nag_cosh (s10acc)

1. Purpose

nag_cosh (s10acc) returns the value of the hyperbolic cosine, $\cosh x$.

2. Specification

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

double nag_cosh(double x, NagError *fail)
```

3. Description

The function calculates an approximate value for the hyperbolic cosine, $\cosh x$.

For $|x| \leq E_1$, (where E_1 is a machine-dependent constant) $\cosh x = \frac{1}{2}(e^x + e^{-x})$.

For $|x| > E_1$, the function fails owing to danger of setting overflow in calculating e^x. The result returned for such calls is $\cosh E_1$, i.e., it returns the result for the nearest valid argument.

4. Parameters

x

Input: the argument x of the function.

fail

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

5. Error Indications and Warnings

NE_REAL_ARG_GT

On entry, $|\mathbf{x}|$ must not be greater than $\langle value \rangle$: $\mathbf{x} = \langle value \rangle$.
The function has been called with an argument too large in absolute magnitude. There is a danger of overflow. The result returned is the value of $\cosh x$ at the nearest valid argument.

6. Further Comments

6.1. Accuracy

If δ and ϵ are the relative errors in the argument and result, respectively, then in principle

$$\epsilon \simeq x \tanh x \delta.$$

That is, the relative error in the argument, x, is amplified by a factor at least $x \tanh x$ in the result. The equality should hold if δ is greater than the ***machine precision*** (δ is due to data errors etc.), but if δ is simply a result of round-off in the machine representation of x then it is possible that an extra figure may be lost in internal calculation round-off.

It should be noted that near $x = 0$ where this amplification factor tends to zero the accuracy will be limited eventually by the ***machine precision***. Also for $|x| \gtrsim 2$

$$\epsilon \sim x\delta = \Delta$$

where Δ is the absolute error in the argument x.

6.2. References

Abramowitz M and Stegun I A (1968) *Handbook of Mathematical Functions* Dover Publications, New York ch 4.5 p 83.

7. See Also

None.

8. Example

The following program reads values of the argument x from a file, evaluates the function at each value of x and prints the results.

8.1. Program Text

```
/* nag_cosh(s10acc) Example Program
 *
 * Copyright 1990 Numerical Algorithms Group.
 *
 * Mark 2 revised, 1992.
 */

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


main()
{
  double x, y;

  /* Skip heading in data file */
  Vscanf("%*[^\n]");
  Vprintf("s10acc Example Program Results\n");
  Vprintf("     x           y\n");
  while (scanf("%lf", &x) != EOF)
    {
      y = s10acc(x, NAGERR_DEFAULT);
      Vprintf("%12.3e%12.3e\n", x, y);
    }
  exit(EXIT_SUCCESS);
}
```

8.2. Program Data

```
s10acc Example Program Data
           -10.0
            -0.5
             0.0
             0.5
            25.0
```

8.3. Program Results

```
s10acc Example Program Results
     x           y
  -1.000e+01   1.101e+04
  -5.000e-01   1.128e+00
   0.000e+00   1.000e+00
   5.000e-01   1.128e+00
   2.500e+01   3.600e+10
```