LECCION 9 - SOLUCION ECUACIONES

In[1]:=
```
Off[General::"spell1"]
Off[General::"spell"]
```

01 - FACTORIZACION DE UNA SKYMATRIZ SIMETRICA

In[3]:=
```
SymmSkyMatrixFactor[S_, tol_] := Module[{p, a, fail, i, j, k, l, m, n, ii, ij, jj, jk, jmj, d, s, row, v},
   row = SymmSkyMatrixRowLengths[S]; s = Max[row]; {p, a} = S; n = Length[p] - 1; v = Table[0, {n}]; fail = 0;
   Do[jj = p[[j + 1]]; If[jj < 0 | row[[j]] == 0, Continue[]]; d = a[[jj]]; jmj = Abs[p[[j]]]; jk = jj - jmj;
    Do[i = j - jk + k; v[[k]] = 0; ii = p[[i + 1]]; If[ii < 0, Continue[]]; m = Min[ii - Abs[p[[i]]], k] - 1;
     ij = jmj + k; v[[k]] = a[[ij]]; v[[k]] -= Take[a, {ii - m, ii - 1}].Take[v, {k - m, k - 1}];
     a[[ij]] = v[[k]] * a[[ii]], {k, 1, jk - 1}]; d -= Take[a, {jmj + 1, jmj + jk - 1}].Take[v, {1, jk - 1}];
    If[Abs[d] < tol * row[[j]], fail = j; a[[jj]] = Infinity; Break[]];
    a[[jj]] = 1 / d, {j, 1, n}]; Return[{{p, a}, fail}]];
```

In[4]:=
```
SymmSkyMatrixRowLengths[S_] := Module[{p, a, i, j, n, ii, jj, m, d, row}, {p, a} = S;
   n = Length[p] - 1; row = Table[0, {n}]; Do[ii = p[[i + 1]]; If[ii < 0, Continue[]]; m = ii - i;
    row[[i]] = a[[ii]]^2; Do[If[p[[j + 1]] > 0, d = a[[m + j]]^2; row[[i]] += d; row[[j]] += d],
     {j, Max[1, Abs[p[[i]]] - m + 1], Min[n, i] - 1}], {i, 1, n}]; Return[Sqrt[row]];];
```

02a - SOLUCION DEL SISTEMA DE ECUACIONES A PARTIR DE LA SKYMATRIZ FACTORIZADA Y DEL VECTOR DE TERMINOS INDEPENDIENTES

In[5]:=
```
SymmSkyMatrixVectorSolve[S_, b_] := Module[{p, a, n, i, j, k, m, ii, jj, bi, x}, {p, a} = S; n = Length[p] - 1;
   x = b; If[n ≠ Length[x], Print["Inconsistentmatrixdimensionsin", "SymmSkyMatrixVectorSolve"];
    Return[Null]]; Do[ii = p[[i + 1]]; If[ii ≥ 0, Continue[]]; ii = -ii;
    k = i - ii + Abs[p[[i]]] + 1; bi = x[[i]]; If[bi == 0, Continue[]];
    Do[jj = p[[j + 1]], If[jj < 0, Continue[]]; m = j - i; If[m < 0, x[[j]] -= a[[ii + m]] * bi; Break[]];
     ij = jj - m; If[ij > Abs[p[[j]]], x[[j]] -= a[[ij]] * bi], {j, k, n}], {i, 1, n}];
   Do[ii = p[[i + 1]]; If[ii < 0, x[[i]] = 0; Continue[]]; imi = Abs[p[[i]]]; m = ii - imi - 1;
    x[[i]] -= Take[a, {imi + 1, imi + m}].Take[x, {i - m, i - 1}], {i, 1, n}];
   Do[ii = Abs[p[[i + 1]]]; x[[i]] *= a[[ii]], {i, 1, n}];
   Do[ii = p[[i + 1]]; If[ii < 0, x[[i]] = b[[i]]; Continue[]]; m = ii - Abs[p[[i]]] - 1;
    Do[x[[i - j]] -= a[[ii - j]] * x[[i]], {j, 1, m}], {i, n, 1, -1}]; Return[x]];
```

02b -SOLUCION PARA TODOS LOS VECTORES DE CARGA CORRESPONDIENTES A LOS DIFERENTES CASOS DE CARGA

In[6]:=
```
SymmSkyMatrixColBlockSolve[S_, b_] :=
  Module[{p, a, n, nrhs, i, j, k, m, r, ii, jj, bi, x}, {p, a} = S; n = Length[p] - 1; x = b;
   If[n ≠ Dimensions[x][[1]], Print["Inconsistentmatrixdimensionsin", "SymmSkyMatrixBlockColSolve"];
    Return[Null]]; nrhs = Dimensions[x][[2]]; Do[ii = p[[i + 1]]; If[ii ≥ 0, Continue[]];
    ii = -ii; k = i - ii + Abs[p[[i]]] + 1; Do[bi = x[[i, r]]; If[bi == 0, Continue[]];
     Do[jj = p[[j + 1]], If[jj < 0, Continue[]]; m = j - i; If[m < 0, x[[j, r]] -= a[[ii + m]] * bi; Break[]];
      ij = jj - m; If[ij > Abs[p[[j]]], x[[j, r]] -= a[[ij]] * bi], {j, k, n}], {r, 1, nrhs}], {i, 1, n}];
   Do[ii = p[[i + 1]]; If[ii < 0, Do[x[[i, r]] = 0, {r, 1, nrhs}]; Continue[]];
    imi = Abs[p[[i]]]; m = ii - imi - 1;
    Do[Do[x[[i, r]] -= a[[imi + j]] * x[[i - m + j - 1, r]], {j, 1, m}], {r, 1, nrhs}], {i, 1, n}];
   Do[ii = Abs[p[[i + 1]]]; Do[x[[i, r]] *= a[[ii]], {r, 1, nrhs}], {i, 1, n}]; Do[ii = p[[i + 1]];
    If[ii < 0, Do[x[[i, r]] = b[[i, r]], {r, 1, nrhs}]; Continue[]]; m = ii - Abs[p[[i]]] - 1;
    Do[Do[x[[i - j, r]] -= a[[ii - j]] * x[[i, r]], {j, 1, m}], {r, 1, nrhs}], {i, n, 1, -1}]; Return[x]];
```

In[7]:=
```
SymmSkyMatrixRowBlockSolve[S_, b_] :=
  Module[{p, a, n, nrhs, i, j, k, m, r, ii, jj, bi, x}, {p, a} = S; n = Length[p] - 1; x = b;
   If[n ≠ Dimensions[x][[2]], Print["Inconsistentmatrixdimensionsin", "SymmSkyMatrixBlockRowSolve"];
    Return[Null]]; nrhs = Dimensions[x][[1]]; Do[ii = p[[i + 1]]; If[ii ≥ 0, Continue[]];
    ii = -ii; k = i - ii + Abs[p[[i]]] + 1; Do[bi = x[[r, i]]; If[bi == 0, Continue[]];
     Do[jj = p[[j + 1]], If[jj < 0, Continue[]]; m = j - i; If[m < 0, x[[j, r]] -= a[[ii + m]] * bi; Break[]];
      ij = jj - m; If[ij > Abs[p[[j]]], x[[r, j]] -= a[[ij]] * bi], {j, k, n}], {r, 1, nrhs}], {i, 1, n}];
   Do[ii = p[[i + 1]]; If[ii < 0, Do[x[[r, i]] = 0, {r, 1, nrhs}]; Continue[]];
    imi = Abs[p[[i]]]; m = ii - imi - 1;
    Do[Do[x[[r, i]] -= a[[imi + j]] * x[[r, i - m + j - 1]], {j, 1, m}], {r, 1, nrhs}], {i, 1, n}];
   Do[ii = Abs[p[[i + 1]]]; Do[x[[r, i]] *= a[[ii]], {r, 1, nrhs}], {i, 1, n}]; Do[ii = p[[i + 1]];
    If[ii < 0, Do[x[[r, i]] = b[[r, i]], {r, 1, nrhs}]; Continue[]]; m = ii - Abs[p[[i]]] - 1;
    Do[Do[x[[r, i - j]] -= a[[ii - j]] * x[[r, i]], {j, 1, m}], {r, 1, nrhs}], {i, n, 1, -1}]; Return[x]];
```

03a - MULTIPLICCION DE UNA SKYMATRIZ POR VECTOR DESPLAZAMIENTOS NODALES PARA OBTENCION FUERZAS NODALES RESULTANTES

In[8]:=
```
SymmSkyMatrixVectorMultiply[S_, x_] :=
  Module[{p, a, n, i, j, k, m, ii, b}, {p, a} = S; n = Length[p] - 1; If[n ≠ Length[x],
    Print["Inconsistentmatrixdimensionsin", "SymmSkyMatrixVectorMultiply"]; Return[Null]];
   b = Table[a[[Abs[p[[i + 1]]]]] * x[[i]], {i, 1, n}]; Do[ii = Abs[p[[i + 1]]]; m = ii - Abs[p[[i]]] - 1;
    If[m ≤ 0, Continue[]]; b[[i]] += Take[a, {ii - m, ii - 1}].Take[x, {i - m, i - 1}];
    Do[b[[i - k]] += a[[ii - k]] * x[[i]], {k, 1, m}], {i, 1, n}]; Return[b]];
```

03b - MULTIPLICACION DE UNA SKYMATRIZ POR SOLUCIONES VECTORES DESPLAZAMIENTOS PARA VARIOS CASOS DE CARGA - OBTENCION VECTORES FUERZAS NODALES RESULTANTES.

In[9]:=
```
SymmSkyMatrixColBlockMultiply[S_, x_] :=
  Module[{p, a, n, nrhs, i, j, k, m, r, ii, aij, b}, {p, a} = S; n = Length[p] - 1; If[n ≠ Dimensions[x][[1]],
    Print["Inconsistentmatrixdimensionsin", "SymmSkyMatrixColBlockMultiply"]; Return[Null]];
   nrhs = Dimensions[x][[2]]; b = Table[0, {n}, {nrhs}];
   Do[ii = Abs[p[[i + 1]]]; m = ii - Abs[p[[i]]] - 1; Do[b[[i, r]] = a[[ii]] * x[[i, r]], {r, 1, nrhs}];
    Do[j = i - k; aij = a[[ii - k]]; If[aij == 0, Continue[]]; Do[b[[i, r]] += aij * x[[j, r]];
     b[[j, r]] += aij * x[[i, r]], {r, 1, nrhs}], {k, 1, m}], {i, 1, n}]; Return[b]];
```

In[10]:=
```
SymmSkyMatrixRowBlockMultiply[S_, x_] :=
  Module[{p, a, n, nrhs, i, j, k, m, r, ii, aij, b}, {p, a} = S; n = Length[p] - 1; If[n ≠ Dimensions[x][[2]],
    Print["Inconsistentmatrixdimensionsin", "SymmSkyMatrixRowBlockMultiply"]; Return[Null]];
   nrhs = Dimensions[x][[1]]; b = Table[0, {nrhs}, {n}];
   Do[ii = Abs[p[[i + 1]]]; m = ii - Abs[p[[i]]] - 1; Do[b[[r, i]] = a[[ii]] * x[[r, i]], {r, 1, nrhs}];
    Do[j = i - k; aij = a[[ii - k]]; If[aij == 0, Continue[]]; Do[b[[r, i]] += aij * x[[r, j]];
     b[[r, j]] += aij * x[[r, i]], {r, 1, nrhs}], {k, 1, m}], {i, 1, n}]; Return[b]];
```

04 - VISUALIZACION DE SKYMATRICES

In[11]:=
```
SymmSkyMatrixLowerTrianglePrint[S_] :=
  Module[{p, a, cycle, i, ii, ij, it, j, jj, j1, j2, jref, jbeg, jend, jt, kcmax, kc, kr, m, n, c, t},
   {p, a} = S; n = Dimensions[p][[1]] - 1; kcmax = 5; jref = 0; Label[cycle];
   Print[""]; jbeg = jref + 1; jend = Min[jref + kcmax, n]; kc = jend - jref;
   t = Table["", {n - jref + 1}, {kc + 1}]; Do[If[p[[j + 1]] > 0, c = "", c = "*"];
    t[[1, j - jref + 1]] = StringJoin[c, "Col", ToString[PaddedForm[j, 3]]], {j, jbeg, jend}];
   it = 1; Do[ii = Abs[p[[i + 1]]]; m = ii - Abs[p[[i]]] - 1; j1 = Max[i - m, jbeg]; j2 = Min[i, jend];
    kr = j2 - j1 + 1; If[kr ≤ 0, Continue[]]; If[p[[i + 1]] > 0, c = "", c = "*"]; it++;
    t[[it, 1]] = StringJoin[c, "Row", ToString[PaddedForm[i, 3]]]; jt = j1 - jbeg + 2; ij = j1 + ii - i;
    Do[t[[it, jt++]] = PaddedForm[a[[ij++]] // FortranForm, {7, 4}], {j, 1, kr}], {i, jbeg, n}];
   Print[TableForm[Take[t, it], TableAlignments → {Right, Right}, TableDirections → {Column, Row},
     TableSpacing → {0, 2}]]; jref = jend; If[jref < n, Goto[cycle]];];
```

In[12]:=
```
SymmSkyMatrixUpperTrianglePrint[S_] :=
  Module[{p, a, cycle, i, ij, it, j, j1, j2, jref, jbeg, jend, kcmax, k, kc, m, n, c, t},
   {p, a} = S; n = Dimensions[p][[1]] - 1; kcmax = 5; jref = 0; Label[cycle];
   Print[""]; jbeg = jref + 1; jend = Min[jref + kcmax, n]; kc = jend - jref;
   t = Table["", {jend + 1}, {kc + 1}]; Do[If[p[[j + 1]] > 0, c = "", c = "*"];
    t[[1, j - jref + 1]] = StringJoin[c, "Col", ToString[PaddedForm[j, 3]]], {j, jbeg, jend}];
   it = 1; Do[it++; If[p[[i + 1]] > 0, c = "", c = "*"];
    t[[it, 1]] = StringJoin[c, "Row", ToString[PaddedForm[i, 3]]]; j = jref;
    Do[j++; If[j < i, Continue[]]; ij = Abs[p[[j + 1]]] + i - j; If[ij ≤ Abs[p[[j]]], Continue[]];
     t[[it, k + 1]] = PaddedForm[a[[ij]] // FortranForm, {7, 4}], {k, 1, kc}], {i, 1, jend}];
   Print[TableForm[Take[t, it], TableAlignments → {Right, Right}, TableDirections → {Column, Row},
     TableSpacing → {0, 2}]]; jref = jend; If[jref < n, Goto[cycle]];];
```

05 - VISUALIZACION TERMINOS NO NULOS DE SKYMATRICES - TERMINOS A ALMACENAR EN VECTOR S

In[13]:=
```
SymmSkyMatrixLowerTriangleMap[S_] :=
  Module[{p, a, cycle, i, ii, ij, it, itop, j, jj, j1, j2, jref, jbeg, jend, jt, kcmax, kc, kr, m, n, c, t},
   {p, a} = S; n = Dimensions[p][[1]] - 1; kcmax = 40; jref = 0; Label[cycle]; Print[""]; jbeg = jref + 1;
   jend = Min[jref + kcmax, n]; kc = jend - jref; itop = 2; If[jend > 9, itop = 3]; If[jend > 99, itop = 4];
   If[jend > 999, itop = 5]; t = Table["", {n - jref + itop}, {kc + 1}]; it = 0; If[itop ≥ 5, it++;
    Do[m = Floor[j / 1000]; If[m > 0, t[[it, j - jref + 1]] = ToString[Mod[m, 10]]], {j, jbeg, jend}]];
   If[itop ≥ 4, it++; Do[m = Floor[j / 100]; If[m > 0, t[[it, j - jref + 1]] = ToString[Mod[m, 10]]],
     {j, jbeg, jend}]]; If[itop ≥ 3, it++;
    Do[m = Floor[j / 10]; If[m > 0, t[[it, j - jref + 1]] = ToString[Mod[m, 10]]], {j, jbeg, jend}]];
   it++; Do[t[[it, j - jref + 1]] = ToString[Mod[j, 10]], {j, jbeg, jend}]; it++;
   Do[If[p[[j + 1]] < 0, t[[it, j - jref + 1]] = "*"], {j, jbeg, jend}];
   Do[ii = Abs[p[[i + 1]]]; m = ii - Abs[p[[i]]] - 1; j1 = Max[i - m, jbeg]; j2 = Min[i, jend];
    kr = j2 - j1 + 1; If[kr ≤ 0, Continue[]]; If[p[[i + 1]] > 0, c = "", c = "*"]; it++;
    t[[it, 1]] = StringJoin[ToString[PaddedForm[i, 2]], c]; jt = j1 - jbeg + 2; ij = j1 + ii - i;
    Do[c = "0"; If[a[[ij]] > 0, c = "+"]; If[a[[ij++]] < 0, c = "-"]; t[[it, jt++]] = c, {j, 1, kr}],
    {i, jbeg, n}]; Print[TableForm[Take[t, it], TableAlignments → {Right, Right},
     TableDirections → {Column, Row}, TableSpacing → {0, 0}]]; jref = jend; If[jref < n, Goto[cycle]];];
```

In[14]:=
```
SymmSkyMatrixUpperTriangleMap[S_] :=
  Module[{p, a, cycle, i, ij, it, itop, j, j1, j2, jref, jbeg, jend, kcmax, k, kc, m, n, c, t},
   {p, a} = S; n = Dimensions[p][[1]] - 1; kcmax = 40; jref = 0; Label[cycle]; Print[""]; jbeg = jref + 1;
   jend = Min[jref + kcmax, n]; kc = jend - jref; itop = 2; If[jend > 9, itop = 3]; If[jend > 99, itop = 4];
   If[jend > 999, itop = 5]; t = Table["", {jend + itop}, {kc + 1}]; it = 0; If[itop ≥ 5, it++;
    Do[m = Floor[j / 1000]; If[m > 0, t[[it, j - jref + 1]] = ToString[Mod[m, 10]]], {j, jbeg, jend}]];
   If[itop ≥ 4, it++; Do[m = Floor[j / 100]; If[m > 0, t[[it, j - jref + 1]] = ToString[Mod[m, 10]]],
     {j, jbeg, jend}]]; If[itop ≥ 3, it++;
    Do[m = Floor[j / 10]; If[m > 0, t[[it, j - jref + 1]] = ToString[Mod[m, 10]]], {j, jbeg, jend}]];
   it++; Do[t[[it, j - jref + 1]] = ToString[Mod[j, 10]], {j, jbeg, jend}]; it++;
   Do[If[p[[j + 1]] < 0, t[[it, j - jref + 1]] = "*"], {j, jbeg, jend}];
   Do[it++; If[p[[i + 1]] > 0, c = "", c = "*"]; t[[it, 1]] = StringJoin[ToString[PaddedForm[i, 2]], c];
    j = jref; Do[j++; If[j < i, Continue[]]; ij = Abs[p[[j + 1]]] + i - j; If[ij ≤ Abs[p[[j]]], Continue[]];
     c = "0"; If[a[[ij]] > 0, c = "+"]; If[a[[ij++]] < 0, c = "-"]; t[[it, k + 1]] = c, {k, 1, kc}],
    {i, 1, jend}]; Print[TableForm[Take[t, it], TableAlignments → {Right, Right},
     TableDirections → {Column, Row}, TableSpacing → {0, 0}]]; jref = jend; If[jref < n, Goto[cycle]];];
```

06 - RECONSTRUCCION DE SKYMATRICES A PARTIR DE FACTORES

In[15]:=
```
SymmSkyMatrixLDUReconstruct[S_] :=
  Module[{p, ldu, a, v, n, i, ii, ij, j, jj, jk, jmj, k, m}, {p, ldu} = S; a = ldu; n = Length[p] - 1;
   v = Table[0, {n}]; Do[jmj = Abs[p[[j]]]; jj = p[[j + 1]]; If[jj < 0, Continue[]]; jk = jj - jmj;
    v[[jk]] = ldu[[jj]]; Do[ij = jmj + k; i = j + ij - jj; ii = p[[i + 1]]; If[ii < 0, v[[k]] = 0; Continue[]];
     If[i ≠ j, v[[k]] = ldu[[ij]] * ldu[[ii]]]; m = Min[ii - Abs[p[[i]]], k]; a[[ij]] = v[[k]]; a[[ij]] +=
      Take[ldu, {ii - m + 1, ii - 1}].Take[v, {k - m + 1, k - 1}], {k, 1, jk}], {j, 1, n}]; Return[{p, a}];];
```

In[16]:=
```
SymmSkyMatrixLDinvUReconstruct[S_] :=
  Module[{p, ldu, a, v, n, i, ii, ij, j, jj, jk, jmj, k, m}, {p, ldu} = S; a = ldu; n = Length[p] - 1;
   v = Table[0, {n}]; Do[jmj = Abs[p[[j]]]; jj = p[[j + 1]]; If[jj < 0, Continue[]]; jk = jj - jmj;
    v[[jk]] = 1 / ldu[[jj]]; Do[ij = jmj + k; i = j + ij - jj; ii = p[[i + 1]]; If[ii < 0, v[[k]] = 0; Continue[]];
     If[i ≠ j, v[[k]] = ldu[[ij]] / ldu[[ii]]]; m = Min[ii - Abs[p[[i]]], k]; a[[ij]] = v[[k]]; a[[ij]] +=
      Take[ldu, {ii - m + 1, ii - 1}].Take[v, {k - m + 1, k - 1}], {k, 1, jk}], {j, 1, n}]; Return[{p, a}];];
```

07 - UTILIDADES ADICIONALES

In[17]:=
```
SymmSkyMatrixConvertToFull[S_] := Module[{p, a, aa, n, j, jj, jmj, k}, {p, a} = S; n = Length[p] - 1;
   aa = Table[0, {n}, {n}]; Do[jmj = Abs[p[[j]]]; jj = Abs[p[[j + 1]]]; aa[[j, j]] = a[[jj]];
    Do[aa[[j, j - k]] = aa[[j - k, j]] = a[[jj - k]], {k, 1, jj - jmj - 1}], {j, 1, n}]; Return[aa];];
```

In[18]:=
```
SymmSkyMatrixConvertUnitUpperTriangleToFull[S_] := Module[{p, ldu, aa, n, j, jj, jmj, k}, {p, ldu} = S;
   n = Length[p] - 1; aa = Table[0, {n}, {n}]; Do[jmj = Abs[p[[j]]]; jj = Abs[p[[j + 1]]];
    aa[[j, j]] = 1; Do[aa[[j - k, j]] = ldu[[jj - k]], {k, 1, jj - jmj - 1}], {j, 1, n}]; Return[aa];];
```

In[19]:=
```
SymmSkyMatrixConvertDiagonalToFull[S_] :=
  Module[{p, ldu, aa, n, i, j, jj, jmj, k}, {p, ldu} = S; n = Length[p] - 1; aa = Table[0, {n}, {n}];
   Do[jj = Abs[p[[j + 1]]]; aa[[j, j]] = ldu[[jj]], {j, 1, n}]; Return[aa];];
```