NAG Toolbox for MATLAB

d01bd

1 Purpose

d01bd calculates an approximation to the integral of a function over a finite interval $[a, b]$:

$$I = \int_a^b f(x)\,dx.$$

It is non-adaptive and as such is recommended for the integration of 'smooth' functions. These **exclude** integrands with singularities, derivative singularities or high peaks on $[a, b]$, or which oscillate too strongly on $[a, b]$.

2 Syntax

```
[result, abserr] = d01bd(f, a, b, epsabs, epsrel)
```

3 Description

d01bd is based on the QUADPACK routine QNG (see Piessens *et al.* 1983). It is a non-adaptive function which uses as its basic rules, the Gauss 10-point and 21-point formulae. If the accuracy criterion is not met, formulae using 43 and 87 points are used successively, stopping whenever the accuracy criterion is satisfied.

This function is designed for smooth integrands only.

4 References

Patterson T N L 1968b The Optimum addition of points to quadrature formulae *Math. Comput.* **22** 847–856

Piessens R, de Doncker–Kapenga E, Überhuber C and Kahaner D 1983 *QUADPACK, A Subroutine Package for Automatic Integration* Springer–Verlag

5 Parameters

5.1 Compulsory Input Parameters

1: **f – string containing name of m-file**

f must return the value of the integrand f at a given point.

Its specification is:

```
[result] = f(x)
```

Input Parameters

1: **x – double scalar**

The point at which the integrand f must be evaluated.

Output Parameters

1: **result – double scalar**

The result of the function.

2: **a – double scalar**

a, the lower limit of integration.

3: **b – double scalar**

b, the upper limit of integration. It is not necessary that $a < b$.

4: **epsabs – double scalar**

The absolute accuracy required. If **epsabs** is negative, the absolute value is used. See Section 7.

5: **epsrel – double scalar**

The relative accuracy required. If **epsrel** is negative, the absolute value is used. See Section 7.

5.2 Optional Input Parameters

None.

5.3 Input Parameters Omitted from the MATLAB Interface

None.

5.4 Output Parameters

1: **result – double scalar**

The approximation to the integral I.

2: **abserr – double scalar**

An estimate of the modulus of the absolute error, which should be an upper bound for $|I - \mathbf{result}|$.

6 Error Indicators and Warnings

There are no specific errors detected by d01bd. However, if **abserr** is greater than

$$\max\{\mathbf{epsabs}, \mathbf{epsrel} \times |\mathbf{result}|\}$$

this indicates that the function has probably failed to achieve the requested accuracy within 87 function evaluations.

7 Accuracy

d01bd attempts to compute an approximation, **result**, such that:

$$|I - \mathbf{result}| \leq tol,$$

where

$$tol = \max\{|\mathbf{epsabs}|, |\mathbf{epsrel}| \times |I|\},$$

and **epsabs** and **epsrel** are user-specified absolute and relative error tolerances. There can be no guarantee that this is achieved, and you are advised to subdivide the interval if you have any doubts about the accuracy obtained. Note that **abserr** contains an estimated bound on $|I - \mathbf{result}|$.

8 Further Comments

The time taken by d01bd depends on the integrand and the accuracy required.

9 Example

d01bd_f.m

```
function [result] = d01bd_f(x)
  result = x^2*sin(10*pi*x);
```

```
a = 0;
b = 1;
epsabs = 0;
epsrel = 0.0001;
[result, abserr] = d01bd('d01bd_f', a, b, epsabs, epsrel)
```

```
result =
   -0.0318
abserr =
   1.3443e-11
```