NAG Library Function Document

nag_scaled_log_gamma (s14ahc)

1 Purpose
nag_scaled_log_gamma (s14ahc) returns the value of \( \ln G(x) \), the scaled logarithm of the gamma function \( \Gamma(x) \).

2 Specification
#include <nag.h>
#include <nags.h>
double nag_scaled_log_gamma (double x, NagError *fail)

3 Description
nag_scaled_log_gamma (s14ahc) calculates an approximate value for \( \ln G(x) \), where
\[
G(x) = \Gamma(x + 1)/x^x.
\]
This is a variant of the \( \ln \Gamma(x) \) function (see also nag_log_gamma (s14abc)), which avoids rounding problems for very large arguments by computing \( \ln \Gamma(x) \) with the Stirling approximation factored out.
For 0 < x < 15, \( \ln G(x) = \ln \Gamma(x + 1) - x \ln x + x \); 
and for 15 \leq x, \( \ln G(x) = \frac{1}{2} \ln x + \ln(\sqrt{2\pi}) + \frac{1}{2} R(1/x^2) \), where \( R \) is a suitable Remez approximation.
For x \leq 0.0, the value \( \ln G(x) \) is undefined; nag_scaled_log_gamma (s14ahc) returns zero and exits with fail.code = NE_REAL_ARG_LE.

4 References

5 Arguments
1: x – double
   Input
   On entry: the argument x of the function.
   Constraint: x > 0.0.

2: fail – NagError *
   Input/Output
   The NAG error argument (see Section 3.6 in the Essential Introduction).

6 Error Indicators and Warnings

NE_ALLOC_FAIL
Dynamic memory allocation failed.
See Section 3.2.1.2 in the Essential Introduction for further information.

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 the Essential Introduction for further information.

**NE_NO_LICENCE**

Your licence key may have expired or may not have been installed correctly. See Section 3.6.5 in the Essential Introduction for further information.

**NE_REAL_ARG_LE**

On entry, \(x = \langle\text{value}\rangle\).
Constraint: \(x > 0.0\).

7 **Accuracy**
nag_scaled_log_gamma (s14ahc) has been designed to produce full relative accuracy for all input arguments. Empirical results obtained by comparing with multiprecision software confirm this.

8 **Parallelism and Performance**

Not applicable.

9 **Further Comments**

None.

10 **Example**

This example reads values of the argument \(x\) from a file, evaluates the function at each value of \(x\) and prints the results.

10.1 **Program Text**

```c
/* nag_scaled_log_gamma (s14ahc) Example Program.
 * Copyright 2014 Numerical Algorithms Group.
 * Mark 9, 2009.
 */
#include <stdio.h>
#include <nag.h>
#include <nag_stdlib.h>
#include <nags.h>

int main(void)
{
    /*Integer scalar and array declarations */
    Integer exit_status = 0;
    /*Double scalar and array declarations */
    double x, y;
    NagError fail;
    INIT_FAIL(fail);

    printf("nag_scaled_log_gamma (s14ahc) Example Program Results\n");
    /* Skip heading in data file*/
    #ifdef _WIN32
    scanf_s("%*[\n ]");
    #else
    scanf("%*[\n ]");
    #endif
    printf("%s%sn", "   x   y");
```
```c
#define _WIN32
while (scanf_s("%lf%*[^
] ", &x) != EOF)
#else
while (scanf("%lf%*[^
] ", &x) != EOF)
#endif
{
    /*
    * nag_scaled_log_gamma (s14ahc)
    * Scaled logarithm of Gamma function, G(x)
    */
    y = nag_scaled_log_gamma(x, &fail);
    if (fail.code != NE_NOERROR)
    {
        printf("Error from nag_scaled_log_gamma (s14ahc) %s\n",
                fail.message);
        exit_status = 1;
        goto END;
    }
    printf("%14.5e%14.5e\n", x, y);
}
END:
    return exit_status;
}

10.2 Program Data
nag_scaled_log_gamma (s14ahc) Example Program Data
    1.0
    1.25
    1.5
    1.75
    2.0
    5.0
    10.0
    20.0
    1000.0

10.3 Program Results
nag_scaled_log_gamma (s14ahc) Example Program Results
    x     y
    1.00000e+00  1.00000e+00
    1.25000e+00  1.09594e+00
    1.50000e+00  1.17649e+00
    1.75000e+00  1.24589e+00
    2.00000e+00  1.30685e+00
    5.00000e+00  1.74030e+00
    1.00000e+01  2.07856e+00
    2.00000e+01  2.42097e+00
    1.00000e+03  4.37290e+00
```
Example Program
Returns the Value of $\ln G(x)$, the Scaled Logarithm of the Gamma Function $\Gamma(x)$