# NAG Library Function Document

# nag_struve_i1ml1 (s18gdc)

## 1 Purpose

**nag_struve_i1ml1 (s18gdc)** returns the value of $I_1(x) - L_1(x)$ where $I_1(x)$ is the modified Bessel function of the first kind of order 1, and $L_1(x)$ is the modified Struve function of order 1.

## 2 Specification

```
#include <nag.h>
#include <nags.h>
double nag_struve_i1ml1 (double x, NagError *fail)
```

## 3 Description

**nag_struve_i1ml1 (s18gdc)** evaluates an approximation to $I_1(x) - L_1(x)$.

Please consult the NIST Digital Library of Mathematical Functions for a detailed discussion of the Struve function including special cases, transformations, relations and asymptotic approximations.

The approximation method used by this function is based on Chebyshev expansions.

## 4 References

NIST Digital Library of Mathematical Functions

MacLeod A J (1996) MISCFUN, a software package to compute uncommon special functions *ACM Trans. Math. Software (TOMS)* **22(3)** 288–301

## 5 Arguments

1: **x** – double *Input*

*On entry*: the argument $x$ of the function.

*Constraint*: **x** $\geq 0.0$.

2: **fail** – NagError * *Input/Output*

The NAG error argument (see Section 3.7 in How to Use the NAG Library and its Documentation).

## 6 Error Indicators and Warnings

**NE_ALLOC_FAIL**

Dynamic memory allocation failed.
See Section 2.3.1.2 in How to Use the NAG Library and its Documentation 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.
See Section 2.7.6 in How to Use the NAG Library and its Documentation for further information.

**NE_NO_LICENCE**

Your licence key may have expired or may not have been installed correctly.
See Section 2.7.5 in How to Use the NAG Library and its Documentation for further information.

**NE_REAL**

On entry, $\mathbf{x} = \langle value \rangle$.
Constraint: $\mathbf{x} \geq 0.0$.

## 7 Accuracy

The Chebyshev coefficients used by this function are internally represented to 20 digits of precision. Calling the number of digits of precision in the floating-point arithmetic being used $t$, then clearly the maximum number of correct digits in the results obtained is limited by $p = \min(t, 20)$.

Apart from this, rounding errors in internal arithmetic may result in a slight loss of accuracy, but it is reasonable to assume that the result is accurate to within a small multiple of the ***machine precision***.

## 8 Parallelism and Performance

**nag_struve_i1ml1 (s18gdc)** is not threaded in any implementation.

## 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

```
/* nag_struve_i1ml1 (s18gdc) Example Program.
 *
 * Copyright 2017 Numerical Algorithms Group.
 *
 * Mark 26.1, 2017.
 */

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

int main(void)
{
  Integer exit_status = 0;
  double x, y;
  /* Nag Types */
  NagError fail;

  INIT_FAIL(fail);

  /* Skip heading in data file */
#ifdef _WIN32
  scanf_s("%*[^\n]");
#else
  scanf("%*[^\n]");
#endif
  printf("nag_struve_i1ml1 (s18gdc) Example Program Results\n");
  printf("     x        I1(x)-L1(x)\n");
#ifdef _WIN32
```

```
  while (scanf_s("%lf", &x) != EOF)
#else
  while (scanf("%lf", &x) != EOF)
#endif
  {
    /* nag_struve_i1ml1 (s18gdc).
     */
    y = nag_struve_i1ml1(x, &fail);
    if (fail.code != NE_NOERROR) {
      printf("Error from nag_struve_i1ml1 (s18gdc).\n%s\n", fail.message);
      exit_status = 1;
      goto END;
    }
    printf("%12.3e%12.3e\n", x, y);
  }

END:
  return exit_status;
}
```

## 10.2 Program Data

```
nag_specfun_struve_i1ml1 (s18gdc) Example Program Data
0.5
1.0
3.0
6.0
8.0
10.0
100
```

## 10.3 Program Results

```
nag_struve_i1ml1 (s18gdc) Example Program Results
     x        I1(x)-L1(x)
   5.000e-01   2.040e-01
   1.000e+00   3.384e-01
   3.000e+00   5.568e-01
   6.000e+00   6.169e-01
   8.000e+00   6.260e-01
   1.000e+01   6.300e-01
   1.000e+02   6.366e-01
```

**Example Program**
Returns values for the Bessel Function - the modified Struve Function $I_1(x)$-$L_1(x)$