

## NAG Library Function Document

### nag\_prob\_beta\_dist (g01eec)

#### 1 Purpose

nag\_prob\_beta\_dist (g01eec) computes the upper and lower tail probabilities and the probability density function of the beta distribution with parameters  $a$  and  $b$ .

#### 2 Specification

```
#include <nag.h>
#include <nagg01.h>

void nag_prob_beta_dist (double x, double a, double b, double tol, double *p,
                        double *q, double *pdf, NagError *fail)
```

#### 3 Description

The probability density function of the beta distribution with parameters  $a$  and  $b$  is:

$$f(B : a, b) = \frac{\Gamma(a+b)}{\Gamma(a)\Gamma(b)} B^{a-1} (1-B)^{b-1}, \quad 0 \leq B \leq 1; a, b > 0.$$

The lower tail probability,  $P(B \leq \beta : a, b)$  is defined by

$$P(B \leq \beta : a, b) = \frac{\Gamma(a+b)}{\Gamma(a)\Gamma(b)} \int_0^\beta B^{a-1} (1-B)^{b-1} dB = I_\beta(a, b), \quad 0 \leq \beta \leq 1; a, b > 0.$$

The function  $I_x(a, b)$ , also known as the incomplete beta function is calculated using nag\_incomplete\_beta (s14ccc).

#### 4 References

Hastings N A J and Peacock J B (1975) *Statistical Distributions* Butterworth

#### 5 Arguments

- |    |  |              |
|----|--|--------------|
| 1: | <b>x</b> – double  | <i>Input</i> |
|    | <i>On entry:</i> $\beta$ , the value of the beta variate.  |              |
|    | <i>Constraint:</i> $0.0 \leq \mathbf{x} \leq 1.0$ .  |              |
| 2: | <b>a</b> – double  | <i>Input</i> |
|    | <i>On entry:</i> $a$ , the first parameter of the required beta distribution.                        |              |
|    | <i>Constraint:</i> $0.0 < \mathbf{a} \leq 10^6$ .  |              |
| 3: | <b>b</b> – double  | <i>Input</i> |
|    | <i>On entry:</i> $b$ , the second parameter of the required beta distribution.                       |              |
|    | <i>Constraint:</i> $0.0 < \mathbf{b} \leq 10^6$ .  |              |
| 4: | <b>tol</b> – double  | <i>Input</i> |
|    | <i>On entry:</i> this argument is no longer referenced, but is included for backwards compatability. |              |

- 5: **p** – double \* *Output*  
*On exit:* the lower tail probability,  $P(B \leq \beta : a, b)$ .
- 6: **q** – double \* *Output*  
*On exit:* the upper tail probability,  $P(B \geq \beta : a, b)$ .
- 7: **pdf** – double \* *Output*  
*On exit:* the probability density function,  $f(B : a, b)$ .
- 8: **fail** – NagError \* *Input/Output*  
 The NAG error argument (see Section 2.7 in How to Use the NAG Library and its Documentation).

## 6 Error Indicators and Warnings

### NE\_ALLOC\_FAIL

Dynamic memory allocation failed.

See Section 2.3.1.2 in How to Use the NAG Library and its Documentation for further information.

### NE\_BAD\_PARAM

On entry, argument  $\langle value \rangle$  had an illegal value.

### NE\_INTERNAL\_ERROR

An internal error has occurred in this function. Check the function call and any array sizes. If the call is correct then please contact NAG for assistance.

An unexpected error has been triggered by this function. Please contact NAG.

See Section 2.7.6 in How to Use the NAG Library and its Documentation for further information.

### NE\_NO\_LICENCE

Your licence key may have expired or may not have been installed correctly.

See Section 2.7.5 in How to Use the NAG Library and its Documentation for further information.

### NE\_REAL\_ARG\_GT

On entry,  $x = \langle value \rangle$ .

Constraint:  $x \leq 1.0$ .

### NE\_REAL\_ARG\_LE

On entry,  $a = \langle value \rangle$  and  $b = \langle value \rangle$ .

Constraint:  $a > 0.0$ .

On entry,  $a = \langle value \rangle$  and  $b = \langle value \rangle$ .

Constraint:  $b > 0.0$ .

### NE\_REAL\_ARG\_LT

On entry,  $x = \langle value \rangle$ .

Constraint:  $x \geq 0.0$ .

## 7 Accuracy

The accuracy is limited by the error in the incomplete beta function. See Section 7 in nag\_incomplete\_beta (s14ccc) for further details.

## 8 Parallelism and Performance

nag\_prob\_beta\_dist (g01eec) is not threaded in any implementation.

## 9 Further Comments

None.

## 10 Example

This example reads values from a number of beta distributions and computes the associated upper and lower tail probabilities and the corresponding value of the probability density function.

### 10.1 Program Text

```

/* nag_prob_beta_dist (g01eec) Example Program.
 *
 * NAGPRODCODE Version.
 *
 * Copyright 2016 Numerical Algorithms Group.
 *
 * Mark 26, 2016.
 */

#include <nag.h>
#include <stdio.h>
#include <nag_stdlib.h>
#include <nagg01.h>

int main(void)
{
    Integer exit_status = 0;
    double a, b, p, pdf, q, tol, x;
    NagError fail;

    INIT_FAIL(fail);

    /* Skip heading in data file */
#ifdef _WIN32
    scanf_s("%*[^\\n]");
#else
    scanf("%*[^\\n]");
#endif
    printf("nag_prob_beta_dist (g01eec) Example Program Results\\n");
    printf("      x          a          b          p          q          pdf\\n\\n");
#ifdef _WIN32
    while (scanf_s("%lf %lf %lf %lf", &x, &a, &b, &tol) != EOF)
#else
    while (scanf("%lf %lf %lf %lf", &x, &a, &b, &tol) != EOF)
#endif
    {
        /* nag_prob_beta_dist (g01eec).
         * Upper and lower tail probabilities and probability
         * density function for the beta distribution
         */
        nag_prob_beta_dist(x, a, b, tol, &p, &q, &pdf, &fail);
        if (fail.code != NE_NOERROR) {
            printf("Error from nag_prob_beta_dist (g01eec).\\n%s\\n", fail.message);
            exit_status = 1;
            goto END;
        }
        printf("%7.4f%13.4e%13.4e%13.4e%13.4e\\n", x, a, b, p, q, pdf);
    }
}

```

```

    }

END:
    return exit_status;
}

```

## 10.2 Program Data

nag\_prob\_beta\_dist (g01eec) Example Program Data

```

0.25  1.0  2.0  1.9
0.75  1.5  1.5  0.0001
0.5   2.0  1.0  1.01

```

## 10.3 Program Results

nag\_prob\_beta\_dist (g01eec) Example Program Results

x	a	b	p	q	pdf
0.2500	1.0000e+00	2.0000e+00	4.3750e-01	5.6250e-01	1.5000e+00
0.7500	1.5000e+00	1.5000e+00	8.0450e-01	1.9550e-01	1.1027e+00
0.5000	2.0000e+00	1.0000e+00	2.5000e-01	7.5000e-01	1.0000e+00

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