DSM Solver - Benchmark Problem - Comprehensive

In this run, an arbitary structure is create to compare the result with the commercial software.

```
clear all
```

Definition of the Problem

Define ***Unit***

```
% { Force_Unit, Length_Unit }
Unit = {'kip', 'ft'}
```

```
Unit = 1×2 cell
'kip'       'ft'
```

Define ***Table of Node***

```
% i th Row = i th Node
% Row = [ X_Coordinate, Y_Coordinate ]
Node_Table =   [0   0;
                10  0;
                20  0;
                30  0;
                40  0;
                0   6;
                10  6;
                20  6;
                30  6];
```

Define ***Table of Element***

```
% i th Row = i th Element
% Row = [ Property_Type, Begin_Node_ID, End_Node_ID, Begin_Hinge?, End_Hinge? ]
Element_Table =    [1   1   6   0   0;
                    1   2   7   0   0;
                    1   3   8   0   0;
                    1   4   9   0   0;
                    1   5   9   0   0;
                    1   6   7   0   1;
                    1   7   8   0   0;
                    1   8   9   0   0;
                    1   7   3   1   0];
```

Define ***Property of Element***

```
% i th Row = i th Property
% Row = [ E, A, I ]
Element_Property = [29000*144 3.54/144 53.8/144^2];
```

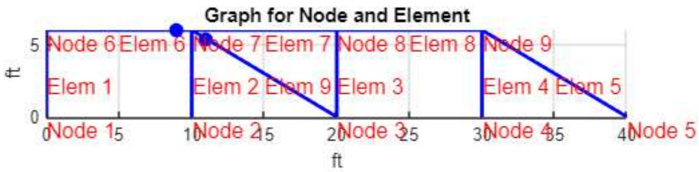
Review ***Initial Graph***

Element Hinge is shown as a Solid Blue Circle on the End of the Member

```
% Size Parameter for Font, Marksize, and Line Width
Size_Parameter = 240
```

```
Size_Parameter = 240
```

```
% Plot Initial Graph
Graph_Initial(Node_Table, Element_Table, Unit, Size_Parameter)
```



Define ***Eccentrial Boundary Condition on Node***

Support arbitary direction (not necessary along the direction of global axis).

One definition per node only, the program will use the last definition if there is multiple boundary condition on the same node.

```
% i th Row = i th Eccential_Boundary_Condition
% [ Node_ID, Restriction_on_Translation_x, Restriction_on_Translation_y, Restriction_on_Rotation_on_z, Angle(deg) ]
Boundary_H =   [1   1   1   1   0;
                2   1   1   1   0;
                3   1   1   0   0;
                4   1   1   0   0;
                5   1   1   1   0];
```

Define ***Natural Boundary Condition on Node***

One definition per node only, the program will use the last definition if there is multiple boundary conditions on the same node.

```
% i th Row = i th Natural_Boundary_Condition
% Row = [ Node_ID, F_X, F_Y, M_Z ]
Boundary_Q =    [6  50  0   0];
```

Define ***Natural Boundary Condtion on Element***

Support multiple boundary conditions on the same element.

*Please see the **Element_Load_Type_Table** for the instruction.*

```
% i th Row = i th Natural_Boundary_Condition
% Row = [ Element_ID, Load_Parameter_1, Load_Parameter_2, Length_Ratio_Parameter_1, Ratio_Parameter_2 ]
Element_Q =    [6   1   40  0   0.2     0.8;
                7   1   20  0   0.5     0.5;
                7   3   10  0   0       0;
                9   3   20  0   0       0;
                8   4   -5  12  0.2     0.3];
```

Define ***Support Movement***

*Will only be effective only if the associate **Eccentrail Boundary Condition** has been defined.*

One definition per node only, the program will use the last definition if there is multiple boundary conditions on the same node.

```
% i th Row = i th Boundary_Movement
% Row = [ Node_ID, U_X, U_Y, Theta_Z ]
Boundary_Movement =     [];
```

Review ***Completed Graph***

RED Square and H** on Node indicate the **Eccential Boundary Condition on Node

Magenta Star and Q** on Node indicate the **Natural Boundary Condition on Node (if defined)

Magenta EQ** on Element indicate the **Natural Boundary Condition on Element

Green Pentagram and U** on Node indicate the **Support Movement on Node

BLUE Solid Circle** on Element indicate **Hinge on Element end

BLUE Hollow Circle** on Node indicate **Global Hinge on Node

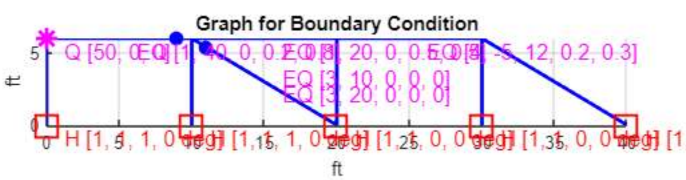
```
% Check Global Hinge
```

```
Global_Hinge = Global_Hinge_Check(Node_Table, Element_Table)
```

```
Global_Hinge = 9×1 logical array
   0
   0
   0
   0
   0
   0
   0
   0
   0
```

```
% Plot Completed Graph
Graph_Boundary(Node_Table, Element_Table, Unit, Global_Hinge, Size_Parameter, Boundary_H, Boundary_Q, Element_Q, Boundary_Movement)
```

```
Discription =
    'RED Square and H on Node indicate the eccential boundary condition on node
     Magenta Star and Q on Node indicate the natural boundary condition on node (if defined)
     Magenta EQ on Element indicate the natural boundary condition on element
     Green Pentagram and U on Node indicate the boundary movement on node
     BLUE Solid Circle on Element indicate hinge on element end
     BLUE Hollow Circle on Node indicate global hinge on node'
```



Solution of the Problem

```
% Assemble Global Stiffness Matrix
K_global = Global_Stiffness_Matrix(Node_Table, Element_Table, Element_Property);

% Evaluate Global Force Vector from Element Load
F_E = Global_Force_Vector(Node_Table, Element_Table, Element_Q);

% Evaluate Global Force Vector from Node Load & Support Movement
[F_Q, F_H] = Global_Boundary_Force_Vector(K_global, Boundary_Q, Boundary_Movement);

% Assemble Special Structural Stiffness Matrix with the Consideration of Arbitary Support Direction
[K_structural_special, F_structural_special, TK_global, Boundary_Restriction_List, Global_Hinge_List] = Boundary_Process(K_global, F_E, F_

% Compute Structural Displacement on Special Space
U_structural_special = K_structural_special\F_structural_special;
```

Stability Check

Please note that a solution can exist if within the eigen space even if the structure is unstable

```
% Check the Stability of the Problem
Stability = Stability_Check(K_structural_special)
```

```
Stability = 'Structure is stable'
```

Result of the Problem

```
% Recover Global Displacement
U_global = Global_Displacement(U_structural_special, TK_global, Boundary_Restriction_List, Global_Hinge_List, Boundary_Movement)
```

```
U_global = 27×1
```

```
        0
        0
        0
        0
        0
        0
        0
        0
   0.0358
        0
```

```
% Compute Global Support Reaction
F_R = Global_Boundary_Reaction(K_global, U_global, F_E, F_Q, Boundary_Restriction_List)
```

```
F_R = 27×1
   10.1209
   36.0805
  -19.9208
   18.0957
  141.3863
  -39.3954
   14.0333
  188.7101
         0
   -1.6192
```

Element Force Diagram

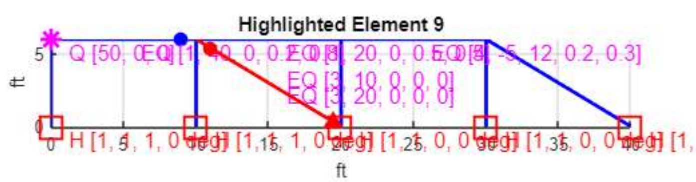
Triangle** indicates **the Direction (End) of the the Member

```
% Define Element_ID the User want to read
Element_ID = 9
```

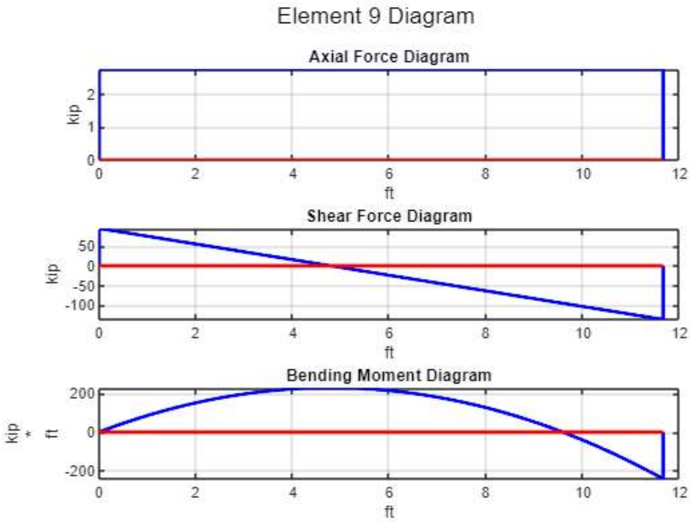
```
Element_ID = 9
```

```
% Highlight the Element on the Structure
Graph_Highlight_Element(Element_ID, Node_Table, Element_Table, Unit, Global_Hinge, Size_Parameter, Boundary_H, Boundary_Q, Element_Q, Bour
```

```
Discription = 
    'RED Square and H on Node indicate the eccential boundary condition on node
     Magenta Star and Q on Node indicate the natural boundary condition on node (if defined)
     Magenta EQ on Element indicate the natural boundary condition on element
     Green Pentagram and U on Node indicate the boundary movement on node
     BLUE Solid Circle on Element indicate hinge on element end
     BLUE Hollow Circle on Node indicate global hinge on node'
Discription = 'Triangle indicates the end of the member'
```




```
% Obtain Element Force Diagram
Element_Force_Diagram(Element_ID, Unit, U_global, Node_Table, Element_Table, Element_Property, Element_Q, 3)
```




```
ans = 'Local Force at Element End'
ans = 'Element Force at Node 7'
Fx = 2.7542
Fy = 95.8289
Mz = 0
ans = 'Element Force at Node 3'
Fx = 2.7542
Fy = -137.4092
Mz = -242.4529
```