Appendix A

This is a listing of the combined maneuver program with the non-linear tire model. All the latest attributes mentioned in section 5.4 are included in this version. The linear tire model is included but commented out.

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50 CLEAR       :  KEY 1,""          'CLEARS COMPUTER AND DISABLES F1 KEY
100 COLOR 2,8,8
150 DEFDBL A-Z                      'DEFINES DOUBLE PRECISION VARIABLES
200 DEF FNARCSIN(X)=ATN(X/SQR(1#-X*X))     'DEFINES AN ARCSINE FUNCTION
250       DIM A(36),B(6),D(6)  :  PI=3.1415927#  :  G=980.65
300 REM
350 REM
400 REM ************************************************************************
450 REM ****  1.) READ THE NUMBER OF SOLUTIONS.                                **
500 REM ****  2.) ENTER THE SOLUTION DO-LOOP AND READ THE FIRST SET OF INPUT**
550 REM ****  3.) CALCULATE THE DERIVED VALUES FROM THE INPUT                   **
600 REM ****  4.) ECHO THE INPUT, THE INITIAL GUESS FOR THE SOLUTION VECTOR,**
650 REM ****      AND THE DERIVED VALUES FROM THE INPUT.                       **
700 REM ************************************************************************
750 REM
800 REM
850 OPEN "D:TENDOF.DAT" FOR INPUT AS #1
900      INPUT #1,INPTLINE0$,NSOL%,ECHOIN%,ECHOOUT%
950  FOR ISOL% =1 TO NSOL%
1000 INPUT #1,INPTLINE1$,A,L1,L2,H,M,DRVAXL$
1050 INPUT #1,INPTLINE2$,FYTFL,FYTFR,FZBL,FYBL
1100 INPUT #1,INPTLINE3$,THETA,SSV,DEL,BETA
1150 INPUT #1,INPTLINE4$,KF,KB,KTB,KTF,KPF,KPB
1200 INPUT #1,INPTLINE5$,IZZ,IXZ,IYZ
1250 INPUT #1,INPTLINE6$,TF,TB,BP,ER,MO
1300 INPUT #1,INPTLINE7$,CALPHAB,CALPHAF,CI
1350 CLOSE
1400 REM
1450 REM
1500 REM ************************************************************************
1550 REM WE WANT THE INITIAL GUESS TO BE THE SAME EACH TIME WE INCREMENT THETA
1600 REM SO WE SAVE THEM TO BE RESET EACH TIME. ALSO WE WANT THE SPINDLE TO
1650 REM C.G. DISTANCE TO BE SET TO DESIGN POSITION (H) EACH TIME.
1700 REM ************************************************************************
1750 DELSS=DEL: BETASS=BETA:FYTFLSS=FYTFL:FYTFRSS=FYTFR:FZBLSS=FZBL:FYBLSS=FYBL
1800 SSV=0#
1850 FOR ISSV%=1 TO 3
1900   IF ISSV%=1 THEN OPEN "D:OUTPUT1.PRN" FOR OUTPUT AS #1
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1950   IF ISSV%=1 THEN OPEN "B:OUTPUT2.PRN" FOR OUTPUT AS #2
2000 IF ISSV%=1 THEN SSV=3129#
2050 IF ISSV%=2 THEN SSV=2011#
2100 IF ISSV%=3 THEN SSV=447#
2150   A=0#                                          '------(==INCREMENT THE
2200   FOR IACL%=1 TO 4                                    '| ACCELERATION
2250   THETA=0#                                            '| MAGNITUDE, OPEN 2
2300   A=A+.2#*G                                           '| OUTPUT FILES, AND
2350   GSS$="A="+STR$(A/G)+"G's"                           '| WRITE A LABEL TO
2400   GS$=GSS$+"   VEL.="+STR$(CINT(SSV*.036))+"KM/HR"    '| THE OUTPUT FILES.
2450   PRINT #1,CHR$(34);GS$;CHR$(34)                      '|
2500   PRINT #2,CHR$(34);GS$;CHR$(34)                 '------
2550     FOR ITHET%=1 TO 16                        'INCREMENT THETA AND RESTART
2600     THETA=THETA+PI/16#
2650 REM**** CALCULATE THE INITIAL GUESS FOR THIS SOLUTION ******************
2660     BETAS=BETASS+.1#*IACL%*SIN(THETA)/ISSV%                              '#
2670     DELS=DELSS+.1#*IACL%*SIN(THETA)/ISSV%                                '#
2680     FZBLS=-M*G/4#                                                        '#
2690     FYTFLS=M*A*SIN(THETA)/4#  : FYTFRS=FYTFLS  : FYBLS=FYTFLS            '#
2700 DEL=DELS :BETA=BETAS :FYTFL=FYTFLS :FYTFR=FYTFRS :FZBL=FZBLS :FYBL=FYBLS
2750     HFR=H    : HFL=H      : HBR=H        : HBL=H :  HSTEP=.01#           '#
2800 REM ********************************************************************
2850 REM ******************** DERIVED VALUES ************************
2900         R=(A*SIN(THETA))/SSV                                             '#
2950         RHO=SSV*SSV/(A*SIN(THETA))                                       '#
3000         RD=-(A*A/(SSV*SSV))*SIN(THETA)*COS(THETA)                        '#
3050           C1=((KTB+KB+2#*KPB)*KTF*(KF+2#*KPF)*TF)                        '#
3100         C=C1/((KTF+KF+2#*KPF)*KTB*(KB+2#*KPB)*TB)                        '#
3150 REM ******************** END OF DERIVED VALUES ******************
3200 PRINT :PRINT
3250 REM*************************************************************************
3300 REM   I  M   M  PPPP  U   U TTTTT      EEEEE  CCC   M   M   000     #
3350 REM   I  MM  M  P   P U   U   T        E     C   C  M   M  0   0    #
3400 REM   I  M M M  PPPP  U   U   T        EEEE  C      MMMMM  0   0    #
3450 REM   I  M  MM  P     U   U   T        E     C   C  M   M  0   0    #
3500 REM   I  M   M  P      UUU    T        EEEEE  CCC   M   M   000     #
3550 REM*************************************************************************
3600 PRINT"THETA=";THETA;"  A=";A;"    SSV=";SSV
3650 IF ECHOIN%=1 THEN GOTO 3700:PRINT"INPUT ECHO STOPPED,ECHOIN #1":GOTO 5700
3700 PRINT"VEHICLE ACCELERATION IS ..............(CM/SEC**2).....(A)=)";A
3750 PRINT"FRACTION OF BRAKING AT FRONT.........(UNITLESS)......(BP)=)";BP
3800 PRINT"BACK LATERAL TIRE STIFFNESS.............(N/RAD)..(CALPHAB)=)";CALPHAB
3850 PRINT"FRONT LATERAL TIRE STIFFNESS............(N/RAD)..(CALPHAF)=)";CALPHAF
3900 PRINT"RWD OR FWD SPECIFIER.................(UNITLESS).(DRVAXL$)=)";DRVAXL$
3950 PRINT"SPINDLE TO CG VERTICAL DISTANCE AT DESIGN.(CM).........(H)=)";H
4000 PRINT"MASS CROSS PRODUCT OF INERTIA......((kg/100)CM^2)...(IXZ)=)";IXZ
4050 PRINT"MASS CROSS PRODUCT OF INERTIA .....((kg/100)CM^2)...(IYZ)=)";IYZ
4100 PRINT"MASS MOMENT OF INERTIA ABOUT Z ....((kg/100)CM^2)...(IZZ)=)";IZZ
4150 PRINT"BACK WHEEL RATE PER WHEEL..............(N/CM).......(KB)=)";KB
4200 PRINT"FRONT WHEEL RATE PER WHEEL.............(N/CM).......(KF)=)";KF
4250 PRINT"BACK ROLL RATE DUE TO STAB. BAR .......(N/CM)......(KPB)=)";KPB
4300 PRINT"FRONT ROLL RATE DUE TO STAB. BAR .....(N/CM)......(KPF)=)";KPF
4350 PRINT"BACK RADIAL TIRE RATE PER TIRE .......(N/CM)......(KTB)=)";KTB
4400 PRINT"FRONT RADIAL TIRE RATE PER TIRE .......(N/CM)......(KTF)=)";KTF
4450 PRINT"DISTANCE FROM C.G. TO FRNT WHEEL.........(CM).......(L1)=)";L1
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4500 PRINT"DISTANCE FROM C.G. TO REAR WHEEL..... (CM).....(L2)=)";L2
4550 PRINT"MASS OF THE SPRUNG MASS.....(KG/10).....(M)=)";M
4600 REM T"COEFICIENT OF FRICTION.....(UNITLESS).(MO)=)";MO
4650 PRINT"VEHICLE VELOCITY IS .....(CM/SEC)..(SSV)=)";SSV
4700 PRINT"BACK TRACK WIDTH .....(CM).....(TB)=)";TB
4750 PRINT"FRONT TRACK WIDTH .....(CM).....(TF)=)";TF
4800 PRINT"INITIAL ANGLE BETWEEN V AND A IS .....(RAD)...(THETA)=)";THETA
4850 PRINT
4900 PRINT
4950     PRINT"         THE INITIAL GUESS AT THE SOLUTION VECTOR IS:"
5000 PRINT"SIDESLIP ANGLE BETWEEN V AND X DIR....(RAD).....(BETA)=)";BETA
5050 PRINT"THE STEER ANGLE (FRONT ONLY) .....(RAD).....(DEL)=)";DEL
5100 PRINT"Y DIR FORCE AT FRONT LEFT.....(NEWTONS).(FYTFL)=)";FYTFL
5150 PRINT"Y DIR FORCE AT FRONT RIGHT.....(NEWTONS).(FYTFR)=)";FYTFR
5200 PRINT"Y DIR FORCE AT FRONT RIGHT.....(NEWTONS)..(FYBL)=)";FYBL
5250 PRINT"Z DIR FORCE AT BACK LEFT.....(NEWTONS)..(FZBL)=)";FZBL
5300 REM ************************************************************************
5350 PRINT
5400 PRINT
5450 PRINT"THE CONSTANTS DERIVED FROM THE INPUT:"
5500 PRINT"ROLL STIFFNESS DISTRIBUTION CONSTANT.....(UNITLESS)...(C)=)";C
5550 PRINT"THE RADIUS OF THE TURN.....(METERS)...(RHO)=)";RHO/100
5600 PRINT"YAW VELOCITY DUE TO CURVED PATH .....(RAD/SEC)....(R)=)";R
5650 PRINT"YAW ACCELERATION DUE TO CURVED PATH ..(RAD/SEC^2).(RD)=)";RD
5700 REM  ************************************************************************
5725 IF ITHETX>1 THEN 7100
5750 PRINT #1,CHR$(34);"  A  ";CHR$(34);CHR$(34);" SSV ";CHR$(34); '--
5800 PRINT #1,CHR$(34);"THETA";CHR$(34);CHR$(34);"BETA ";CHR$(34); ' |<= PRINT
5850 PRINT #1,CHR$(34);"DEL  ";CHR$(34);CHR$(34);"RHO  ";CHR$(34); ' |A HEADER
5900 PRINT #1,CHR$(34);"FYTFL";CHR$(34);CHR$(34);"FYTFR";CHR$(34); ' | TO THE
5950 PRINT #1,CHR$(34);"FZBL ";CHR$(34);CHR$(34);"FYBL ";CHR$(34); ' | FIRST
6000 PRINT #1,CHR$(34);" L1  ";CHR$(34);CHR$(34);" L2  ";CHR$(34); ' | OUTPUT
6050 PRINT #1,CHR$(34);"  N  ";CHR$(34);CHR$(34);"  M  ";CHR$(34); ' | FILE
6100 PRINT #1,CHR$(34);" TF  ";CHR$(34);CHR$(34);" TB  ";CHR$(34); ' |
6150 PRINT #1,CHR$(34);" BP  ";CHR$(34);CHR$(34);"DRVAX"          '--
6200 PRINT #2,CHR$(34);"CALFF";CHR$(34);CHR$(34);"CALFB";CHR$(34); '--
6250 PRINT #2,CHR$(34);" KF  ";CHR$(34);CHR$(34);" KB  ";CHR$(34); ' |<= PRINT
6300 PRINT #2,CHR$(34);" KTF ";CHR$(34);CHR$(34);" KTB ";CHR$(34); ' |A HEADER
6350 PRINT #2,CHR$(34);" KPF ";CHR$(34);CHR$(34);" KPB ";CHR$(34); ' | TO THE
6400 PRINT #2,CHR$(34);" IZZ ";CHR$(34);CHR$(34);" IXZ ";CHR$(34); ' | 2ND OUT
6450 PRINT #2,CHR$(34);" IYZ ";CHR$(34)                           '-- FILE
6500 PRINT #1,CSNG(A)    ;CSNG(SSV)  ;
6550 PRINT #1,CSNG(THETA);CSNG(BETA) ;CSNG(DEL)  ; CSNG(RHO) ;    '--
6600 PRINT #1,CSNG(FYTFL);CSNG(FYTFR);CSNG(FZBL) ; CSNG(FYBL);    ' |<= PRINT
6650 PRINT #1,CSNG(L1)   ;CSNG(L2)   ;CSNG(N)    ;CSNG(M)    ;    ' |  THE
6700 PRINT #1,CSNG(TF)   ;CSNG(TB)   ;CSNG(BP)   ;DRVAXL$          ' |UNKNOWNS
6750 PRINT #2,CSNG(CALPHAF);CSNG(CALPHAB);CSNG(KF) ;CSNG(KB) ;    ' | TO THE
6800 PRINT #2,CSNG(KTF) ;CSNG(KTB) ;CSNG(KPF) ;CSNG(KPB) ;    ' | OUTPUT
6850 PRINT #2,CSNG(IZZ) ;CSNG(IXZ) ;CSNG(IYZ)                     '-- FILES.
6900 REM  ************************************************************************
6950 REM  ****** I TTTTT  EEEE  RRRR    AAA  TTTTT  I   000  R   R    *****
7000 REM  ****** I   T    E__  R RR  A   A   T    I  0   0 RR  R    *****
7050 REM  ****** I   T    E    RRRR   AAAAA   T    I  0   0 R R R    *****
7100 REM  ****** I   T    EEEE R  R  A   A   T    I   000  R  RR    *****
7150 REM ************************************************************************
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7200 REM ******  THIS IS THE START OF THE ITERATION LOOP FOR THE NEWTON-   **
7250 REM ******  RAPHSON PROCEDURE.  WE USE THIS PROCEDURE TO SOLVE THE    **
7300 REM ******  NON-LINEAR EQUATIONS FOR THE STEADY STATE SYSTEM ORIENTATION
7350 REM ************************************************************************
7400 PRINT
7450    FOR ITER%=1 TO 50     ' <=======  ITERATION  LOOP FOR SOLUTION ALGOR
7460    IF ABS(BETA)>1# THEN BETA=BETAS        'LIMITS BETA TO 1 RADIAN
7470    IF ABS(DEL)>1# THEN DEL=DELS           'LIMITS DEL TO 1 RADIAN
7480    IF ABS(FZBL)>10000# THEN FZBL=FZBLS    'LIMITS FZBL TO 50000 NEWTONS
7490    IF ABS(FYTFL)>4#*FYTFLS THEN FYTFL=FYTFLS   'LIMITS FYTFL
7500    IF ABS(FYTFR)>4#*FYTFRS THEN FYTFR=FYTFRS   'LIMITS FYTFR
7510    IF ABS(FYBL)>4#*FYBLS THEN FYBL=FYBLS   'LIMITS FYBL
7520    GOSUB 18750            ' <=======  CALL SYSTEM EQUATIONS
7550 B(1)=-F1   : FF1 = F1   '---
7600 B(2)=-F2   : FF2 = F2   ' |<==SAVE FUNCTION VALUES, (F1 TO F6) IN B(X)
7650 B(3)=-F3   : FF3 = F3   ' |          AND FFX
7700 B(4)=-F4   : FF4 = F4   ' |
7750 B(5)=-F5   : FF5 = F5   ' |
7800 B(6)=-F6   : FF6 = F6   '---
7850 PRINT "ITERATION STEP=";ITER%;"    HSTEP=";HSTEP
7900 REM   ************************************************************
7950 REM   ****** DDD   EEEE  RRR   I  V   V    A   TTTTT  I V   V EEEE ****
8000 REM   ****** D  D  E___  R  R  I  V   V   A A    T    I V   V E__  ****
8050 REM   ****** D  D  E     RRR   I   V V   AAAAA   T    I  V V  E    ****
8100 REM   ****** DDD   EEEE  R  R  I    V    A   A   T    I   V   EEEE ****
8150 REM   * DERIVATIVES START HERE FOR THE NEWTON RAPHSON ITERATION PROC.**
8200 REM   ************************************************************
8250    FOR ID%=1  TO  6                  '<==LOOP TO CALCULATE DERIVATIVES
8300       A$=INKEY$                      '---(== IF "F1" IS PRESSED THEN
8350       IF LEN(A$)=2 THEN A$=RIGHT$(A$,1)'  |    STOP THE PROGRAM
8400       IF A$=CHR$(59) THEN GOTO 18200   '---
8450       REM BY PRESSING U OR D THE DERIVATIVE STEP IS CHANGED.
8500       IF A$=CHR$(100) OR A$=CHR$(68) THEN HSTEP=HSTEP*.1# 'DECREASE STEP
8550       IF A$=CHR$(117) OR A$=CHR$(85) THEN HSTEP=HSTEP*10# 'INCREASE STEP
8600     IF ID%=1 THEN HDERV=FYTFL*HSTEP        '---
8650     IF ID%=2 THEN HDERV=FYTFR*HSTEP        ' |<==THIS SETS THE DERIVATIVE
8700     IF ID%=3 THEN HDERV=FZBL*HSTEP         ' |    STEP TO A VALUE THAT IS
8750     IF ID%=4 THEN HDERV=BETA*HSTEP         ' |    PROPORTIONAL TO THE
8800     IF ID%=5 THEN HDERV=DEL*HSTEP          ' |    UNKNOWN ITSELF.
8850     IF ID%=6 THEN HDERV=FYBL*HSTEP         '---
8900 IF ID%=1 THEN FYTFL=FYTFL+HDERV    'RECALL:
8950 IF ID%=2 THEN FYTFR=FYTFR+HDERV    '         f(x+hderv)-f(x)
9000 IF ID%=3 THEN FZBL=FZBL+HDERV      '  F'(x)= ---------------- as hderv->0
9050 IF ID%=4 THEN BETA=BETA+HDERV      '              hderv
9100 IF ID%=5 THEN DEL=DEL+HDERV        '
9150 IF ID%=6 THEN FYBL=FYBL+HDERV
9200    GOSUB 18750                     ' <====|  CALL THE SYSTEM EQUATIONS|
9250    A(ID%*6-5)=(F1-FF1)/HDERV       '--    |  TO CALCULATE  f(x+hder)  |
9300    A(ID%*6-4)=(F2-FF2)/HDERV       ' |
9350    A(ID%*6-3)=(F3-FF3)/HDERV       ' |<=== CALCULATE DERIVATIVES AND PUT
9400    A(ID%*6-2)=(F4-FF4)/HDERV       ' |    THEM INTO THE  "A"  MATRIX.
9450    A(ID%*6-1)=(F5-FF5)/HDERV       ' |
9500    A(ID%*6)=(F6-FF6)/HDERV         '--
9550 IF ID%=1 THEN FYTFL=FYTFL-HDERV    '-----
9600 IF ID%=2 THEN FYTFR=FYTFR-HDERV    '    |
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9650 IF ID%=3 THEN FZBL=FZBL-HDERV      '    |<=== RESET (x+h) TO  x
9700 IF ID%=4 THEN BETA=BETA-HDERV      '    |
9750 IF ID%=5 THEN DEL=DEL-HDERV        '    |
9800 IF ID%=6 THEN FYBL=FYBL-HDERV      '-----
9850     NEXT ID%                       '<==== END OF DERIVATIVE CALCULATION
9900 REM PRINT "JACOBIAN MATRIX:"                          '--
9950 REM FOR AAA%=1 TO 36  :PRINT "A(";AAA%;")=";A(AAA%) ' |
10000 REM NEXT AAA%                                       ' | PRINT "A" & "B"
10050     PRINT "FUNCTION VALUES:"                        ' |
10100     FOR AAB%=1 TO 6  :PRINT "F";AAB%;"=";B(AAB%)    ' |  MATRIX
10150     NEXT AAB%                                       '--
10200 REM*************************************************************************
10250 REM**  CCC     A    L    L         SSS  I  M     M    QQQ           *
10300 REM** C   C   A A   L    L        S     I  MM   MM   Q   Q          *
10350 REM** C      A   A  L    L         SS   I  M M M M  Q   Q Q        *
10400 REM** C   C  AAAAA  L    L           S  I  M  M  M  Q   QQ         *
10450 REM**  CCC   A   A  LLLL LLLL     SSS   I  M     M   QQQ Q        *
10500 REM*  ITS TIME TO CALL SIMQ, THE GAUSS ELIMINATION BACK SUBSTITUTION  *
10550 REM*       SUBROUTINE TO TAKE AN ITERATION STEP IN THE NEWTON-RAPHSON *
10600 REM*************************************************************************
10650       N%=6
10700       IS=0
10750       GOSUB 28100             ' <=== CALL SIMQ(A,B,N%,IS)
10800       IF IS=1 THEN 12850
10850 REM*************************************************************************
10900 REM*  NOW THE UNKNOWNS ARE UPDATED, WRITTEN OUT, AND CHECKED FOR      *
10950 REM*       CONVERGENCE. (ERROR MESSAGE BRANCHING OCCURS HERE ALSO)    *
11000 REM*************************************************************************
11050       FYTFL=FYTFL+B(1)    ' ---
11100       FYTFR=FYTFR+B(2)    '   |
11150       FZBL=FZBL+B(3)      '   |<===UNKNOWNS UPDATED BY NEWTON RAPHSON
11200       BETA=BETA+B(4)      '   |     CORRECTION FACTORS
11250       DEL=DEL+B(5)        '   |
11300       FYBL=FYBL+B(6)      ' ---
11350 REM*************************************************************************
11400       B(1)=FYTFL          ' ---
11450       B(2)=FYTFR          '   |
11500       B(3)=FZBL           '   |<===SAVE UNKNOWNS FOR CONVERGENCE TEST
11550       B(4)=BETA           '   |
11600       B(5)=DEL            '   |
11650       B(6)=FYBL           ' ---
11700 REM PRINT "UNKNOWNS IN STEP";ITER%;"BETA=";B(4);"DEL=";B(5)      '--(=FOR
11750 REM PRINT "FYTFL=";FYTFL;"FYTFR=";FYTFR,"FZBL=";FZBL;"FYBL=";FYBL'|DEBUG-
11800 REM PRINT "CORRECTION FACTORS:  B1=";B(1);"B2=";B(2)             '|GING
11850 REM PRINT "B3=";B(3);"B4=";B(4),"B5=";B(5);"B6=";B(6)           '--
11900 REM
11950 IF  ITER%=49  THEN    12700      '      <==== STOP TO MANY ITERATIONS
12000 REM*************************************************************************
12050 REM* EEEE M   M DDD       CCC    00   M   M      TTTTT EEEE  SSS TTTTT *
12100 REM* E    MM  M D  D     C   C  0 0  MM  M        T   E    S      T   *
12150 REM* EEE  M M M D  D    C      0   0 M M M        T   EEE   SS    T   *
12200 REM* E    M  MM D  D     C   C  0 0  M  MM        T   E       S   T   *
12250 REM* EEEE M   M DDD       CCC    00   M   M *     T   EEEE SSS    T   *
12300 REM*     THE CONVERGENCE TEST DO-LOOP AND OTHER END CONDITION TESTS.   *
12350 REM*************************************************************************
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12400 FOR JTEST% = 1 TO 6
12450       IF  (ABS(B(JTEST%)/D(JTEST%))) > .000001# THEN 12600
12500 NEXT JTEST%
12550       GOTO 13350
12600 NEXT ITER%
12650       GOTO 13350
12700 PRINT
12750 PRINT "ITERATION STOPPED, 49 STEPS TAKEN, NO CONVERGENCE" :PRINT :PRINT
12800       GOTO 13350
12850 PRINT
12900 PRINT "          KS WAS SET TO  1  IN SIMQ, THE MATRIX IS SINGULAR"
12950       GOTO 13350
13000 REM*************************************************************************
13050 REM****        000    U   U  TTTTT  PPPP   U   U  TTTTT          ******
13100 REM****       O   O   U   U    T    P   P  U   U    T            ******
13150 REM****       O     O  U   U    T    PPPP   U   U    T            ******
13200 REM****       O   O   U   U    T    P      U   U    T            ******
13250 REM****        000     UUU     T    P       UUU     T            ******
13300 REM*************************************************************************
13350 TLLTD=(FZFL-FZFR)/(FZFL-FZFR+FZBL-FZBR)
13400 USCOEF=((FZFL+FZFR)/CALPHAF)+((FZBL+FZBR)/CALPHAB)
13450 IF ECHOOUT%=1 THEN GOTO 13500:PRINT"OUTPUT STOPPED IN INPUT":GOTO 16050
13500 REM*************************************************************************
13550 PRINT "  THE FINAL VALUES FOR THE SOL'N AFTER";ITER%;"ITERATIONS ARE:"
13600 PRINT "************************ITERATED VARIABLES:"
13650 PRINT "SIDESLIP ANGLE .......................(RAD)....(BETA)=)";BETA
13700 PRINT "THE STEER ANGLE (FRONT ONLY) ..........(RAD).....(DEL)=)";DEL
13750 PRINT "Y DIR FORCE AT FRONT LEFT.............(NEWTONS).(FYTFL)=)";FYTFL
13800 PRINT "Y DIR FORCE AT FRONT RIGHT............(NEWTONS).(FYTFR)=)";FYTFR
13850 PRINT "Y DIR FORCE AT BACK LEFT..............(NEWTONS).(FYBL)=)";FYBL
13900 PRINT "Z DIR FORCE AT BACK LEFT..............(NEWTONS).(FZBL)=)";FZBL
13950 PRINT "************************INTERNAL VARIABLES:"
14000 PRINT "X DIR FORCE AT FRONT LEFT.............(NEWTONS).(FXTFL)=)";FXTFL
14050 PRINT "X DIR FORCE AT FRONT RIGHT............(NEWTONS).(FXTFR)=)";FXTFR
14100 PRINT "X DIR FORCE AT BACK LEFT..............(NEWTONS).(FXBL)=)";FXBL
14150 PRINT "X DIR FORCE AT BACK RIGHT.............(NEWTONS).(FXBR)=)";FXBR
14200 PRINT "Y DIR FORCE AT BACK RIGHT.............(NEWTONS).(FYBR)=)";FYBR
14250 PRINT "Z DIR FORCE AT FRONT LEFT.............(NEWTONS).(FZFL)=)";FZFL
14300 PRINT "Z DIR FORCE AT FRONT RIGHT............(NEWTONS).(FZFR)=)";FZFR
14350 PRINT "Z DIR FORCE AT BACK RIGHT.............(NEWTONS).(FZBR)=)";FZBR
14400 PRINT "SLIP ANGLE  AT FRONT LEFT.............(RAD)....(ALFFL)=)";ALFFL
14450 PRINT "SLIP ANGLE  AT FRONT RIGHT............(RAD)....(ALFFR)=)";ALFFR
14500 PRINT "SLIP ANGLE  AT BACK LEFT..............(RAD)....(ALFBL)=)";ALFBL
14550 PRINT "SLIP ANGLE  AT BACK RIGHT.............(RAD)....(ALFBR)=)";ALFBR
14600 PRINT "SPIN. TO C.G. VERT DISTANCE AT FRONT LEFT..(CM)..(HFL)=)";HFL
14650 PRINT "SPIN. TO C.G. VERT DISTANCE AT FRONT RIGHT.(CM)..(HFR)=)";HFR
14700 PRINT "SPIN. TO C.G. VERT DISTANCE AT BACK LEFT...(CM)..(HBL)=)";HBL
14750 PRINT "SPIN. TO C.G. VERT DISTANCE AT BACK RIGHT..(CM)..(HBR)=)";HBR
14800 PRINT "SPINDLE TO GROUND  DISTANCE AT FRONT LEFT..(CM).(ZSFL)=)";ZSFL
14850 PRINT "SPINDLE TO GROUND  DISTANCE AT FRONT RIGHT.(CM).(ZSFR)=)";ZSFR
14900 PRINT "SPINDLE TO GROUND  DISTANCE AT BACK LEFT...(CM).(ZSBL)=)";ZSBL
14950 PRINT "SPINDLE TO GROUND  DISTANCE AT BACK RIGHT..(CM).(ZSBR)=)";ZSBR
15000 PRINT "ROLL ABOUT THE X AXIS.................(RAD)...(PHI)=)";PHI
15050 PRINT "PITCH ABOUT THE Y AXIS.................. (RAD).(PITCH)=)";PITCH
15100 PRINT "SPRUNG MASS VERTICLE DEFLECTION.........(CM).....(ZC)=)";ZC
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```
15150 PRINT "TOTAL LATERAL LOAD TRANSFER DISTRIBUTION.(NONE)(TLLTD)=)";TLLTD
15200 PRINT "UNDERSTEER COEFICIENT.....(??).(USCOEF)=)";USCOEF
15250 REM T ".....(CM).....(XX)=)";
15300     PRINT "VELOCITY BODY FIXED  X  DIRECTION...(CM/SEC).....(U)=)";U
15350     PRINT "VELOCITY BODY FIXED  Y  DIRECTION...(CM/SEC).....(V)=)";V
15400 REM PRINT "FRONT STEER ANGLE.....(RAD).....(DF)=)";DF
15450 REM PRINT "FRONT TIRE SATURATION FUNCTION.....(   ).....(FFS)=)";FFS
15500 REM PRINT "REAR TIRE SATURATION FUNCTION.....(   ).....(FRS)=)";
15550 REM PRINT "FRONT TIRE LONGITUDINAL SLIP VALUE..(UNITLESS).(ISF)=)";
15600 REM PRINT "REAR TIRE LONGITTDINAL SLIP VALUE...(UNITLESS).(ISR)=)";
15650 REM PRINT "EMPIRICAL TIRE COEF. - FRONT TIRE...(UNITLESS)..(SF)=)";
15700 REM PRINT "EMPIRICAL TIRE COEF - REAR TIRE.....(UNITLESS)..(SR)=)";
15750 REM PRINT "FRONT SLIP ANGLE IS .....(RAD).....(AF)=)";
15800 REM PRINT "REAR TIRE SLIP ANGLE IS .....(RAD).....(AR)=)";
15850 REM PRINT "SPIN VELOCITY OF THE FRONT TIRE ....(RAD/SEC)...(WF)=)";
15900 REM PRINT "SPIN VELOCITY OF THE REAR TIRE .....(RAD/SEC)...(WR)=)";
15950 REM PRINT "NORMAL FORCE ON THE FRONT TIRE .....(NEWTONS)..(WWF)=)";
16000 REM PRINT "NORMAL FORCE ON THE REAR TIRE .....(NEWTONS)..(WWR)=)';
16050 PRINT
16100 PRINT"   AFTER CONVERGENCE THE FUNCTIONS SHOULD ALL BE ZERO THEY ARE:"
16150 PRINT "F1=";FF1;"F2=";FF2;"F3=";FF3;"F4=";FF4;"F5=";FF5;"F6=";FF6
16200 PRINT
16250 PRINT "AFTER CONVERGENCE, CORRECTION FACTORS SHOULD BE ZERO,THEY ARE:"
16300 PRINT "B1=";B(1);"B2=";B(2);"B3=";B(3);"B4=";B(4);"B5=";B(5);"B6=";B(6)
16350 IF ITHETX>1 THEN GOTO 17450                                    '-
16400 PRINT #1,CHR$(34);"ITERX";CHR$(34);CHR$(34);" KS  ";CHR$(34); ' |
16450 PRINT #1,CHR$(34);" SSV ";CHR$(34);CHR$(34);"  A  ";CHR$(34); ' |
16500 PRINT #1,CHR$(34);"THETA";CHR$(34);CHR$(34);"BETA ";CHR$(34); ' |<=PRINT
16550 PRINT #1,CHR$(34);"  DEL";CHR$(34);CHR$(34);" ZC  ";CHR$(34); ' | HEADER
16600 PRINT #1,CHR$(34);"  PHI";CHR$(34);CHR$(34);"PITCH";CHR$(34); ' | TO THE
16650 PRINT #1,CHR$(34);"X VEL";CHR$(34);CHR$(34);"Y VEL";CHR$(34); ' | FIRST
16700 PRINT #1,CHR$(34);"ALFFL";CHR$(34);CHR$(34);"ALFFR";CHR$(34); ' | OUTPUT
16750 PRINT #1,CHR$(34);"ALFBL";CHR$(34);CHR$(34);"ALFBR";CHR$(34); ' | FILE
16800 PRINT #1,CHR$(34);" ZSFL";CHR$(34);CHR$(34);" ZSFR";CHR$(34); ' |
16850 PRINT #1,CHR$(34);" ZSBL";CHR$(34);CHR$(34);" ZSBR"           '--
16900 PRINT #2,CHR$(34);"FXTFL";CHR$(34);CHR$(34);"FXTFR";CHR$(34); '--
16950 PRINT #2,CHR$(34);" FXBL";CHR$(34);CHR$(34);" FXBR";CHR$(34); ' |<=PRINT
17000 PRINT #2,CHR$(34);"FYTFL";CHR$(34);CHR$(34);"FYTFR";CHR$(34); ' | HEADER
17050 PRINT #2,CHR$(34);" FYBL";CHR$(34);CHR$(34);" FYBR";CHR$(34); ' | TO THE
17100 PRINT #2,CHR$(34);" FZFL";CHR$(34);CHR$(34);" FZFR";CHR$(34); ' | SECOND
17150 PRINT #2,CHR$(34);" FZBL";CHR$(34);CHR$(34);" FZBR";CHR$(34); ' | OUTPUT
17200 PRINT #2,CHR$(34);"  HFL";CHR$(34);CHR$(34);"  HFR";CHR$(34); ' | FILE
17250 PRINT #2,CHR$(34);"  HBL";CHR$(34);CHR$(34);"  HBR";CHR$(34); ' |
17300 PRINT #2,CHR$(34);"TLLTD";CHR$(34);CHR$(34);"USCOEF";CHR$(34);'--
17350 PRINT #2,CHR$(34);"  VD ";CHR$(34);CHR$(34);"  UD ";CHR$(34) '--
17400 Q=180/PI
17450 PRINT #1,ITERX       ;CSNG(KS)    ;CSNG(SSV)  ;CSNG(A); '-------------
17500 PRINT #1,CSNG(THETA*Q);CSNG(BETA*Q);CSNG(DEL*Q);CSNG(ZC);'           |
17550 PRINT #1,CSNG(PHI*Q)  ;CSNG(PITCH*Q);CSNG(U)   ;CSNG(V) ;'  THE      |
17600 PRINT #1,CSNG(ALFFL*Q);CSNG(ALFFR*Q);                    '   UNKNOWNS |
17650 PRINT #1,CSNG(ALFBL*Q);CSNG(ALFBR*Q);                    '   ARE      |
17700 PRINT #1,CSNG(ZSFL) ;CSNG(ZSFR) ;CSNG(ZSBL) ;CSNG(ZSBR)  '   WRITTEN  |
17750 PRINT #2,CSNG(FXTFL);CSNG(FXTFR);CSNG(FXBL) ;CSNG(FXBR) ;'   TO THE   |
17800 PRINT #2,CSNG(FYTFL);CSNG(FYTFR);CSNG(FYBL) ;CSNG(FYBR) ;'   OUTPUT   |
17850 PRINT #2,CSNG(FZFL) ;CSNG(FZFR) ;CSNG(FZBL) ;CSNG(FZBR) ;'   FILES.   |
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```
17900 PRINT #2,CSNG(HFL) ;CSNG(HFR) ;CSNG(HBL) ;CSNG(HBR) ;'          |
17950 PRINT #2,CSNG(TLLTD);CSNG(USCOEF);CSNG(VD) ;CSNG(UD)   '----------
18000      NEXT      ITHET%
18050      NEXT      IACL%
18100      NEXT      ISSV%
18150      NEXT      ISOL%
18200 PRINT :PRINT
18250 IF A$=CHR$(59) THEN PRINT"SOLUTION STOPPED BY USER BY PRESSING F1."
18300 CLOSE
18350       END
18400 REM************************************************************************
18450 REM    EEEEE   QQQ   U   U    A    TTTTT  I   000   R   R   SSS     #
18500 REM    E      Q   Q  U   U   A A     T    I  0   0  RR  R  S        #
18550 REM    EEE    Q   Q  U   U  A   A    T    I  0   0  R R R   SSS     #
18600 REM    E      Q  QQ  U   U  AAAAA    T    I  0   0  R  RR      S    #
18650 REM    EEEEE   QQQ Q  UUU   A   A    T    I   000   R   R   SSS     #
18700 REM************************************************************************
18750 REM ***********************************************************************
18800 REM ***  THIS IS THE BEGINNING OF THE EQUATION SUBROUTINE        ***
18850 REM ***********************************************************************
18900                U=SSV*COS(BETA)          :SD=SIN(DEL)
18950                V=SSV*SIN(BETA)          :CD=COS(DEL)
19000                UD=A*COS(BETA+THETA)     :TF2=TF/2#
19050                VD=A*SIN(THETA+BETA)     :TB2=TB/2#
19100                SUMFX=M*(UD-R*V)         ' # MEANS DOUBLE PRECISION CONST
19150                SUMFZ=-M*G
19200                SUMFY=M*(VD+R*U)
19250                SUMTX=(IXZ*RD-IYZ*R*R)
19300                SUMTY=(IYZ*RD+IXZ*R*R)
19350                SUMTZ=IZZ*RD
19400  GOSUB 23200     'CALL SUBROUTINE FOR FWD OR RWD OR BRAKING
19450        FZBR1=(SUMTY+SUMFZ*L1-FZBL*(L2+L1)-FIBR*HBR-FIBL*HBL)
19500 FZBR=(FZBR1-(FITFR*HFR+FITFL*HFL)*CD+(FYTFR*HFR+FYTFL*HFL)*SD)/(L1+L2)
19550 FZFL=(SUMFZ-FZBR*(1#+C)-FZBL*(1#-C))/2#
19600 FZFR=SUMFZ-FZBR-FZBL-FZFL
19650 FYBR=SUMFY-FYBL-(FITFR+FITFL)*SD-(FYTFR+FYTFL)*CD
19700 REM  ***********************************************************************
19750 REM  ** NOW WE HAVE ALL 12 FORCES (GUESSED OR CALCULATED).  NOW WE    ***
19800 REM  ** SEND THESE FORCES TO THE SUSPENSION SUBROUTINE TO GET CAMBER  ***
19850 REM  ** TOE, ETC.  THEN ITERATE ON THE TIRE RELATIONS AND SUMTZ       ***
19900 REM  ***********************************************************************
19950 GOSUB 24350  ' CALL THE SUSPENSION SUBROUTINE
20000 REM   **********************************************************************
20050 REM   **  THE FOLLOWING EQUATIONS  (SUM OF THE TORQUES ABOUT THE Z AND **
20100 REM   **  THE TIRE RELATION EQUATIONS FOR CONSTRAINTS IMPOSED BY TIRE  **
20150 REM   **  CHARACTERISTICS) ARE THE EQUATIONS USED IN THE NEWTON RAPHSON**
20200 REM   **  ITERATION, SO WE WANT F1 THRU F5 TO GO TO ZERO.              **
20250 REM   **********************************************************************
20300        F1ONE=(FIBL-FIBR)*TB2-(FYBR+FYBL)*L2+(FYTFR+FYTFL)*L1*CD
20350        F1TWO=(FITFL+FITFR)*L1*SD+(FITFL-FITFR)*TF2*CD
20400 F1=F1ONE+F1TWO-SUMTZ+(FYTFR-FYTFL)*TF2*SD
20450        F2ONE=(FZBR-FZBL)*TB2+(FZFR-FZFL)*TF2-(FITFL*SD+FYTFL*CD)*HFL
20500 F2=F2ONE-SUMTX-(FITFR*SD+FYTFR*CD)*HFR-FYBR*HBR-FYBL*HBL
20550 REM
20600 REM  FIRST SOME PRELIM. CALCULATIONS TO FIND SLIP ANGLES__from here___
```

```
20650 REM                                                                    |
20700       RAYFRNT=SQR(L1*L1+TF*TF/4@) :  RAYBCK=SQR(L2*L2+TB*TB/4@)    '  |
20750       ANGLE=ATN(TF/(2@*L1))       :  BANGLE=ATN(TB/(2@*L2))        '  |
20800       ANGFR=(PI/2@+BETA-ANGLE)    :  ANGBR=(PI/2@-BETA-BANGLE)     '  |
20850       ANGFL=(PI/2@+BETA+ANGLE)    :  ANGBL=(PI/2@-BETA+BANGLE)     ' /
20900  TBS4=TB*TB/4@ :TFS4=TF*TF/4@ :L12=L1*L1 :L22=L2*L2 :RHO2=RHO*RHO '  |
20950             RHOFR=SQR(RHO2+TFS4+L12-2@*RHO*RAYFRNT*COS(ANGFR))    '  |
21000       ETA=FNARCSIN((RAYFRNT/RHOFR)*SIN(ANGFR))                     '  |
21050             RHOFL=SQR(RHO2+TFS4+L12-2@*RHO*RAYFRNT*COS(ANGFL))     '  |
21100       XI =FNARCSIN((RAYFRNT/RHOFL)*SIN(ANGFL))                     ' /
21150             RHOBR=SQR(RHO2+TBS4+L22-2@*RHO*RAYBCK*COS(ANGBR))      '  |
21200       LAMBDA=FNARCSIN((RAYBCK/RHOBR)*SIN(ANGBR))                   '  |
21250             RHOBL=SQR(RHO2+TBS4+L22-2@*RHO*RAYBCK*COS(ANGBL))      '  |
21300       ZETA=FNARCSIN((RAYBCK/RHOBL)*SIN(ANGBL))           ' (--to here--|
21350 REM
21400 REM  NOW CALCULATE EACH SLIP ANGLE AND CALL THE TIRE SUBROUTINE.
21450 REM
21500       ALFFL=BETA+XI-DEL
21550       ALF=ALFFL
21600       CALF=CALPHAF
21650       FZ=FZFL
21700       FX=FXTFL
21750     GOSUB 25500              'CALL TIRE SUBROUTINE TO GET FYTFL-PRIME (FY)
21800 F3 = FY-FYTFL
21850       ALFFR=BETA+ETA-DEL
21900       ALF=ALFFR
21950       CALF=CALPHAF
22000       FZ=FZFR
22050       FX=FXTFR
22100     GOSUB 25500              'CALL TIRE SUBROUTINE TO GET FYTFR-PRIME (FY)
22150 F4 = FY-FYTFR
22200       ALFBL=BETA-ZETA
22250       CALF=CALPHAB
22300       ALF=ALFBL
22350       FZ=FZBL
22400       FX=FXBL
22450     GOSUB 25500              ' CALL TIRE SUBROUTINE TO GET FYBL-PRIME (FY)
22500 F5 = FY-FYBL
22550       ALFBR=BETA-LAMBDA
22600       ALF=ALFBR
22650       CALF=CALPHAB
22700       FZ=FZBR
22750       FX=FXBR
22800     GOSUB 25500              ' CALL TIRE SUBROUTINE TO GET FYBR-PRIME (FY)
22850 F6 = FY-FYBR
22900        RETURN
22950        END
23000 REM ************************************************************************
23050 REM *  DDDD   RRRR   I  V   V  EEEEE      EEEEE   QQQ   U   U    A     *
23100 REM *  D   D  R   R  I  V   V  E          E      Q   Q  U   U   A A    *
23150 REM *  D   D  RRRR   I  V   V  EEEE       EEEE   Q   Q  U   U  A   A   *
23200 REM *  D   D  R   R  I   V V   E          E      Q  QQ  U   U  AAAAA   *
23250 REM *  DDDD   R   R  I    V    EEEEE      EEEEE   QQQ Q  UUU   A   A  * *
23300 REM ************************************************************************
23350     IF THETA < PI/2@ THEN GOTO 23700   ' CHECK TO SEE IF WE ARE BRAKING
```

```
23400          FIBR1=2#*(1#+((BP*CD)/(1#-BP)))    '----
23450          FIBR=(SUMFX+(FYTFR+FYTFL)*SD)/FIBR1'   |
23500          FXTFR=FIBR*BP/(1#-BP)              '   |<===BRAKING CONSTRAINTS
23550          FXTFL=FXTFR                        '   |
23600          FIBL=FIBR                          '----
23650        RETURN
23700   IF DRVAXL$ <> "RWD" THEN GOTO 24000  'CHECK IF WE HAVE REAR WHEEL DRIVE
23750          FXTFL=0#                           ' ----
23800          FXTFR=0#                           '    |<=== REAR WHEEL DRIVE
23850          FIBR=.5#*(SUMFX+(FYTFR+FYTFL)*SD)  '    |     CONSTRAINTS
23900          FIBL=FIBR                          ' ----
23950        RETURN
24000          FIBL=0#                            ' ----
24050          FIBR=0#                            '    |
24100          FXTFR1=(SUMFX+(FYTFR+FYTFL)*SD)    '    |<===FRONT WHEEL DRIVE
24150          FXTFR=FXTFR1/(CD*2#)               '    |    CONSTRAINTS
24200          FXTFL=FXTFR                        ' ----
24250        RETURN
24300        END
24350 REM ************************************************************************
24400 REM *   SSSS  U   U   SSSS  PPPP   EEEEE  R   R   SSSS  I   000   R   R *
24450 REM *  S      U   U  S      P   P  E      RR  R  S      I  0   0  RR  R *
24500 REM *   SSS   U   U   SSS   PPPP   EEEE   R R R   SSS   I  0   0  R R R *
24550 REM *      S  U   U      S  P      E      R  RR      S  I  0   0  R  RR *
24600 REM *  SSSS    UUU   SSSS   P      EEEEE  R   R  SSSS   I   000   R   R *
24650 REM ************************************************************************
24700    ZSFR=-FZFR/KTF : ZSFL=-FZFL/KTF : ZSBR=-FZBR/KTB : ZSBL=-FZBL/KTB   '*
24750     PHI=(FZFL-FZFR)*(KTF+KF+2#*KPF)/(TF*KTF*(KF+2#*KPF))               '*
24800       ZC1=(-L1/KB)*(FZBR+FZBL)-(L2/KF)*(FZFL+FZFR)                     '*
24850     ZC=(ZC1+L1*(ZSBR+ZSBL)+L2*(ZSFR+ZSFL))/(2#*(L1+L2))               '*
24900     PITCH=((2#*ZC-ZSFR-ZSFL)/(2#*L1))+(FZFL+FZFR)/(2#*KF*L1)          '*
24950  REM                                                                   '*
25000     BFR=B-ZC+ZSFR   ' ---|                                             *
25050     BFL=B-ZC+ZSFL   '    |<===SPINDLE TO C.G.                           *
25100     BBR=B-ZC+ZSBR   '    |    DISTANCES                                 *
25150     BBL=B-ZC+ZSBL   ' ---|                                             *
25200 RETURN                                                                 '*
25250 REM ************************************************************************
25300 REM **     TTTTT  I  RRRRR   EEEEE   SSSS                               *
25350 REM **       T    I  R    R  E      S                                    *
25400 REM **       T    I  RRRRR   EEEE    SSS                                 *
25450 REM **       T    I  R    R  E          S                                *
25500 REM **       T    I  R    R  EEEEE  SSSS                                 *
25550 REM ************************************************************************
25600 REM    FY =  -CALPHA*ALF           ' SIMPLE LINEAR TIRE MODEL            *
25650 IS=0#
25700 REM CALF=713900                                                    '---
25750 TA2=(TAN(ALF))*TAN(ALF)
25850 ISUB%=0  : IF FX)0# THEN  ISUB%=1      'SET FLAG FOR TRACTION OR BRAKING
25900 FOR II%=1 TO 15                        '----
25950 ON 1+ISUB% GOSUB 26650,27250           '   |     NEWTON RAPHSON LOOP
26000 X1=XX1                                 '   |     TO FIND THE VARIABLE
26050 IS=IS+.001#                            '   |     "IS"
26100 ON 1+ISUB% GOSUB 26650,27250           '   |
26150 DFIIS=(XX1-X1)/(.001#)                 '   |
```

```
26200 IS=IS-.001#                                  '   |
26250 DIS=-X1/(DF1IS+1.0D-10)                      '   |
26300 IS=IS+DIS                                    '   |
26350 IF(ABS(X1/(IS+1.0D-10))) > .001# THEN NEXT IISX '----
26375 IF IISX=15 THEN 26575
26400 FY=(CALF*FS*TAN(ALF))/(1#-IS)                ' FOR BRAKING
26450 IF FX>0# THEN FY=(CALF*FS*TAN(ALF))/(1#+IS)  'FOR TRACTION
26500 REM PRINT "CONVERGENCE"
26550 RETURN
26575 PRINT "TIRE DID NOT CONVERGE FOR A VALUE OF 'IS'"
26600 END
26650 SNUMERATOR=MO*FZ*(1#-ER*SSV*SQR((IS*IS)+TA2))*(1#-IS)'---  BRAKING
26700 SDENOMINATOR=2#*SQR(CI*CI*IS*IS+CALF*CALF*TA2)       '  |  EQUATION
26750 S=SNUMERATOR/SDENOMINATOR                            '  |  SUBROUTINE
26800 GOSUB 26950                                          '  |
26850 KX1=((CI*IS*FS)/(1#-IS))-FX                          '---
26900 RETURN                                               '
26950 IF S(=-1# THEN FS=-1                                 '---  LOGIC ROUTINE
27000 IF S)-1# AND S(=0# THEN FS=S*(2#+S)                  '  |  TO DETERMINE
27050 IF S)0# AND S(1# THEN FS=S*(2#-S)                    '  |  THE VALUE OF
27100 IF S)=1# THEN FS=1#                                  '  |  THE SATURATION
27150 RETURN                                               '---  FUNCTION.
27200 END                                                  '
27250 SNUMERATOR=MO*FZ*(1#-ER*SSV*SQR((IS*IS)+TA2))*(1#+IS)'---   TRACTION
27300 SDENOMINATOR=2#*SQR(CI*CI*IS*IS+CALF*CALF*TA2)       '  |   EQUATIONS
27350 S=SNUMERATOR/SDENOMINATOR                            '  |   SUBROUTINE
27400 GOSUB 26950                                          '  |
27450 KX1=((CI*IS*FS)/(1#+IS))-FX                          '  |
27500 RETURN                                               '---
27550 END
27600 REM                                                                    *
27650 REM ****************************************************************
27700 RETURN
27750 REM ****************************************************************
27800 REM         SSSS  I  M     M   QQQ         SSSS  U   U  BBBBB        *
27850 REM        S      I  MM   MM  Q   Q       S      U   U  B    B       *
27900 REM         SSS   I  M M M M  Q   Q        SSS   U   U  BBBBB        *
27950 REM            S  I  M  M  M  Q  QQ           S  U   U  B    B       *
28000 REM        SSSS   I  M     M   QQQ Q      SSSS    UUU   BBBBB  #     *
28050 REM ****************************************************************
28100 REM
28150 REM    ..............................................................
28200 REM    SUBROUTINE SIMQ
28250 REM
28300 REM    PURPOSE
28350 REM      OBTAIN A SOLUTION OF A SET OF SIMULTANEOUS LINEAR EQUATIONS AX=B
28400 REM
28450 REM    DESCRIPTION OF PARAMETERS
28500 REM      A -   MATRIX OF COEFFICIENTS STORED COLUMNWISE.  THESE  ARE
28550 REM            ARE DESTROYED IN THE COMPUTATION.  THE SIZE OF THE MATRIX
28600 REM            A MATRIX IS N BY N
28650 REM      B -   VECTOR OF ORIGINAL CONSTANTS (LENGTH N). THEST ARE
28700 REM            REPLACED BY THE FINAL SOLUTION VALUES, VECTOR  X.
28750 REM      N -   NUMBER OF EQUATIONS AND VARIABLES.  N MUST BE .GT. ONE.
28800 REM      KS -  OUTPUT DIGET
```

```
28850 REM               0 FOR A NORMAL SOLUTION
28900 REM               1 FOR A SINGULAR SET OF EQUATIONS.
28950 REM
29000 REM
29050 REM   REMARKS
29100 REM     MATRIX  A  MUST BE GENERAL.
29150 REM     IF MATRIX  A  IS SINGULAR, SOLUTION VALUES ARE MEANINGLESS.
29200 REM     AN ALTERNATIVE SOLUTION MAY BE OBTAINED BY USING MATRIX INVERSION
29250 REM       (MINV) AND MATRIX PRODUCT (GMPRD)
29300 REM
29350 REM
29400 REM    SUBROUTINES AND FUNCTION SUBPROGRAMS REQUIRED.
29450 REM      NONE
29500 REM
29550 REM
29600 REM    METHOD
29650 REM       METHOD OF SOLUTION IS BY ELIMINATION USING LARGEST PIVOTAL
29700 REM       DIVISOR.  EACH STAGE OF ELIMINATION CONSISTS OF INTERCHANGING
29750 REM       ROWS WHEN NECESSARY TO AVOID DIVISION BY ZERO OR SMALL ELEM.
29800 REM          THE FORWARD SOLUTION TO OBTAIN THE VARIABLE N IS DONE IN N
29850 REM       STAGES.  THE BACK SOLUTION FOR THE OTHER VARIABLES IS
29900 REM       CALCULATED BE SUCCESSIVE SUBSTITUTIONS.  FINAL SOLUTION
29950 REM       VALUES ARE DEVELOPED IN VECTOR B, WITH VARIABLE 1 IN B(1),
30000 REM       VARIABLE 2 IN B(2),.....,VARIABLE N IN B(N).
30050 REM       IF NO PIVOT CAN BE FOUND EXCEEDING A TOLERANCE OF 1.0E-20
30100 REM       THE MATRIX IS CONCIDERED SINGULAR AND KS IS SET TO 1. THIS
30150 REM       TOLERANCE CAN BE MODIFIED BY REPLACING THE FIRST STATEMENT.
30200 REM    ..............................................................
30250 REM
30300 REM
30350 REM
30400 REM
30450 REM    FORWARD SOLUTION
30500 REM
30550        TOL=1D-20
30600        KS=0
30650        JJ%=-N%
30700  FOR J%=1 TO N%
30750        JY%=J%+1
30800        JJ%=JJ%+N%+1
30850        BIGA=0
30900        IT%=JJ%-J%
30950  FOR I%=J% TO N%
31000 REM
31050 REM    SEARCH FOR THE MAXIMUM COEFFICIENT IN THE COLUMN
31100 REM
31150        IJ%=IT%+I%
31200 REM T "BIGA=";BIGA;"A(IJ)=A(";IJ%;")=";A(IJ%)
31250        IF (ABS(BIGA)-ABS(A(IJ%))) < 0! THEN 31300 ELSE 31400
31300        BIGA=A(IJ%)
31350        IMAX%=I%
31400  NEXT I%
31450 REM
31500 REM    TEST FOR PIVOT LESS THAN TOLERANCE ( SINGULAR MATRIX )
31550 REM
```

```
31600        IF(ABS(BIGA)-TOL) < 0! THEN 31650 ELSE 31900
31650        KS=1
31700        RETURN
31750 REM
31800 REM    INTERCHANGE ROWS IF NECESSARY
31850 REM
31900        II%=J%+N%*(J%-2)
31950        IT%=IMAX%-J%
32000  FOR K%=J% TO N%
32050        II%=II%+N%
32100        I2%=II%+IT%
32150        SAVEE=A(II%)
32200        A(II%)=A(I2%)
32250        A(I2%)=SAVEE
32300 REM
32350 REM    DIVIDE EQUATION BY THE LEADING COEFFICIENT
32400 REM
32450        A(II%)=A(II%)/BIGA
32500 NEXT K%
32550        SAVEE=B(IMAX%)
32600        B(IMAX%)=B(J%)
32650        B(J%)=SAVEE/BIGA
32700 REM
32750 REM    ELIMINATE THE NEXT VARIABLE
32800 REM
32850        IF (J%-N%) < 0 OR (J%-N%) > 0 THEN 32900 ELSE 33650
32900        IQS%=N%*(J%-1)
32950 FOR IX% = JY% TO N%
33000        IXJ%=IQS%+IX%
33050        IT%=J%-IX%
33100  FOR JX% = JY% TO N%
33150        IXJX%=N%*(JX%-1)+IX%
33200        JJX%=IXJX%+IT%
33250        A(IXJX%)=A(IXJX%)-(A(IXJ%)*A(JJX%))
33300 NEXT JX%
33350        B(IX%)=B(IX%)-(B(J%)*A(IXJ%))
33400 NEXT IX%
33450 NEXT J%
33500 REM
33550 REM    BACK SOLUTION
33600 REM
33650        NY%=N%-1
33700        IT%=N%*N%
33750 FOR J% = 1 TO NY%
33800        IA%=IT%-J%
33850        IB%=N%-J%
33900        IO%=N%
33950 FOR K% = 1 TO J%
34000 REM T "B(IB)=B(";IB%;")=";B(IB%)
34050 REM T "B(IB)=B(";IB%;")=";B(IB%);"A(IA)=A(";IA%;")=";A(IA%);
34100 REM T "B(IO)=B(";IO%;")=;B(IO%)
34150        B(IB%)=B(IB%)-(A(IA%)*B(IO%))
34200        IA%=IA%-N%
34250        IO%=IO%-1
34300 NEXT K%
```

```
34350 NEXT J%
34400         RETURN
34450         END
```