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```
> read "M5.txt"
> Help5( )
```

RecToSeq(INI,REC,N), GrowthC(INI,REC,K) , GrowthCe(REC)
LeslieMod(SUR,FER): e.g. LeslieMod([9/10,9/10],[0,1,1]);
LeslieMat(SUR,FER); e.g. LeslieMat([9/10,9/10],[0,1,1]); **(1)**

```
> GrowthCe([0.1, 1.14, 0.829, 0.0829])
```

$$1.385647080 \quad \textbf{(2)}$$

```
> L := Matrix( [[0.1, 1.2, 0.9, 0.1], [0.95, 0 , 0, 0], [0, 0.97, 0, 0], [0, 0, 0.9, 0]] )
```

$$L := \begin{bmatrix} 0.1 & 1.2 & 0.9 & 0.1 \\ 0.95 & 0 & 0 & 0 \\ 0 & 0.97 & 0 & 0 \\ 0 & 0 & 0.9 & 0 \end{bmatrix} \quad \textbf{(3)}$$

```
> Eigenvalues(L)
```

$$\begin{bmatrix} 1.38573262885364 + 0.\,I \\ -0.583351516086360 + 0.403125877485025\,I \\ -0.583351516086360 - 0.403125877485025\,I \\ -0.119029596680917 + 0.\,I \end{bmatrix} \quad \textbf{(4)}$$

%As shown by the eigenvalues, the largest eigenvalue is ~1.386 which was calculated by GrowthCe

```
> with(LinearAlgebra)
```

[*&x*, *Add*, *Adjoint*, *BackwardSubstitute*, *BandMatrix*, *Basis*, *BezoutMatrix*, *BidiagonalForm*, *BilinearForm*, *CARE*, *CharacteristicMatrix*, *CharacteristicPolynomial*, *Column*, *ColumnDimension*, *ColumnOperation*, *ColumnSpace*, *CompanionMatrix*, *CompressedSparseForm*, *ConditionNumber*, *ConstantMatrix*, *ConstantVector*, *Copy*, *CreatePermutation*, *CrossProduct*, *DARE*, *DeleteColumn*, *DeleteRow*, *Determinant*, *Diagonal*, *DiagonalMatrix*, *Dimension*, *Dimensions*, *DotProduct*, *EigenConditionNumbers*, *Eigenvalues*, *Eigenvectors*, *Equal*, *ForwardSubstitute*, *FrobeniusForm*, *FromCompressedSparseForm*, *FromSplitForm*, *GaussianElimination*, *GenerateEquations*, *GenerateMatrix*, *Generic*, *GetResultDataType*, *GetResultShape*, *GivensRotationMatrix*, *GramSchmidt*, *HankelMatrix*, *HermiteForm*, *HermitianTranspose*, *HessenbergForm*, *HilbertMatrix*, *HouseholderMatrix*, *IdentityMatrix*, *IntersectionBasis*, *IsDefinite*, *IsOrthogonal*, *IsSimilar*, *IsUnitary*, *JordanBlockMatrix*, *JordanForm*, *KroneckerProduct*, *LA_Main*, *LUDecomposition*, *LeastSquares*, *LinearSolve*, *LyapunovSolve*, *Map*, *Map2*, *MatrixAdd*, *MatrixExponential*, *MatrixFunction*, *MatrixInverse*, *MatrixMatrixMultiply*, *MatrixNorm*, *MatrixPower*, *MatrixScalarMultiply*, *MatrixVectorMultiply*, *MinimalPolynomial*, *Minor*, *Modular*, *Multiply*, *NoUserValue*, *Norm*, *Normalize*, *NullSpace*, *OuterProductMatrix*, *Permanent*, *Pivot*, *PopovForm*, *ProjectionMatrix*, *QRDecomposition*, *RandomMatrix*, *RandomVector*, *Rank*, *RationalCanonicalForm*, *ReducedRowEchelonForm*, *Row*, *RowDimension*, *RowOperation*, *RowSpace*, *ScalarMatrix*, *ScalarMultiply*, *ScalarVector*, *SchurForm*, *SingularValues*, *SmithForm*, *SplitForm*, **(5)**

StronglyConnectedBlocks, *SubMatrix*, *SubVector*, *SumBasis*, *SylvesterMatrix*, *SylvesterSolve*, *ToeplitzMatrix*, *Trace*, *Transpose*, *TridiagonalForm*, *UnitVector*, *VandermondeMatrix*, *VectorAdd*, *VectorAngle*, *VectorMatrixMultiply*, *VectorNorm*, *VectorScalarMultiply*, *ZeroMatrix*, *ZeroVector*, *Zip*]

> $P := Matrix\left(\left[\left[0.5, \frac{(1-0.5)}{3}, \frac{(1-0.5)}{3}, \frac{(1-0.5)}{3}\right], \left[\frac{(1-0.4)}{3}, 0.4, \frac{(1-0.4)}{3}, \frac{(1-0.4)}{3}\right], \left[\frac{(1-0.3)}{3}, \frac{(1-0.3)}{3}, 0.3, \frac{(1-0.3)}{3}\right], \left[\frac{(1-0.2)}{3}, \frac{(1-0.2)}{3}, \frac{(1-0.2)}{3}, 0.2\right]\right]\right)$

$$P := \begin{bmatrix} 0.5 & 0.1666666667 & 0.1666666667 & 0.1666666667 \\ 0.2000000000 & 0.4 & 0.2000000000 & 0.2000000000 \\ 0.2333333333 & 0.2333333333 & 0.3 & 0.2333333333 \\ 0.2666666667 & 0.2666666667 & 0.2666666667 & 0.2 \end{bmatrix} \quad (6)$$

> $P2 := MatrixPower(P, 1000)$

$$P2 := \quad (7)$$

[[0.315197007189532, 0.262664172672962, 0.225140719443162, 0.196998129500332],
[0.315197007144515, 0.262664172635447, 0.225140719411007, 0.196998129472196],
[0.315197007112359, 0.262664172608651, 0.225140719388038, 0.196998129452099],
[0.315197007176892, 0.262664172662428, 0.225140719434133, 0.196998129492432]]

> $ArrayTools:-AddAlongDimension(P2, 2)$

$$\begin{bmatrix} 1.00000002880599 \\ 1.00000002866316 \\ 1.00000002856115 \\ 1.00000002876589 \end{bmatrix} \quad (8)$$

%Rows are all identical

> $ArrayTools:-AddAlongDimension(P, 1)$

$$\begin{bmatrix} 1.200000000 & 1.066666667 & 0.9333333334 & 0.8000000000 \end{bmatrix} \quad (9)$$

> $ArrayTools:-AddAlongDimension(P2, 1)$

$$\begin{bmatrix} 1.26078802862330 & 1.05065669057949 & 0.900562877676340 & 0.787992517917059 \end{bmatrix} \quad (10)$$

%Summing the columns will give us the fraction of the surfers that stay on each of the above web-sites. By decreasing popularity, the websites are ranked in the following order (S1 > S2 > S3> S4).

>