

# NAG Library Routine Document

## G01BKF

**Note:** before using this routine, please read the Users' Note for your implementation to check the interpretation of *bold italicised* terms and other implementation-dependent details.

### 1 Purpose

G01BKF returns the lower tail, upper tail and point probabilities associated with a Poisson distribution.

### 2 Specification

```
SUBROUTINE G01BKF (RLAMDA, K, PLEK, PGTK, PEQK, IFAIL)
  INTEGER          K, IFAIL
  REAL (KIND=nag_wp) RLAMDA, PLEK, PGTK, PEQK
```

### 3 Description

Let  $X$  denote a random variable having a Poisson distribution with parameter  $\lambda (> 0)$ . Then

$$\text{Prob}\{X = k\} = e^{-\lambda} \frac{\lambda^k}{k!}, \quad k = 0, 1, 2, \dots$$

The mean and variance of the distribution are both equal to  $\lambda$ .

G01BKF computes for given  $\lambda$  and  $k$  the probabilities:

$$\begin{aligned} \text{PLEK} &= \text{Prob}\{X \leq k\} \\ \text{PGTK} &= \text{Prob}\{X > k\} \\ \text{PEQK} &= \text{Prob}\{X = k\}. \end{aligned}$$

The method is described in Knüsel (1986).

### 4 References

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

### 5 Parameters

- |    |  |               |
|----|--|---------------|
| 1: | RLAMDA – REAL (KIND=nag_wp)<br><i>On entry:</i> the parameter $\lambda$ of the Poisson distribution.<br><i>Constraint:</i> $0.0 < \text{RLAMDA} \leq 10^6$ . | <i>Input</i>  |
| 2: | K – INTEGER<br><i>On entry:</i> the integer $k$ which defines the required probabilities.<br><i>Constraint:</i> $K \geq 0$ .                                 | <i>Input</i>  |
| 3: | PLEK – REAL (KIND=nag_wp)<br><i>On exit:</i> the lower tail probability, $\text{Prob}\{X \leq k\}$ .   | <i>Output</i> |
| 4: | PGTK – REAL (KIND=nag_wp)<br><i>On exit:</i> the upper tail probability, $\text{Prob}\{X > k\}$ .  | <i>Output</i> |

- 5: PEQK – REAL (KIND=nag\_wp) *Output*  
*On exit:* the point probability,  $\text{Prob}\{X = k\}$ .
- 6: IFAIL – INTEGER *Input/Output*  
*On entry:* IFAIL must be set to 0, -1 or 1. If you are unfamiliar with this parameter you should refer to Section 3.3 in the Essential Introduction for details.  
 For environments where it might be inappropriate to halt program execution when an error is detected, the value -1 or 1 is recommended. If the output of error messages is undesirable, then the value 1 is recommended. Otherwise, if you are not familiar with this parameter, the recommended value is 0. **When the value -1 or 1 is used it is essential to test the value of IFAIL on exit.**  
*On exit:* IFAIL = 0 unless the routine detects an error or a warning has been flagged (see Section 6).

## 6 Error Indicators and Warnings

If on entry IFAIL = 0 or -1, explanatory error messages are output on the current error message unit (as defined by X04AAF).

Errors or warnings detected by the routine:

IFAIL = 1

On entry,  $\text{RLAMDA} \leq 0.0$ .

IFAIL = 2

On entry,  $K < 0$ .

IFAIL = 3

On entry,  $\text{RLAMDA} > 10^6$ .

IFAIL = -99

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

See Section 3.8 in the Essential Introduction for further information.

IFAIL = -399

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

See Section 3.7 in the Essential Introduction for further information.

IFAIL = -999

Dynamic memory allocation failed.

See Section 3.6 in the Essential Introduction for further 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, and to a relative accuracy of at least  $10^{-3}$  on machines of lower precision (provided that the results do not underflow to zero).

## 8 Parallelism and Performance

Not applicable.

## 9 Further Comments

The time taken by G01BKF depends on  $\lambda$  and  $k$ . For given  $\lambda$ , the time is greatest when  $k \approx \lambda$ , and is then approximately proportional to  $\sqrt{\lambda}$ .

## 10 Example

This example reads values of  $\lambda$  and  $k$  from a data file until end-of-file is reached, and prints the corresponding probabilities.

### 10.1 Program Text

```

Program g01bkfe

!      G01BKF Example Program Text

!      Mark 25 Release. NAG Copyright 2014.

!      .. Use Statements ..
      Use nag_library, Only: g01bkf, nag_wp
!      .. Implicit None Statement ..
      Implicit None
!      .. Parameters ..
      Integer, Parameter          :: nin = 5, nout = 6
!      .. Local Scalars ..
      Real (Kind=nag_wp)          :: peqk, pgtk, plek, rlamda
      Integer                      :: ifail, k
!      .. Executable Statements ..
      Write (nout,*) 'G01BKF Example Program Results'
      Write (nout,*)

!      Skip heading in data file
      Read (nin,*)

!      Display titles
      Write (nout,*) '      RLAMDA      K      PLEK      PGTK      PEQK'
      Write (nout,*)

!      Loop over all data
d_lp: Do
      Read (nin,*,Iostat=ifail) rlamda, k
      If (ifail/=0) Then
!          All data processed
          Exit d_lp
      End If

!          Calculate probability
          ifail = 0
          Call g01bkf(rlamda,k,plek,pgtk,peqk,ifail)

!          Display results
          Write (nout,99999) rlamda, k, plek, pgtk, peqk
      End Do d_lp

99999 Format (1X,F10.3,I6,3F10.5)
      End Program g01bkfe

```

### 10.2 Program Data

```

G01BKF Example Program Data
  0.75      3      : RLAMDA, K
  9.20     12
 34.00     25
175.00    175

```

### 10.3 Program Results

G01BKF Example Program Results

| RLAMDA  | K   | PLEK    | PGTK    | PEQK    |
|---------|-----|---------|---------|---------|
| 0.750   | 3   | 0.99271 | 0.00729 | 0.03321 |
| 9.200   | 12  | 0.86074 | 0.13926 | 0.07755 |
| 34.000  | 25  | 0.06736 | 0.93264 | 0.02140 |
| 175.000 | 175 | 0.52009 | 0.47991 | 0.03014 |

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