

# 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  $\epsilon$  and  $\delta$  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

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

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
```

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