

nag_ode_ivp_adams_interp (d02qzc)

1. Purpose

nag_ode_ivp_adams_interp (d02qzc) interpolates components of the solution of a non-stiff system of first order ordinary differential equations from information provided by **nag_ode_ivp_adams_roots (d02qfc)**. Normally this function will be used in conjunction with the integration function, **nag_ode_ivp_adams_roots (d02qfc)**, operating in one-step mode.

2. Specification

```
#include <nag.h>
#include <nagd02.h>

void nag_ode_ivp_adams_interp(Integer neqf, double twant, Integer nwant,
                             double ywant[], double ypwant[], Nag_ODE_Adams *opt, NagError *fail)
```

3. Description

nag_ode_ivp_adams_interp evaluates the first **nwant** components of the solution of a non-stiff system of first order ordinary differential equations at any point using the method of Watts and Shampine (1986) and information generated by **nag_ode_ivp_adams_roots (d02qfc)**. **nag_ode_ivp_adams_interp** should not normally be used to extrapolate outside the current range of the values produced by the integration routine.

4. Parameters

neqf

Input: the number of differential equations.
Constraint: **neqf** ≥ 1 .

twant

Input: the point at which components of the solution and derivative are to be evaluated. **twant** should not normally be an extrapolation point, that is **twant** should satisfy

opt.tcurr – **opt.hlast** \leq **twant** \leq **opt.tcurr**.

or if integration is proceeding in the negative direction

opt.tcurr – **opt.hlast** \geq **twant** \geq **opt.tcurr**.

Extrapolation is permitted but not recommended and a **fail.code** value of **NW_EXTRAPOLATION** is returned whenever extrapolation is attempted.

nwant

Input: the number of components of the solution and derivative whose values, at **twant**, are required. The first **nwant** components are evaluated.
Constraint: $1 \leq \text{nwant} \leq \text{neqf}$.

ywant[nwant]

Output: **ywant**[$i - 1$] contains the calculated value of the i th component of the solution at **twant**, for $i = 1, 2, \dots, \text{nwant}$.

ypwant[nwant]

Output: **ypwant**[$i - 1$] contains the calculated value of the i th component of the derivative at **twant**, for $i = 1, 2, \dots, \text{nwant}$.

opt

Input: the structure of type **Nag_ODE_Adams** as output from the integration function **nag_ode_ivp_adams_roots (d02qfc)**. The structure **must** be passed unchanged. (See Section 6 for comments about deallocation of memory from **opt**.)

fail

The NAG error parameter, see the Essential Introduction to the NAG C Library.
It is recommended that **fail.print** be set to **TRUE**.

5. Error Indications and Warnings

NE_NO_INTEGRATE

The integrator function nag_ode_ivp_adams_roots (d02qfc) has not been called.

NE_NEQF

The value of **neqf** supplied is not the same as that given to the setup function nag_ode_ivp_adams_setup (d02qwc). **neqf** = $\langle value \rangle$ but the value given to nag_ode_ivp_adams_setup (d02qwc) was $\langle value \rangle$.

NE_NWANT_GT

nwant is greater than the value of **neqf** given to the setup function nag_ode_ivp_adams_setup (d02qwc). **nwant** = $\langle value \rangle$, **neqf** = $\langle value \rangle$.

NE_INT_ARG_LT

On entry, **nwant** must not be less than 1: **nwant** = $\langle value \rangle$.

NE_NO_STEPS

No successful integration steps were taken in the call(s) to the integration function nag_ode_ivp_adams_roots (d02qfc).

NW_EXTRAPOLATION

Extrapolation requested, **twant** = $\langle value \rangle$.

6. Further Comments

When interpolation for only a few components is required then it is more efficient to order the components of interest so that they are numbered first.

The structure **opt** will contain pointers which have been allocated memory during a call to nag_ode_ivp_adams_setup (d02qwc). This allocated memory is used by nag_ode_ivp_adams_roots (d02qfc) and nag_ode_ivp_adams_interp. When all calls to these functions have been completed the function nag_ode_ivp_adams_free (d02qyc) may be called to free the allocated memory from the structure.

6.1. Accuracy

The error in interpolation is of a similar order to the error arising from the integration. The same order of accuracy can be expected when extrapolating using nag_ode_ivp_adams_interp. However, the actual error in extrapolation will, in general, be much larger than for interpolation.

6.2. References

Watts H A and Shampine L F (1986) Smoother Interpolants for Adams Codes *SIAM J. Sci. Statist. Comput.* **7** 334–345.

7. See Also

nag_ode_ivp_adams_roots (d02qfc)
nag_ode_ivp_adams_setup (d02qwc)
nag_ode_ivp_adams_free (d02qyc)

8. Example

We solve the equation

$$y'' = -y, \quad y(0) = 0, \quad y'(0) = 1$$

reposed as

$$\begin{aligned} y_1' &= y_2 \\ y_2' &= -y_1 \end{aligned}$$

over the range $[0, \pi/2]$ with initial conditions $y_1 = 0$ and $y_2 = 1$ using vector error control (**vectol** = **TRUE**) and nag_ode_ivp_adams_roots (d02qfc) in one-step mode (**one_step** = **TRUE**). nag_ode_ivp_adams_interp is used to provide solution values at intervals of $\pi/16$.

8.1. Program Text

```

/* nag_ode_ivp_adams_interp(d02qzc) Example Program
 *
 * Copyright 1991 Numerical Algorithms Group.
 *
 * Mark 2, 1991.
 * Mark 6 revised, 2000.
 */

#include <nag.h>
#include <stdio.h>
#include <nag_stdlib.h>
#include <nagd02.h>
#include <nagx01.h>

static void ftry03(Integer neqf, double x, double y[], double yp[],
                  Nag_User *comm);

#define NEQF 2
#define TSTART 0.0

main()
{
    double atol[NEQF], rtol[NEQF], y[NEQF], ywant[NEQF], ypwant[NEQF];
    Boolean crit, alter_g, vectol, one_step, sophist;
    double t, tinc, tout, tcrit, twant, hmax, pi;
    Integer max_step, i, j, neqf, neqg, nwant;
    Nag_Start state;
    Nag_ODE_Adams opt;
    static NagError fail;

    fail.print = TRUE;

    Vprintf("d02qzc Example Program Results\n");
    pi = X01AAC;
    state = Nag_NewStart;
    neqf = NEQF;
    neqg = 0;
    sophist = FALSE;
    vectol = TRUE;
    for (i = 0; i < 2; ++i)
    {
        atol[i] = 1e-08;
        rtol[i] = 0.0001;
    }
    one_step = TRUE;
    crit = TRUE;
    tinc = pi * 0.0625;
    tcrit = tinc * 8.0;
    tout = tcrit;
    max_step = 500;
    hmax = 2.0;
    t = TSTART;
    twant = TSTART + tinc;
    nwant = 2;
    y[0] = 0.0;
    y[1] = 1.0;
    Vprintf("\n      T          Y(1)    Y(2)\n");
    Vprintf(" %6.4f    %7.4f %7.4f  \n",t, y[0], y[1]);

    d02qwc(&state, neqf, vectol, atol, rtol, one_step, crit,
          tcrit, hmax, max_step, neqg, &alter_g, sophist, &opt, &fail);

    j = 1;

    while (t < tout && fail.code == NE_NOERROR)
    {
        d02qfc(neqf, ftry03, &t, y, tout, NULLDFN, NAGUSER_DEFAULT, &opt, &fail);

```

```

    while (twant <= t && fail.code == NE_NOERROR)
    {
        d02qzc(neqf, twant, nwant, ywant, ypwant, &opt, &fail);

        Vprintf(" %6.4f   %7.4f %7.4f  \n",twant, ywant[0], ywant[1]);
        ++j;
        twant = (double)j*tinc + 0.0;
    }
}
/* Free the memory which was allocated by
 * d02qwc to the pointers inside opt.
 */
d02qyc(&opt);

if (fail.code == NE_NOERROR) exit(EXIT_SUCCESS);
else exit(EXIT_FAILURE);
}                                     /* main */

static void ftry03(Integer neqf, double x, double y[], double yp[],
                  Nag_User *comm)
{
    yp[0] = y[1];
    yp[1] = -y[0];
}                                     /* ftry03 */

```

8.2. Program Data

None.

8.3. Program Results

d02qzc Example Program Results

| T | Y(1) | Y(2) |
|--------|--------|--------|
| 0.0000 | 0.0000 | 1.0000 |
| 0.1963 | 0.1951 | 0.9808 |
| 0.3927 | 0.3827 | 0.9239 |
| 0.5890 | 0.5556 | 0.8315 |
| 0.7854 | 0.7071 | 0.7071 |
| 0.9817 | 0.8315 | 0.5556 |
| 1.1781 | 0.9239 | 0.3827 |
| 1.3744 | 0.9808 | 0.1951 |
| 1.5708 | 1.0000 | 0.0000 |
