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 3.6 in the Essential Introduction).

6 Error Indicators and Warnings

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.

NE_INVALID_STATE

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

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 Users' Note for 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.
 *
 * Copyright 2008, Numerical Algorithms Group.
 *
 * Mark 9, 2009.
 */
/* 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;

  /* Initialise 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;
    }

  /* Initialise 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
```