nag_deviates_normal_dist (g01cec)

1. Purpose

nag_deviates_normal_dist (g01cec) returns the deviate, x_p, associated with the given lower tail probability, p, of the standardised Normal distribution.

2. Specification

```
#include <nag.h>
#include <nagg01.h>

double nag_deviates_normal_dist(double p, NagError *fail)
```

3. Description

x_p is calculated for the given p such that

$$p = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{x_p} e^{-u^2/2}\, du \qquad -\infty < x_p < \infty.$$

The method used is an extension of that of Beasley and Springer (1977). p is first replaced by $q = p - 0.5$.

(a) If $|q| \leq 0.3$, x_p is computed by a rational Chebyshev approximation

$$x_p = s\frac{A(s^2)}{B(s^2)}$$

where $s = \sqrt{2\pi}q$ and A, B are polynomials of degree 7.

(b) If $0.3 < |q| \leq 0.42$, x_p is computed by a rational Chebyshev approximation

$$x_p = \operatorname{sign} q \left(\frac{C(t)}{D(t)}\right)$$

where $t = |q| - 0.3$ and C, D are polynomials of degree 5.

(c) If $|q| > 0.42$, x_p is computed as

$$x_p = \operatorname{sign} q \left(\frac{E(u)}{F(u)}\right) + u$$

where $u = \sqrt{-2\log(\min(p, 1-p))}$ and E, F are polynomials of degree 6.

4. Parameters

p
Input: the probability, p, from the standardised Normal distribution.
Constraint: $0.0 < \mathbf{p} < 1.0$.

fail
The NAG error parameter, see the Essential Introduction to the NAG C Library.

5. Error Indications and Warnings

NE_REAL_ARG_LE
On entry, **p** must not be less than or equal to 0.0: **p** = ⟨*value*⟩.

NE_REAL_ARG_GE
On entry, **p** must not be greater than or equal to 1.0: **p** = ⟨*value*⟩.

6. Further Comments

If X is a Normal random variable with mean μ and variance σ^2, the deviate corresponding to a lower tail probability of p is $\mu + \sigma x_p$, where x_p is the standardised Normal deviate returned by nag_deviates_normal_dist.

6.1. Accuracy

The function attempts to attain a relative precision of 5.0×10^{-13}.

6.2. References

Beasley J D and Springer S G (1977) Algorithm AS111: The percentage points of the Normal distribution *Appl. Stat.* **26** 118–120.

7. See Also

nag_cumul_normal (s15abc)
nag_cumul_normal_complem (s15acc)

8. Example

The deviates corresponding to several lower tail probabilities from the standard Normal distribution are calculated and printed.

8.1. Program Text

```
/* nag_deviates_normal_dist(g01cec) Example Program
 *
 * Copyright 1990 Numerical Algorithms Group.
 *
 * Mark 2 revised, 1992.
 */

#include <nag.h>
#include <stdio.h>
#include <nag_stdlib.h>
#include <nagg01.h>

#define NMAX 5

main()
{
  double x;
  static double p[] = {0.95, 0.5, 0.995, 0.75, 0.001};
  Integer i;

  Vprintf("g01cec Example Program Results\n");
  Vprintf("  Prob.     Deviate\n\n");
  for (i=0; i<NMAX; i++)
    {
      x = g01cec(p[i], NAGERR_DEFAULT);
      Vprintf("%7.3f%11.4f\n", p[i], x);
    }
  exit(EXIT_SUCCESS);
}
```

8.2. Program Data

None.

8.3. Program Results

```
g01cec Example Program Results
  Prob.     Deviate

  0.950     1.6449
  0.500     0.0000
  0.995     2.5758
  0.750     0.6745
  0.001    -3.0902
```