

nag_binomial_dist (g01bjc)**1. Purpose**

nag_binomial_dist (g01bjc) returns the lower tail, upper tail and point probabilities associated with a Binomial distribution.

2. Specification

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

```
void nag_binomial_dist(Integer n, double p, Integer k, double *plek,
                      double *pgtk, double *peqk, NagError *fail)
```

3. Description

Let X denote a random variable having a Binomial distribution with parameters n and p ($n \geq 0$ and $0 < p < 1$). Then

$$\text{Prob}\{X = k\} = \binom{n}{k} p^k (1-p)^{n-k}, \text{ for } k = 0, 1, \dots, n.$$

The mean of the distribution is np and the variance is $np(1-p)$.

This routine computes for given n , p and k the probabilities:

```
plek = Prob{ $X \leq k$ }
pgtk = Prob{ $X > k$ }
peqk = Prob{ $X = k$ }.
```

The method is similar to the method for the Poisson distribution described in Knüsel (1986).

4. Parameters

n

Input: the parameter n of the Binomial distribution.
Constraint: **n** ≥ 0 .

p

Input: the parameter p of the Binomial distribution.
Constraint: $0.0 < \mathbf{p} < 1.0$.

k

Input: the integer k which defines the required probabilities.
Constraint: $0 \leq \mathbf{k} \leq \mathbf{n}$.

plek

Output: the lower tail probability, $\text{Prob}\{X \leq k\}$.

pgtk

Output: the upper tail probability, $\text{Prob}\{X > k\}$.

peqk

Output: the point probability, $\text{Prob}\{X = k\}$.

fail

The NAG error parameter, see the Essential Introduction to the NAG C Library.

5. Error Indications and Warnings

NE_INT_ARG_LT

On entry, **n** must not be less than 0: **n** = $\langle \text{value} \rangle$.

On entry, **k** must not be less than 0: **k** = $\langle \text{value} \rangle$.

NE_2_INT_ARG_GT

On entry, $k = \langle value \rangle$ while $n = \langle value \rangle$. These parameters must satisfy $k \leq n$.

NE_ARG_TOO_LARGE

On entry, n is too large to be represented exactly as a double precision number.

NE_REAL_ARG_LE

On entry, p must not be less than or equal to 0.0: $p = \langle value \rangle$.

NE_REAL_ARG_GE

On entry, p must not be greater than or equal to 1.0: $p = \langle value \rangle$.

NE_VARIANCE_TOO_LARGE

On entry, the variance ($= np(1 - p)$) exceeds 10^6 .

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 consult NAG for assistance.

6. Further Comments

The time taken by the routine depends on the variance ($= np(1 - p)$) and on k . For given variance, the time is greatest when $k \approx np$ ($=$ the mean), and is then approximately proportional to the square-root of the variance.

6.1. Accuracy

Results are correct to a relative accuracy of at least 10^{-6} on machines with a precision of 9 or more decimal digits, and to a relative accuracy of at least 10^{-3} on machines of lower precision (provided that the results do not underflow to zero).

6.2. References

Knüsel L (1986) Computation of the Chi-square and Poisson Distribution. *SIAM J. Sci. Statist. Comput.* **7** 1022–1036.

7. See Also

nag_poisson_dist (g01bkc)
nag_hypergeom_dist (g01blc)

8. Example

This example program reads values of n and p from a data file until end-of-file is reached, and prints the corresponding probabilities.

8.1. Program Text

```
/* nag_binomial_dist(g01bjc) Example Program.
 *
 * Copyright 1996 Numerical Algorithms Group.
 *
 * Mark 4, 1996.
 *
 */

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

main()
{
    double plek, peqk, pgtk;
    double p;

    Integer k, n;
```

```

Vprintf("g01bjc Example Program Results\n");
/*      Skip heading in data file */
Vscanf("%*[^\\n] ");

Vprintf("\\n");
Vprintf("      n      p      k      plek      pgtk      peqk\\n\\n");

while ((scanf("%ld %lf %ld%*[^\\n]", &n, &p, &k)) != EOF)
{
    g01bjc(n, p, k, &plek, &pgtk, &peqk, NAGERR_DEFAULT);
    Vprintf("%5ld%8.3f%5ld%10.5f%10.5f%10.5f\\n", n, p, k, plek, pgtk, peqk);
}

exit(EXIT_SUCCESS);
}

```

8.2. Program Data

```

g01bjc Example Program Data
4 0.50 2 : n, p, k
19 0.44 13
100 0.75 67
2000 0.33 700

```

8.3. Program Results

```

g01bjc Example Program Results

```

n	p	k	plek	pgtk	peqk
4	0.500	2	0.68750	0.31250	0.37500
19	0.440	13	0.99138	0.00862	0.01939
100	0.750	67	0.04460	0.95540	0.01700
2000	0.330	700	0.97251	0.02749	0.00312
