

Numerics of Dynamical Systems

Assignment 6

Conny Schweigert

Barcelona
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1 Programme

```
c*****
c
c  MAIN_RTBP_FLOW6.2.f
c
c      We integrate the harmonic oscillator field with Taylor
c      from t=ti up to t=tmax
c      idir= +1 (integration forward in time); =-1 (backward)
c      np= number of intermediate points (apart from the initial one)
c          that we want to write on the file orbit.d. If np=1
c          only the initial and final points are written
c
c  input: xi , ti ,tmax ,idir ,np
c*****
      implicit real*8 (a-h,o-z)
      parameter (n=20,m=4)
      dimension xi(n),x(n),O(m,m)
      common/param/xmu
      write(*,*)'xmu'
      read(*,*) xmu
      write(*,*)'C'
      read(*,*) C
      open(10,file='orbit.d',status='unknown')
      write(*,*) 'Initial condition x1,...,x20'
      read(*,*) (xi(i),i=1,n)
      write(*,*) 'ti,tmax,np (number of points) '
      read(*,*) ti,tmax,np
c  particular example integration up to t=pi
c      pi=4.d0*datan(1.d0)
c      tmax=pi/2.d0
c      if (tmax.ge.ti)then
c          'idir (=1 forward in time, =-1 backward) '
c              idir=1
c          else
c              idir=-1
c          endif
c      do i=1,n
c          x(i)=xi(i)
c      enddo
c          write(*,*)ti,'    initial t, initial cond:'
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c      write(*,*)(x(i),i=1,n)
      xinit = x(1)
      yinit = x(2)
      dxinit = x(3)
      dyinit = x(4)
      call jacobi(x,C,xmu,n)
c Test on determinant of M
      call matrix(x,m,n)
c REMARK: xinctime positive
      xinctime=dabs(tmax-ti)/np
      write (10,*) ti ,(x(ii),ii=1,n)
      do 20 i=1,np
        call flow(ti,n,x,idir,xinctime)
        write (10,*) ti ,(x(ii),ii=1,n)
        call jacobi(x,C,xmu,n)
c Test on determinant of M
      call matrix(x,m,n)
20    continue
c      real M(4,4)
      write(*,*)ti,' final t, final point:'
      write(*,*)(x(i),i=1,n)
      xfinal = x(1)
      yfinal = x(2)
      dxfinal = x(3)
      dyfinal = x(4)
      xdiff = abs(xinit - xfinal)
      ydiff = abs(yinit - yfinal)
      dxdiff = abs(dxinit - dxfinal)
      dydiff = abs(dyinit - dyfinal)
      write(*,*)'xdiff,ydiff,dxdiff,dydiff'
      write(*,*) xdiff, ydiff, dxdiff, dydiff
      end

subroutine jacobi(x,C,xmu,n)
implicit real*8 (a-h,o-z)
dimension x(n)
ro = dsqrt((x(1) - xmu)*(x(1) - xmu)+x(2)*x(2))
rt = dsqrt((x(1) - xmu + 1.d0)*(x(1) - xmu + 1.d0)+x(2)*x(2))
rest = 0.5d0 * xmu * (1.d0-xmu)
ome = 0.5d0*(x(1)*x(1) + x(2)*x(2)) + (1.d0 - xmu)/ro + xmu / rt + rest
Cnew = 2*ome - (x(3)*x(3) + x(4)*x(4))

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```

    Cdiff = dabs(C - Cnew)
    if (Cdiff.gt.1.d-3) then
    write(*,*) 'Jacobi integral not conserved'
    endif
    end

c Test on determinant of M
    subroutine matrix(x,m,n)
    implicit real*8 (a-h,o-z)
    dimension x(n),O(m,m)
    do k=1,m
    do l=1,m
    O(k,l) = x(4*k+l)
    end do
    end do
    write(*,*) O
    call DET(O,DETA,m)
    z = DETA - 1.
    if(z.gt.1.d-10) then
    write(*,*) 'Determinant of M is not equal to one'
    endif
    end

subroutine flow(t,n,x,idir,xinctemps)
IMPLICIT REAL*8 (A-H,O-Z)
dimension x(n)
common/param/xmu
c write(*,*) 'a,b,c,d'
c read(*,*) aa,bb,cc,dd
tmax=t+idir*xinctemps

c
c parameters for the integration
c
    hab=0.1e-16
    hre=0.1e-16
    pabs=dlog10(hab)
    prel=dlog10(hre)
c Option of control of step
    istep=1
    ht=0.d0

```

```

1      CALL taylor_f77_eq_rtbp_var_(t,x,idir,istep,pabs,prel,tmax,ht,iordre,
c      write(10,100) t,(x(i),i=1,n)
      if (idir.eq.1.and.t.lt.tmax)go to 1
      if (idir.eq.-1.and.t.gt.tmax)go to 1
c check t=tmax
      if (dabs(t-tmax).le.1.d-13)return
      write(*,*)'problems in taylor'
      stop
c 100      format(f15.8,2f22.15)
      return
      end

```

1.1 Output forward in time

```
conny.schweigert@fme-desktop:~$ ./main_rtbp_flow6_2
```

```

xmu
9.538750000000000E-004
C
3.001906450000000
Initial condition x1,...,x20
.1001005021494284E+01,0,0,-.1215976572734674E-02, 1.,0.,0.,0.,0.,1.,0.,0.,0.,0.
ti,tmax,np (number of points)
0,0.6277954078877794E+01,20
1.0000000000000000      0.0000000000000000      0.0000000000000000
0.0000000000000000      0.0000000000000000      1.0000000000000000
0.0000000000000000      0.0000000000000000      0.0000000000000000
0.0000000000000000      1.0000000000000000      0.0000000000000000
0.0000000000000000      0.0000000000000000      0.0000000000000000
1.0000000000000000
1.1464877728510399      -3.0775791852596657E-002      0.92564759884647196
-0.29316889526402540      -8.5565504094847429E-006      1.0000492857400074
-8.1509951759367222E-005      3.1792741079970081E-004      0.30875849641084757
-9.7727505785003471E-002      0.95104722604815495      -0.61756341757245203
9.7721719747963842E-002      0.29338455762755111      0.61749038239823029
0.80459284554391342
1.5715959496565026      -0.24260350380916706      1.7606039913773663
-1.1441144390941178      -6.7453096175748429E-005      1.0002044216233372
-3.1811834439480753E-004      6.8184722259248347E-004      0.58729468172366395
-0.38138429033646359      0.80904633772793022      -1.1749301450322700
0.38129683916827167      0.46609244939222788      1.1743942162822676
0.23741474241001481

```

2.2336984584069435	-0.79889438334632856	2.4232655193897150
-2.4699150363823770	-2.2213791672396856E-004	1.0004865283489957
-6.8683556952167418E-004	1.1332324963760059E-003	0.80838316130406684
-0.82331938702592911	0.58806930749724107	-1.6177576654872583
0.82291729716886763	0.40920911725755471	1.6161990260883841
-0.64624518536049658		
3.0680615835166822	-1.8294852668058126	2.8492285542393718
-4.1413174187862678	-5.0875409884156648E-004	1.0009284938780620
-1.1518504801496339E-003	1.7049667675641080E-003	0.95048440567289305
-1.3804469631079681	0.30995999049313872	-1.9028531843154834
1.3793397161191021	3.6206422231210955E-002	1.8998886156279540
-1.7602038372940143		
3.9932873059648735	-3.4179596473094396	2.9975799210448861
-5.9952823111490190	-9.5063464439661290E-004	1.0015717452940049
-1.6680242418732395E-003	2.4181268266231203E-003	0.99985341451743459
-1.9984436223636806	2.1149534595610309E-003	-2.0024012738897006
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-2.9957468884728016		
4.9193610852175329	-5.5934658781101216	2.8547498887192293
-7.8508635650664065	-1.5560459941014924E-003	1.0024621876501136
-2.1852845782601494E-003	3.2799363905060999E-003	0.95186154821320756
-2.6170494590829021	-0.30526429640153896	-1.9067100926310139
2.6133520966784500	-1.8446069417462039	1.9019332988241360
-4.2322138445053721		
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-9.5269027303503879	-2.3173964597028840E-003	1.0036457122007112
-2.6534883776107784E-003	4.2830911581137948E-003	0.81141107452729866
-3.1759602779192333	-0.58215347813630358	-1.6251986444776607
3.1708481696603874	-3.3529816515575877	1.6212093688855940
-5.3487937507630336		
6.4237862026166734	-11.538391036557586	1.7817623281255714
-10.859820506462574	-3.2119828542856851E-003	1.0051637182004227
-3.0272800465914376E-003	5.4065188966558346E-003	0.59241653074416589
-3.6207367469221183	-0.80162007421614767	-1.1855138397580747
3.6146936207718130	-5.1785162806267335	1.1838116531992644
-6.2363862610394403		
6.8571611040436489	-15.095938700279241	0.95737985973928874
-11.719747947373955	-4.2042000057067952E-003	1.0070490900464792
-3.2704790558591291E-003	6.6174958364617108E-003	0.31641852083025629
-3.9081497894011372	-0.94239403312515568	-0.63084878840725811
3.9020962587698347	-7.2350224570781538	0.63263357462444381

-6.8083570256792276		
7.0153665516120354	-18.837594696262407	4.2890208762258908E-002
-12.023378581083648	-5.2489981285097492E-003	1.0093230254377057
-3.3595798925331994E-003	7.8749069513208113E-003	1.0474955185646784E-002
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-7.0091084290766235		
6.8839708977456722	-22.582770511592305	-0.87270901247362231
-11.742233962177309	-6.2962549658641155E-003	1.0119930252517155
-3.2860344328809474E-003	9.1333257572288259E-003	-0.29546370381013032
-3.9180159578107192	-0.94236299057397910	0.59941628533747315
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-6.8195940695813286		
6.4767206619551203	-26.150988550018479	-1.7003110877246059
-10.905493419238230	-7.2956434506207899E-003	1.0150522405907103
-3.0571015894160125E-003	1.0347509824931444E-002	-0.57144740250035131
-3.6404703848545017	-0.80156056188473923	1.1540749364375720
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-6.2592106044655624		
5.8342364805654912	-29.379674635306095	-2.3591671631886775
-9.5970957948818096	-8.2015286065125273E-003	1.0184802383845797
-2.6951818518598635E-003	1.1476868712958329E-002	-0.79041939830131547
-3.2055642124026460	-0.58207027399823708	1.5937479047800067
3.2097056462493359	-15.490778109039612	-1.5830107305567234
-5.3838716668580124		
5.0201461417007121	-32.140173304539076	-2.7846278753854787
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-2.2356944041027000E-003	1.2489464991038727E-002	-0.93084084693371039
-2.6565284589440790	-0.30516369778485153	1.8752405112138464
2.6637178939226693	-17.012204275093179	-1.8668908908231614
-4.2804627500171009		
4.1149938958828400	-34.350402616691497	-2.9344585601333915
-6.1203480076282597	-9.5995736873171547E-003	1.0263066937832266
-1.7236908618318324E-003	1.3365155769847016E-002	-0.97879930893080569
-2.0478049425772094	2.2260426022253643E-003	1.9709039908171972
2.0570130115409562	-18.165560914950131	-1.9666031711028420
-3.0582465666560332		
3.2084737522776834	-35.982908722208286	-2.7931096627324257
-4.2971779670480634	-1.0059320508611698E-002	1.0306206482144529
-1.2095209927484203E-003	1.4097567008036965E-002	-0.92939464588118903
-1.4397009349456307	0.31007507861263722	1.8713174832312869

```

1.4495085589090637      -18.932374154794974      -1.8718440550212205
-1.8380927733202825
  2.3907076980177728      -37.067545125366713      -2.3734682587649356
-2.6587493392314370      -1.0364007480492104E-002      1.0351428799838120
-7.4396072301053436E-004      1.4694707658226882E-002      -0.78725733918462515
-0.89247996274824293      0.58818330725623880      1.5861712630260096
0.90138027307399726      -19.332385275346027      -1.5913136044756151
-0.74061225251494545
  1.7434069156862075      -37.688536525151839      -1.7158297785661007
-1.3677968213566571      -1.0536334081860700E-002      1.0398339828208465
-3.7327095995660979E-004      1.5178164513012101E-002      -0.56613365342589572
-0.46046945495229391      0.80915640101299724      1.1432797400769674
0.46715675208441099      -19.421601707057039      -1.1520189865031820
0.12563287901744313
  1.3317943609426159      -37.976236897377746      -0.88410242867052202
-0.55309428568954866      -1.0612210855819216E-002      1.0446631931998314
-1.3466943740706244E-004      1.5580958645133737E-002      -0.28756358215638339
-0.18675948383744612      0.95115331175073548      0.58583543454618869
0.19032586386530642      -19.286810021447494      -0.59672881761982810
0.67469909164347752
  1.1981155159840304      -38.094402589559941      4.0437692304637451E-002
-1.0637317370853046E-002      1.0496114921986552      -5.2663237228601665E-005
1.5944277017500105E-002      2.1227941548766283E-002      -9.9005210346062883E-002
1.0001050953044976      -3.1818565726743908E-002      9.9005210339762520E-002
-19.037097235011448      2.0208119537002855E-002      0.85160107150362008
  6.2779540788777943
  final t, final point:
  1.0010050214942838      -4.8468905755258418E-013      -1.5580871553892706E-013
-1.2159765727346567E-003      1.1981155159840304      -1.0637317370853046E-002
2.1227941548766283E-002      9.9005210339762520E-002      -38.094402589559941
1.0496114921986552      -9.9005210346062883E-002      -19.037097235011448
4.0437692304637451E-002      -5.2663237228601665E-005      1.0001050953044976
2.0208119537002855E-002      -0.29695538436455254      1.5944277017500105E-002
-3.1818565726743908E-002      0.85160107150362008
  xdiff , ydiff , dxdiff , dydiff
  2.2204460492503131E-016      4.8468905755258418E-013      1.5580871553892706E-013
1.7347234759768071E-017

```

1.2 Output forward in time

```
conny.schweigert@fme-desktop:~$ ./main_rtbp_flow6_2
```



```

xmu
9.538750000000000E-004
C
3.001906450000000
Initial condition x1,...,x20
.1001005021494284E+01,0,0,-.1215976572734674E-02, 1.,0.,0.,0.,0.,1.,0.,0.,0.,0.
ti,tmax,np (number of points)
0,-0.6277954078877794E+01,20
1.0000000000000000      0.0000000000000000      0.0000000000000000
0.0000000000000000      0.0000000000000000      1.0000000000000000
0.0000000000000000      0.0000000000000000      0.0000000000000000
0.0000000000000000      1.0000000000000000      0.0000000000000000
0.0000000000000000      0.0000000000000000      0.0000000000000000
1.0000000000000000
1.1464877728510399      3.0775791852596657E-002 -0.92564759884647196
-0.29316889526402540      8.5565504094847429E-006 1.0000492857400074
-8.1509951759367222E-005 -3.1792741079970081E-004 -0.30875849641084757
-9.7727505785003471E-002 0.95104722604815495 0.61756341757245203
9.7721719747963842E-002 -0.29338455762755111 -0.61749038239823029
0.80459284554391342
1.5715959496565026      0.24260350380916706 -1.7606039913773663
-1.1441144390941178      6.7453096175748429E-005 1.0002044216233372
-3.1811834439480753E-004 -6.8184722259248347E-004 -0.58729468172366395
-0.38138429033646359      0.80904633772793022 1.1749301450322700
0.38129683916827167      -0.46609244939222788 -1.1743942162822676
0.23741474241001481
2.2336984584069435      0.79889438334632856 -2.4232655193897150
-2.4699150363823770      2.2213791672396856E-004 1.0004865283489957
-6.8683556952167418E-004 -1.1332324963760059E-003 -0.80838316130406684
-0.82331938702592911      0.58806930749724107 1.6177576654872583
0.82291729716886763      -0.40920911725755471 -1.6161990260883841
-0.64624518536049658
3.0680615835166822      1.8294852668058126 -2.8492285542393718
-4.1413174187862678      5.0875409884156648E-004 1.0009284938780620
-1.1518504801496339E-003 -1.7049667675641080E-003 -0.95048440567289305
-1.3804469631079681      0.30995999049313872 1.9028531843154834
1.3793397161191021      -3.6206422231210955E-002 -1.8998886156279540
-1.7602038372940143
3.9932873059648735      3.4179596473094396 -2.9975799210448861
-5.9952823111490190      9.5063464439661290E-004 1.0015717452940049
-1.6680242418732395E-003 -2.4181268266231203E-003 -0.99985341451743459

```

-1.9984436223636806	2.1149534595610309E-003	2.0024012738897006
1.9961919967029003	0.70860263333654527	-1.9981471094115111
-2.9957468884728016		
4.9193610852175329	5.5934658781101216	-2.8547498887192293
-7.8508635650664065	1.5560459941014924E-003	1.0024621876501136
-2.1852845782601494E-003	-3.2799363905060999E-003	-0.95186154821320756
-2.6170494590829021	-0.30526429640153896	1.9067100926310139
2.6133520966784500	1.8446069417462039	-1.9019332988241360
-4.2322138445053721		
5.7564802813320108	8.3278477817122045	-2.4356049869870513
-9.5269027303503879	2.3173964597028840E-003	1.0036457122007112
-2.6534883776107784E-003	-4.2830911581137948E-003	-0.81141107452729866
-3.1759602779192333	-0.58215347813630358	1.6251986444776607
3.1708481696603874	3.3529816515575877	-1.6212093688855940
-5.3487937507630336		
6.4237862026166734	11.538391036557586	-1.7817623281255714
-10.859820506462574	3.2119828542856851E-003	1.0051637182004227
-3.0272800465914376E-003	-5.4065188966558346E-003	-0.59241653074416589
-3.6207367469221183	-0.80162007421614767	1.1855138397580747
3.6146936207718130	5.1785162806267335	-1.1838116531992644
-6.2363862610394403		
6.8571611040436489	15.095938700279241	-0.95737985973928874
-11.719747947373955	4.2042000057067952E-003	1.0070490900464792
-3.2704790558591291E-003	-6.6174958364617108E-003	-0.31641852083025629
-3.9081497894011372	-0.94239403312515568	0.63084878840725811
3.9020962587698347	7.2350224570781538	-0.63263357462444381
-6.8083570256792276		
7.0153665516120354	18.837594696262407	-4.2890208762258908E-002
-12.023378581083648	5.2489981285097492E-003	1.0093230254377057
-3.3595798925331994E-003	-7.8749069513208113E-003	-1.0474955185646784E-002
-4.0104327105230499	-0.99086803634061182	1.5715246042956044E-002
4.0055577235362971	9.4138009117174555	-2.1433728803540886E-002
-7.0091084290766235		
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conny.schweigert@fme-desktop:~$

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