

NAG Library Function Document

nag_cumul_normal_complem (s15acc)

1 Purpose

nag_cumul_normal_complem (s15acc) returns the value of the complement of the cumulative Normal distribution function, $Q(x)$.

2 Specification

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

double nag_cumul_normal_complem (double x)
```

3 Description

nag_cumul_normal_complem (s15acc) evaluates an approximate value for the complement of the cumulative Normal distribution function

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

The function is based on the fact that

$$Q(x) = \frac{1}{2} \operatorname{erfc}\left(\frac{x}{\sqrt{2}}\right)$$

and it calls nag_erfc (s15adc) to obtain the necessary value of *erfc*, the complementary error function.

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, then in principle they are related by

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

For x negative or small positive this factor is always less than one and accuracy is mainly limited by *machine precision*. For large positive x we find $\epsilon \sim x^2\delta$ and hence to a certain extent relative accuracy is unavoidably lost. However the absolute error in the result, E , is given by

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

and since this factor is always less than one absolute accuracy can be guaranteed for all x .

8 Parallelism and Performance

nag_cumul_normal_complem (s15acc) is not threaded in any implementation.

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_complem (s15acc) Example Program.
 *
 * NAGPRODCODE Version.
 *
 * Copyright 2016 Numerical Algorithms Group.
 *
 * Mark 26, 2016.
 *
 */

#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 */
#ifdef _WIN32
    scanf_s("%*[\n]");
#else
    scanf("%*[\n]");
#endif
    printf("nag_cumul_normal_complem (s15acc) Example Program Results\n");
    printf("      x          y\n");
#ifdef _WIN32
    while (scanf_s("%lf", &x) != EOF)
    #else
    while (scanf("%lf", &x) != EOF)
    #endif
    {
        /* nag_cumul_normal_complem (s15acc).
         * Complement of cumulative Normal distribution function
         * Q(x)
         */
        y = nag_cumul_normal_complem(x);
    }
}
```

```
    printf("%12.3e%12.3e\n", x, y);  
}  
  
    return exit_status;  
}
```

10.2 Program Data

```
nag_cumul_normal_complem (s15acc) Example Program Data  
      -20.0  
      -1.0  
       0.0  
       1.0  
       2.0  
      20.0
```

10.3 Program Results

```
nag_cumul_normal_complem (s15acc) Example Program Results  
      x              y  
-2.000e+01  1.000e+00  
-1.000e+00  8.413e-01  
 0.000e+00  5.000e-01  
 1.000e+00  1.587e-01  
 2.000e+00  2.275e-02  
 2.000e+01  2.754e-89
```
