

# NAG Library Routine Document

## G05TKF

**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

G05TKF generates a vector of pseudorandom integers, each from a discrete Poisson distribution with differing parameter.

### 2 Specification

```
SUBROUTINE G05TKF (M, VLAMDA, STATE, X, IFAIL)
INTEGER          M, STATE(*), X(M), IFAIL
REAL (KIND=nag_wp) VLAMDA(M)
```

### 3 Description

G05TKF generates  $m$  integers  $x_j$ , each from a discrete Poisson distribution with mean  $\lambda_j$ , where the probability of  $x_j = I$  is

$$P(x_j = I) = \frac{\lambda_j^I \times e^{-\lambda_j}}{I!}, \quad I = 0, 1, \dots,$$

where

$$\lambda_j \geq 0, \quad j = 1, 2, \dots, m.$$

The methods used by this routine have low set up times and are designed for efficient use when the value of the parameter  $\lambda$  changes during the simulation. For large samples from a distribution with fixed  $\lambda$  using G05TJF to set up and use a reference vector may be more efficient.

When  $\lambda < 7.5$  the product of uniforms method is used, see for example Dagpunar (1988). For larger values of  $\lambda$  an envelope rejection method is used with a target distribution:

$$f(x) = \frac{1}{3} \quad \text{if } |x| \leq 1,$$

$$f(x) = \frac{1}{3}|x|^{-3} \quad \text{otherwise.}$$

This distribution is generated using a ratio of uniforms method. A similar approach has also been suggested by Ahrens and Dieter (1989). The basic method is combined with quick acceptance and rejection tests given by Maclaren (1990). For values of  $\lambda \geq 87$  Stirling's approximation is used in the computation of the Poisson distribution function, otherwise tables of factorials are used as suggested by Maclaren (1990).

One of the initialization routines G05KFF (for a repeatable sequence if computed sequentially) or G05KGF (for a non-repeatable sequence) must be called prior to the first call to G05TKF.

### 4 References

Ahrens J H and Dieter U (1989) A convenient sampling method with bounded computation times for Poisson distributions *Amer. J. Math. Management Sci.* 1–13

Dagpunar J (1988) *Principles of Random Variate Generation* Oxford University Press

Maclaren N M (1990) A Poisson random number generator *Personal Communication*

## 5 Parameters

- 1: M – INTEGER *Input*  
*On entry:*  $m$ , the number of Poisson distributions for which pseudorandom variates are required.  
*Constraint:*  $M \geq 1$ .
- 2: VLAMDA(M) – REAL (KIND=nag\_wp) array *Input*  
*On entry:* the means,  $\lambda_j$ , for  $j = 1, 2, \dots, M$ , of the Poisson distributions.  
*Constraint:*  $0.0 \leq \text{VLAMDA}(j) \leq \text{X02BBF}/2.0$ , for  $j = 1, 2, \dots, M$ .
- 3: STATE(\*) – INTEGER array *Communication Array*  
**Note:** the actual argument supplied must be the array STATE supplied to the initialization routines G05KFF or G05KGF.  
*On entry:* contains information on the selected base generator and its current state.  
*On exit:* contains updated information on the state of the generator.
- 4: X(M) – INTEGER array *Output*  
*On exit:* the  $m$  pseudorandom numbers from the specified Poisson distributions.
- 5: 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,  $M < 1$ .

IFAIL = 2

On entry,  $\text{VLAMDA}(j) < 0.0$  for at least one value of  $j$ .

On entry,  $2 \times \text{VLAMDA}(j) > \text{X02BBF}()$  for at least one value of  $j$ .

IFAIL = 3

On entry, STATE vector was not initialized or has been corrupted.

## 7 Accuracy

Not applicable.

## 8 Further Comments

None.

## 9 Example

This example prints ten pseudorandom integers from five Poisson distributions with means  $\lambda_1 = 0.5$ ,  $\lambda_2 = 5$ ,  $\lambda_3 = 10$ ,  $\lambda_4 = 500$  and  $\lambda_5 = 1000$ . These are generated by ten calls to G05TKF, after initialization by G05KFF.

### 9.1 Program Text

```

Program g05tkfe

!      G05TKF Example Program Text

!      Mark 24 Release. NAG Copyright 2012.

!      .. Use Statements ..
Use nag_library, Only: g05kff, g05tkf, nag_wp
!      .. Implicit None Statement ..
Implicit None
!      .. Parameters ..
Integer, Parameter          :: lseed = 1, nin = 5, nout = 6
!      .. Local Scalars ..
Integer                     :: genid, i, ifail, lstate, m, n, subid
!      .. Local Arrays ..
Real (Kind=nag_wp), Allocatable :: lambda(:)
Integer                     :: seed(lseed)
Integer, Allocatable        :: state(:), x(:)
!      .. Executable Statements ..
Write (nout,*) 'G05TKF Example Program Results'
Write (nout,*)

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

!      Read in the base generator information and seed
Read (nin,*) genid, subid, seed(1)

!      Initial call to initialiser to get size of STATE array
lstate = 0
Allocate (state(lstate))
ifail = 0
Call g05kff(genid,subid,seed,lseed,state,lstate,ifail)

!      Reallocate STATE
Deallocate (state)
Allocate (state(lstate))

!      Initialize the generator to a repeatable sequence
ifail = 0
Call g05kff(genid,subid,seed,lseed,state,lstate,ifail)

!      Read in sample size
Read (nin,*) n

!      Read in the distribution parameters
Read (nin,*) m

Allocate (x(n),lambda(m))

!      Read in rest of distribution parameters
Read (nin,*) lambda(1:m)

!      Generate N sets of the M variates
Do i = 1, n
    ifail = 0

```

```

      Call g05tkf(m,lambda,state,x,ifail)

!      Display the variates
      Write (nout,99999) i, x(1:m)
      End Do

99999 Format (1X,6(1X,I12))
      End Program g05tkfe

```

## 9.2 Program Data

```

G05TKF Example Program Data
1 1 1762543          :: GENID,SUBID,SEED(1)
10                  :: N
5                   :: M
0.5 5.0 10.0 500.0 1000.0 :: LAMBDA

```

## 9.3 Program Results

G05TKF Example Program Results

1	1	6	12	507	1003
2	0	9	11	520	1028
3	1	3	7	483	1041
4	0	3	11	513	1012
5	1	5	9	496	940
6	0	6	17	548	990
7	1	9	8	512	1035
8	0	4	10	458	1029
9	1	6	13	523	971
10	0	9	16	519	999

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