# NAG Library Function Document

# nag_normal_pdf_vector (g01kqc)

## 1 Purpose

nag_normal_pdf_vector (g01kqc) returns a number of values of the probability density function (PDF), or its logarithm, for the Normal (Gaussian) distributions.

## 2 Specification

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

```
void nag_normal_pdf_vector (Nag_Boolean ilog, Integer lx, const double x[],
     Integer lxmu, const double xmu[], Integer lxstd, const double xstd[],
     double pdf[], Integer ivalid[], NagError *fail)
```

## 3 Description

The Normal distribution with mean $\mu_i$, variance ${\sigma_i}^2$; has probability density function (PDF)

$$f(x_i, \mu_i, \sigma_i) = \frac{1}{\sigma_i \sqrt{2\pi}} e^{-(x_i-\mu_i)^2/2{\sigma_i}^2}, \quad \sigma_i > 0.$$

The input arrays to this function are designed to allow maximum flexibility in the supply of vector arguments by re-using elements of any arrays that are shorter than the total number of evaluations required. See Section 2.6 in the g01 Chapter Introduction for further information.

## 4 References

None.

## 5 Arguments

1: **ilog** – Nag_Boolean *Input*

*On entry*: the value of **ilog** determines whether the logarithmic value is returned in PDF.

**ilog** = Nag_FALSE
$f(x_i, \mu_i, \sigma_i)$, the probability density function is returned.

**ilog** = Nag_TRUE
$\log(f(x_i, \mu_i, \sigma_i))$, the logarithm of the probability density function is returned.

2: **lx** – Integer *Input*

*On entry*: the length of the array **x**.

*Constraint*: **lx** $> 0$.

3: **x**[**lx**] – const double *Input*

*On entry*: $x_i$, the values at which the PDF is to be evaluated with $x_i = \mathbf{x}[j]$, $j = (i-1) \bmod \mathbf{lx}$, for $i = 1, 2, \ldots, \max(\mathbf{lx}, \mathbf{lxstd}, \mathbf{lxmu})$.

4: **lxmu** – Integer *Input*

*On entry*: the length of the array **xmu**.

*Constraint*: **lxmu** $> 0$.

5: **xmu**[**lxmu**] – const double *Input*

*On entry*: $\mu_i$, the means with $\mu_i = \mathbf{xmu}[j]$, $j = (i-1) \bmod \mathbf{lxmu}$.

6: **lxstd** – Integer *Input*

*On entry*: the length of the array **xstd**.

*Constraint*: $\mathbf{lxstd} > 0$.

7: **xstd**[**lxstd**] – const double *Input*

*On entry*: $\sigma_i$, the standard deviations with $\sigma_i = \mathbf{xstd}[j]$, $j = (i-1) \bmod \mathbf{lxstd}$.

*Constraint*: $\mathbf{xstd}[j-1] \geq 0.0$, for $j = 1, 2, \ldots, \mathbf{lxstd}$.

8: **pdf**[*dim*] – double *Output*

**Note**: the dimension, *dim*, of the array **pdf** must be at least $\max(\mathbf{lx}, \mathbf{lxstd}, \mathbf{lxmu})$.

*On exit*: $f(x_i, \mu_i, \sigma_i)$ or $\log(f(x_i, \mu_i, \sigma_i))$.

9: **ivalid**[*dim*] – Integer *Output*

**Note**: the dimension, *dim*, of the array **ivalid** must be at least $\max(\mathbf{lx}, \mathbf{lxstd}, \mathbf{lxmu})$.

*On exit*: **ivalid**$[i-1]$ indicates any errors with the input arguments, with

**ivalid**$[i-1] = 0$
No error.

**ivalid**$[i-1] = 1$
$\sigma_i < 0$.

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

The NAG error argument (see Section 3.6 in the Essential Introduction).

## 6 Error Indicators and Warnings

**NE_ARRAY_SIZE**

On entry, array size = ⟨*value*⟩.
Constraint: $\mathbf{lx} > 0$.

On entry, array size = ⟨*value*⟩.
Constraint: $\mathbf{lxmu} > 0$.

On entry, array size = ⟨*value*⟩.
Constraint: $\mathbf{lxstd} > 0$.

**NE_BAD_PARAM**

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

**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.

**NW_IVALID**

On entry, at least one value of **xstd** was invalid.
Check **ivalid** for more information.

## 7 Accuracy

Not applicable.

## 8 Parallelism and Performance

Not applicable.

## 9 Further Comments

None.

## 10 Example

This example prints the value of the Normal distribution PDF at four different points $x_i$ with differing $\mu_i$ and $\sigma_i$.

### 10.1 Program Text

```
/* nag_normal_pdf_vector (g01kqc) Example Program.
 *
 * Copyright 2011, Numerical Algorithms Group.
 *
 * Mark 23, 2011.
 */
#include <stdio.h>
#include <nag.h>
#include <nag_stdlib.h>
#include <nagg01.h>

int main(void)
{
  /* Integer scalar and array declarations */
  Integer lx, lxmu, lxstd, i, lout;
  Integer *ivalid = 0;
  Integer exit_status = 0;

  /* NAG structures */
  NagError fail;
  Nag_Boolean ilog;

  /* Double scalar and array declarations */
  double *x = 0, *xmu = 0, *xstd = 0, *pdf = 0;

  /* Character scalar and array declarations */
  char cilog[40];

  /* Initialise the error structure to print out any error messages */
  INIT_FAIL(fail);

  printf("nag_normal_pdf_vector (g01kqc) Example Program Results\n\n");

  /* Skip heading in data file*/
  scanf("%*[^\n] ");

  /* Read in the flag indicating whether logs are required */
  scanf("%39s%*[^\n] ", cilog);
  ilog = (Nag_Boolean) nag_enum_name_to_value(cilog);

  /* Read in the input vectors */
  scanf("%ld%*[^\n] ", &lx);
  if (!(x = NAG_ALLOC(lx, double))) {
    printf("Allocation failure\n");
    exit_status = -1;
    goto END;
  }
  for (i = 0; i < lx; i++)
    scanf("%lf", &x[i]);
  scanf("%*[^\n] ");
  scanf("%ld%*[^\n] ", &lxmu);
  if (!(xmu = NAG_ALLOC(lxmu, double))) {
    printf("Allocation failure\n");
    exit_status = -1;
    goto END;
  }
  for (i = 0; i < lxmu; i++)
    scanf("%lf", &xmu[i]);
  scanf("%*[^\n] ");
  scanf("%ld%*[^\n] ", &lxstd);
  if (!(xstd = NAG_ALLOC(lxstd, double))) {
    printf("Allocation failure\n");
    exit_status = -1;
    goto END;
  }
  for (i = 0; i < lxstd; i++)
    scanf("%lf", &xstd[i]);
  scanf("%*[^\n] ");


  /* Allocate memory for output */
  lout = MAX(lx,MAX(lxmu,lxstd));
  if (!(pdf = NAG_ALLOC(lout, double)) ||
      !(ivalid = NAG_ALLOC(lout, Integer))) {
    printf("Allocation failure\n");
    exit_status = -1;
    goto END;
  }

  /* Calculate probability */
  nag_normal_pdf_vector(ilog,lx,x,lxmu,xmu,lxstd,xstd,pdf,ivalid,&fail);
  if (fail.code != NE_NOERROR) {
    printf("Error from nag_normal_pdf_vector (g01kqc).\n%s\n",
            fail.message);
    exit_status = 1;
    if (fail.code != NW_IVALID) goto END;
  }

  /* Display title */
  printf("   x        xmu       xstd       pdf      ivalid\n");
  printf(" ------------------------------------------------\n");

  /* Display results */
  for (i = 0; i < lout; i++)
    printf("%6.2f    %6.2f    %6.2f    %9.3e    %3ld\n",
           x[i%lx], xmu[i%lxmu], xstd[i%lxstd], pdf[i], ivalid[i]);

 END:
  NAG_FREE(x);
  NAG_FREE(xmu);
  NAG_FREE(xstd);
  NAG_FREE(pdf);
  NAG_FREE(ivalid);

  return(exit_status);
}
```

## 10.2 Program Data

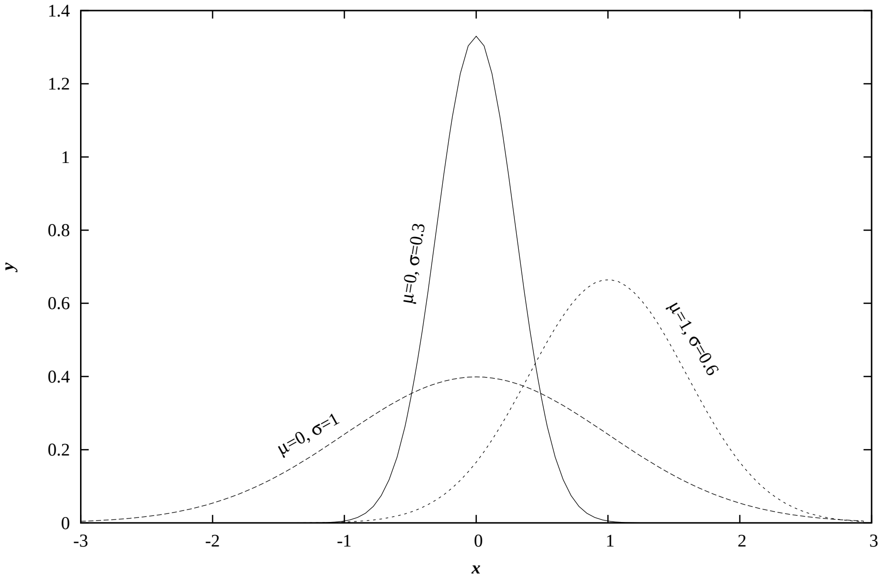
```
nag_normal_pdf_vector (g01kqc) Example Program Data
Nag_FALSE             :: ILOG
4                     :: LX
1.0 4.0 0.1 1.0       :: X
4                     :: LXMU
0.0 2.0 0.0 0.0       :: XMU
4                     :: LXSTD
1.0 1.0 0.01 10.0     :: XSTD
```

## 10.3 Program Results

```
nag_normal_pdf_vector (g01kqc) Example Program Results

   x         xmu        xstd        pdf       ivalid
 ------------------------------------------------
  1.00      0.00       1.00    2.420e-01       0
  4.00      2.00       1.00    5.399e-02       0
  0.10      0.00       0.01    7.695e-21       0
  1.00      0.00      10.00    3.970e-02       0
```

**Example Program**
Plots of the Gaussian Function (or Normal Distribution).


1.4
1.2
1
0.8
0.6
0.4
0.2
0
y
-3
-2
-1
0
1
2
3
x
μ=0, σ=0.3
μ=1, σ=0.6
μ=0, σ=1