



1 SUMMARY

To **draw on the graph plotter a cubic spline** defined by its knots, function values and first derivative values at the knots. The spline function, $s(x)$ say, is defined by the values of x , $s(x)$ and $s'(x)$ at the ends of each cubic polynomial piece. In the usual case when $s(x)$ and $s'(x)$ are continuous at the joins the data has the form $[x(i), s(i), s'(i)]$, $i=1, 2, \dots, n$, where $x(1) < x(2) < \dots < x(n)$. In this case $s(i)$ and $s'(i)$ are the values of $s(x)$ and $s'(x)$ respectively at $x=x(i)$. The curve $s(x)$ is drawn for x in the range $x(1) \leq x \leq x(n)$. If discontinuities in the curve are required, they must be introduced by the user: the method is described in Section 5.

This subroutine may be used to plot mathematical functions or curve fits to data, such as those computed by subroutines TS01, VB05, VB06 or VC03.

The spline is approximated by a sequence of straight line segments to within an accuracy under the control of the user. The method is described in S. Marlow and M.J.D. Powell, AERE R.7470.

The user is expected to have initialized graph plotting through the GHOST system and set the scaling before calling the subroutine. **Remark:** The subroutine is dependent on the local graph plotting system only through one subroutine and that is one for drawing a sequence of line segments.

ATTRIBUTES — **Version:** 1.0.0. **Types:** OB12A. **Calls:** SHVECS (a GHOST subroutine). **Original date:** October 1972. **Origin:** S.Marlow and M.J.D.Powell, Harwell.

2 HOW TO USE THE PACKAGE

2.1 The argument list and calling sequence

There is only a single precision version of this routine, called by

```
CALL OB12A(N, X, S, DS, DELTA)
```

All the quantities in the argument list must be set by the user, and they are not changed by the subroutine.

is an INTEGER specifying the number of data points. It must be greater than one.

X is a REAL one dimensional array of length at least **N**, which must contain the values of the spline points $x(i)$.

S is a REAL one dimensional array of length at least **N**, which must contain the values of the functions $s(i)$.

DS is a REAL one dimensional array of length at least **N**, which must contain the values of the derivatives $s'(i)$.

Note that unless the device of Section 5 is employed the condition $x(i) < x(j)$, ij , should be satisfied.

DELTA is a REAL variable that defines a tolerance for the plotted curve, which is needed because in order to plot $s(x)$ it must be approximated by a piecewise linear function, $p(x)$ say. If **DELTA** is positive the inequality

$$|(s(x) - p(x))| \leq \text{DELTA}, \quad x(1) \leq x \leq x(n)$$

is satisfied automatically. In this case we recommend that the value of **DELTA** be chosen to correspond to 0.01 inch on the graph paper. However if $\text{DELTA} \leq 0$, then a suitable tolerance is chosen automatically by the subroutine. This tolerance is equal to the range of $s(x)$ divided by **AC**, and usually **AC**=500 (See Section 3).

2.2 Use of COMMON

The subroutine includes the statement

```
COMMON/OB12C/AC, LP, RELX
```

and the values of **AC**, **LP** and **RELX** are set to 500, 6 and 1000 respectively by a BLOCK DATA subprogram. Therefore

the user can change their values. The purpose of AC is defined at the end of Section 2. The purpose of LP is that it is the data set reference number (Fortran stream number) for any diagnostic messages from the subroutine. The purpose of RELX is described in the report by Marlow and Powell mentioned in Section 7.

3 GENERAL INFORMATION

Use of common: See Section 2.2.

Workspace: Two real arrays each of length 127 are used for workspace. They do not restrict the use of OB12A in any way. **Other Routines:** Subroutine PTJOIN(XPOSNS, YPOSNS, ISTART, ISTOP, ICODE) is called, which is a part of the GHOST graph plotting package. This can easily be replaced with a dummy routine.

Input/output: See Section 4.

4 DIAGNOSTIC MESSAGES

In two situations a diagnostic message is given because nothing is plotted. One is when $N \leq 1$, and the other is when the x values are not presented in ascending order.

5 PLOTTING DISCONTINUITIES IN $s(x)$ AND $s'(x)$

We use the convention that $s(x)$ is plotted for x in the range $x(i), x(i+1)$ if and only if $x(i+1)$ is greater than $x(i)$. Therefore $x(s)$ is continuous but $s(x)$ is discontinuous at $x=x(i)$ if $x(i)=x(i+1)$, $s(i)=s(i+1)$, but $s'(i) \neq s'(i+1)$. Similarly $s(x)$ is discontinuous at $x=x(i)$ if $x(i)=x(i+1)$ but $s(i) \neq s(i+1)$. This convention may also be used to plot two separate spline functions using a single call of OB12A, because if $x(i)x(i+1)$ then the plotting of one spline function will finish at $x(i)$, and the plotting of a new spline function will begin at $x(i+1)$.

6 METHOD

This will be described in a Harwell report by S. Marlow and M.J.D. Powell. Some inefficiencies may occur if the first derivative $s'(x)$ is very large over only a small part of the range $x(1) \leq x \leq x(n)$. In this case it may be preferable to treat the section where the first derivative is large by a separate call of OB12A.

8 EXAMPLE

Suppose that we want to plot the function

$$f(x) = 20 \frac{x}{1+4x^2}, \quad 0 \leq x \leq 5.$$

We first use the subroutine TS01A to calculate a cubic spline approximation to the function with an accuracy of 0.01 and then apply the output to subroutine OB12A. This example shows us how to use OB12A to draw the curve above.

```

REAL*4 XN(100), FN(100), GN(100), W(125)
EXTERNAL CALCFX
-----
N=11                               No. of data points
ACC=0.01                            accuracy of approximation
CALL TS01A(0.,5.,ACC,100,N,XN,FN,GN,
1      2,W,CALCFX)                 obtain approximation
CALL PAPER(1)                       switch on graph plotter
DELTA=0.01                          set tolerance of plotted curve
CALL FRAME                          request new frame
CALL PSPACE (.1,.9,.1,.9)          set up plotter space
CALL CSPACE (0.,1.,0.,1.)         set up character space
CALL MAP (0.,7.,0.,7.)            set up mathematical space
CALL AXES                          draw axes on graph
CALL PTPLOT (XN,FN,1,N,45)        plot data points

```

```
CALL OB12A (N,XN, FN,GN,DELTA)           draw curve
-----
CALL GREND                               switch off graph plotter
STOP
END

SUBROUTINE CALCFX(X,F)
-----
F = 20.*X/(1.+4.*X*X)                   define function
-----
RETURN
END
```