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

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

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

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_complem (s15acc) Example Program.
 *
 * Copyright 2014 Numerical Algorithms Group.
 *
 * Mark 1, 1990.
 *
 * Mark 3 revised, 1994.
 */

#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
```