Program MESHGEN

Program MESHGEN is an automatic mesh generator which uses quadrilaterals with parabolic sides. These quadrilaterals may be joined together in any specified manner. The figures on the following pages illustrate how the program works. Figure 1 shows a complete finite element mesh composed of 6-nodded triangular elements. Figure 2 shows an exploded view illustrating the four loops used in this discretization. Figure 3 defines the loop numbers and their side numbers used by MESHGEN. The loop numbering is arbitrary as is the numbering of each side of a loop provided it is done counterclockwise. Also shown on in Figure 3 are the eight points describing the sides of each loop. The three points along any side are used to define the parabolic curve in the x-y plane used for the side. Hence, even though the seven points along sides 1, 2, and 3 of loop 1 all lie in a circle, the actual boundary is made up of three parabolas joined at the corner points (dark circles).

Although three of the 4 sides of loops 2, 3, and 4 are straight lines, the side coordinate points (open circles) do not necessarily fall at the center of these sides. Notice that they have been moved toward loop 1 and as a consequence the elements shown in the Figure 1 have likewise been moved toward loop 1. As you gain experience in using MESHGEN you will find that it has the versatility needed to generate a wide variety of meshes. When it cannot be made to produce exactly a desired configuration (for example, nodal points on the boundary of loop 1 not lying in a prefect circle), the user may use MESHGEN to obtain a mesh very close to that which is desired, and then manually adjust whatever data are necessary to achieve the geometry required.

It should be noted that when two loops are joined, the common sides must have the same number of divisions (hence nodal points). As shown in Figure 2, side 1 of loop 3 is joined to side 2 of loop 2 in the previous example. Note that each of these sides has 5 divisions.

The numbering of the elements and nodal points begins in the first loop and continues through the last loop. For any given loop the node numbering represents the addition to the last nodal point number and element number assigned by the previous loop. The diagonal defines the element in each square is chosen to be the shortest of the two distances after mapping to the x-y plane. In the case where a series of rectangular elements are created with equal diagonals, MESHGEN will alternate the direction of the diagonal from one element to the next.

One final note before the input file to MESHGEN is described. The order in which the nodal points are numbered is critical since it determines the band width of the "stiffness" matrix. Program MESHGEN can produce a very undesirable node point numbering. When this happens, a new numbering can be developed through the subroutine ORDER. Use of this subroutine will be described in the next section.



Figure 1. Example of a completed mesh generated by MESHGEN



Figure 2. Exploded view showing the four loops used in MESHGEN



Figure 3. Example of a loop and side numbering scheme

The following is an example of nodal point and element numbers designated by MESHGEN for a typical loop. If this is not the first loop then these numbers will start where the previous nodal point and element numbers left off. Subroutine ORDER will change the nodal point numbers if IRDER = 1, but will keep the same element numbers. The printed output will designate the numbering scheme above as the old node point number and those assigned by ORDER as the new node point numbers.

MESHGEN Input

The following is the format of the input file read by MESHGEN

Variables

NNPE, NUMLPS

NDIV(I,1),NDIV(I,2) ((JOIN(I,J,K),K+1,2),J=1,8) (XCOR(I,J),YCOR(I,J),J=1,8)

* One set of data is required for each loop

NNPE = number of nodes per element (must be either 3 or 6)
NUMLPS = number of loops
NDIV(I,1), NDIV(I,2) = the number of divisions on sides 1 and 2 of loop I
JOIN(I,J,K) = loop I, side J is joined to loop JOIN(I,J,1) side JOIN(I,J,2)
XCOR(I,J), YCOR(I,J) = the x and y coordinates of loop I's control points

The following is the input file read by MESHGEN for the example problem shown in Figures 1-3.

$\begin{array}{cccccccccccccccccccccccccccccccccccc$	NNPE, NUMLPS NDIV(I,1), NDIV(I,2) JOIN(I,J,K) XCOR(I,J),YCOR(I,J) Loop 1
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$\begin{array}{r} & 4 \\ 0 & 0 \\ 0.000 \\ 1.200 \\ 3.000 \\ 1.180 \\ 0.400 \\ 0.200 \\ 0.000 \\ 0.000 \end{array}$	$5 \\ 0 & 0 \\ -2.500 \\ -2.500 \\ -2.500 \\ -0.960 \\ -0.300 \\ -0.458 \\ -0.500 \\ -1.200 $	1	1	0	0	Loop 2
$\begin{array}{c} & 5 \\ & 2 \\ & 2 \\ & 0.400 \\ & 1.180 \\ & 3.000 \\ & 3.000 \\ & 3.000 \\ & 1.180 \\ & 0.400 \\ & 0.500 \end{array}$	$ \begin{array}{r} $	0	0	1	2	Loop 3
$\begin{array}{c} & 4 \\ 1 & 3 \\ 0.000 \\ 0.200 \\ 0.400 \\ 1.180 \\ 3.000 \\ 1.200 \\ 0.000 \\ 0.000 \end{array}$	$\begin{array}{c} 5\\ 3 & 3\\ 0.500\\ 0.458\\ 0.300\\ 0.960\\ 2.500\\ 2.500\\ 2.500\\ 2.500\\ 1.200\end{array}$	0	0	0	0	Loop 4

These data are fairly self-explanatory with the possible exception of the JOIN array. Notice that the input data for this array has four groups of two integers each. These four groups correspond to the four sides of the loop under consideration. Thus, for loop 3 the two members of the first group indicate that side 1 is joined to loop 2 side 2. The next two groups being zeros indicate that sides 2 and 3 are not joined to an earlier defined loop. The last group indicates side 4 of this loop is joined to loop 1, side 2.

Inspection of the mesh presented in Figures 1-3 will help clarify this explanation. Notice that the JOIN array for any loop only states how that loop is joined to loops already formed and not to loops which will be formed. Hence the JOIN array for loop 1 is always zeros. Finally, it should be pointed out that the first coordinate listed for a loop must be for a comer point; the following coordinates must be listed counterclockwise; and finally, the first three coordinates specify which side of the loop will be designated number 1. It does not matter what orientation in the x-y plane this first side has, but once it is designated, the other three sides are numbered consecutively in a counterclockwise fashion.