



## 1 SUMMARY

Estimate the value of the  $n$  **dimension integral**

$$\int_{a_1}^{b_1} \int_{a_2}^{b_2} \dots \int_{a_n}^{b_n} f(x_1, x_2, \dots, x_n) dx_1 dx_2 \dots dx_n \quad n < 20$$

to a specified accuracy by a **Monte Carlo method**.

The method is that of ‘Weighted Uniform Sampling’, see, M.J.D. Powell and J. Swann, AERE TP.207, 1966.

The sampling method requires an approximation to  $f(x)$  which has the properties

$$\int_R g(\mathbf{x}) d\mathbf{x} = 1$$

where  $R$  is the region of integration and

$$f(\mathbf{x}) \approx \alpha g(\mathbf{x})$$

where  $\alpha$  is a constant.

The user must provide a subroutine to compute values of  $f(x)$  and  $g(x)$ .

**ATTRIBUTES** — **Version:** 1.0.0. **Types:** QM01A; QM01AD. **Calls:** FA01 and EVAL (a user subroutine). **Original date:** June 1966. **Origin:** D.Green, Harwell.

## 2 HOW TO USE THE PACKAGE

### 2.1 The Argument list

*The single precision version*

```
CALL QM01A(A,B,N,ACC,MXTEST,ANS,IPRINT)
```

*The double precision version*

```
CALL QM01AD(A,B,N,ACC,MXTEST,ANS,IPRINT)
```

A is a REAL (DOUBLE PRECISION in the D version) array which must be set by the user to the lower limits of the integrations  $a_i, i=1,2,\dots,n$ , see section 1.

B is a REAL (DOUBLE PRECISION in the D version) array which must be set by the user to the upper limits of the integrations  $b_i, i=1,2,\dots,n$ , see section 1.

N is an INTEGER variable which must be set by the user to  $n$  the dimension of the integral. **Restriction:**  $n < 20$ .

ACC is a REAL (DOUBLE PRECISION in the D version) variable which the user must set to the absolute accuracy that the integral value is required. If this accuracy is not attained ACC will be returned set to an estimate of the accuracy obtained.

MXTEST is an INTEGER variable which must be set by the user to limit the number of calls to EVAL (see §2.2). The limit is set to  $5 \times 10^{\text{MXTEST}}$ . *Think before setting MXTEST > 3.*

ANS is a REAL (DOUBLE PRECISION in the D version) variable returned set to the computed value of the integral.

IPRINT is an INTEGER variable which must be set by the user to control printing. The possible values are:

IPRINT=0 there is no printing,

IPRINT  $\neq 0$  printing will occur to diagnose: accuracy not attained,  
IPRINT  $> 0$  the answer, an error estimate, and the largest value of MXTEST used will be printed.

### 2.3 The subroutine to evaluate the functions

The user must provide a subroutine to compute values of the functions  $f(\mathbf{x})$  and  $g(\mathbf{x})$  for any value of  $\mathbf{x}$  within the range of integration. The subroutine must take the form:

*The single precision version*

```
SUBROUTINE EVAL(X,F,G)
```

*The double precision version*

```
SUBROUTINE EVAL(X,F,G)  
DOUBLE PRECISION X(*),F,G
```

- X is a REAL (DOUBLE PRECISION in the D version) array of length at least  $n$  which will hold the values of  $x_i$ ,  $i=1,2,\dots,n$ .
- F is a REAL (DOUBLE PRECISION in the D version) variable which EVAL must set to the value of  $f(x_1, x_2, \dots, x_n)$ .
- G is a REAL (DOUBLE PRECISION in the D version) variable which EVAL must set to the value of  $g(x_1, x_2, \dots, x_n)$ .

## 3 GENERAL INFORMATION

**Use of common:** none.

**Workspace:** none.

**Other routines called directly:** FA01A/AD is called (and the user supplied subroutine EVAL).

**Input/output:** printing is produced on unit 6, see argument INPRINT.

**Restrictions:**  $n < 20$ .

## 4 METHOD

See the Harwell report produced by M.J.D. Powell (Feb. 1966).