NAG Library Function Document

nag_rand_cauchy (g05scc)

1 Purpose

nag_rand_cauchy (g05scc) generates a vector of pseudorandom numbers from a Cauchy distribution with median a and semi-interquartile range b.

2 Specification

```
#include <nag.h>
#include <nagg05.h>
void nag_rand_cauchy (Integer n, double xmed, double semiqr, Integer state[],
     double x[], NagError *fail)
```

3 Description

The distribution has PDF (probability density function)

$$f(x) = \frac{1}{\pi b\left(1 + \left(\frac{x-a}{b}\right)^2\right)}.$$

nag_rand_cauchy (g05scc) returns the value

$$a + b\frac{2y_1 - 1}{y_2},$$

where y_1 and y_2 are a pair of consecutive pseudorandom numbers from a uniform distribution over $(0, 1)$, such that

$$(2y_1 - 1)^2 + y_2^2 \leq 1.$$

One of the initialization functions nag_rand_init_repeatable (g05kfc) (for a repeatable sequence if computed sequentially) or nag_rand_init_nonrepeatable (g05kgc) (for a non-repeatable sequence) must be called prior to the first call to nag_rand_cauchy (g05scc).

4 References

Kendall M G and Stuart A (1969) *The Advanced Theory of Statistics (Volume 1)* (3rd Edition) Griffin

Knuth D E (1981) *The Art of Computer Programming (Volume 2)* (2nd Edition) Addison–Wesley

5 Arguments

1: **n** – Integer *Input*

On entry: n, the number of pseudorandom numbers to be generated.

Constraint: $\mathbf{n} \geq 0$.

2: **xmed** – double *Input*

On entry: a, the median of the distribution.

3: **semiqr** – double *Input*

On entry: b, the semi-interquartile range of the distribution.

Constraint: **semiqr** ≥ 0.0.

4: **state**[dim] – Integer *Communication Array*

Note: the dimension, dim, of this array is dictated by the requirements of associated functions that must have been previously called. This array MUST be the same array passed as argument **state** in the previous call to nag_rand_init_repeatable (g05kfc) or nag_rand_init_nonrepeatable (g05kgc).

On entry: contains information on the selected base generator and its current state.

On exit: contains updated information on the state of the generator.

5: **x**[**n**] – double *Output*

On exit: the n pseudorandom numbers from the specified Cauchy distribution.

6: **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_BAD_PARAM

On entry, argument ⟨*value*⟩ had an illegal value.

NE_INT

On entry, **n** = ⟨*value*⟩.
Constraint: **n** ≥ 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 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_INVALID_STATE

On entry, **state** vector has been corrupted or not initialized.

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.

NE_REAL

On entry, **semiqr** = ⟨*value*⟩.
Constraint: **semiqr** ≥ 0.0.

7 Accuracy

Not applicable.

8 Parallelism and Performance

nag_rand_cauchy (g05scc) is threaded by NAG for parallel execution in multithreaded implementations of the NAG Library.

Please consult the x06 Chapter Introduction for information on how to control and interrogate the OpenMP environment used within this function. Please also consult the Users' Notefor your implementation for any additional implementation-specific information.

9 Further Comments

None.

10 Example

This example prints the first five pseudorandom real numbers from a Cauchy distribution with median 1.0 and semi-interquartile range 2.0, generated by a single call to nag_rand_cauchy (g05scc), after initialization by nag_rand_init_repeatable (g05kfc).

10.1 Program Text

```
/* nag_rand_cauchy (g05scc) Example Program.
 *
 * NAGPRODCODE Version.
 *
 * Copyright 2016 Numerical Algorithms Group.
 *
 * Mark 26, 2016.
 */
/* Pre-processor includes */
#include <stdio.h>
#include <math.h>
#include <nag.h>
#include <nag_stdlib.h>
#include <nagg05.h>

int main(void)
{
  /* Integer scalar and array declarations */
  Integer exit_status = 0;
  Integer i, lstate;
  Integer *state = 0;

  /* NAG structures */
  NagError fail;

  /* Double scalar and array declarations */
  double *x = 0;

  /* Set the distribution parameters */
  double xmed = 1.0e0;
  double semiqr = 2.0e0;

  /* Set the sample size */
  Integer n = 5;

  /* Choose the base generator */
  Nag_BaseRNG genid = Nag_Basic;
  Integer subid = 0;

  /* Set the seed */
  Integer seed[] = { 1762543 };
```

```
  Integer lseed = 1;

  /* Initialize the error structure */
  INIT_FAIL(fail);

  printf("nag_rand_cauchy (g05scc) Example Program Results\n\n");

  /* Get the length of the state array */
  lstate = -1;
  nag_rand_init_repeatable(genid, subid, seed, lseed, state, &lstate, &fail);
  if (fail.code != NE_NOERROR) {
    printf("Error from nag_rand_init_repeatable (g05kfc).\n%s\n",
           fail.message);
    exit_status = 1;
    goto END;
  }

  /* Allocate arrays */
  if (!(x = NAG_ALLOC(n, double)) || !(state = NAG_ALLOC(lstate, Integer)))
  {
    printf("Allocation failure\n");
    exit_status = -1;
    goto END;
  }

  /* Initialize the generator to a repeatable sequence */
  nag_rand_init_repeatable(genid, subid, seed, lseed, state, &lstate, &fail);
  if (fail.code != NE_NOERROR) {
    printf("Error from nag_rand_init_repeatable (g05kfc).\n%s\n",
           fail.message);
    exit_status = 1;
    goto END;
  }

  /* Generate the variates */
  nag_rand_cauchy(n, xmed, semiqr, state, x, &fail);
  if (fail.code != NE_NOERROR) {
    printf("Error from nag_rand_cauchy (g05scc).\n%s\n", fail.message);
    exit_status = 1;
    goto END;
  }

  /* Display the variates */
  for (i = 0; i < n; i++)
    printf("%10.4f\n", x[i]);

END:
  NAG_FREE(x);
  NAG_FREE(state);

  return exit_status;
}
```

10.2 Program Data

None.

10.3 Program Results

```
nag_rand_cauchy (g05scc) Example Program Results

    6.1229
    2.2328
   -2.2118
    0.4118
    0.9892
```