

1 SUMMARY

To **draw on the graph plotter a smooth, tangentially continuous curve** through a given sequence of points $x_i, y_i \quad i=1,2,\dots,n$ where optionally, the directions at each point may be specified. Cusps and closed curves can be drawn if required.

The smooth curve is generated as a sequence of straight line segments. The method is described in S. Marlow and M.J.D. Powell, AERE R.7092 (1972) and is based on a method due to D.J. McConologue.

The user is expected to have initialized graph plotting through the GHOST system and set the scaling before calling the subroutine.

ATTRIBUTES — **Version:** 1.0.0. **Types:** OB11A, OB11B. **Calls:** NB01 and SHVECS (a GHOST subroutine). **Original date:** March 1972. **Origin:** S.Marlow and M.J.D.Powell, Harwell.

2 HOW TO USE THE PACKAGE

2.1 The argument list and calling sequence

If the direction of the curve is given at each data point,

```
CALL OB11A(N,X,Y,CS,SN,DELTA
```

If the direction of the curve at each data point is to be calculated by the subroutine,

```
CALL OB11B(N,X,Y,DELTA
```

N is an INTEGER variable which must be set by the user to the number of data points.

X and **Y** are REAL arrays of length at least n which must be set by the user to the co-ordinates of the data points. If it is required that the curve drawn is closed then set $\{ X(N), Y(N) \} = \{ X(1), Y(1) \}$. If a discontinuity in the slope of the plotted curve is required then the data point should be repeated. For example if $\{ X(I+1), Y(I+1) \} = \{ X(I), Y(I) \}$ then a cusp will occur at this point.

It is desirable that a unit in the x -direction gives the same distance on the graph paper as a unit in the y -direction. This can be achieved by a change of variables. Otherwise the appearance of the curve is liable to be poor.

CS and **SN** are REAL arrays of length at least N which must be set by the user so that the vector $\{ CS(I), SN(I) \}$ is the direction of the plotted curve at the point $\{ X(I), Y(I) \} \quad I=1,2,\dots,N$. If the I th and $I+1$ th data point are the same then the incoming direction of the curve at point I will be $\{ CS(I), SN(I) \}$ and the outgoing direction will be $\{ CS(I+1), SN(I+1) \}$.

DELTA is A REAL variable which must be set by the user to the tolerance for the plotted curve. A tolerance is needed because the smooth curve has to be drawn as a sequence of straight line segments. If the given value of DELTA is positive then the straight line segments will not deviate from the smooth curve by more than the value of DELTA, but if $DELTA \leq 0$ then a tolerance is chosen automatically.

Good quality curves will be obtained if the user sets the value of DELTA to correspond to about 0.01 inches on the output medium.

2.2 Use of COMMON

The subroutine includes the named common block

```
COMMON/OB11D/AC,LP
```

and the usual values of AC and LP are set by a block data subprogram to 500 and 6 respectively. The user may alter these values if desired. The purpose of AC is to set the default value of DELTA to

$$\max[\max[X(i)]-\min[X(i)],\max[Y(i)]-\min[Y(i)]]/AC.$$

LP is the Fortran stream number for diagnostic messages.

3 GENERAL INFORMATION

Use of common: See section 2.2.

Workspace: Two private arrays, each of length 127, are used as private workspace. The size of these arrays does not restrict the use of OB11A/B. **Calls:** The routine calls Harwell Subroutine Library member NB01A and GHOST plotting routine SHVECS.

Input/output: See section 4.

Restrictions: $n > 1$.

4. DIAGNOSTIC MESSAGES

Diagnostic messages will be printed under two circumstances: if the value of N is not greater than one, or if an iteration fails to converge. We are confident that this failure to converge will not occur unless DELTA is unreasonably small in comparison with the coordinates of the data points.

5. TWO IMPORTANT REMARKS

The user may obtain a discontinuity in the slope of the plotted curve at a data point by repeating the data point. For example, if $(x_{i+1}, y_{i+1}) = (x_i, y_i)$ then a cusp will occur at this point. If the entry point OB11A is used in this case, then the incoming direction of the curve at the data point is given by $(CS(i), SN(i))$ and the outgoing direction is given by $(CS(I+1), SN(I+1))$.

It is desirable that a unit in the x -direction gives the same distance on the graph paper as a unit in the y -direction. This can be achieved by a change of variables. Otherwise the appearance of the curve is liable to be poor.

6. METHOD

The curve through the data points is defined by an algorithm due to D.J. McConalogue. A new method is used to approximate the curve by the sequence of straight lines which is actually plotted. Full details are given in S. Marlow and M.J.D. Powell, AERE R.7092 (1972).

7. EXAMPLE

Suppose that we want to plot the curve defined by the set of data points $x(t), y(t)$ for $t=(k-1)/2, k=1,2,\dots,13$ where

$$x(t) = 1 + (t-1)^2(t-5)^2/6$$

$$y(t) = 1 + (t-6)^2/5.$$

The example shows how to use OB11A to draw this curve, using the data points with corresponding directions, as well as how to use OB11B to plot the same curve using only the data points.

```

      REAL*4 X(20),Y(20),CS(20),SN(20)
      -----
      -----
      C Switch on graph plotter
        CALL PAPER(1)
      C Set number of data points
        N = 13
      C Compute data points

```

```
      DO 1 I=1,N
        A = (I-1)*0.5
        X(I) = (((A-1.0)*(A-5.0))**2)/6.0+1.0
        Y(I) = (A*(A-6.0)**2)/5.0+1.0
        CS(I) = 2.0*(A-1.0)*(A-3.0)*(A-5.0)/3.0
        SN(I) = 3.0*(A-2.0)*(A-6.0)/5.0
      1 CONTINUE
C Set tolerance of plotted curve
      DELTA = 0.1
C Request new frame
      CALL FRAME
C Set up plotter space
      CALL PSPACE(0.2,0.8,0.1,0.9)
C Set up character space
      CALL CSPACE(0.0,1.0,0.0,1.0)
C Set up mathematical space
      CALL MAP(0.0,6.0,0.0,8.0)
C Draw axes for graph
      CALL AXES
C Plot data points
      CALL PTPLOT(X,Y,1,N,45)
C Draw curve using directions
      CALL OB11A(N,X,Y,CS,SN,DELTA)
C Now set up data to draw curve
C using only data points, with
C a cusp at the origin.
      X(14)=X(13)
      Y(14)=Y(13)
      N=14
C Request new frame
      CALL FRAME
C Set up plotter space
      CALL PSPACE(0.2,0.8,0.1,0.9)
C Set up character space
      CALL CSPACE(0.0,1.0,0.0,1.0)
C Set up mathematical space
      CALL MAP(0.0,6.0,0.0,8.0)
C Draw axes for graph
      CALL AXES
C Plot data points
      CALL PTPLOT(X,Y,1,N,45)
C Draw curve using only data points
      CALL OB11B(N,X,Y,DELTA)
-----
-----
C Switch off graph plotter
      CALL GREND
      STOP
      END
```