

## NAG C Library Function Document

### nag\_rngs\_gamma (g05lfc)

#### 1 Purpose

nag\_rngs\_gamma (g05lfc) generates a vector of pseudo-random numbers taken from a gamma distribution with  $a$  and  $b$ .

#### 2 Specification

```
#include <nag.h>
#include <nagg05.h>
```

```
void nag_rngs_gamma (double a, double b, Integer n, double x[], Integer igen,
                    Integer iseed[], NagError *fail)
```

#### 3 Description

The gamma distribution has PDF (probability density function)

$$f(x) = \frac{1}{b^a \Gamma(a)} x^{a-1} e^{-x/b} \quad \text{if } 0 \leq x; \quad a, b > 0.0$$

$$f(x) = 0 \quad \text{otherwise.}$$

One of three algorithms is used to generate the variates depending upon the value of  $a$ :

- (i) if  $a < 1$ , a switching algorithm described by Dagpunar (1988) (called G6) is used. The target distributions are  $f_1(x) = cax^{a-1}/t^a$  and  $f_2(x) = (1-c)e^{-(x-t)}$ , where  $c = t/(t + ae^{-t})$ , and the switching argument,  $t$ , is taken as  $1 - a$ . This is similar to Ahrens and Dieter's GS algorithm (see Ahrens and Dieter (1974)) in which  $t = 1$ ;
- (ii) if  $a = 1$ , the gamma distribution reduces to the exponential distribution and the method based on the logarithmic transformation of a uniform random variate is used;
- (iii) if  $a > 1$ , the algorithm given by Best (1978) is used. This is based on using a Student's  $t$ -distribution with two degrees of freedom as the target distribution in an envelope rejection method.

One of the initialization functions nag\_rngs\_init\_repeatable (g05kbc) (for a repeatable sequence if computed sequentially) or nag\_rngs\_init\_nonrepeatable (g05kcc) (for a non-repeatable sequence) must be called prior to the first call to nag\_rngs\_gamma (g05lfc).

#### 4 References

Ahrens J H and Dieter U (1974) Computer methods for sampling from gamma, beta, Poisson and binomial distributions *Computing* **12** 223–46

Best D J (1978) Letter to the Editor *Appl. Statist.* **27** 181

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

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

#### 5 Arguments

1: **a** – double

*Input*

*On entry:*  $a$ , the argument of the gamma distribution.

*Constraint:*  $a > 0.0$ .

- 2: **b** – double *Input*  
*On entry:* *b*, the argument of the gamma distribution.  
*Constraint:*  $\mathbf{b} > 0.0$ .
- 3: **n** – Integer *Input*  
*On entry:* *n*, the number of pseudo-random numbers to be generated.  
*Constraint:*  $\mathbf{n} \geq 0$ .
- 4: **x**[*dim*] – double *Output*  
**Note:** the dimension, *dim*, of the array **x** must be at least  $\max(1, \mathbf{n})$ .  
*On exit:* the *n* pseudo-random numbers from the specified gamma distribution.
- 5: **igen** – Integer *Input*  
*On entry:* must contain the identification number for the generator to be used to return a pseudo-random number and should remain unchanged following initialization by a prior call to one of the functions nag\_rngs\_init\_repeatable (g05kbc) or nag\_rngs\_init\_nonrepeatable (g05kcc).
- 6: **iseed**[4] – Integer *Input/Output*  
*On entry:* contains values which define the current state of the selected generator.  
*On exit:* contains updated values defining the new state of the selected generator.
- 7: **fail** – NagError \* *Input/Output*  
The NAG error argument (see Section 2.6 of the Essential Introduction).

## 6 Error Indicators and Warnings

### NE\_BAD\_PARAM

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

### NE\_INT

On entry,  $\mathbf{n} = \langle value \rangle$ .  
Constraint:  $\mathbf{n} \geq 0$ .

### 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.

### NE\_REAL

On entry,  $\mathbf{a} = \langle value \rangle$ .  
Constraint:  $\mathbf{a} > 0.0$ .  
On entry,  $\mathbf{b} = \langle value \rangle$ .  
Constraint:  $\mathbf{b} > 0.0$ .

## 7 Accuracy

Not applicable.

## 8 Further Comments

None.

## 9 Example

The example program prints a set of five pseudo-random numbers from a gamma distribution with arguments  $a = 5.0$  and  $b = 1.0$ , generated by a single call to `nag_rngs_gamma` (g05lfc), after initialization by `nag_rngs_init_repeatable` (g05kbc).

### 9.1 Program Text

```

/* nag_rngs_gamma (g05lfc) Example Program.
 *
 * Copyright 2001 Numerical Algorithms Group.
 *
 * Mark 7, 2001.
 */

#include <stdio.h>
#include <nag.h>
#include <nag_stdlib.h>
#include <nagg05.h>

int main(void)
{
    /* Scalars */
    Integer igen, j, n;
    Integer exit_status=0;
    NagError fail;

    /* Arrays */
    double *x=0;
    Integer iseed[4];

    INIT_FAIL(fail);
    Vprintf("nag_rngs_gamma (g05lfc) Example Program Results\n\n");

    n = 5;
    /* Allocate memory */
    if ( !(x = NAG_ALLOC(n, double)) )
    {
        Vprintf("Allocation failure\n");
        exit_status = -1;
        goto END;
    }

    /* Initialise the seed to a repeatable sequence */
    iseed[0] = 1762543;
    iseed[1] = 9324783;
    iseed[2] = 42344;
    iseed[3] = 742355;
    /* igen identifies the stream. */
    igen = 1;
    /* nag_rngs_init_repeatable (g05kbc).
     * Initialize seeds of a given generator for random number
     * generating functions (that pass seeds explicitly) to give
     * a repeatable sequence
     */
    nag_rngs_init_repeatable(&igen, iseed);

    Vprintf("Gamma Dist --- A=5.0, B=1.0\n");

    /* nag_rngs_gamma (g05lfc).
     * Generates a vector of random numbers from a gamma
     * distribution, seeds and generator number passed
     * explicitly
     */
    nag_rngs_gamma(5.0, 1.0, n, x, igen, iseed, &fail);
    if (fail.code != NE_NOERROR)
    {
        Vprintf("Error from nag_rngs_gamma (g05lfc).\n%s\n", fail.message);
        exit_status = 1;
    }
}

```

```
        goto END;
    }
    for (j = 0; j < n; ++j)
    {
        vprintf("%10.4f\n", x[j]);
    }
END:
    if (x) NAG_FREE(x);
    return exit_status;
}
```

## 9.2 Program Data

None.

## 9.3 Program Results

nag\_rngs\_gamma (g05lfc) Example Program Results

```
Gamma Dist --- A=5.0, B=1.0
 3.2806
 4.6512
 4.0683
 4.6252
 7.6745
```

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