t=, 50, *with initial conditions*, [0.5, 0.5], *the ultimate behavior is*

[0.4833972445, 0.3258528831]

and with initial conditions, [0.1, 0.1]

[0.4832258567, 0.3260399162]

and with initial conditions, $\left[\frac{1}{2}, 1\right]$

[0.4802226200, 0.3293121122] **(10)**

```
> ExpGenLotka(2, 50);
```

The Equilibrium points are

{[0., 0.], [0., 25.], [0.7470902800, 0.3460207612], [2.272727273, 0.]}

The stable Equilibrium points are

{[0., 25.], [2.272727273, 0.]}

at time t=, 50, *with initial conditions*, [0.5, 0.5], *the ultimate behavior is*

$[1.526861210 \times 10^{-836}, 24.99999902]$

and with initial conditions, [0.1, 0.1]

$[1.314085974 \times 10^{-729}, 24.99999902]$

and with initial conditions, $\left[\frac{1}{2}, 1\right]$

$[3.069228037 \times 10^{-884}, 24.99999902]$ **(11)**

```
> #prob 2
> ExpGenLotka(3, 50);
```

The Equilibrium points are

{[−2.220427937, 3.037949132, −0.2994213430], [−0.8064516129, 0., 2.150537634], [0., 0., 0.], [0., 0., 1.282051282], [0., 0.4658385093, 0.6728778468], [0., 0.5555555556, 0.], [0.4115226337, 0.1028806584, 0.], [0.5102040816, 0., 0.]}

The stable Equilibrium points are

{[−2.220427937, 3.037949132, −0.2994213430], [0., 0.4658385093, 0.6728778468]}

at time t=, 50, *with initial conditions*, [0.5, 0.5, 0.5], *the ultimate behavior is*

$[8.007954436 \times 10^{-14}, 0.4676326267, 0.6605454926]$

and with initial conditions, [0.1, 0.1, 0.1]

$$[5.167031143 \times 10^{-8}, 0.4853243302, 0.5361394621]$$

and with initial conditions, $\left[\frac{1}{3}, \frac{2}{3}, 1\right]$

$$[5.037421637 \times 10^{-17}, 0.4638929380, 0.6861892135] \quad \textbf{(12)}$$

> *ExpGenLotka*(3, 50);

The Equilibrium points are

$$\{[-3.571428571, 0., 1.970443350], [0., 0., 0.], [0., 0., 0.8620689655], [0., 0.1614205004, 0.6255044391], [0., 2.173913043, 0.], [0.7009564161, 0.4242084385, 0.02284598689], [0.7224819380, 0.4462388440, 0.], [1.470588235, 0., 0.]\}$$

The stable Equilibrium points are

$$\{[0., 0., 0.8620689655], [0., 2.173913043, 0.]\}$$

at time t=, 50, *with initial conditions,* [0.5, 0.5, 0.5], *the ultimate behavior is*

$$[0.0001208146267, 2.077923563, 9.941872176 \times 10^{-21}]$$

and with initial conditions, [0.1, 0.1, 0.1]

$$[0.001022378751, 0.05858961588, 0.7729243236]$$

and with initial conditions, $\left[\frac{1}{3}, \frac{2}{3}, 1\right]$

$$[5.197569345 \times 10^{-7}, 2.155116524, 1.652508062 \times 10^{-30}] \quad \textbf{(13)}$$

> *ExpGenLotka*(3, 50);

The Equilibrium points are

$$\{[0., 0., 0.], [0., 0., 2.777777778], [0., 0.5952380952, 0.], [0., 1.773049645, -1.063829787], [0.4464285714, 0.2444727891, 0.], [0.5617977528, 0., 0.], [1.243034719, 1.050150021, -1.293041863], [6.250000000, 0., -6.250000000]\}$$

The stable Equilibrium points are

$$\{[0., 0., 2.777777778], [1.243034719, 1.050150021, -1.293041863]\}$$

at time t=, 50, *with initial conditions,* [0.5, 0.5, 0.5], *the ultimate behavior is*

$$[9.026751012 \times 10^{-9}, 5.052404766 \times 10^{-55}, 2.777777700]$$

and with initial conditions, [0.1, 0.1, 0.1]

$$[4.654527713 \times 10^{-9}, 2.724569061 \times 10^{-53}, 2.777777706]$$

and with initial conditions, $\left[\frac{1}{3}, \frac{2}{3}, 1\right]$

$$[3.457644376 \times 10^{-9}, 9.450451799 \times 10^{-57}, 2.777777708] \quad \textbf{(14)}$$

> *ExpGenLotka*(3, 50);

The Equilibrium points are

$$\{[0., 0., 0.], [0., 0., 0.6250000000], [0., 0.02724795640, 0.5994550409], [0., 0.9433962264, 0.], [0.1589903065, -0.5063876282, 0.9427354737], [0.6303580434, 0.9077155824, 0.], [0.6666666667, 0., 0.], [0.7084265474, 0., -0.07457121551]\}$$

The stable Equilibrium points are

$$\{[0.1589903065, -0.5063876282, 0.9427354737], [0.6303580434, 0.9077155824, 0.]\}$$

at time t=, 50, *with initial conditions,* [0.5, 0.5, 0.5], *the ultimate behavior is*

$$[0.6304899760, 0.9049728769, 4.065973970 \times 10^{-11}]$$

and with initial conditions, [0.1, 0.1, 0.1]

$$[0.6313206749, 0.8876002255, 1.268680945 \times 10^{-8}]$$

and with initial conditions, $\left[\frac{1}{3}, \frac{2}{3}, 1\right]$

$$[0.6304743690, 0.9052975613, 4.920308192 \times 10^{-11}] \quad \textbf{(15)}$$

> *ExpGenLotka*(3, 50);

The Equilibrium points are

$$\{[-0.08695652174, 0.6304347826, 0.], [0., -2.484472050, 2.795031056], [0., 0., 0.], [0., 0., 1.219512195], [0., 0.6250000000, 0.], [0.5613466877, -0.06940286321, 0.5926460182], [0.6386861314, 0., 0.4562043796], [1.470588235, 0., 0.]\}$$

The stable Equilibrium points are

$$\{[0., 0., 1.219512195]\}$$

at time t=, 50, *with initial conditions,* [0.5, 0.5, 0.5], *the ultimate behavior is*

$$[0.004576733154, 6.434152505 \times 10^{-7}, 1.025283644]$$

and with initial conditions, [0.1, 0.1, 0.1]

[0.1711491100, 0.2100927963, 0.4020651155]

and with initial conditions, $\left[\frac{1}{3}, \frac{2}{3}, 1\right]$

$[3.975567231 \times 10^{-10}, 5.457477131 \times 10^{-15}, 1.201782225]$ **(16)**

> *ExpGenLotka*(3, 50);

The Equilibrium points are

{[0., 0., 0.], [0., 0., 4.166666667], [0., 2.225130890, 0.4581151832], [0., 8.333333333, 0.], [0.6578947368, 0., 0.], [1.875397330, 0., −1.303242212], [4.954954955, −6.531531532, 0.], [6.040806003, −7.990472979, −0.1348958772]}

The stable Equilibrium points are

{[0., 0., 4.166666667], [0., 8.333333333, 0.], [6.040806003, −7.990472979, −0.1348958772]}

at time t=, 50, *with initial conditions*, [0.5, 0.5, 0.5], *the ultimate behavior is*

$[8.341971592 \times 10^{-70}, 7.300301696 \times 10^{-23}, 4.166666582]$

and with initial conditions, [0.1, 0.1, 0.1]

$[8.110649657 \times 10^{-66}, 3.533951740 \times 10^{-22}, 4.166666582]$

and with initial conditions, $\left[\frac{1}{3}, \frac{2}{3}, 1\right]$

$[9.658387016 \times 10^{-73}, 1.072193238 \times 10^{-23}, 4.166666582]$ **(17)**

> *ExpGenLotka*(3, 50);

The Equilibrium points are

{[−0.1579778831, 1.290152712, 0.], [0., 0., 0.], [0., 0., 0.8196721311], [0., 1.282051282, 0.], [0., 1.312861593, −0.6008010681], [0.3000378689, 1.298707604, −0.6248361444], [0.4096900606, 0., 0.7659422871], [0.9803921569, 0., 0.]}

The stable Equilibrium points are

{[0., 1.282051282, 0.]}

at time t=, 50, *with initial conditions*, [0.5, 0.5, 0.5], *the ultimate behavior is*

[0.05077492496, 1.276496623, 0.01571123586]

and with initial conditions, [0.1, 0.1, 0.1]

[0.07826292239, 1.269284318, 0.02286325887]

and with initial conditions, $\left[\frac{1}{3}, \frac{2}{3}, 1\right]$

[0.03168275822, 1.277959273, 0.01717669069] **(18)**

> *ExpGenLotka*(3, 50);

The Equilibrium points are

{[0., 0., 0.], [0., 0., 0.5555555556], [0., 0.6097560976, 0.], [0., 0.7042253521, −0.1173708920], [0.3744043567, 0., 0.5513955071], [0.6009200690, −2.160724554, 2.613571018], [0.6097560976, 0., 0.], [0.6891798759, −0.1550654721, 0.]}

The stable Equilibrium points are

{[0.3744043567, 0., 0.5513955071]}

at time t=, 50, *with initial conditions*, [0.5, 0.5, 0.5], *the ultimate behavior is*

[0.4326160116, 0.00001185576796, 0.5507162093]

and with initial conditions, [0.1, 0.1, 0.1]

[0.1489306693, 0.1305992330, 0.4245586111]

and with initial conditions, $\left[\frac{1}{3}, \frac{2}{3}, 1\right]$

[0.3473057771, 0.0005729557738, 0.5509974534] **(19)**

> *ExpGenLotka*(3, 50);

The Equilibrium points are

{[−0.01746092585, 0.2100989452, 0.5343327229], [0., 0., 0.], [0., 0., 0.5555555556], [0., 0.2066115702, 0.5280073462], [0., 0.6172839506, 0.], [0.07518796992, 0., 0.5263157895], [0.3711201080, 0.4385964912, 0.], [0.5494505494, 0., 0.]}

The stable Equilibrium points are

{[0., 0.2066115702, 0.5280073462]}

at time t=, 50, *with initial conditions*, [0.5, 0.5, 0.5], *the ultimate behavior is*

[0.02933061950, 0.2004818831, 0.5171382552]

and with initial conditions, [0.1, 0.1, 0.1]

[0.02608211351, 0.2011813481, 0.5183575536]

and with initial conditions, $\left[\frac{1}{3}, \frac{2}{3}, 1\right]$

[0.02639949184, 0.2011130204, 0.5182386486] **(20)**

```
> ExpGenLotka(3, 50);
```

The Equilibrium points are

{[0., −0.2886836028, 0.8083140878], [0., 0., 0.], [0., 0., 0.5319148936], [0., 1.470588235, 0.], [0.2960294787, 0.3881505403, 0.09729640210], [0.3911806543, 0.3200568990, 0.], [0.7342896175, 0., 0.3756830601], [0.7812500000, 0., 0.]}

The stable Equilibrium points are

{[0., 1.470588235, 0.], [0.7342896175, 0., 0.3756830601]}

at time t=, 50, *with initial conditions*, [0.5, 0.5, 0.5], *the ultimate behavior is*

[0.5636251800, 0.004826829789, 0.4058712031]

and with initial conditions, [0.1, 0.1, 0.1]

[0.1412013782, 0.5550417495, 0.09638631041]

and with initial conditions, $\left[\frac{1}{3}, \frac{2}{3}, 1\right]$

[0.3682684896, 0.1288746555, 0.3019497108] **(21)**

```
> #prob 3
> ExpGenLotka(4, 50);
```

The Equilibrium points are

{[−17.18750000, 0., 32.03125000, 0.], [−0.02433267635, 0.08029783196, 0., 0.6119668102], [0., 0., 0., 0.], [0., 0., 0., 0.6172839506], [0., 0., 0.9615384615, 0.], [0., 0., 0.9853603604, −0.1126126126], [0., 0.1196172249, 0.7775119617, 0.], [0., 0.1292546316, 0.7611661640, 0.007180812868], [0., 0.1838235294, 0., 0.5514705882], [0., 1.219512195, 0., 0.], [0.1095504947, 0.6785961617, −0.4000433824, 0.5651651317], [1.557152635, 0., −1.976386037, 0.5817932923], [4.166666667, 0., 0., 0.], [4.719764012, −0.7374631268, 0., 0.], [11.98522829, −21.70993733, 12.69583706, 0.]}

The stable Equilibrium points are

{[−17.18750000, 0., 32.03125000, 0.], [4.166666667, 0., 0., 0.]}

at time t=, 50, *with initial conditions*, [0.5, 0.5, 0.5, 0.5], *the ultimate behavior is*

$[4.166475734, 6.059103610 \times 10^{-6}, 1.376443278 \times 10^{-88}, 0.00001820385317]$

and with initial conditions, [0.1, 0.1, 0.1, 0.1]

$[4.166657821, 8.778168389 \times 10^{-7}, 1.879444552 \times 10^{-105}, 7.733110661 \times 10^{-7}]$

and with initial conditions, $\left[\frac{1}{4}, \frac{1}{2}, \frac{3}{4}, 1\right]$

$[4.073517472, 1.423221683 \times 10^{-8}, 7.742361187 \times 10^{-30}, 0.009238559887]$ **(22)**

> *ExpGenLotka*(4, 50);

The Equilibrium points are

{[−0.2272727273, 0., 1.060606061, 0.], [0., −2.262443439, 1.923076923, 0.], [0., −0.6045557595, −1.295476627, 2.261686279], [0., 0., 0., 0.], [0., 0., 0., 0.7246376812], [0., 0., 0.7575757576, 0.], [0., 0.2503128911, 0., 0.4380475594], [0., 0.9803921569, 0., 0.], [0.08337303478, 0., 0., 0.6074321105], [0.08798075197, 0., 0.03770603656, 0.5763637017], [0.1645912014, −0.5256711238, 0.8089210983, 0.], [0.1646282671, −0.06895849550, −0.07721323305, 0.6225126772], [0.2149773554, −0.1000679113, 0., 0.5369936451], [1.079489696, 0.04906771344, 0., 0.], [1.086956522, 0., 0., 0.]}

The stable Equilibrium points are

{[0.2149773554, −0.1000679113, 0., 0.5369936451], [1.079489696, 0.04906771344, 0., 0.]}

at time t=, 50, *with initial conditions*, [0.5, 0.5, 0.5, 0.5], *the ultimate behavior is*

$[0.6047137690, 0.4628308558, 1.430056970 \times 10^{-6}, 8.719728035 \times 10^{-15}]$

and with initial conditions, [0.1, 0.1, 0.1, 0.1]

[0.1061913430, 0.0002225201713, 0.1263253242, 0.4887276589]

and with initial conditions, $\left[\frac{1}{4}, \frac{1}{2}, \frac{3}{4}, 1\right]$

[0.2970517326, 0.4564472205, 0.1513808037, 0.00009548676835] **(23)**

> *ExpGenLotka*(4, 50);

The Equilibrium points are

{[−0.1321003963, 0.5944517834, 0., 0.], [−0.05117707267, 0., 0.5117707267, 0.], [0., 0., 0., 0.], [0., 0., 0., 1.190476190], [0., 0., 0.3758169935, 0.6535947712], [0., 0., 0.5000000000,

0.], [0., 0.2278922691, 0.3912332352, 0.2246210882], [0., 0.2298095863, 0.4333552200, 0.], [0., 0.4809286899, 0., 0.3316749585], [0., 0.5263157895, 0., 0.], [0.1558519799, 0.4309940257, 0., 0.1091400420], [0.2021039494, 0.1400692771, 0.4269019047, −0.07371528150], [0.2673277717, 0., 0.4308550641, 0.04031341274], [0.3591380686, 0., 0., 0.4722000532], [0.3598704173, 0.06889576218, 0.3972500330, 0.], [3.846153846, 0., 0., 0.]}

The stable Equilibrium points are

{[0., 0.2278922691, 0.3912332352, 0.2246210882], [3.846153846, 0., 0., 0.]}

at time t=, 50, *with initial conditions*, [0.5, 0.5, 0.5, 0.5], *the ultimate behavior is*

$[1.098371451 \times 10^{-6}, 0.2277983845, 0.3916647855, 0.2229248972]$

and with initial conditions, [0.1, 0.1, 0.1, 0.1]

$[1.874804787 \times 10^{-7}, 0.2278639471, 0.3913596074, 0.2241274299]$

and with initial conditions, $\left[\frac{1}{4}, \frac{1}{2}, \frac{3}{4}, 1\right]$

$[2.644631015 \times 10^{-8}, 0.2278957192, 0.3912159286, 0.2246895671]$ **(24)**

> *ExpGenLotka*(4, 50);

The Equilibrium points are

{[0., −0.1893939394, 0.7196969697, 0.], [0., 0., 0., 0.], [0., 0., 0., 0.5154639175], [0., 0., 0.05141388175, 0.4884318766], [0., 0., 0.7142857143, 0.], [0., 0.1962229457, 0.1660201884, 0.3998541150], [0., 0.3323194773, 0., 0.4675002816], [0., 0.5154639175, 0., 0.], [0.1600235137, 0., −0.03102496693, 0.5053803824], [0.2579535684, 0., 0., 0.4729148753], [0.2682267581, 0.1405611626, −0.004671326896, 0.4533892089], [0.2806746170, 0.1276549740, 0., 0.4507426442], [1.840490798, 0., 0.03067484663, 0.], [1.851851852, 0., 0., 0.], [2.362440191, −1.134370016, −0.1307814992, 0.], [2.367841410, −1.266519824, 0., 0.]}

The stable Equilibrium points are

{[0.2806746170, 0.1276549740, 0., 0.4507426442]}

at time t=, 50, *with initial conditions*, [0.5, 0.5, 0.5, 0.5], *the ultimate behavior is*

[0.6895923499, 0.0001611565406, 0.08268088076, 0.3526112483]

and with initial conditions, [0.1, 0.1, 0.1, 0.1]

[0.5014484570, 0.01686214274, 0.06516238771, 0.3945098884]

and with initial conditions, $\left[\frac{1}{4}, \frac{1}{2}, \frac{3}{4}, 1\right]$

[0.7552250526, 0.0001203536744, 0.09634443653, 0.3328972962] **(25)**

> *ExpGenLotka*(4, 50);

The Equilibrium points are

{[−0.1921894219, 0., 0.7226322263, 0.6226937269], [−0.03718463272, 0.2242453759, 0.6174568697, 0.4276943750], [0., 0., −5.555555556, 5.555555556], [0., 0., 0., 0.], [0., 0., 0., 0.8928571429], [0., 0., 1.111111111, 0.], [0., 0.1657458564, 0., 0.8839779006], [0., 0.2975083674, 1.022685013, 0.01859427296], [0., 0.3004291845, 1.044349070, 0.], [0., 0.6024096386, 0., 0.], [0.1922298665, 0., 0., 0.5564548766], [0.3539716622, 0.3661603091, 0., 0.2537910031], [0.8159934721, 0.3467972256, 0., 0.], [0.8981847082, 0.5178438521, −0.6805767557, 0.], [1.162790698, 0., 0., 0.], [2.453468697, 0., −3.468697124, 0.]}

The stable Equilibrium points are

{[−0.03718463272, 0.2242453759, 0.6174568697, 0.4276943750], [0., 0., −5.555555556, 5.555555556], [0.8159934721, 0.3467972256, 0., 0.]}

at time t=, 50, *with initial conditions*, [0.5, 0.5, 0.5, 0.5], *the ultimate behavior is*

$[0.8160870642, 0.3463013982, 0.0008015534921, 5.848576715 \times 10^{-12}]$

and with initial conditions, [0.1, 0.1, 0.1, 0.1]

$[0.8219511543, 0.3416544283, 0.0006363706370, 5.563903122 \times 10^{-11}]$

and with initial conditions, $\left[\frac{1}{4}, \frac{1}{2}, \frac{3}{4}, 1\right]$

$[0.8186824876, 0.3397021395, 0.009214694686, 3.250659480 \times 10^{-8}]$ **(26)**

> *ExpGenLotka*(4, 50);

The Equilibrium points are

{[−0.4163739783, 0.3274153252, 1.090011168, −0.4752375140], [0., −0.05224660397, 0., 1.044932079], [0., 0., 0., 0.], [0., 0., 0., 1.020408163], [0., 0., 0.9259259259, 0.], [0., 0., 1.587301587, −1.020408163], [0., 1.162790698, 0., 0.], [0., 1.741293532, −0.3316749585, 0.], [0., 2.455977757, −4.572134693, 5.746061168], [0.2147598594, 0.8980866849, 0., 0.], [0.9852216749, 0., 0.8210180624, −0.1759324419], [1.300601267, −3.106009453, 0., 2.292530787], [1.851851852, 0., 0.5144032922, 0.], [7.142857143, 0., 0., 0.], [8.083832335,

28.04391218, −21.12441783, 0.]}

The stable Equilibrium points are

{[0., 0., 0.9259259259, 0.]}

at time t=, 50, *with initial conditions*, [0.5, 0.5, 0.5, 0.5], *the ultimate behavior is*

$[0.001328724292, 4.745917342 \times 10^{-9}, 0.8685157127, 0.08298224766]$

and with initial conditions, [0.1, 0.1, 0.1, 0.1]

$[0.002176625218, 6.404353117 \times 10^{-8}, 0.8978165560, 0.04022497308]$

and with initial conditions, $\left[\frac{1}{4}, \frac{1}{2}, \frac{3}{4}, 1\right]$

$[0.0001714001519, 8.839462734 \times 10^{-9}, 0.8505710808, 0.1092374991]$ **(27)**

> *ExpGenLotka*(4, 50);

The Equilibrium points are

{[−20.58823529, 0., 4.779411765, 0.], [−0.3986048829, 0., 0., 1.270553064], [0., −9.829059829, 25.21367521, 0.], [0., 0., 0., 0.], [0., 0., 0., 0.8196721311], [0., 0., 1.562500000, 0.], [0., 0., 10.93750000, −3.125000000], [0., 0.1689790110, 0., 0.5869797225], [0., 0.6190375645, −2.089371749, 0.7207708697], [0., 2.777777778, 0., 0.], [0.2691910319, 0., 0.3061366837, 0.4047674059], [0.3644680802, −0.1752058023, 0.2302758578, 0.5656216555], [2.155172414, 0.8620689655, 0., 0.], [2.586683131, 0.4955642934, −0.03412082020, 0.], [2.777777778, 0., 0., 0.], [3.203761923, −2.420472105, 0., 0.5288538392]}

The stable Equilibrium points are

{[−0.3986048829, 0., 0., 1.270553064], [2.155172414, 0.8620689655, 0., 0.]}

at time t=, 50, *with initial conditions*, [0.5, 0.5, 0.5, 0.5], *the ultimate behavior is*

$[2.115088156, 0.9105793097, 7.929184842 \times 10^{-7}, 9.247953547 \times 10^{-36}]$

and with initial conditions, [0.1, 0.1, 0.1, 0.1]

$[2.130835896, 0.8915783114, 7.711548337 \times 10^{-6}, 2.803378864 \times 10^{-35}]$

and with initial conditions, $\left[\frac{1}{4}, \frac{1}{2}, \frac{3}{4}, 1\right]$

$[2.066480063, 0.9683484648, 6.423833502 \times 10^{-8}, 8.762634464 \times 10^{-33}]$ **(28)**

> *ExpGenLotka*(4, 50);

The Equilibrium points are

{[−0.5885997522, 1.889714994, 0., 0.], [−0.2790684083, 0.7393121183, 0., 0.4251775226], [0., −0.1751313485, 0.7342044995, 0.1683955274], [0., 0., 0., 0.], [0., 0., 0., 0.8928571429], [0., 0., 0.7042253521, 0.], [0., 0.2964426877, 0., 0.5434782609], [0., 0.4288777698, 0.6075768406, 0.], [0., 1.515151515, 0., 0.], [0.06680254532, 0.6168703509, 0.4786512707, 0.], [0.2911563670, −0.4195038334, 0.3952934677, 0.4649598405], [0.4865330156, 0., 0.06798987013, 0.1029204456], [0.6097560976, 0., 0., 0.], [0.6348400203, 0., 0., −0.02539360081], [0.6559766764, 0., −0.1457725948, 0.]}

The stable Equilibrium points are

{[0.06680254532, 0.6168703509, 0.4786512707, 0.], [0.2911563670, −0.4195038334, 0.3952934677, 0.4649598405]}

at time t=, 50, *with initial conditions*, [0.5, 0.5, 0.5, 0.5], *the ultimate behavior is*

$[0.1546955809, 0.8420660437, 0.2869841708, 1.832410175 \times 10^{-6}]$

and with initial conditions, [0.1, 0.1, 0.1, 0.1]

[0.2532514039, 0.2391004782, 0.3458392797, 0.008094302489]

and with initial conditions, $\left[\frac{1}{4}, \frac{1}{2}, \frac{3}{4}, 1\right]$

[0.1617469624, 0.6384077709, 0.3480623013, 0.00002338132015] **(29)**

> *ExpGenLotka*(4, 50);

The Equilibrium points are

{[0., 0., −0.4163649529, 1.122375091], [0., 0., 0., 0.], [0., 0., 0., 0.6944444444], [0., 0., 4.166666667, 0.], [0., 0.3708123183, 0.1044102038, 0.5407824175], [0., 0.4482477588, 0., 0.6384134746], [0., 0.8233532934, 0.04990019960, 0.], [0., 0.8928571429, 0., 0.], [0.2612775482, 0.4713326446, 0.2423381543, 0.], [0.3175625631, 0.1697236568, 0.3109890099, 0.2698001620], [0.4712349840, 0., 0.3092550279, 0.2522453227], [0.5453501722, 0.7175660161, 0., 0.], [0.6529209622, 0., 0.2491408935, 0.], [0.7729476105, 0.3317071655, 0., 0.4490087627], [1.066758431, 0., 0., 0.4129387474], [1.162790698, 0., 0., 0.]}

The stable Equilibrium points are

{[0., 0., 4.166666667, 0.], [0.7729476105, 0.3317071655, 0., 0.4490087627]}

at time t=, 50, *with initial conditions*, [0.5, 0.5, 0.5, 0.5], *the ultimate behavior is*

$[0.7481179640, 0.3512237415, 3.886035745 \times 10^{-17}, 0.4588241514]$

and with initial conditions, [0.1, 0.1, 0.1, 0.1]

$[1.449540891 \times 10^{-33}, 1.629955580 \times 10^{-12}, 4.166666608, 6.547470028 \times 10^{-11}]$

and with initial conditions, $\left[\frac{1}{4}, \frac{1}{2}, \frac{3}{4}, 1\right]$

$[0.7773144167, 0.3167611399, 2.580772473 \times 10^{-16}, 0.4686812640]$ **(30)**

> *ExpGenLotka*(4, 50);

The Equilibrium points are

{[−42.59259259, 38.27160494, 0., 0.], [−3.903865717, 3.874194642, 0., 0.4514242116], [−0.2732075757, 0.7483998924, −0.6966158109, 0.7316118782], [0., 0., −0.1788036411, 0.9752925878], [0., 0., 0., 0.], [0., 0., 0., 0.9615384615], [0., 0., 0.7812500000, 0.], [0., 0.2961766290, 0., 0.8077544426], [0., 0.4282937159, −0.4560249637, 0.7742340293], [0., 0.5209656925, 0.2033036849, 0.], [0., 0.5747126437, 0., 0.], [1.278875923, −0.9535603715, 1.499404620, 0.], [1.808510638, 0., 0., 0.2659574468], [1.880156318, 0., 0.05102040816, 0.2344767694], [3.333333333, 0., 0., 0.], [3.846153846, 0., −0.2403846154, 0.]}

The stable Equilibrium points are

{[−42.59259259, 38.27160494, 0., 0.], [0., 0.2961766290, 0., 0.8077544426], [3.333333333, 0., 0., 0.]}

at time t=, 50, *with initial conditions*, [0.5, 0.5, 0.5, 0.5], *the ultimate behavior is*

$[0.001067283336, 0.2941487987, 0.00007563550706, 0.8085356807]$

and with initial conditions, [0.1, 0.1, 0.1, 0.1]

$[0.0005078763080, 0.2952598043, 0.00003151972679, 0.8080906091]$

and with initial conditions, $\left[\frac{1}{4}, \frac{1}{2}, \frac{3}{4}, 1\right]$

$[0.0004192998247, 0.2954111000, 0.00003292097416, 0.8080373669]$ **(31)**

> *#prob 4*

> *ExpGenLotka*(5, 50);

The Equilibrium points are

{[−1.288198307, 1.349807432, −0.2416691978, 0.5279433550, 0.], [−0.5345376137, 0.6001296763, 0., 0.4674376875, 0.], [−0.2336492801, 0., 0.7766237206, −0.08513536523, 0.], [−0.1803864017, 0.3208571963, −0.04622649757, 0.1680707552, 0.4040928132], [−0.02682315515, 0.1694831213, 0., 0.1506298749, 0.4117179229], [0., −0.1302700142, 0., 0.6158218854, 0.], [0., 0., 0., 0., 0.], [0., 0., 0., 0., 0.5747126437], [0., 0., 0., 0.03818980332, 0.5632995990], [0., 0., 0., 0.5882352941, 0.], [0., 0., 0.2335933855, −0.01943911669, 0.4140531854], [0., 0., 0.2446619217, 0., 0.4003558719], [0., 0., 0.6201675258, 0.04832474227, 0.], [0., 0., 0.6250000000, 0., 0.], [0., 0.1393638013, 0., 0.1467110143, 0.4219399441], [0., 0.1789843868, 0.08696763341, 0.1561077233, 0.3261869841], [0., 0.2372567628, 0.3170613103, 0.2619628389, 0.], [0., 0.4038648819, −0.3117302221, 0., 0.4812007103], [0., 0.6670224120, 0., 0., 0.05336179296], [0., 0.7142857143, 0., 0., 0.], [0., 0.8626198083, −0.3993610224, 0., 0.], [0.04815239904, 0., 0.2381235076, 0.01451168190, 0.3746652419], [0.1691093574, 0., 0., 0.5862457723, 0.], [0.1720377646, 0., 0., 0.1634813890, 0.4329161949], [0.1955671447, 0.5215123859, 0., 0., 0.], [0.2019647933, 0.3341145963, 0., 0., 0.2044581858], [0.3030303030, 0., 0.1515151515, 0., 0.3030303030], [0.4379927456, 0.01754238365, 0.08586221114, 0., 0.2631954228], [0.5186388480, 0.1590605276, 0.1184493291, 0., 0.], [0.6713780919, 0., 0., 0., 0.2120141343], [0.9433962264, 0., 0., 0., 0.], [5.555555556, 0., −2.777777778, 0., 0.]}

The stable Equilibrium points are

{[−0.1803864017, 0.3208571963, −0.04622649757, 0.1680707552, 0.4040928132], [0., 0.1789843868, 0.08696763341, 0.1561077233, 0.3261869841]}

at time t=, 50, *with initial conditions*, [0.5, 0.5, 0.5, 0.5, 0.5], *the ultimate behavior is*

[0.0003427978129, 0.1795317639, 0.2474680427, 0.1443687052, 0.2217372641]

and with initial conditions, [0.1, 0.1, 0.1, 0.1, 0.1]

[0.01648500297, 0.1638546226, 0.1272987700, 0.1640697944, 0.2939129940]

and with initial conditions, $\left[\frac{1}{5}, \frac{2}{5}, \frac{3}{5}, \frac{4}{5}, 1\right]$

[0.00005838338360, 0.1292283678, 0.2872722615, 0.1265647340, 0.2409929137] **(32)**

> *ExpGenLotka*(5, 50);

The Equilibrium points are

{[−0.9389671362, 0., 1.324614353, 0., 0.], [−0.2061011492, 1.075612058, 0., −0.7300283129, 0.8722866818], [0., −0.6254252701, 1.762764462, −0.2244790242, 0.],

[0., 0., 0., 0., 0.], [0., 0., 0., 0., 1.111111111], [0., 0., 0., 0.7102803738, 0.9532710280], [0., 0., 0., 0.8196721311, 0.], [0., 0., 0.3581173261, 0.4263301501, 0.], [0., 0., 1.002367306, −0.3276850237, 0.4043109893], [0., 0., 1.190476190, 0., 0.], [0., 0., 1.830357143, 0., −0.3125000000], [0., 0.1061571125, 1.167728238, 0., 0.], [0., 0.5441466684, 0.1836048791, −0.2335136155, 0.6574347852], [0., 0.7867412141, 0., −0.3793929712, 0.6709265176], [0., 0.8607314370, 0.1588474326, 0., 0.4137421500], [0., 1.212121212, 0., 0., 0.3030303030], [0., 1.612903226, 0., 0., 0.], [0., 1.923076923, 0., −1.923076923, 0.], [0.2809350204, 0., 0.1967617414, 0.4884194724, 0.], [0.2933057281, 0.2415458937, 0., 0., 0.5003450656], [0.2935128159, 0.1591631606, 0.03693172876, 0., 0.5262246750], [0.3467270394, 0., 0.07690897237, 0., 0.5196448945], [0.3634475597, 0., 0., 0.6230529595, 0.4153686397], [0.4761904762, 0., 0., 0., 0.3809523810], [0.4860392968, 0., 0., 0.6204756980, 0.], [0.5882352941, 0., 0., 0., 0.], [0.7239984425, 0.09179142767, −0.2638676427, 0.6818576523, 0.], [0.8300395257, −0.3952569170, 0., 0., 0.], [0.8309675999, 0., −0.2989504567, 0.8204155387, −0.1128367510], [0.9760320544, −0.1152706176, −0.3526808136, 1.000893799, −0.2567378387], [1.238025055, −1.860722181, 0., 2.966101695, 0.], [2.824931413, −8.620541838, 2.634173525, 0., 0.]}

The stable Equilibrium points are

{[0., 0., 1.830357143, 0., −0.3125000000], [0., 0.8607314370, 0.1588474326, 0., 0.4137421500], [1.238025055, −1.860722181, 0., 2.966101695, 0.]}

at time t=, 50, *with initial conditions*, [0.5, 0.5, 0.5, 0.5, 0.5], *the ultimate behavior is*

$[3.889589837 \times 10^{-8}, 1.146683378, 0.01127767552, 0.06830694037, 0.3303786248]$

and with initial conditions, [0.1, 0.1, 0.1, 0.1, 0.1]

$[8.857873134 \times 10^{-8}, 0.9864156802, 0.07733379365, 0.02573623011, 0.3934168446]$

and with initial conditions, $\left[\frac{1}{5}, \frac{2}{5}, \frac{3}{5}, \frac{4}{5}, 1\right]$

$[4.981146274 \times 10^{-7}, 1.155315043, 0.0001912960021, 0.1090178177, 0.3277334990]$ **(33)**

> *ExpGenLotka*(5, 50);

The Equilibrium points are

{[−0.4083806818, 0., 0.9055397727, 0., 0.], [−0.3506097561, 0., 0.8291759054, 0.1699926090, 0.], [0., −7.928384586, 1.358446337, 3.686915188, 3.896316745], [0., −1.833059158, 1.970859060, 0.3610571068, 0.], [0., −1.182687882, 0., 1.097212177, 0.8218817805], [0., −1.116071429, 0., 0., 1.562500000], [0., −0.9848484848, 1.439393939, 0., 0.], [0., −0.4960317460, −0.1278432335, 0., 1.108656521], [0., 0.,

−0.06443298969, 0., 0.7087628866], [0., 0., 0., 0., 0.], [0., 0., 0., 0., 0.6944444444], [0., 0., 0., 0.3817733990, 0.4187192118], [0., 0., 0., 0.5813953488, 0.], [0., 0., 0.1088822482, 0.2622711089, 0.4808303662], [0., 0., 0.7042253521, 0., 0.], [0., 0.2388535032, 0., 0.3980891720, 0.], [0., 0.5494505494, 0., 0., 0.], [0.2525919920, 0., 0.2521469935, 0.03703200727, 0.2924182285], [0.2660349204, 0., 0.2432213113, 0., 0.3041566842], [0.2768525975, −0.3273933582, 0.2138789947, 0., 0.5516441357], [0.4977245601, 1.339571107, 0.1800559450, −0.7601795255, −0.4675066214], [0.5022126364, 0.6302258527, 0.08976388947, −0.3676324311, 0.], [0.5565622573, 0.4271291742, 0., 0., 0.], [0.5593869732, 0., 0., 0.1455938697, 0.], [0.5801293391, 0., 0., 0.2255957223, −0.2017048252], [0.5813953488, 0., 0., 0., 0.], [0.5896705978, 0., 0., 0., −0.05083367222], [0.6140083541, 0.8327208189, 0., −0.5360248113, 0.], [1.143904730, 6.428593073, 0., 0., −5.751340868], [1.389561915, 1.094230895, −0.7975902037, 0., 0.], [1.994743918, 12.50919162, 0., −7.722371850, −5.978792929]}

The stable Equilibrium points are

{[0.2525919920, 0., 0.2521469935, 0.03703200727, 0.2924182285], [1.389561915, 1.094230895, −0.7975902037, 0., 0.]}

at time t=, 50, *with initial conditions*, [0.5, 0.5, 0.5, 0.5, 0.5], *the ultimate behavior is*

[0.2498122034, 0.0007651620228, 0.2458522209, 0.04131229248, 0.3040451109]

and with initial conditions, [0.1, 0.1, 0.1, 0.1, 0.1]

[0.2834863883, 0.0001623317450, 0.2255638203, 0.04823444363, 0.2892140363]

and with initial conditions, $\left[\frac{1}{5}, \frac{2}{5}, \frac{3}{5}, \frac{4}{5}, 1\right]$

[0.2123411881, 0.0007696865246, 0.2667994913, 0.04665340359, 0.3130982809] **(34)**

> *ExpGenLotka*(5, 50);

The Equilibrium points are

{[−1.149675157, 2.829042454, 0., 0.6162702226, −0.6773430160], [−0.4649675261, 2.568392049, 0., 0., −0.2976776225], [−0.3179568894, 1.299603102, 0., 0.3482907076, 0.], [−0.1641152140, −1.336332042, 0.9469645214, 1.102790475, 0.], [−0.1546619532, 1.745470614, 0., 0., 0.], [0., −1.285783600, 0.8531457221, 0.9420993045, 0.], [0., −0.5249895620, 1.907564985, 1.039051030, −4.281803694], [0., 0., 0., −0.6254598970, 2.207505519], [0., 0., 0., 0., 0.], [0., 0., 0., 0., 1.020408163], [0., 0., 0., 1.515151515, 0.], [0., 0., 0.04351610096, 1.392515231, 0.], [0., 0., 1.681051906, 1.211451126, −4.572366075], [0., 0., 1.724137931, 0., 0.], [0., 0., 3.590664273, 0., −6.014362657], [0., 0.5376344086,

1.612903226, 0., 0.], [0., 0.9262557891, 0., 0.1959387246, 0.], [0., 1.003988174, 0., 0.1775828885, −0.09523998492], [0., 1.388888889, 0., 0., 0.], [0., 1.417322835, 0., 0., −0.07874015748], [0., 2.364434376, 3.794421634, 0., −8.247203738], [0.1131827289, 0., 0.0007647481684, 1.269481960, 0.], [0.1137656428, 0., 0., 1.270383011, 0.], [0.2596153846, 0., 0., 0., 0.6442307692], [0.4104115983, −0.1137285152, 1.054213889, 0., 0.], [0.4376367615, 0., 0.9846827133, 0., 0.], [0.4678323767, 0., 0., −0.2099531430, 0.7410110930], [1.247450331, −1.798266581, −0.5104565167, 0., 1.607530248], [1.522236776, −1.092586737, −0.3991136994, −0.5835068713, 1.551439573], [1.577709349, 0., −1.400222393, 0., 1.477632367], [1.667789994, 0., −1.114499927, −0.3620381669, 1.474458223], [12.50000000, 0., 0., 0., 0.]}

The stable Equilibrium points are

{[0., 0., 0., 1.515151515, 0.], [0., 0.5376344086, 1.612903226, 0., 0.], [12.50000000, 0., 0., 0., 0.]}

at time t=, 50, *with initial conditions*, [0.5, 0.5, 0.5, 0.5, 0.5], *the ultimate behavior is*

$[6.381595835 \times 10^{-7}, 0.4942105958, 1.622285123, 4.257364872 \times 10^{-25}, 0.00001614063890]$

and with initial conditions, [0.1, 0.1, 0.1, 0.1, 0.1]

$[3.943532974 \times 10^{-6}, 0.2921860504, 1.664949993, 5.141988674 \times 10^{-23}, 9.010435385 \times 10^{-6}]$

and with initial conditions, $\left[\frac{1}{5}, \frac{2}{5}, \frac{3}{5}, \frac{4}{5}, 1\right]$

$[3.704458219 \times 10^{-8}, 0.4840611720, 1.624467731, 1.406745798 \times 10^{-25}, 0.00002100888921]$ **(35)**

> *ExpGenLotka*(5, 50);

The Equilibrium points are

{[−21.74059140, 16.59946237, 0., 3.897849462, 0.], [−3.968253968, 5.555555556, 0., 0., 0.], [−2.878114738, 5.360247247, 0., 0., −0.5022213637], [−0.06297229219, 0., 0., 0., 0.6926952141], [0., −0.9981851180, 0., 6.896551724, 0.], [0., 0., −9.191176471, 0., 11.76470588], [0., 0., −0.2185457516, 0.7986111111, 0.6311274510], [0., 0., 0., −2.075471698, 1.509433962], [0., 0., 0., 0., 0.], [0., 0., 0., 0., 0.6849315068], [0., 0., 0., 2.380952381, 0.], [0., 0., 1.718213058, 0.1718213058, 0.], [0., 0., 2.083333333, 0., 0.], [0., 0.1856427102, 0.7370498682, 0.5935045755, 0.], [0., 0.7004135582, 0.9115005676, 0.8258494162, −0.9434296951], [0., 1.172786442, 0., 22.85398502, −8.731425764], [0., 2.631578947, 0., 0., 0.], [0., 2.765486726, 0., 0., −0.1106194690], [0., 6.407076720, −1.653439153, 0., 0.8349867725], [0., 10.40268456, −2.684563758, 0., 0.], [0.1075513617, 0., 0., −0.1095139778, 0.7151773027], [0.5755662830, 0., 0.1299665800,

0.1856665429, 0.], [0.5868544601, 0., 0., 0.3129890454, 0.], [0.6526038233, −3.783783784, 2.050098879, 0., 0.], [0.6724413039, 0., 0.2621381354, 0., 0.], [0.6834363140, −0.7575913720, 1.319870419, 0., −0.7724671903], [0.7311586052, 0., 3.007344670, 0., −3.030503540], [0.8983620889, −0.1070367724, 0.9498088828, −0.4202118377, −0.3730756845], [0.9097618439, 0., 1.139519079, −0.4314627154, −0.6294947511], [1.008251538, −0.3713024637, 0.8984096366, −0.6473304734, 0.], [1.190476190, 0., 0., 0., 0.], [2333.123487, −2044.285714, 0., −808.9104116, 622.4697337]}

The stable Equilibrium points are

{[0., −0.9981851180, 0., 6.896551724, 0.], [0., 0., 2.083333333, 0., 0.], [0., 6.407076720, −1.653439153, 0., 0.8349867725], [2333.123487, −2044.285714, 0., −808.9104116, 622.4697337]}

at time t=, 50, *with initial conditions*, [0.5, 0.5, 0.5, 0.5, 0.5], *the ultimate behavior is*

$[1.321877965 \times 10^{-12}, 2.118015143 \times 10^{-14}, 2.080751188, 0.0005337044644, 2.631550806 \times 10^{-33}]$

and with initial conditions, [0.1, 0.1, 0.1, 0.1, 0.1]

$[2.037207288 \times 10^{-10}, 3.032541618 \times 10^{-9}, 2.071428153, 1.683399035 \times 10^{-10}, 2.693569318 \times 10^{-23}]$

and with initial conditions, $\left[\frac{1}{5}, \frac{2}{5}, \frac{3}{5}, \frac{4}{5}, 1\right]$

$[5.113776579 \times 10^{-13}, 1.530327718 \times 10^{-13}, 1.965139347, 0.04463959047, 3.911471841 \times 10^{-32}]$ **(36)**

> *ExpGenLotka*(5, 50);

The Equilibrium points are

{[−1.189499590, 0., 1.681706317, 0., 0.], [−1.151450780, 0., −0.5865881331, 1.783903829, 0.], [−1.004732186, 0., 1.841437487, 0., −0.3051916878], [−0.5776636714, 0., 0., 1.091142490, 0.], [−0.2372570029, 0., 0., 2.380223481, −2.173580285], [−0.1401146888, 0., 0.1803269762, 1.867148656, −1.667553292], [−0.1377897561, 0.3757046424, 0., 0., 0.5785705019], [−0.07921524673, 0.2732072430, 0.2589415398, 0., 0.4535378598], [0., −0.1946787800, 0., 0., 0.6164828034], [0., −0.1601556359, 0.06386574438, 0., 0.5816695488], [0., 0., 0., 0., 0.], [0., 0., 0., 0., 0.6024096386], [0., 0., 0., 0.5319148936, 0.], [0., 0., 0., 0.6422924901, −0.1482213439], [0., 0., 0.03067171046, 0.6760556180, −0.2032000818], [0., 0., 0.08477449983, 0., 0.5595116989], [0., 0., 0.6666666667, 0., 0.],

[0., 0.4044887814, 0., 0.1134993500, 0.4405256670], [0., 0.5193845871, 0.1429280255, 0.1206284700, 0.3515632990], [0., 1.086956522, 0.6521739130, 0., 0.], [0., 1.288170047, 0.4861019046, 0.1303636926, 0.], [0., 1.978417266, 0., 0.08992805755, 0.], [0., 2., 0., 0., 0.], [0.01657524671, 0.3146851958, 0., 0.1094853578, 0.4513091401], [0.03012447976, 0.2905481967, 0.06129316509, 0.1092614162, 0.4219733922], [0.3874051352, 0.3110935200, 0.3319330377, 0., 0.], [0.3927426451, 0.3121145847, 0.3178555304, 0.007587141960, 0.], [0.4780279906, 0.4996256407, 0., −0.04247537868, 0.], [0.4847876964, 0.4680708793, 0., 0., 0.], [1.227495908, 0., 0., 0., 0.5728314239], [2.173913043, 0., 0., 0., 0.]}

The stable Equilibrium points are

{[0., 0.5193845871, 0.1429280255, 0.1206284700, 0.3515632990], [1.227495908, 0., 0., 0., 0.5728314239]}

at time t=, 50, *with initial conditions*, [0.5, 0.5, 0.5, 0.5, 0.5], *the ultimate behavior is*

$[1.227495802, 4.420117459 \times 10^{-20}, 1.809371716 \times 10^{-16}, 2.387576101 \times 10^{-31}, 0.5728314320]$

and with initial conditions, [0.1, 0.1, 0.1, 0.1, 0.1]

$[1.227495802, 8.722730135 \times 10^{-23}, 1.332475011 \times 10^{-18}, 1.549009773 \times 10^{-35}, 0.5728314320]$

and with initial conditions, $\left[\frac{1}{5}, \frac{2}{5}, \frac{3}{5}, \frac{4}{5}, 1\right]$

$[4.604511511 \times 10^{-10}, 0.5107978309, 0.1455508965, 0.1201073629, 0.3519553814]$ **(37)**

> *ExpGenLotka*(5, 50);

The Equilibrium points are

{[−20.12987013, 0., 0., 0., 7.792207792], [−7.230499562, 0.6134969325, 0., 0., 3.155127082], [−6.102665107, 0., 2.283498492, 0., 1.920354527], [−1.664914251, 0.6631666206, 0.7360144691, 0., 0.8870930120], [−1.446120977, 0.5207637869, 0., 2.116437442, 0.], [−1.427214728, 0.5235685065, −0.1826482176, 2.242576657, 0.], [−1.304347826, 0., 0., 2.173913043, 0.], [−1.264729785, 0., −0.3678818134, 2.428600453, 0.], [−0.2732876302, 0., 0., 0.8414732265, 0.3500874387], [−0.1854676389, 0., −0.2052166991, 0.8986166706, 0.3724019967], [−0.08292165240, 0.7282565546, 0.1019528801, 0.1741023437, 0.4857703750], [−0.03706278989, 0.7351949416, 0., 0.1964037176, 0.4982547060], [0., 0., −0.6012950971, 0., 1.595744681], [0., 0., −0.3549913941, 0.7176665847, 0.6108618146], [0., 0., 0., 0., 0.], [0., 0., 0., 0., 1.250000000], [0., 0., 0., 0.3401360544, 0.8503401361], [0.,

0., 0., 0.6493506494, 0.], [0., 0., 0.2673002673, 0.4306504306, 0.], [0., 0., 0.5434782609, 0., 0.], [0., 0.7068223725, 0., 0., 0.7375537800], [0., 0.7072567314, −0.01442249021, 0., 0.7455318016], [0., 0.7205538554, 0.03086457531, 0.09980538446, 0.5925799973], [0., 0.7260717247, 0., 0.1310405691, 0.5696253309], [0., 0.8362585174, 0.5162089614, 0., 0.], [0., 0.8704061896, 0., 0.2763194253, 0.], [0., 0.8773155351, 0.7144263315, −0.3111723577, 0.], [0., 0.9433962264, 0., 0., 0.], [1.653543307, 0.7874015748, 0., 0., 0.], [2., 0., 0., 0., 0.], [2.507114514, 0.8657661630, −0.7655617460, 0., 0.], [3.361792956, 0., −1.173959445, 0., 0.]}

The stable Equilibrium points are

{[−1.446120977, 0.5207637869, 0., 2.116437442, 0.], [0., 0.7205538554, 0.03086457531, 0.09980538446, 0.5925799973]}

at time t=, 50, *with initial conditions*, [0.5, 0.5, 0.5, 0.5, 0.5], *the ultimate behavior is*

[0.01324960158, 0.7161423788, 0.02721413826, 0.03567208391, 0.6598466577]

and with initial conditions, [0.1, 0.1, 0.1, 0.1, 0.1]

[0.1014557582, 0.7276601868, 0.001456552981, 0.00003595173956, 0.6479223019]

and with initial conditions, $\left[\frac{1}{5}, \frac{2}{5}, \frac{3}{5}, \frac{4}{5}, 1\right]$

[0.007983466897, 0.7293696568, 0.05452728168, 0.1174619393, 0.5346426684] **(38)**

> *ExpGenLotka*(5, 50);

The Equilibrium points are

{[0., −1.326750473, 0.9105755771, 1.366549557, 0.], [0., −0.6657353903, 1.037068301, 1.011109948, −0.4560848532], [0., −0.2052636251, 0., 0.4171844488, 1.212719688], [0., 0., 0., 0., 0.], [0., 0., 0., 0., 1.470588235], [0., 0., 0., 0.6628787879, 1.041666667], [0., 0., 0., 4.545454545, 0.], [0., 0., 0.5681818182, 0., 0.], [0., 0., 0.8004002001, −0.4752376188, 0.], [0., 0., 1.813775885, 2.665589661, −2.548098105], [0., 0., 3.409090909, 0., −2.840909091], [0., 0.3623188406, 0., 0., 1.449275362], [0., 0.7575757576, 0., 0., 0.], [0., 0.7577077164, −0.008709284097, 0., 0.], [0., 3.238719068, 0., −1.637554585, 0.], [0., 13.61717101, 39.54961295, 0., −49.34904996], [0.05057216423, −0.1295097461, 0., 0.3368911502, 1.133787654], [0.2034776175, 0., 0., 0., 0.9618941916], [0.2042098649, 0., 0., −0.02748978951, 0.9778510839], [0.2144082333, 0.4716981132, 0., 0., 0.], [0.2879325691, 0.3699692228, 0.2439652122, 0., 0.], [0.3491867624, 0.1311091274, 0., 0., 0.5899090277], [0.3693406956, 1.450760999, 3.977373492, 0., −4.568310037], [0.4527012514, 0.3281451583, 0.3259112979, −0.1149198997, −0.01828955000],

[0.4583976707, 0.3221279537, 0.3134180263, −0.1191285799, 0.], [0.4643566259, 0., −0.7173509255, 0., 1.216934606], [0.7378876270, 0., −1.235415503, −3.195789114, 3.256169966], [0.7743023612, 0., 0.02299908004, 0.8816314014, 0.], [0.8105369807, 0., 0., 0.8611955420, 0.], [0.9756840413, 0.3755763796, 0., −0.6064823669, 0.], [1.181102362, 0., 0.3937007874, 0., 0.], [1.515151515, 0., 0., 0., 0.]}

The stable Equilibrium points are

{[0., 0., 0., 4.545454545, 0.], [0., 0.3623188406, 0., 0., 1.449275362], [0., 13.61717101, 39.54961295, 0., −49.34904996], [1.181102362, 0., 0.3937007874, 0., 0.]}

at time t=, 50, *with initial conditions*, [0.5, 0.5, 0.5, 0.5, 0.5], *the ultimate behavior is*

$[0.00005498987583, 1.228473756 \times 10^{-28}, 4.867895353 \times 10^{-40}, 4.545033490, 4.018333915 \times 10^{-15}]$

and with initial conditions, [0.1, 0.1, 0.1, 0.1, 0.1]

$[0.0002533074828, 2.355245844 \times 10^{-19}, 3.319866152 \times 10^{-34}, 4.543498156, 1.900479812 \times 10^{-8}]$

and with initial conditions, $\left[\frac{1}{5}, \frac{2}{5}, \frac{3}{5}, \frac{4}{5}, 1\right]$

$[0.00001596403852, 2.277632872 \times 10^{-27}, 7.505766465 \times 10^{-44}, 4.545332292, 5.696159267 \times 10^{-13}]$ **(39)**

> *ExpGenLotka*(5, 50);

The Equilibrium points are

{[−72.13401734, 0., 65.49821198, −23.72825822, 39.68611335], [−27.76507728, −5.734809168, 19.23706728, −5.683864944, 26.34340247], [−4.385277487, −0.1682065759, 6.865729155, 0., −0.1034784341], [−4.250678733, −0.1746606335, 6.581900452, 0., 0.], [−4.170739655, 0., 6.915933529, 0., −0.6109481916], [−3.131991051, 0., 4.865771812, 0., 0.], [−3.118622864, −1.670905328, 0., −1.706631647, 9.690781892], [−1.513119745, 0., 0., −2.620324732, 6.813569150], [0., −4.716981132, 6.603773585, 0., 0.], [0., −3.511941103, 0.1348536542, −0.4447237685, 4.777458550], [0., −3.388307432, 0., −0.4845473447, 4.924763012], [0., −2.220346138, 1.433094133, 0., 1.880540312], [0., 0., 0., −2.530541012, 4.363001745], [0., 0., 0., 0., 0.], [0., 0., 0., 0., 2.631578947], [0., 0., 0., 0.7936507936, 0.], [0., 0., 0.6756756757, 0., 0.], [0., 0., 0.6993006993, −0.04995004995, 0.], [0., 0., 4.045092838, 0., −3.116710875], [0., 0., 6.085376930, −4.102331214, −3.209203754], [0., 0.2628257387, 0.1414852330, 0.4310656875, 0.], [0., 0.5150334076, 0., 0.4175946548, 0.], [0., 3.125000000, 0., 0., 0.],

[0., 16.21621622, 0., 0., −6.756756757], [0.1495215311, 0., 0., 0.6180223285, 0.], [0.2191820070, 0.1288410572, 0., 0.4421244896, 0.], [0.2482727312, 0.1303351040, −0.02959266115, 0.4425626247, 0.], [0.7001236010, 0., −0.5760992872, 0.6662603071, 0.], [0.9920471403, −0.05871930114, 0., 0., 1.099184111], [1.080246914, 0., 0., 0., 0.9259259259], [2.785145889, 0.1657824934, 0., 0., 0.], [4.166666667, 0., 0., 0., 0.]}

The stable Equilibrium points are

{[−4.385277487, −0.1682065759, 6.865729155, 0., −0.1034784341], [0., 0., 0., 0., 2.631578947], [0., 16.21621622, 0., 0., −6.756756757], [4.166666667, 0., 0., 0., 0.]}

at time t=, 50, *with initial conditions*, [0.5, 0.5, 0.5, 0.5, 0.5], *the ultimate behavior is*

$[1.870625188 \times 10^{-20}, 0.03989347472, 4.972624873 \times 10^{-24}, 2.657373554 \times 10^{-7}, 2.569455294]$

and with initial conditions, [0.1, 0.1, 0.1, 0.1, 0.1]

$[3.983639316 \times 10^{-13}, 0.5476685352, 5.316047225 \times 10^{-18}, 9.898290173 \times 10^{-6}, 1.903926284]$

and with initial conditions, $\left[\frac{1}{5}, \frac{2}{5}, \frac{3}{5}, \frac{4}{5}, 1\right]$

$[4.049829841 \times 10^{-20}, 0.009572640601, 3.848087390 \times 10^{-26}, 4.571539029 \times 10^{-8}, 2.614643854]$ **(40)**

> *ExpGenLotka*(5, 50);

The Equilibrium points are

{[−0.6578414703, 1.174247025, 0.7099627561, 0., 0.], [−0.2484709480, 0., 1.701070336, 0., 0.], [−0.1976284585, 1.739130435, 0., 0., 0.], [−0.003106443679, 0.4753482892, 0.2483906819, 0.2864654190, 0.], [0., 0., 0., −0.3633314701, 1.732811627], [0., 0., 0., 0., 0.], [0., 0., 0., 0., 1.111111111], [0., 0., 0., 3.333333333, 0.], [0., 0., 0.1533742331, 2.402862986, 0.], [0., 0., 0.4019483990, 0.1684806375, 0.3404839415], [0., 0., 0.7695195195, 0., 0.1876876877], [0., 0., 1.136363636, 0., 0.], [0., 0.4490507577, 0.2816356986, 0.04870467717, 0.05115919213], [0., 0.4735792622, 0.2492522433, 0.2741774676, 0.], [0., 0.4874651811, 0., 0., 0.4178272980], [0., 0.5046583851, 0.3105590062, 0., 0.], [0., 0.5295175624, 0.3195090986, 0., −0.02539145154], [0., 0.8160237389, 0., 0.6676557864, 0.], [0., 0.9247766119, 0., −0.2821744393, 0.2787050815], [0., 1.250000000, 0., 0., 0.], [0.1175935721, 0.7938658996, 0., 0.2539846298, 0.], [0.3091589481, 0., 0.2747617956, 0.3885881215, 0.], [0.6292093084, 0., 0.1660644604, 0.4099776575, −0.3210158713], [0.7020808662, 0., 0., 0.4313990864, 0.], [0.7436490990, 0.3786652702, 0.02170764197, 0.3528988920, −0.6853037866],

[0.7751580572, 0.3937472959, 0., 0.3532236487, −0.7078678680], [0.9096696954, 0., 0., 0.4370151485, −0.4048358858], [1.521602518, 1.413824265, 0.2716652276, 0., −2.510568243], [1.597826087, 0., 1.508454106, 0., −2.048309179], [1.929207203, 1.616642517, 0., 0., −2.817222107], [4.545454545, 0., 0., 0., 0.], [8.296943231, 0., 0., 0., −5.895196507]}

The stable Equilibrium points are

{[−0.2484709480, 0., 1.701070336, 0., 0.], [−0.1976284585, 1.739130435, 0., 0., 0.], [0., 0., 0., 3.333333333, 0.], [4.545454545, 0., 0., 0., 0.]}

at time t=, 50, *with initial conditions*, [0.5, 0.5, 0.5, 0.5, 0.5], *the ultimate behavior is*

$[1.006800784 \times 10^{-11}, 0.09268813340, 0.003141951486, 2.708601484, 1.661215969 \times 10^{-32}]$

and with initial conditions, [0.1, 0.1, 0.1, 0.1, 0.1]

$[4.543393943, 3.898130310 \times 10^{-20}, 1.104169641 \times 10^{-95}, 1.205170434 \times 10^{-11}, 2.082542838 \times 10^{-28}]$

and with initial conditions, $\left[\frac{1}{5}, \frac{2}{5}, \frac{3}{5}, \frac{4}{5}, 1\right]$

[0.0003011743658, 0.0009983021035, 1.128045434, 0.01058487764, $8.702324180 \times 10^{-15}$] **(41)**

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