NAG Library Function Document

nag_cumul_normal (s15abc)

1 Purpose

nag_cumul_normal (s15abc) returns the value of the cumulative Normal distribution function, $P(x)$.

2 Specification

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

```
double nag_cumul_normal (double x)
```

3 Description

nag_cumul_normal (s15abc) evaluates an approximate value for the cumulative Normal distribution function

$$P(x) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{x} e^{-u^2/2}\, du.$$

The function is based on the fact that

$$P(x) = \tfrac{1}{2}\mathrm{erfc}\left(\frac{-x}{\sqrt{2}}\right)$$

and it calls nag_erfc (s15adc) to obtain a value of *erfc* for the appropriate argument.

4 References

Abramowitz M and Stegun I A (1972) *Handbook of Mathematical Functions* (3rd Edition) Dover Publications

5 Arguments

1: **x** – double *Input*

On entry: the argument x of the function.

6 Error Indicators and Warnings

None.

7 Accuracy

Because of its close relationship with *erfc*, the accuracy of this function is very similar to that in nag_erfc (s15adc). If ϵ and δ are the relative errors in result and argument, respectively, they are in principle related by

$$|\epsilon| \simeq \left| \frac{x e^{-\frac{1}{2}x^2}}{\sqrt{2\pi} P(x)} \delta \right|$$

so that the relative error in the argument, x, is amplified by a factor, $\frac{x e^{-\frac{1}{2}x^2}}{\sqrt{2\pi} P(x)}$, in the result.

For x small and for x positive this factor is always less than one and accuracy is mainly limited by ***machine precision***.

For large negative x the factor behaves like $\sim x^2$ and hence to a certain extent relative accuracy is unavoidably lost.

However the absolute error in the result, E, is given by

$$|E| \simeq \left| \frac{xe^{-\frac{1}{2}x^2}}{\sqrt{2\pi}} \delta \right|$$

so absolute accuracy can be guaranteed for all x.

8 Parallelism and Performance

Not applicable.

9 Further Comments

None.

10 Example

This example reads values of the argument x from a file, evaluates the function at each value of x and prints the results.

10.1 Program Text

```
/* nag_cumul_normal (s15abc) Example Program.
 *
 * Copyright 1990 Numerical Algorithms Group.
 *
 * Mark 1, 1990.
 */

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

int main(void)
{
  Integer exit_status = 0;
  double  x, y;

  /* Skip heading in data file */
  scanf("%*[^\n]");
  printf("nag_cumul_normal (s15abc) Example Program Results\n");
  printf("     x           y\n");
  while (scanf("%lf", &x) != EOF)
    {
      /* nag_cumul_normal (s15abc).
       * Cumulative Normal distribution function P(x)
       */
      y = nag_cumul_normal(x);
      printf("%12.3e%12.3e\n", x, y);
    }

  return exit_status;
}
```

10.2 Program Data

```
nag_cumul_normal (s15abc) Example Program Data
           -20.0
            -1.0
             0.0
             1.0
             2.0
            20.0
```

10.3 Program Results

```
nag_cumul_normal (s15abc) Example Program Results
     x           y
  -2.000e+01   2.754e-89
  -1.000e+00   1.587e-01
   0.000e+00   5.000e-01
   1.000e+00   8.413e-01
   2.000e+00   9.772e-01
   2.000e+01   1.000e+00
```