

## nag\_monotonic\_intg (e01bhc)

### 1. Purpose

**nag\_monotonic\_intg (e01bhc)** evaluates the definite integral of a piecewise cubic Hermite interpolant over the interval  $[a, b]$ .

### 2. Specification

```
#include <nag.h>
#include <nage01.h>

void nag_monotonic_intg(Integer n, double x[], double f[], double d[],
                        double a, double b, double *integral, NagError *fail)
```

### 3. Description

This function evaluates the definite integral of a piecewise cubic Hermite interpolant, as computed by **nag\_monotonic\_interpolant (e01bec)**, over the interval  $[a, b]$ .

If either  $a$  or  $b$  lies outside the interval from  $x[0]$  to  $x[n - 1]$ , computation of the integral involves extrapolation and a warning is returned.

The function is derived from routine PCHIA in Fritsch (1982).

### 4. Parameters

**n**  
**x[n]**  
**f[n]**  
**d[n]**

Input: **n**, **x**, **f** and **d** must be unchanged from the previous call of **nag\_monotonic\_interpolant (e01bec)**.

**a**  
**b**

Input: the interval  $[a, b]$  over which integration is to be performed.

**integral**

Output: the value of the definite integral of the interpolant over the interval  $[a, b]$ .

**fail**

The NAG error parameter, see the Essential Introduction to the NAG C Library.

### 5. Error Indications and Warnings

**NE\_INT\_ARG\_LT**

On entry, **n** must not be less than 2: **n** =  $\langle value \rangle$ .

**NE\_NOT\_MONOTONIC**

On entry,  $x[r - 1] \geq x[r]$  for  $r = \langle value \rangle$ :  $x[r - 1] = \langle value \rangle$ ,  $x[r] = \langle value \rangle$ .  
The values of  $x[r]$ , for  $r = 0, 1, \dots, n - 1$  are not in strictly increasing order.

**NW\_INTERVAL\_EXTRAPOLATE**

On entry, limits **a**, **b** must not be outside interval  $[x[0], x[n - 1]]$ , **a** =  $\langle value \rangle$ , **b** =  $\langle value \rangle$ ,  
 $x[0] = \langle value \rangle$ ,  $x[\langle value \rangle] = \langle value \rangle$ . Extrapolation was performed to compute the integral.  
The value returned is therefore unreliable.

### 6. Further Comments

The time taken by the function is approximately proportional to the number of data points included within the interval  $[a, b]$ .

#### 6.1. Accuracy

The computational error in the value returned for **integral** should be negligible in most practical situations.

## 6.2. References

Fritsch F N (August 1982) *PCHIP Final Specifications* Lawrence Livermore National Laboratory report UCID-30194.

## 7. See Also

nag\_monotonic\_interpolant (e01bec)

## 8. Example

This example program reads in values of **n**, **x**, **f** and **d**. It then reads in pairs of values for **a** and **b**, and evaluates the definite integral of the interpolant over the interval [**a**, **b**] until end-of-file is reached.

### 8.1. Program Text

```

/* nag_monotonic_intg(e01bhc) Example Program
 *
 * Copyright 1991 Numerical Algorithms Group.
 *
 * Mark 2, 1991.
 */

#include <nag.h>
#include <stdio.h>
#include <nag_stdlib.h>
#include <nage01.h>

#define NMAX 50

main()
{
    double a, b, integral, d[NMAX], f[NMAX], x[NMAX];
    Integer n, r;

    Vprintf("e01bhc Example Program Results\n");
    Vscanf("%*[^\\n]"); /* Skip heading in data file */
    Vscanf("%ld",&n);
    if (n>0 && n<=NMAX)
    {
        for (r=0; r<n; r++)
            Vscanf("%lf%lf%lf",&x[r], &f[r], &d[r]);
        Vprintf("                                Integral\n");
        Vprintf("          a                                b          over (a,b)\n");
        /* Read a, b pairs until end of file and compute
         * definite integrals.
         */
        while(scanf("%lf%lf",&a,&b) !=EOF)
        {
            e01bhc(n, x, f, d, a, b, &integral, NAGERR_DEFAULT);
            Vprintf("%13.4f      %13.4f      %13.4f\n",a,b,integral);
        }
        exit(EXIT_SUCCESS);
    }
    else
    {
        Vfprintf(stderr,"n is out of range : n = %ld\n",n);
        exit(EXIT_FAILURE);
    }
}

```

**8.2. Program Data**

e01bhc Example Program Data

```

9
7.990 0.00000E+0 0.00000E+0
8.090 0.27643E-4 5.52510E-4
8.190 0.43749E-1 0.33587E+0
8.700 0.16918E+0 0.34944E+0
9.200 0.46943E+0 0.59696E+0
10.00 0.94374E+0 6.03260E-2
12.00 0.99864E+0 8.98335E-4
15.00 0.99992E+0 2.93954E-5
20.00 0.99999E+0 0.00000E+0
7.99      20.0
10.0      12.0
12.0      10.0
15.0      15.0

```

**8.3. Program Results**

e01bhc Example Program Results

a	b	Integral over (a,b)
7.9900	20.0000	10.7648
10.0000	12.0000	1.9622
12.0000	10.0000	-1.9622
15.0000	15.0000	0.0000

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