JOB NUMBER MA11D, MAXIMUM RUNNING TIME 005 MINUTES, MAXIMUM OUTPUT 060 PAGES. JOB RUN 0, 1900

TIME 12 00 A.M. MICHAEL MINOVICH DEBUG RUN 2

* FORTRAN

error in statement print out

My first UCLA computer facility "Job number" was "MA11" obtained in Feb. 1962. This was changed to CF07 in March 1962 which was a special job classification without time limitations.

Hence, this listing which was the result of an actual computer complication of my gravity thrust trajectory program was done at UCLA sometime in Feb or March 1962.

The planet sequence $P_1 - P_2 - P_3 - P_4 - \cdots - P_N$ is defined by the matrix NP(I,M). A total of 10 different trajectory sequences could be considered each having a maximum of 10 planetary encounters. For exam

the program to consider 4 different missions of the form

Earth - Jupiter - Uranus

Earth - Venus - Mercury

Earth - Mars - Venus - Mercury

Earth - Mars - Jupiter - Saturn - Uranus - Neptune - Pluto

I would set

$$NP(I,P,M) = \begin{pmatrix} 3 & 5 & 7 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 3 & 2 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 3 & 4 & 2 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 3 & 4 & 5 & 6 & 7 & 8 & 9 & 0 & 0 & 0 \end{pmatrix}$$

The beginning of the calculations would begin by

Launch Planet = Earth (Mission 1) Launch Planet = Earth (Mission 2) Launch Planet = Earth (Mission 3)

Jupiter Venus Mars

Arrival Planet = Uranus Arrival Planet = Mercury Venus Arrival Planet = Mercury

↓ ↓ ↓

Data Data etc

↓ ↓

next mission next mission

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MAIID
C     TEST PROGRAM FOR THE DETERMINATION OF INTERPLANETARY ROUND TRIP
C                  TRAJECTORIES FOR FREE FALL SPACE VEHICLES
    1 FORMAT(F7.1,F9.6,F11.6,F11.6,F11.6,E14.6,F9.6)
    2 FORMAT(6E12.6)
    3 FORMAT(F6.0,9F7.0)
    4 FORMAT(F6.2,9F7.2)
    5 FORMAT(E6.1,4E8.1)
  515 FORMAT(E12.7,3E14.7)
    6 FORMAT(I2)
    7 FORMAT(10I5)
    8 FORMAT(1H1,80H                                        THIS IS REC
   1ONNAISSANCE MISSION NUMBER  I2)
    9 FORMAT(1H )
   10 FORMAT(35H TRAJECTORY PARAMETERS FOR MISSION  I3,26H CORRESPONDING
   1 TO LAUNCH =  F9.3,33H AND FIRST PLANETARY INTERCEPT =  F9.3)
   11 FORMAT(1H ,F9.3,F13.6,2F11.6,F14.3,F10.3,F16.3,F13.6,2F11.6)
   12 FORMAT(1H ,F8.3,F9.3,E14.5,E12.5,E14.5,2E12.5,E14.5,2E12.5)
   13 FORMAT(32H DISTANCE OF CLOSEST APPROACH =  F10.2,32H VELOCITY AT C
   1LOSEST APPROACH =  F7.3,30H ENERGY AT CLOSEST APPROACH =  F8.3)
   14 FORMAT(60H                                          ASYMPTOTIC LAUNCH VECT
   1OR =  3E15.6)
   15 FORMAT(28H          INJECTION ENERGY =  F8.3,31H          INJECTION
   1 VELOCITY =  F6.3,30H          TOTAL FLIGHT TIME =  F8.3)
   16 FORMAT(39H TRAJECTORY PARAMETERS FOR LAUNCH DATE  F10.3,13H  OF M
   1ISSION  I2,23H  ARE BEING CALCULATED  )
   17 FORMAT(110H  LAUNCH   INTERCEPT  RETURN    THETA12 THETA23   A12
   1    A23       IE      IV     TISI      DOCA       VOCA     DA       TT  )
   18 FORMAT(1H ,F9.3,2F10.3,2F8.2,2F9.5,F8.2,F7.2,F7.3,F11.2,F8.2,F7.2,
   1F9.3)
  201 FORMAT(1H0,72H                                                    LAUN
   1CH PLANET = MERCURY  )
  202 FORMAT(1H0,72H                                                    LAUN
   1CH PLANET = VENUS    )
  203 FORMAT(1H0,72H                                                    LAUN
   1CH PLANET = EARTH    )
  204 FORMAT(1H0,72H                                                    LAUN
   1CH PLANET = MARS     )
  205 FORMAT(1H0,72H                                                    LAUN
   1CH PLANET = JUPITER  )
  206 FORMAT(1H0,72H                                                    LAUN
   1CH PLANET = SATURN   )
  207 FORMAT(1H0,72H                                                    LAUN
   1CH PLANET = URANUS   )
  208 FORMAT(1H0,72H                                                    LAUN
   1CH PLANET = NEPTUNE  )
  209 FORMAT(1H0,72H                                                    LAUN
   1CH PLANET = PLUTO    )
  211 FORMAT(1H0,62H
   1  MERCURY  )
  212 FORMAT(1H0,62H
   1  VENUS    )
  213 FORMAT(1H0,62H
   1  EARTH    )
  214 FORMAT(1H0,62H
   1  MARS     )
```

Third comment cards were left over from the computer program I wrote at JPL in Dec 1961 when I computed some Earth–Venus–Earth trajectories for testing purposes.

```
MAIN
  215 FORMAT(1H0,62H
     1  JUPITER   )
  216 FORMAT(1H0,62H
     1  SATURN    )
  217 FORMAT(1H0,62H
     1  URANUS    )
  218 FORMAT(1H0,62H
     1  NEPTUNE   )
  219 FORMAT(1H0,62H
     1  PLUTO     )
  221 FORMAT(1H0,72H                                                  ARRI
     1VAL PLANET = MERCURY   )
  222 FORMAT(1H0,72H                                                  ARRI
     1VAL PLANET = VENUS     )
  223 FORMAT(1H0,72H                                                  ARRI
     1VAL PLANET = EARTH     )
  224 FORMAT(1H0,72H                                                  ARRI
     1VAL PLANET = MARS      )
  225 FORMAT(1H0,72H                                                  ARRI
     1VAL PLANET = JUPITER   )
  226 FORMAT(1H0,72H                                                  ARRI
     1VAL PLANET = SATURN    )
  227 FORMAT(1H0,72H                                                  ARRI
     1VAL PLANET = URANUS    )
  228 FORMAT(1H0,72H                                                  ARRI
     1VAL PLANET = NEPTUNE   )
  229 FORMAT(1H0,72H                                                  ARRI
     1VAL PLANET = PLUTO     )
      DIMENSION A(4,517,9)
      DIMENSION G(7,9)
      DIMENSION EX(9),EY(9),EZ(9),HX(9),HY(9),HZ(9)
      DIMENSION NP(10,10)
      DIMENSION TCA(10),BLI(10),TL(10,10),ELI(10),TL1(10,10),NNM(10)
      DIMENSION PP(10),PPX(10),PPY(10),PPZ(10)
      DIMENSION VPX(10),VPY(10),VPZ(10)
      DIMENSION EA(10),EE(10),EL(10),EH(10),THETA(10)
      DIMENSION EHX(10),EHY(10),EHZ(10),EEX(10),EEY(10),EEZ(10)
      DIMENSION VLX(10),VLY(10),VLZ(10),VAX(10),VAY(10),VAZ(10)
      DIMENSION VILX(10),VILY(10),VILZ(10),VIAX(10),VIAY(10),VIAZ(10)
      DIMENSION VILS(10),VIAS(10),C3L(10),C3A(10),VAS(10),VLS(10)
      DIMENSION D(3),B(3),E(3),VIAVS(10),VIA(10),VIL(10),CSOL(10),TT(3)
      DIMENSION VILU1(10),VILU2(10),VIAU1(10),VIAU2(10),TI4(10)
      DIMENSION HA(10),HE(10),HH(10),DOCA(10),TINS(10),TOT(10)
      DIMENSION TI3(10),TIM(10),DEFA(10),NPM(10),NA(10,10),NL(10)
      DIMENSION HEX(10),HEY(10),HEZ(10),HHX(10),HHY(10),HHZ(10)
      DIMENSION RIAX(10),RIAY(10),RIAZ(10),RILX(10),RILY(10),RILZ(10)
      DIMENSION TS(2,10),PPS(2,10),RSX(2,10),RSY(2,10),RSZ(2,10)
      DIMENSION TTIP(10),ALTINJ(10),TI(10),TIO(10),DTO(10)
      DIMENSION C3CA(10),VICA(10),VICAU1(10),VICAU2(10)
      DIMENSION RAX(10),RAY(10),RAZ(10),RLX(10),RLY(10),RLZ(10)
      READ INPUT TAPE 5,1,((G(I,J),I=1,7),J=1,9)
      DO 20 K=1,9
   20 READ INPUT TAPE 5,2,EX(K),EY(K),EZ(K),HX(K),HY(K),HZ(K)
      READ INPUT TAPE 5,3,(BLI(M),M=1,10)
      READ INPUT TAPE 5,4,(TI3(M),M=1,10)
      READ INPUT TAPE 5,4,(TI(M),M=1,10)
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MAIIO
      READ INPUT TAPE 5,4,(TIO(M),M=1,IC)
      READ INPUT TAPE 5,6,NM
      READ INPUT TAPE 5,5,D1,D2,D3,D4,D5
      READ INPUT TAPE 5,515,U,CF1,CF2,CF3
      READ INPUT TAPE 5,6,NTAPE
      READ INPUT TAPE 5,7,((NP(IP,M),IP=1,10),M=1,NM)
      READ INPUT TAPE 5,7,(NNM(M),M=1,10)
      READ INPUT TAPE 5,4,(TI4(M),M=1,IC)
      READ INPUT TAPE 5,4,(TIM(M),M=1,IC)
      READ INPUT TAPE 5,7,(NPM(M),M=1,10)
      READ INPUT TAPE 5,7,((NA(IP,M),IP=1,10),M=1,NM)
      READ INPUT TAPE 5,7,(NL(M),M=1,10)
      READ INPUT TAPE 5,3,(ALTINJ(M),M=1,10)
      READ INPUT TAPE 5,4,(DTD(M),M=1,10)
      REWIND NTAPE
      READ TAPE NTAPE,A
      DO 130 M=1,NM
      I5=NP(1,M)
      I6=NPM(M)
      I61=I6-1
      GO TO (231,232,233,234,235,236,237,238,239),I5
  231 WRITE OUTPUT TAPE 6,201
      GO TO 270
  232 WRITE OUTPUT TAPE 6,202
      GO TO 270
  233 WRITE OUTPUT TAPE 6,203
      GO TO 270
  234 WRITE OUTPUT TAPE 6,204
      GO TO 270
  235 WRITE OUTPUT TAPE 6,205
      GO TO 270
  236 WRITE OUTPUT TAPE 6,206
      GO TO 270
  237 WRITE OUTPUT TAPE 6,207
      GO TO 270
  238 WRITE OUTPUT TAPE 6,208
      GO TO 270
  239 WRITE OUTPUT TAPE 6,209
      GO TO 270
  270 DO 280 I7=2,I61
      I8=NP(I7,M)
       GO TO (241,242,243,244,245,246,247,248,249),I8
  241 WRITE OUTPUT TAPE 6,211
      GO TO 280
  242 WRITE OUTPUT TAPE 6,212
      GO TO 280
  243 WRITE OUTPUT TAPE 6,213
      GO TO 280
  244 WRITE OUTPUT TAPE 6,214
      GO TO 280
  245 WRITE OUTPUT TAPE 6,215
      GO TO 280
  246 WRITE OUTPUT TAPE 6,216
      GO TO 280
  247 WRITE OUTPUT TAPE 6,217
      GO TO 280
```

```
      WRITE OUTPUT TAPE 6,218
      GO TO 280
  249 WRITE OUTPUT TAPE 6,219
  280 CONTINUE
      I9=NP(I6,M)
      GO TO (251,252,253,254,255,256,257,258,259),I9
  251 WRITE OUTPUT TAPE 6,221
      GO TO 290
  252 WRITE OUTPUT TAPE 6,222
      GO TO 290
  253 WRITE OUTPUT TAPE 6,223
      GO TO 290
  254 WRITE OUTPUT TAPE 6,224
      GO TO 290
  255 WRITE OUTPUT TAPE 6,225
      GO TO 290
  256 WRITE OUTPUT TAPE 6,226
      GO TO 290
  257 WRITE OUTPUT TAPE 6,227
      GO TO 290
  258 WRITE OUTPUT TAPE 6,228
      GO TO 290
  259 WRITE OUTPUT TAPE 6,229
  290 CONTINUE
      WRITE OUTPUT TAPE 6,9
      DO 299 N=1,2
      DO 298 IP=1,10
  298 TS(N,IP)=0.
  299 CONTINUE
      N=0
      NC1=0
      NC2=0
      NN2=0
      IP=1
      I1=1
      SKIP=1.
      TCA(IP)=BLI(M)
      IF(DTD(M))921,921,21
  921 WRITE OUTPUT TAPE 6,17
   21 K=NP(IP,M)
      J=1
   22 IF(A(1,J,K)-TCA(IP))23,24,24
   23 J=J+1
      GO TO 22
   24 J1=J-1
      P1JX=A(2,J1,K)
      P1JY=A(3,J1,K)
      P1JZ=A(4,J1,K)
      P2JX=A(2,J,K)
      P2JY=A(3,J,K)
      P2JZ=A(4,J,K)
      DPX=P2JX-P1JX
      DPY=P2JY-P1JY
      DPZ=P2JZ-P1JZ
      F=(TCA(IP)-A(1,J1,K))/(A(1,J,K)-A(1,J1,K))
      ZX=P1JX+F*DPX
```

WRITE

IF(TCA(IP)-43120.) 22, 22,

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      ZY=PIJY+F*DPY
      ZZ=PIJZ+F*DPZ
      ZS=ZX**2+ZY**2+ZZ**2
      Z=SQRTF(ZS)
      PUX=ZX/Z
      PUY=ZY/Z
      PUZ=ZZ/Z
      PP(IP)=G(4,K)/(1.+EX(K)*PUX+EY(K)*PUY+EZ(K)*PUZ)
      PPX(IP)=PP(IP)*PUX
      PPY(IP)=PP(IP)*PUY
      PPZ(IP)=PP(IP)*PUZ
      VPX(IP)=(HY(K)*(PUZ+EZ(K))-HZ(K)*(PUY+EY(K)))/G(4,K)
      VPY(IP)=(HZ(K)*(PUX+EX(K))-HX(K)*(PUZ+EZ(K)))/G(4,K)
      VPZ(IP)=(HX(K)*(PUY+EY(K))-HY(K)*(PUX+EX(K)))/G(4,K)
      IF(SKIP-1.)25,25,26
   25 IP=IP+1
      TCA(IP)=TCA(IP-1)+TIM(M)
      SKIP=SKIP+1.
      GO TO 21
   26 PX=PPX(IP-1)
      PY=PPY(IP-1)
      PZ=PPZ(IP-1)
      T=TCA(IP)-TCA(IP-1)
      QX=PPX(IP)
      QY=PPY(IP)
      QZ=PPZ(IP)
  261 PS=PX**2+PY**2+PZ**2
      P=SQRTF(PS)
      QS=QX**2+QY**2+QZ**2
      Q=SQRTF(QS)
      PQ=PX*QX+PY*QY+PZ*QZ
      C=SQRTF(PS+QS-2.*PQ)
      S=(P+Q+C)/2.
      PXQZ=PX*QY-PY*QX
      IF(PXQZ)60,29,29
   29 Z=(SQRTF(2./U)/3.)*(SQRTF(S**3)-SQRTF((S-C)**3))
      IF(Z-T)32,30,30
   30 I11=0
      I22=180
      GO TO 72
   32 N=0
   33 AN=S*(.5+(.5)**N)
      X1N=1.-S/AN
      X2N=1.-(S-C)/AN
      SX1N=SQRTF(1.-X1N**2)
      SX2N=SQRTF(1.-X2N**2)
      Y1N=X1N/SX1N
      Y2N=X2N/SX2N
      Z1=3.*3.1415927*SQRTF(AN/U)
      Z2=1.5*(SQRTF(AN/U))*(SX2N+ATANF(Y2N)-SX1N-ATANF(Y1N))
      Z3=1./SQRTF(AN*U)
      Z4=(S-C)*SQRTF((1.-X2N)/(1.+X2N))-S*SQRTF((1.-X1N)/(1.+X1N))
      GAN=Z1+Z2+Z3*Z4
      IF(GAN)35,36,34
   34 N=N+1
      IF(N-35)33,36,36
```