

## NAG Library Function Document

### nag\_prob\_poisson\_vector (g01skc)

#### 1 Purpose

nag\_prob\_poisson\_vector (g01skc) returns a number of the lower tail, upper tail and point probabilities for the Poisson distribution.

#### 2 Specification

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

void nag_prob_poisson_vector (Integer ll, const double l[], Integer lk,
    const Integer k[], double plek[], double pgtk[], double peqk[],
    Integer ivalid[], NagError *fail)
```

#### 3 Description

Let  $X = \{X_i : i = 1, 2, \dots, m\}$  denote a vector of random variables each having a Poisson distribution with parameter  $\lambda_i$  ( $> 0$ ). Then

$$\text{Prob}\{X_i = k_i\} = e^{-\lambda_i} \frac{\lambda_i^{k_i}}{k_i!}, \quad k_i = 0, 1, 2, \dots$$

The mean and variance of each distribution are both equal to  $\lambda_i$ .

nag\_prob\_poisson\_vector (g01skc) computes, for given  $\lambda_i$  and  $k_i$  the probabilities:  $\text{Prob}\{X_i \leq k_i\}$ ,  $\text{Prob}\{X_i > k_i\}$  and  $\text{Prob}\{X_i = k_i\}$  using the algorithm described in Kn̄sel (1986).

The input arrays to this function are designed to allow maximum flexibility in the supply of vector arguments by re-using elements of any arrays that are shorter than the total number of evaluations required. See Section 2.6 in the g01 Chapter Introduction for further information.

#### 4 References

Kn̄sel L (1986) Computation of the chi-square and Poisson distribution *SIAM J. Sci. Statist. Comput.* **7** 1022–1036

#### 5 Arguments

- 1: **ll** – Integer *Input*  
*On entry:* the length of the array **l**.  
*Constraint:* **ll** > 0.
- 2: **l[ll]** – const double *Input*  
*On entry:*  $\lambda_i$ , the parameter of the Poisson distribution with  $\lambda_i = \mathbf{l}[j]$ ,  $j = (i - 1) \bmod \mathbf{ll}$ , for  $i = 1, 2, \dots, \max(\mathbf{ll}, \mathbf{lk})$ .  
*Constraint:*  $0.0 < \mathbf{l}[j - 1] \leq 10^6$ , for  $j = 1, 2, \dots, \mathbf{ll}$ .
- 3: **lk** – Integer *Input*  
*On entry:* the length of the array **k**.  
*Constraint:* **lk** > 0.

- 4: **k[*lk*]** – const Integer *Input*  
*On entry:*  $k_i$ , the integer which defines the required probabilities with  $k_i = \mathbf{k}[j]$ ,  $j = (i - 1) \bmod \mathbf{lk}$ .  
*Constraint:*  $\mathbf{k}[j - 1] \geq 0$ , for  $j = 1, 2, \dots, \mathbf{lk}$ .
- 5: **plek[*dim*]** – double *Output*  
**Note:** the dimension, *dim*, of the array **plek** must be at least  $\max(\mathbf{ll}, \mathbf{lk})$ .  
*On exit:*  $\text{Prob}\{X_i \leq k_i\}$ , the lower tail probabilities.
- 6: **pgtk[*dim*]** – double *Output*  
**Note:** the dimension, *dim*, of the array **pgtk** must be at least  $\max(\mathbf{ll}, \mathbf{lk})$ .  
*On exit:*  $\text{Prob}\{X_i > k_i\}$ , the upper tail probabilities.
- 7: **peqk[*dim*]** – double *Output*  
**Note:** the dimension, *dim*, of the array **peqk** must be at least  $\max(\mathbf{ll}, \mathbf{lk})$ .  
*On exit:*  $\text{Prob}\{X_i = k_i\}$ , the point probabilities.
- 8: **ivalid[*dim*]** – Integer *Output*  
**Note:** the dimension, *dim*, of the array **ivalid** must be at least  $\max(\mathbf{ll}, \mathbf{lk})$ .  
*On exit:* **ivalid**[*i* - 1] indicates any errors with the input arguments, with  
**ivalid**[*i* - 1] = 0  
     No error.  
**ivalid**[*i* - 1] = 1  
     On entry,  $\lambda_i \leq 0.0$ .  
**ivalid**[*i* - 1] = 2  
     On entry,  $k_i < 0$ .  
**ivalid**[*i* - 1] = 3  
     On entry,  $\lambda_i > 10^6$ .
- 9: **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 3.2.1.2 in How to Use the NAG Library and its Documentation for further information.

### NE\_ARRAY\_SIZE

On entry, array size = *<value>*.

Constraint: **lk** > 0.

On entry, array size = *<value>*.

Constraint: **ll** > 0.

**NE\_BAD\_PARAM**

On entry, argument *<value>* 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 3.6.6 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 3.6.5 in How to Use the NAG Library and its Documentation for further information.

**NW\_INVALID**

On entry, at least one value of **l** or **k** was invalid.  
Check **ivalid** for more information.

**7 Accuracy**

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

**8 Parallelism and Performance**

nag\_prob\_poisson\_vector (g01skc) is not threaded in any implementation.

**9 Further Comments**

The time taken by nag\_prob\_poisson\_vector (g01skc) to calculate each probability depends on  $\lambda_i$  and  $k_i$ . For given  $\lambda_i$ , the time is greatest when  $k_i \approx \lambda_i$ , and is then approximately proportional to  $\sqrt{\lambda_i}$ .

**10 Example**

This example reads a vector of values for  $\lambda$  and  $k$ , and prints the corresponding probabilities.

**10.1 Program Text**

```

/* nag_prob_poisson_vector (g01skc) Example Program.
 *
 * NAGPRODCODE Version.
 *
 * Copyright 2016 Numerical Algorithms Group.
 *
 * Mark 26, 2016.
 */
#include <stdio.h>
#include <nag.h>
#include <nag_stdlib.h>
#include <nagg01.h>

int main(void)
{
    /* Integer scalar and array declarations */
    Integer lk, ll, i, lout;
    Integer *ivalid = 0, *k = 0;
    Integer exit_status = 0;

    /* NAG structures */
    NagError fail;

```

```

/* Double scalar and array declarations */
double *peqk = 0, *pgtk = 0, *plek = 0, *l = 0;

/* Initialize the error structure to print out any error messages */
INIT_FAIL(fail);

printf("nag_prob_poisson_vector (g01skc) Example Program Results\n\n");

/* Skip heading in data file */
#ifdef _WIN32
scanf_s("%*[\n] ");
#else
scanf("%*[\n] ");
#endif

#ifdef _WIN32
scanf_s("%" NAG_IFMT "%*[\n] ", &l1);
#else
scanf("%" NAG_IFMT "%*[\n] ", &l1);
#endif
if (!(l = NAG_ALLOC(l1, double)))
{
printf("Allocation failure\n");
exit_status = -1;
goto END;
}
for (i = 0; i < l1; i++)
#ifdef _WIN32
scanf_s("%lf", &l[i]);
#else
scanf("%lf", &l[i]);
#endif
#ifdef _WIN32
scanf_s("%*[\n] ");
#else
scanf("%*[\n] ");
#endif

#ifdef _WIN32
scanf_s("%" NAG_IFMT "%*[\n] ", &l2);
#else
scanf("%" NAG_IFMT "%*[\n] ", &l2);
#endif
if (!(k = NAG_ALLOC(l2, Integer)))
{
printf("Allocation failure\n");
exit_status = -1;
goto END;
}
for (i = 0; i < l2; i++)
#ifdef _WIN32
scanf_s("%" NAG_IFMT "", &k[i]);
#else
scanf("%" NAG_IFMT "", &k[i]);
#endif
#ifdef _WIN32
scanf_s("%*[\n] ");
#else
scanf("%*[\n] ");
#endif

/* Allocate memory for output */
lout = MAX(l1, l2);
if (!(peqk = NAG_ALLOC(lout, double)) ||
!(pgtk = NAG_ALLOC(lout, double)) ||
!(plek = NAG_ALLOC(lout, double)) ||
!(ivalid = NAG_ALLOC(lout, Integer)))
{
printf("Allocation failure\n");
exit_status = -1;
}

```

```

    goto END;
}

/* Calculate probability */
nag_prob_poisson_vector(l1, l, lk, k, plek, pgtk, peqk, ivalid, &fail);
if (fail.code != NE_NOERROR) {
    printf("Error from nag_prob_poisson_vector (g01skc).\n%s\n",
           fail.message);
    exit_status = 1;
    if (fail.code != NW_IVALID)
        goto END;
}

/* Display title */
printf("      l          k          plek          pgtk          peqk  ivalid\n");
printf("-----\n");

/* Display results */
for (i = 0; i < lout; i++)
    printf(" %6.2f      %6" NAG_IFMT "      %6.3f      %6.3f      %6.3f      %3" NAG_IFMT
           "\n", l[i % l1], k[i % lk], plek[i], pgtk[i], peqk[i], ivalid[i]);

END:
    NAG_FREE(l);
    NAG_FREE(k);
    NAG_FREE(plek);
    NAG_FREE(pgtk);
    NAG_FREE(peqk);
    NAG_FREE(ivalid);

    return (exit_status);
}

```

## 10.2 Program Data

```

nag_prob_poisson_vector (g01skc) Example Program Data
4
0.75 9.20 34.0 175.0
4
3 12 25 175
:: l1
:: l
:: lk
:: k

```

## 10.3 Program Results

nag\_prob\_poisson\_vector (g01skc) Example Program Results

l	k	plek	pgtk	peqk	ivalid
0.75	3	0.993	0.007	0.033	0
9.20	12	0.861	0.139	0.078	0
34.00	25	0.067	0.933	0.021	0
175.00	175	0.520	0.480	0.030	0