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PROGRESS REPORT
FOR
EFFECTIVENESS OF GEOMETRIC DESIGN
CRITERIA FOR RURAL HIGHWAYS
Contract No. DOT-FH-11-9575
Modification No. 3
"STUDY OF CENTERLINE CROWN"
Work Order No. 2
Task E - "Comparison of Simulation Programs"

Prepared

for

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By

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1.0 INTRODUCTION

As a part of Work Order No. 2, "Study of Centerline Crown" of contract DOT-FH-11-9575, two vehicle simulation programs are to be utilized to study the effects of the centerline crown on a wide range of vehicles. The two vehicle simulation programs to be utilized for the study are as follows:

(1) Highway-Vehicle-Object Simulation Model (HVOSM)

The HVOSM is a computerized mathematical model which was originally developed at Cornell Aeronautical Laboratory in 1968 (Ref. 1) and was subsequently refined by Calspan Corporation (Ref. 2). The HVOSM is capable of simulating the dynamic responses of a two-axle vehicle traversing a three-dimensional terrain configuration. The simulated vehicle includes up to five rigid masses; viz., ^usprung mass and unsprung masses of each of the suspensions or axles.

(2) HSRI/MVMA PHASE4

The PHASE4 simulation program is a general purpose mathematical model for simulating the three-dimensional dynamic responses of trucks, tractor/trailers and triples combinations. The PHASE4 program was developed in 1980 by the Highway Safety Research Institute (HSRI) of the University of Michigan under the sponsorship of the Motor Vehicle Manufacturers Association (MVMA) and the Federal Highway Administration (FHWA) (e.g., refs. 3, 4).

The two simulation programs to be utilized for the simulation study aspects of the reported research project can each accommodate single-unit trucks with a single rear axle. The enclosed report documents a comparison of the response characteristics that the two

simulation programs predict for identical vehicles and maneuvers. The comparison runs are to be used as an aid in the interpretation of results of the Task F simulation studies.

2.0 PROCEDURE

The first task in the performance of the Comparison of Simulation Program (CSP) runs was to prepare the input parameter data decks for the two simulation programs. A detailed discussion of the preparation of the input data decks is presented in section 5.0.

Some modifications of the PHASE4 and HVOSM programs were required in preparation for and as a result of the CSP runs. The modifications are discussed in section 7.

The performance of the CSP runs is discussed in section 6.0.

3.0 CONCLUSIONS

- (1) A general agreement of the response characteristics predicted by the HVOSM and PHASE4 programs exists for maneuvers of the type to be investigated in Task F of the Crossover Crown Study.
- (2) The effects of the "small angle" assumptions of the PHASE4 program are negligible for the type of maneuvers to be investigated in the crossover crown simulation study.
- (3) For the maneuvers investigated within the reported research project, the cost for one simulated second with the PHASE4 program was approximately 55% greater than that of the HVOSM program.

4.0 RECOMMENDATIONS

- (1) The input data format for the PHASE4 program should be simplified and/or standardized to reduce the cumbersome task of creating and modifying an input data deck.

5.0 VEHICLE PARAMETER INPUTS

The vehicle used for the comparison simulation study runs was a 1974 White Road Boss (4x2) Heavy Truck. Measured properties of the vehicle were reported in a study of truck tire properties performed by the Highway Safety Research Institute (ref. 5).

Appendices A and B contain the input card decks and input parameter listings for the HVOSM and PHASE4 programs that were used in the comparison study runs. The creation of the data decks for the two simulation programs consisted primarily of the conversion of units for the input parameters to the requirements of each of the programs.

The preparation of some of the inputs for the two simulation programs required additional preparation beyond unit conversion. The inputs requiring additional preparation were as follows:

5.1 HVOSM Tire Model Inputs

5.2 Roll-Steer Coefficient

5.3 Auxiliary Roll Stiffness

5.1 HVOSM Tire Model Inputs

The side force characteristics of the tires within the HVOSM are simulated by a mathematical model in which the small-angle cornering stiffness, C_{SO} , and the small-angle camber stiffness, C_{CO} , vary with the vertical load, F'_R . Measured tire properties are fitted with the following equations:

$$(1) \quad C_{SO} = A_0 + A_1(F'_R) - \frac{A_1}{A_2}(F'_R)^2$$

$$(2) \quad C_{CO} = A_3 F'_R - \frac{A_3}{A_4}(F'_R)^2$$

For the Comparison of Simulation Program (CSP) runs performed within this task of the subject research project, the simulation of the variation of C_{CO} was not utilized due to (1) the lack of a provision for simulation of its effects within the PHASE4 program and (2) the negligible effects of the variation of camber force for a rigid-axle truck in the maneuvers to be investigated. Therefore, the task of fitting the measured tire data reduced to the determination of an appropriate set of coefficients, A_0 through A_2 .

The truck tire utilized for the White Truck simulation runs was a Uniroyal Fleetmaster Triple Tread, 10x20F truck tire. The tire properties were measured and reported in reference 5 (HSRI tire no. H-1).

The procedure employed to determine the HVOSM tire model coefficients was as follows:

5.1.1 Determination of HVOSM Tire Model Coefficients

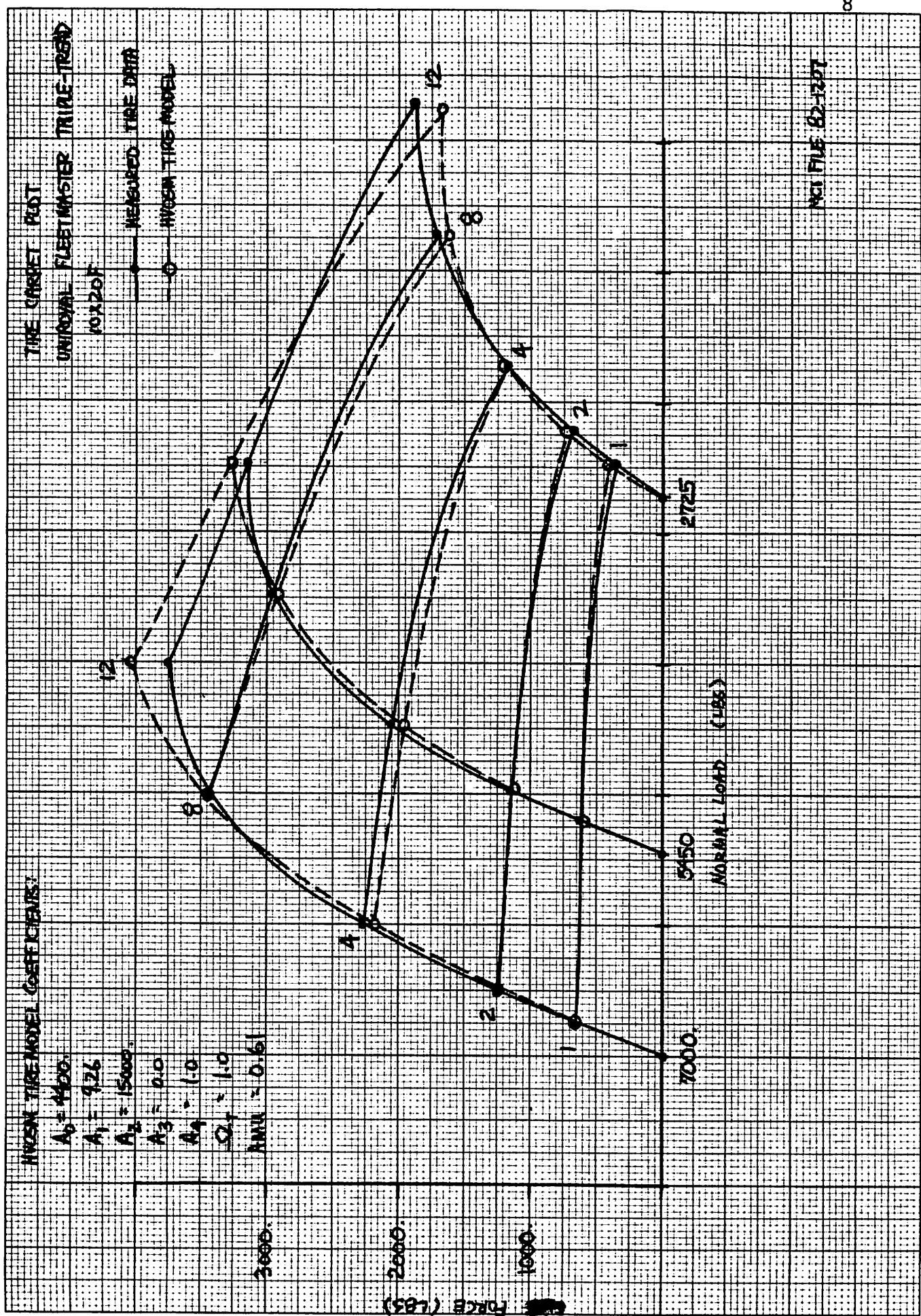
TIRE: Uniroyal Fleetmaster Triple-Tread
10x20F, 8" Rim, 100 psi
TIRF Tire No. 7
Run No. 13
Speed 55 mph
Vertical Load: 2715, 5430, 7000 lbs.

FROM: Reference 5, Vol. II, p.110

PROCEDURE:

- (1) A carpet plot of the experimental tire data was prepared. For each vertical load the slope of the cornering stiffness at slip angles 4 degrees and less was approximated by a straight line fit.
- (2) A second-order polynomial fit was run through the three coefficients from step (1) to determine the HVOSM Tire Model coefficients (note: it is necessary to multiply the camber stiffness by 57.29578 prior to the curve fit).

FIG. 62-27



(3) The three coefficients from step (2) were used to create a carpet plot of the simulated tire by the TIRPROP3.BAS program.

(4) The HVOSM tire model carpet plot was then compared with the measured tire data carpet plot to determine the degree of correlation within the operating range to be investigated. If an inadequate correlation of the carpet plots was found, an adjustment of the coefficients was performed and step (3) repeated.

L E A S T - S Q U A R E S P O L Y N O M I A L S
CORNERRING STIFFNESS FOR 5450 LB NORMAL LOAD

10

NUMBER OF POINTS = 4
MEAN VALUE OF X = 1.75
MEAN VALUE OF Y = 956.75
STD ERROR OF Y = 869.6402

POLYFIT OF DEGREE 1 INDEX OF DETERM = .9942489 TERM
COEFFICIENT

0 68.20001
1 507.7429

HVOSM TIRE MODEL COEFFICIENTS:

A(0) = 68.20001
A(1) = 507.7429

X-ACTUAL	Y-ACTUAL	Y-CALC	DIFF	PCT-DIFF
0.00000	0.00000	68.20001	-68.20001	-100.00000
1.00000	624.00000	575.94290	48.05713	8.34408
2.00000	1148.00000	1083.68600	64.31421	5.93477
4.00000	2055.00000	2099.17200	-44.17139	-2.10423

STD ERROR OF ESTIMATE FOR Y = 80.77178

L E A S T - S Q U A R E S P O L Y N O M I A L S
CORNERSRING STIFFNESS FOR 7000 LB NORMAL LOAD

NUMBER OF POINTS = 4
MEAN VALUE OF X = 1.75
MEAN VALUE OF Y = 1047.25
STD ERROR OF Y = 966.9062

POLYFIT OF DEGREE 1 INDEX OF DETERM = .9965028 TERM
COEFFICIENT

0 58.19995
1 565.1715

X-ACTUAL	Y-ACTUAL	Y-CALC	DIFF	PCT-DIFF
0.00000	0.00000	58.19995	-58.19995	-100.00000
1.00000	662.00000	623.37140	38.62860	6.19672
2.00000	1247.00000	1188.54300	58.45716	4.91839
4.00000	2280.00000	2318.88600	-38.88574	-1.67691

STD ERROR OF ESTIMATE FOR Y = 70.03122

Step (1)

L E A S T - S Q U A R E S P O L Y N O M I A L S
C O R N E R I N G S T I F F N E S S F O R 2 7 2 5 L B N O R M A L L O A D

11

NUMBER OF POINTS = 4
MEAN VALUE OF X = 1.75
MEAN VALUE OF Y = 554.25
STD ERROR OF Y = 498.2599

POLYFIT OF DEGREE 1 INDEX OF DETERM = .9917343 TERM
COEFFICIENT

0 45.80002
1 290.5429

X-ACTUAL	Y-ACTUAL	Y-CALC	DIFF	PCT-DIFF
0.00000	0.00000	45.80002	-45.80002	-100.00000
1.00000	366.00000	336.34290	29.65714	8.81753
2.00000	674.00000	626.88580	47.11426	7.51561
4.00000	1177.00000	1207.97100	-30.97144	-2.56392

STD ERROR OF ESTIMATE FOR Y = 55.48049

Step (1) (cont'd)

LEAST-SQUARES POLYNOMIALS
FIT OF CORNERING STIFFNESS FOR 3 LOADS

12

NUMBER OF POINTS = 3
MEAN VALUE OF X = 5058.334
MEAN VALUE OF Y = 26038.67
STD ERROR OF Y = 8301.05

POLYFIT OF DEGREE 2 INDEX OF DETERM = 1 TERM COEFFICIENT

0	-4283.808
1	9.236408
2	-5.711848E-04

HVOSM TIRE MODEL COEFFICIENTS:

A(0) = -4283.808
A(1) = 9.236408
A(2) = 16170.61

X-ACTUAL	Y-ACTUAL	Y-CALC	DIFF	PCT-DIFF
2725.00000	16644.00000	16644.00000	0.00000	0.00000
5450.00000	29089.00000	29089.00000	0.00000	0.00000
7000.00000	32383.00000	32383.00000	0.00000	0.00000

STD ERROR OF ESTIMATE FOR Y = 0

Step (2)

"FILE=> LSQFIT3.BAS ON DISKETTE=> #26 DATE IS 03-31-1983 TIME IS 15:11:50

PAGE = 1

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10 KEY OFF:CLS
20 PRINT" ENTER M, # OF DATA POINTS"
30 PRINT"      M, LEAST DEGREE OF FIT REQUIRED"
40 PRINT"      REF$, REFERENCE WORD(S) UP TO 20 CHARACTERS"
50 INPUT M,N,N$
60 REM
70 DIM A(15),B(15),S(15),G(15),U(15),D(15)
80 DIM Q(100),P(100),X(100),Y(100),C(100)
90 Z = 0
100 O = 1
110 K = 12
120 N = N + 1
130 IF N>12 THEN GOTO 1560
140 IF M<N THEN GOTO 1590
150 IF M>100 THEN GOTO 1530
160 T7 = Z
170 T8 = Z
180 W7 = Z
190 FOR I=1 TO M
200 INPUT "ENTER X,Y DATA PAIR -->"; X(I),Y(I)
210 Y(I) = Y(I)*57.29578
220 W7 = W7+X(I)
230 T7 = T7+Y(I)
240 T8 = T8+Y(I)^2
250 'EXT I
260 ,9 = (M*T8-T7^2)/(M^2-M)
270 CLS:PRINT DATE$,TIME$
280 REM
290 LPRINT "L E A S T - S Q U A R E S P O L Y N O M I A L S "
291 PRINT "L E A S T - S Q U A R E S P O L Y N O M I A L S "
300 LPRINT N$
301 PRINT N$
310 LPRINT
311 PRINT
320 LPRINT "      NUMBER OF POINTS = "M
321 PRINT "      NUMBER OF POINTS = "M
330 LPRINT "      MEAN VALUE OF X = "W7/M
331 PRINT "      MEAN VALUE OF X = "W7/M
340 LPRINT "      MEAN VALUE OF Y = "T7/M
341 PRINT "      MEAN VALUE OF Y = "T7/M
350 LPRINT "      STD ERROR OF Y = "SQR(T9)
351 PRINT "      STD ERROR OF Y = "SQR(T9)
360 LPRINT
361 PRINT
371 PRINT "CODES ARE 0=STOP,1=COEFF,2=SUMMARY,3=NEXT DEGREE"
380 FOR I=1 TO M
390 P(I) = Z
400 Q(I) = 0
410 NEXT I
420 FOR I = 1 TO 11
430   (I) = Z
440 B(I) = Z
450 S(I) = Z
460 NEXT I

```

Program for Steps (1) and (2)

=====

FILE=> LSQFIT3.BAS ON DISKETTE=> #26 DATE IS 03-31-1983 TIME IS 15:12:06 PAGE = 2

=====

1 I = Z
480 F1 = Z
490 W1 = M
500 N4 = K
510 I = 1
520 K1 = 2
530 IF N=0 THEN GOTO 550
540 K1 = N4
550 W = Z
560 FOR L=1 TO M
570 W = W+Y(L)*Q(L)
580 NEXT L
590 S(I) = W/W1
600 IF I-N4>= 0 THEN GOTO 800
610 IF I-M>= 0 THEN GOTO 800
620 E1 = Z
630 FOR L=1 TO M
640 E1 = E1+X(L)*Q(L)*Q(L)
650 NEXT L
660 E1 = E1/W1
670 A(I+1) = E1
680 W = Z
690 FOR L=1 TO M
700 V = (X(L)-E1)*Q(L)-F1*P(L)
710 P(L) = Q(L)
720 Q(L) = V
730 J = W+ V*V
740 NEXT L
750 F1 = W/W1
760 B(I+2) = F1
770 W1 = W
780 I = I+1
790 GOTO 550
800 FOR L = 1 TO 13
810 G(L) = Z
820 NEXT L
830 G(2) = 0
840 FOR J=1 TO N
850 S1 = Z
860 FOR L=2 TO N+1
870 IF L=2 THEN GOTO 890
880 G(L)=G(L)-A(L-1)*G(L-1)-B(L-1)*G(L-2)
890 S1 = S1+S(L-1)*G(L)
900 NEXT L
910 U(J) = S1
920 L=N+1
930 FOR I2=3 TO N+1
940 G(L) = G(L-1)
950 L = L-1
960 NEXT I2
970 G(2) = Z
980 EXT J
990 F = Z
1000 FOR L=1 TO M
1010 C(L) = Z

```
=====FILE=> LSQFIT3.BAS ON DISKETTE=> #26 DATE IS 03-31-1983 TIME IS 15:12:17 PAGE = 3=====
1 J = N
1030 FOR I2=1 TO N
1040 C(L) = C(L)*X(L)+U(J)
1050 J = J-1
1060 NEXT I2
1070 T3 = Y(L)-C(L)
1080 T = T+T3^2
1090 NEXT L
1100 IF M>N THEN GOTO 1130
1110 T5= 0
1120 GOTO 1140
1130 T5 = T/(M-N)
1140 Q7 = 1-T/(T9*(M-1))
1150 PRINT
1151 LPRINT
1160 PRINT "POLYFIT OF DEGREE " N-1" INDEX OF DETERM = "Q7;
1161 LPRINT "POLYFIT OF DEGREE " N-1" INDEX OF DETERM = "Q7;
1170 REM
1180 GOSUB 1610
1190 IF R=0 THEN GOTO 1640
1200 IF R=2 THEN GOTO 1310
1210 IF R=3 THEN GOTO 1500
1220 PRINT " TERM ","COEFFICIENT"
1221 LPRINT " TERM ","COEFFICIENT"
1230 FOR J=1 TO N
1240 I2 = J-1
1250 PRINT I2,U(J)
1251 LPRINT I2,U(J)
1260 D(J) = U(J)
1270 NEXT J
1280 D(J+1) = 0!
1290 D(J+2) = 0!
1300 IF R=1 THEN GOTO 1460
1310 PRINT
1311 LPRINT
1320 PRINT " X-ACTUAL Y-ACTUAL Y-CALC DIFF PCT-DIFF"
1321 LPRINT " X-ACTUAL Y-ACTUAL Y-CALC DIFF PCT-DIFF"
1330 PRINT
1331 LPRINT
1340 FOR L=1 TO M
1350 Q8 = Y(L)-C(L)
1360 REM
1370 PRINT USING "#####.####";X(L);Y(L);C(L);Q8;
1371 LPRINT USING "#####.####";X(L);Y(L);C(L);Q8;
1380 IF C(L) = 0 THEN GOTO 1410
1390 PRINT USING "#####.####";100*Q8/ C(L)
1391 LPRINT USING "#####.####";100*Q8/ C(L)
1400 GOTO 1420
1410 PRINT "INFINITE"
1411 LPRINT "INFINITE"
1420 NEXT L
1 PRINT
1431 LPRINT
1440 PRINT " STD ERROR OF ESTIMATE FOR Y = "SQR(T5)
1441 LPRINT " STD ERROR OF ESTIMATE FOR Y = "SQR(T5)
```

FILE=> LSQFIT3.BAS ON DISKETTE=> #26 DATE IS 03-31-1983 TIME IS 15:12:34

PAGE = 4

```
1 IF K=N THEN GOTO 1640
1450 PRINT
1461 LPRINT
1470 GOSUB 1650
1480 GOSUB 1610
1490 GOTO 1190
1500 N = N+1
1510 IF MCN THEN GOTO 1580
1520 GOTO 800
1530 PRINT
1540 PRINT "PROGRAM SIZE LIMIT IS 100 DATA POINTS"
1550 GOTO 1640
1560 PRINT "ELEVENTH DEGREE IS THE LIMIT"
1570 GOTO 1640
1580 PRINT
1590 PRINT "TOO FEW POINTS FOR FITTING DEGREE" N-1
1600 GOTO 1640
1610 INPUT "WHAT NEXT":R
1620 RETURN
1630 DATA 1E75,1E75
1640 GOTO 1750
1650 INPUT "ENTER 1 FOR TIRE DATA,0 TO SKIP";CHOICE:IF CHOICE=0 THEN RETURN
1655 IF DONE = 1 THEN RETURN
1660 PRINT "HVOSM TIRE MODEL COEFFICIENTS:"
1661 LPRINT "HVOSM TIRE MODEL COEFFICIENTS:"
1 PRINT
1 LPRINT
1680 FOR J=1 TO N
1690 I2 = J-1
1700 IF J = 3 THEN U(J) = -U(2)/U(3)
1710 PRINT "A("I2") = ",U(J)
1711 LPRINT "A("I2") = ",U(J)
1720 D(J) = U(J)
1730 NEXT J
1740 DONE = 1:RETURN
1750 KEY ON:END
```

TEST2 UNIROYAL 10X20F TIRES CARPET PLOT DATA

02-28-1983 16:21:22

TIRE COEFFICIENTS: A0 = 4290
 A1 = 9.26
 A2 = 16118
 A3 = 0
 A4 = 1
 A5 = .6
 A6 = 0
 A7 = 0
 OMEGT = 1
 MU = .6

FRCP	ALP	PHICI	FS	BETP	BETBR	FS1	BETP1	BETBR	SOL#	
2725.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.6
2725.0	1.0	0.0	-402.4	0.0	-0.3	0.0	0.0	0.0	1.0	0.6
2725.0	2.0	0.0	-732.7	0.0	-0.5	0.0	0.0	0.0	1.0	0.6
2725.0	3.0	0.0	-998.0	0.0	-0.8	0.0	0.0	0.0	1.0	0.6
2725.0	4.0	0.0	-1205.4	0.0	-1.1	0.0	0.0	0.0	1.0	0.6
2725.0	5.0	0.0	-1362.0	0.0	-1.3	0.0	0.0	0.0	1.0	0.6
2725.0	6.0	0.0	-1475.1	0.0	-1.6	0.0	0.0	0.0	1.0	0.6
2725.0	7.0	0.0	-1551.6	0.0	-1.9	0.0	0.0	0.0	1.0	0.6
2725.0	8.0	0.0	-1598.7	0.0	-2.2	0.0	0.0	0.0	1.0	0.6
2725.0	9.0	0.0	-1623.6	0.0	-2.4	0.0	0.0	0.0	1.0	0.6
2725.0	10.0	0.0	-1633.3	0.0	-2.7	0.0	0.0	0.0	1.0	0.6
2725.0	11.0	0.0	-1635.0	0.0	-3.0	0.0	0.0	0.0	1.0	0.6
2725.0	12.0	0.0	-1635.0	0.0	-3.2	0.0	0.0	0.0	1.0	0.6
5450.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.6
5450.0	1.0	0.0	-614.7	0.0	-0.2	0.0	0.0	0.0	1.0	0.6
5450.0	2.0	0.0	-1147.1	0.0	-0.4	0.0	0.0	0.0	1.0	0.6
5450.0	3.0	0.0	-1603.2	0.0	-0.6	0.0	0.0	0.0	1.0	0.6
5450.0	4.0	0.0	-1988.7	0.0	-0.8	0.0	0.0	0.0	1.0	0.6
5450.0	5.0	0.0	-2309.7	0.0	-1.0	0.0	0.0	0.0	1.0	0.6
5450.0	6.0	0.0	-2572.0	0.0	-1.2	0.0	0.0	0.0	1.0	0.6
5450.0	7.0	0.0	-2781.6	0.0	-1.4	0.0	0.0	0.0	1.0	0.6
5450.0	8.0	0.0	-2944.3	0.0	-1.6	0.0	0.0	0.0	1.0	0.6
5450.0	9.0	0.0	-3066.2	0.0	-1.8	0.0	0.0	0.0	1.0	0.6
5450.0	10.0	0.0	-3153.1	0.0	-2.0	0.0	0.0	0.0	1.0	0.6
5450.0	11.0	0.0	-3211.0	0.0	-2.2	0.0	0.0	0.0	1.0	0.6
5450.0	12.0	0.0	-3245.6	0.0	-2.4	0.0	0.0	0.0	1.0	0.6
7000.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.6
7000.0	1.0	0.0	-675.1	0.0	-0.2	0.0	0.0	0.0	1.0	0.6
7000.0	2.0	0.0	-1273.6	0.0	-0.3	0.0	0.0	0.0	1.0	0.6
7000.0	3.0	0.0	-1800.3	0.0	-0.5	0.0	0.0	0.0	1.0	0.6
7000.0	4.0	0.0	-2259.6	0.0	-0.7	0.0	0.0	0.0	1.0	0.6
7000.0	5.0	0.0	-2656.3	0.0	-0.9	0.0	0.0	0.0	1.0	0.6
7000.0	6.0	0.0	-2994.8	0.0	-1.0	0.0	0.0	0.0	1.0	0.6
7000.0	7.0	0.0	-3279.8	0.0	-1.2	0.0	0.0	0.0	1.0	0.6
7000.0	8.0	0.0	-3515.9	0.0	-1.4	0.0	0.0	0.0	1.0	0.6
7000.0	9.0	0.0	-3707.7	0.0	-1.5	0.0	0.0	0.0	1.0	0.6
7000.0	10.0	0.0	-3859.9	0.0	-1.7	0.0	0.0	0.0	1.0	0.6
7000.0	11.0	0.0	-3976.9	0.0	-1.9	0.0	0.0	0.0	1.0	0.6
7000.0	12.0	0.0	-4063.4	0.0	-2.0	0.0	0.0	0.0	1.0	0.6

fleetmaster triple tread

03-02-1983 09:15:03

TIRE COEFFICIENTS: A0 = 4400
 A1 = 9.26
 A2 = 15000
 A3 = 0
 A4 = 1
 A5 = .61
 A6 = 0
 A7 = 0
 OMEGT = 1
 MU = .61

FRCP	ALP	PHICI	FS	BETP	BETBR	FS1	BETP1	BETBR	SOL#	
2725.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.6
2725.0	1.0	0.0	-400.0	0.0	-0.3	0.0	0.0	0.0	1.0	0.6
2725.0	2.0	0.0	-730.0	0.0	-0.5	0.0	0.0	0.0	1.0	0.6
2725.0	3.0	0.0	-996.9	0.0	-0.8	0.0	0.0	0.0	1.0	0.6
2725.0	4.0	0.0	-1207.2	0.0	-1.1	0.0	0.0	0.0	1.0	0.6
2725.0	5.0	0.0	-1367.8	0.0	-1.3	0.0	0.0	0.0	1.0	0.6
2725.0	6.0	0.0	-1485.3	0.0	-1.6	0.0	0.0	0.0	1.0	0.6
2725.0	7.0	0.0	-1566.4	0.0	-1.8	0.0	0.0	0.0	1.0	0.6
2725.0	8.0	0.0	-1618.0	0.0	-2.1	0.0	0.0	0.0	1.0	0.6
2725.0	9.0	0.0	-1646.6	0.0	-2.4	0.0	0.0	0.0	1.0	0.6
2725.0	10.0	0.0	-1659.1	0.0	-2.6	0.0	0.0	0.0	1.0	0.6
2725.0	11.0	0.0	-1662.2	0.0	-2.9	0.0	0.0	0.0	1.0	0.6
2725.0	12.0	0.0	-1662.3	0.0	-3.2	0.0	0.0	0.0	1.0	0.6
5450.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.6
5450.0	1.0	0.0	-597.7	0.0	-0.2	0.0	0.0	0.0	1.0	0.6
5450.0	2.0	0.0	-1119.1	0.0	-0.4	0.0	0.0	0.0	1.0	0.6
5450.0	3.0	0.0	-1569.4	0.0	-0.6	0.0	0.0	0.0	1.0	0.6
5450.0	4.0	0.0	-1953.8	0.0	-0.8	0.0	0.0	0.0	1.0	0.6
5450.0	5.0	0.0	-2277.5	0.0	-1.0	0.0	0.0	0.0	1.0	0.6
5450.0	6.0	0.0	-2545.8	0.0	-1.2	0.0	0.0	0.0	1.0	0.6
5450.0	7.0	0.0	-2763.8	0.0	-1.3	0.0	0.0	0.0	1.0	0.6
5450.0	8.0	0.0	-2936.8	0.0	-1.5	0.0	0.0	0.0	1.0	0.6
5450.0	9.0	0.0	-3069.9	0.0	-1.7	0.0	0.0	0.0	1.0	0.6
5450.0	10.0	0.0	-3168.5	0.0	-1.9	0.0	0.0	0.0	1.0	0.6
5450.0	11.0	0.0	-3237.6	0.0	-2.1	0.0	0.0	0.0	1.0	0.6
5450.0	12.0	0.0	-3282.5	0.0	-2.3	0.0	0.0	0.0	1.0	0.6
7000.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.6
7000.0	1.0	0.0	-644.7	0.0	-0.2	0.0	0.0	0.0	1.0	0.6
7000.0	2.0	0.0	-1221.0	0.0	-0.3	0.0	0.0	0.0	1.0	0.6
7000.0	3.0	0.0	-1732.7	0.0	-0.5	0.0	0.0	0.0	1.0	0.6
7000.0	4.0	0.0	-2183.7	0.0	-0.6	0.0	0.0	0.0	1.0	0.6
7000.0	5.0	0.0	-2577.9	0.0	-0.8	0.0	0.0	0.0	1.0	0.6

7000.0	6.0	0.0-2918.9	0.0	-1.0	0.0	0.0	0.0	0.0	1.0	0.6
7000.0	7.0	0.0-3210.8	0.0	-1.1	0.0	0.0	0.0	0.0	1.0	0.6
7000.0	8.0	0.0-3457.3	0.0	-1.3	0.0	0.0	0.0	0.0	1.0	0.6
7000.0	9.0	0.0-3662.2	0.0	-1.4	0.0	0.0	0.0	0.0	1.0	0.6
7000.0	10.0	0.0-3829.4	0.0	-1.6	0.0	0.0	0.0	0.0	1.0	0.6
7000.0	11.0	0.0-3962.7	0.0	-1.8	0.0	0.0	0.0	0.0	1.0	0.6
7000.0	12.0	0.0-4066.0	0.0	-1.9	0.0	0.0	0.0	0.0	1.0	0.6

FILE=> TIRPROP3.BAS ON DISKETTE=> #26 DATE IS 03-31-1983 TIME IS 15:10:55

PAGE = 1

```

10 INPUT "ENTER TITLE FOR TIRE DATASET ";TITLE$
20 INPUT "ENTER A0,A1,A2,A3,A4,A5,A6,A7,OMEGT " ;A0,A1,A2,A3,A4,A5,A6,A7,OMEGT
30 INPUT"ENTER FRMIN,FRINC,NF,ALPMIN,ALPINC,NA";FRMIN,FRINC,NF,ALPMIN,ALPINC,NA
40 INPUT"ENTER PHIMIN,PHIINC,NP";PHIMIN,PHIINC,NP
50 INPUT "ENTER MU,IREP";AMU,IREP
55 IF IREP = 1 GOTO 90
60 A12 = A1/A2:A23=A2*A3/A1:A234=A2*A3/A4
70 OMT2M1=OMEGT*A1*A2*(OMEGT-1)
80 OMT2A2=(OMEGT*A2*A3*(A4-OMEGT*A2))/(A4*(OMT2M1-A0))
90 CLS:PRINT TITLE$:PRINT:PRINT DATE$,TIME$
100 CLS:LPRINT TITLE$:LPRINT:LPRT DATE$,TIME$
110 PRINT "TIRE COEFFICIENTS: A0 = ",A0,
120 LPRINT "TIRE COEFFICIENTS: A0 = ",A0,
130 PRINT " A1 = ",A1,
140 LPRINT " A1 = ",A1,
150 PRINT " A2 = ",A2
160 PRINT " A3 = ",A3
170 PRINT " A4 = ",A4
180 LPRINT " A2 = ",A2
190 LPRINT " A3 = ",A3
200 LPRINT " A4 = ",A4
201 PRINT " A5 = ",A5
202 PRINT " A6 = ",A6
203 PRINT " A7 = ",A7
204 LPRINT " A5 = ",A5
205 LPRINT " A6 = ",A6
206 LPRINT " A7 = ",A7
210 PRINT " OMEGT = ",OMEGT
220 LPRINT " OMEGT = ",OMEGT
230 PRINT " MU = ",AMU
240 LPRINT " MU = ",AMU
250 PRINT
260 LPRINT
270 PRINT " FRCP ALP PHICI FS BETP BETBR FS1 BETP1 BETBR SOL#"
280 LPRINT " FRCP ALP PHICI FS BETP BETBR FS1 BETP1 BETBR SOL#"
290 RAD = 57.29578
300 FOR I = 1 TO NF
310 J = I -1
320 FRCP = FRMIN + J*FRINC
325 AMU = A5 + A6*FRCP + A7*FRCP^2
330 FOR II = 1 TO NA
340 JJ = II - 1
350 ALP = (ALPMIN + JJ*ALPINC)/RAD
360 FOR III=1 TO NP
370 JJJ = III-1
380 PHICI = (PHIMIN + JJJ*PHIINC)/RAD
390 REM CALCULATE CONSTANTS
400 TERM=ALP:FSMX=AMU*FRCP:PASS=1
410 IF FRCP > OMEG1*A2 THEN 470
420 BETP = (PHICI-.6366*PHICI*ABS(PHICI))*A234*FRCP*(A4-FRCP)/(A1*FRCP*(FRCP-A2)-A0*A2)
        BETBR = ((TERM+BETP-PSITEM)*(A12*FRCP*(FRCP-A2)-A0))/FSMX
440 GOSUB 750:IF PASS=2 THEN GOTO 670
450 BETP1=0:BETBR1=0:FS1=0:SOLN=1!
460 PASS=2:GOTO 420

```

```
=====
FILE=> TIRPROP3.BAS  ON DISKETTE=> #26      DATE IS 03-31-1983 TIME IS 15:11:19          PAGE =      2
=====
4    BETP = (PHICI-.6366*PHICI*ABS(PHICI))*OMT2A2
480 BETBR = (TERM + BETP - PSITEM)*(OMT2M1-A0)/FSMX
490 GOSUB 750 :IF PASS = 2 THEN GOTO 510
500 PASS= 2:GOTO 470
510 REM NEW BETBR CALC PROCEDURE
520 REM - 1ST SAVE OLD NUMBERS
530 BETP1 = BETP
540 BETBR1 = BETBR
550 FS1 = FS
560 SOLN = 2!
570 PASS = 1
580 TEMP1 = TERM + BETP - PSITEM
590 BETBR = TEMP1*(OMT2M1-A0)/FSMX
600 IF(ABS(TEMP1)<.5236) OR (ABS(BETBR)>1!) THEN GOTO 670
610 PRINT "ALTERNATE BETBR TO BE USED" :SOLN=3'
620 TEMP2 = .5236*ABS(BETBR/TEMP1)
630 TEMP3 = (ABS(TEMP1)-.5236)/.5236
640 BETBR = (TEMP2 +(3-TEMP2)*TEMP3)*SGN(BETBR)
650 GOSUB 750:IF PASS=2 THEN GOTO 670
660 PASS=2:GOTO 580
670 ALPOUT = ALP * RAD:PHIOUT=PHICI*RAD
680 REM
690 PRINT USING "#####.#";FRCP;ALPOUT;PHIOUT;FS;BETP;BETBR;FS1;BETP1;BETBR1;SOLN,AMU
700 LPRINT USING "#####.#";FRCP;ALPOUT;PHIOUT;FS;BETP;BETBR;FS1;BETP1;BETBR1;SOLN,AMU
710 NEXT III
720 NEXT II
730 NEXT I
740 GOTO 10
750 REM SIDE FORCE CALC PROCEDURE
760 IF ABS(BETBR) < 3 THEN GOTO 790
770 FS = FSMX*SGN(BETBR)
780 GOTO 800
790 FS = FSMX*(BETBR-BETBR*ABS(BETBR)/3 + BETBR^3/27!)
800 RETURN
```

5.2 Roll-Steer Coefficient

A detailed examination of the procedures utilized to apply roll-steer coefficients within each of the simulation programs utilized for the comparison runs was required as the result of initial discrepancies between the results obtained with the two simulation programs. The discrepancies were attributed to differences discovered in the applications of the roll-steer coefficients. The following versions of the simulation programs were investigated: (1) HVOSM (ref. 2), (2) PHASE4 (refs. 3, 4) and (3) IHVHP (ref. 6).

5.2.1 HVOSM

HVOSM allows the use of a roll-steer coefficient for the rear axle only. The equation which applies the roll-steer coefficient is located within Subroutine VPOS as follows:

```
PSI3 = AKRS*PHIR  
PSI4 = PSI3
```

where:

PSI3 = RR steer angle

PSI4 = LR steer angle

AKRS = Roll steer coefficient

PHIR = Angular displacement of the rear axle relative to the vehicle about a line parallel to the vehicle-fixed X-axis through the rear roll center.

For the HVOSM, a positive roll-steer coefficient produces an understeer response characteristic..

5.2.2 PHASE4

The PHASE4 program allows the input of a roll-steer coefficient for each axle. The equation which applies the roll-steer coefficient

is within Subroutine FCTI as follows:

$$\text{DELT}(\text{IVEH}, \text{JSUS}, \text{KAX}, \text{LSIDE}) = \text{DELT}(\text{IVEH}, \text{JSUS}, \text{KAX}, \text{LSIDE}) + \\ \text{RST}(\text{IVEH}, \text{JSUS}, \text{KAX}) * \\ (\text{PHIBAR}(\text{IVEH}, \text{i}) - \text{THETAX}(\text{IVEH}, \text{JSUS}, \text{KAX}))$$

where:

$\text{DELT}(\text{IVEH}, \text{JSUS}, \text{KAX}, \text{LSIDE})$ = Steer angle of each wheel

$\text{RST}(\text{IVEH}, \text{JSUS}, \text{KAX})$ = Roll steer coefficient

$\text{PHIBAR}(\text{IVEH}, \text{i})$ = Sprung mass Euler angle PHI

$\text{THETAX}(\text{IVEH}, \text{JSUS}, \text{KAX})$ = Roll angle of axle

and,

IVEH = Unit number

JSUS = Suspension (1 = Front, 2 = Rear)

KAX = Axle number on the suspension

LSIDE = Side of the Axle (1 = Left, 2 = Right)

For PHASE4, the instruction manual (ref. 2) states that a "positive entry implies an incremental steer to the right. . . . Here a positive RST has an understeer effect" (ref. 3, p. 36). This is true for the front steering axle only, and the opposite is true for all other axles (e.g., a positive RST on any other axle besides the front steer axle has an oversteer effect).

5.2.3 IHVHP

The Improved Hybrid Vehicle Handling Program (IHVHP) was not used for any application runs in the present research effort. However, ~~at the~~ parameter list for the White Truck was obtained in the IHVHP format (ref. 5) ^{therefore} ~~so that~~ ^{needed to} the roll-steer coefficient could be investigated to insure a proper application of the roll-steer coefficient within the other two simulation programs.

The IHVHP permits the input of a roll-steer coefficient for the front and/or rear axles. The equations to apply the roll-steer coefficient (ref. 6, p. A-22) indicate that a positive entry at either axle results in understeer response characteristics.

Since the HVOSM does not allow the input of a roll-steer coefficient for the front axle, it was not used for either of the programs for the comparison runs. The inputs for the two programs for the rear axles roll-steer coefficient was as follows:

HVOSM: AKRS = 0.14 rod/rod

PHASE4: RST = -0.14 deg/deg

5.3 Auxiliary Roll Stiffness

The computer simulation programs used in the present research effort include inputs for auxiliary roll stiffness at the front and rear suspensions. The parameter listing for the White Truck (ref. 5) indicates that the rates are zero for both axles. Leaf-spring suspensions such as those at the front and rear of the White Truck have inherent torsional resistances in roll. Thus, the auxiliary roll stiffness inputs should be used to approximate the effects. Approximation techniques such as in reference 2 (Vol. I, pp. 323-324) can be used where direct measurements cannot be made.

For the present research project, the auxiliary roll stiffness inputs for the White Truck were left at zero as they were reported in reference 5.

6.0 COMPARISON OF SIMULATION PROGRAM RUNS

The following is a discussion of the results of the Comparison of Simulation Program (CSP) runs performed for the subject research project.

6.1 CSP2 - Flat Surface Cornering Maneuver

RUN SPECIFICATIONS: Path: 410 meter radius curve

Terrain: Flat surface

Speed: 120 kph

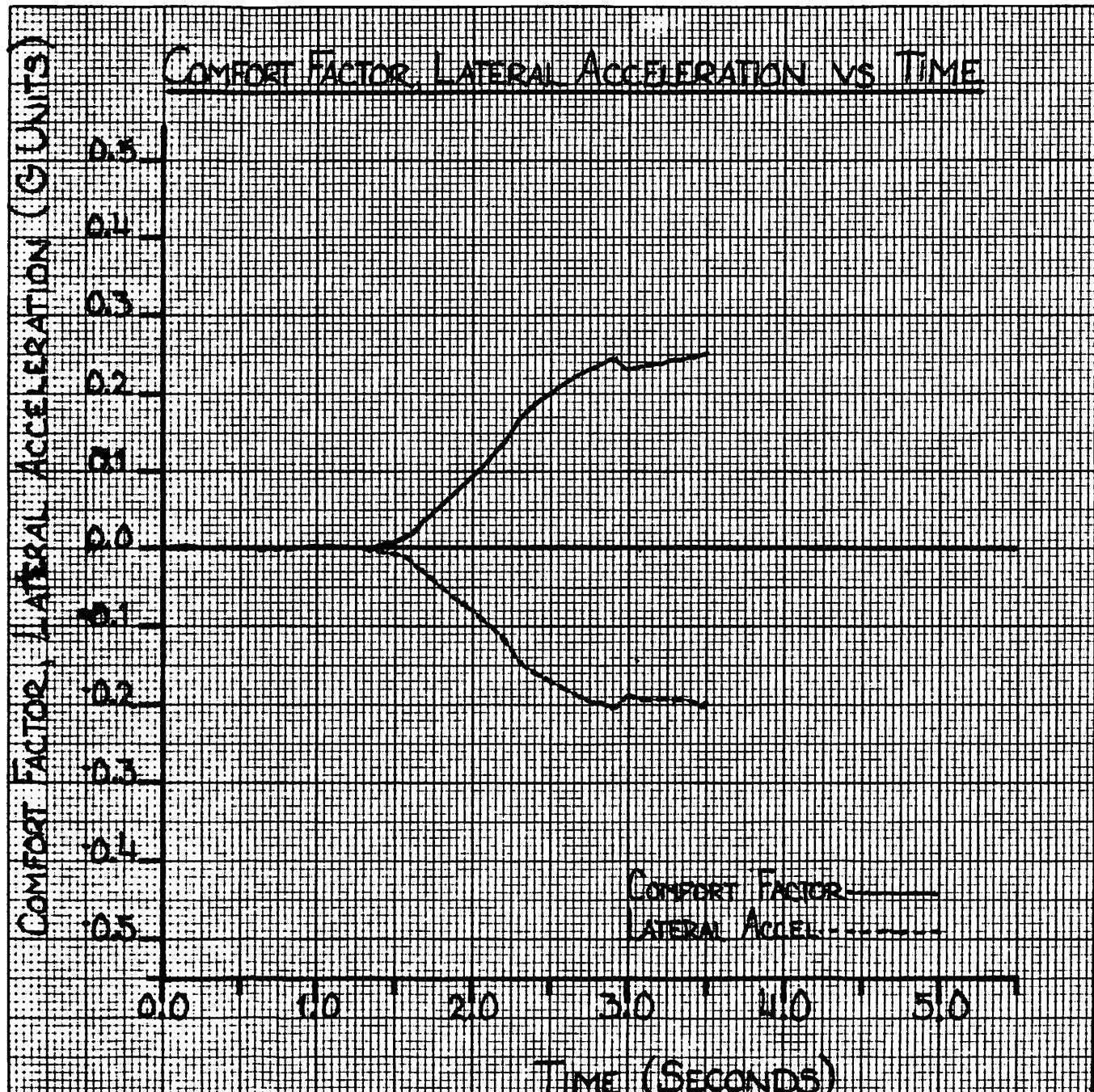
A flat surface cornering maneuver was performed utilizing the path-following algorithms of the two programs to determine both the correlation of results and adequacy of the path-followers.

The PHASE4 program was found to have oscillatory steer responses which were attributed to:

- (1) Error in the Roll-Steer Coefficient definition in the inputs resulting in an oversteer vehicle (see section 5.2).
- (2) Differences in the PHASE4 vs. HVOSM path-follower routines.

As a result, the front wheel steer angle time history from the CSP2-HVOSM run was force fed to the PHASE 4 program.

The two simulation programs were found to have an adequate correlation of results. Some minor discrepancies of the lateral acceleration time history were found to exist. The discrepancy was found to be due to the differences in the friction null band for the coulomb friction of the suspensions. In the PHASE4 program, the null band was found to be automatically calculated and was approximately 8 in/sec. This value was then used in the HVOSM to eliminate the "chatter" which caused the minor discrepancies.



CSP2-HVOSM
FLAT SURFACE CORNERING MANEUVER

VEHICLE: 1974 WHITE TRUCK

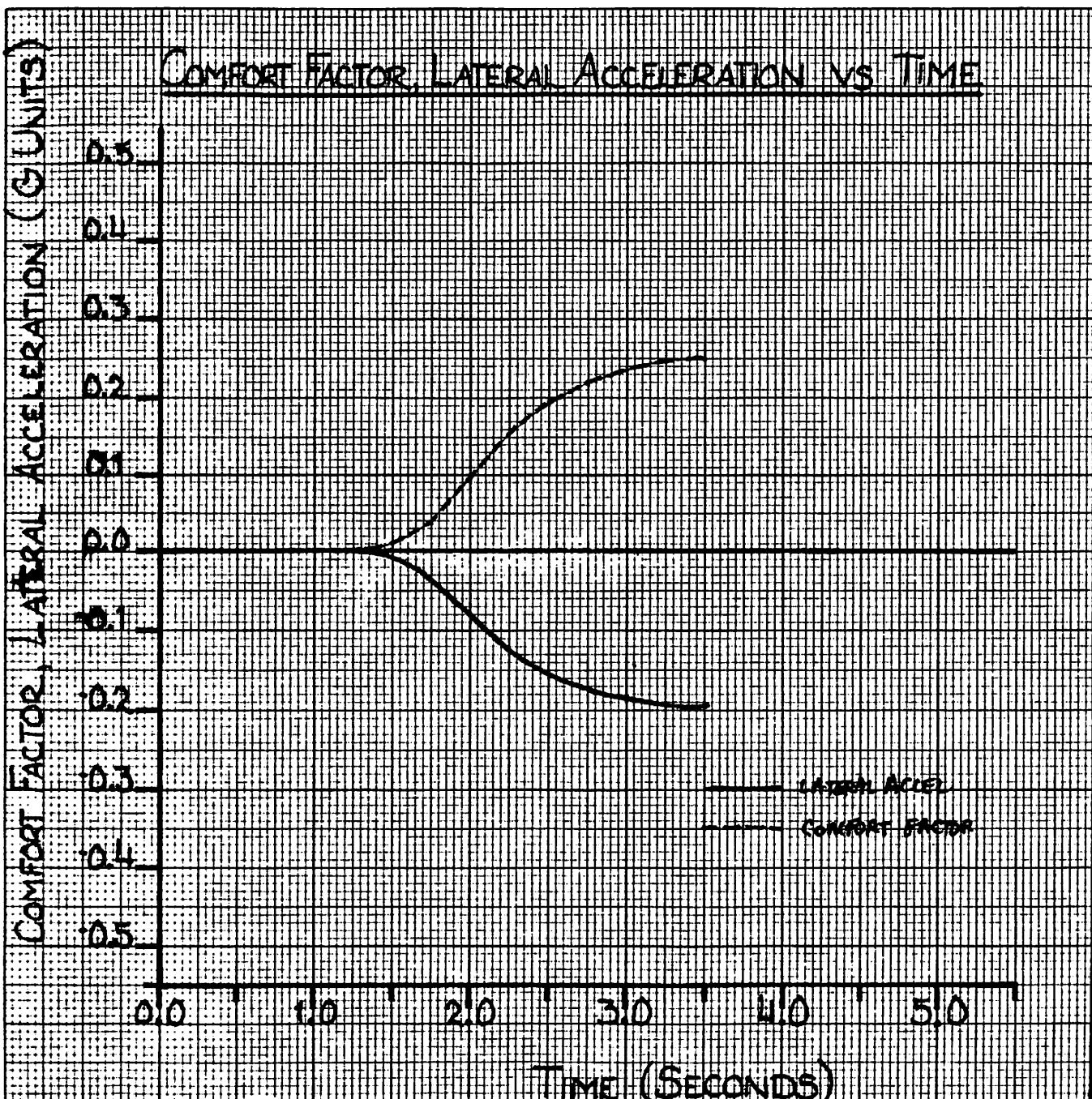
PATH: 410 METER RADIUS CURVE

TERRAIN: FLAT SURFACE

SPEED: 120 kph

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CSP2-HVOSM



CSP2- PHASE4

FLAT SURFACE CORNERING MANEUVER

VEHICLE: 1974 WHITE TRUCK

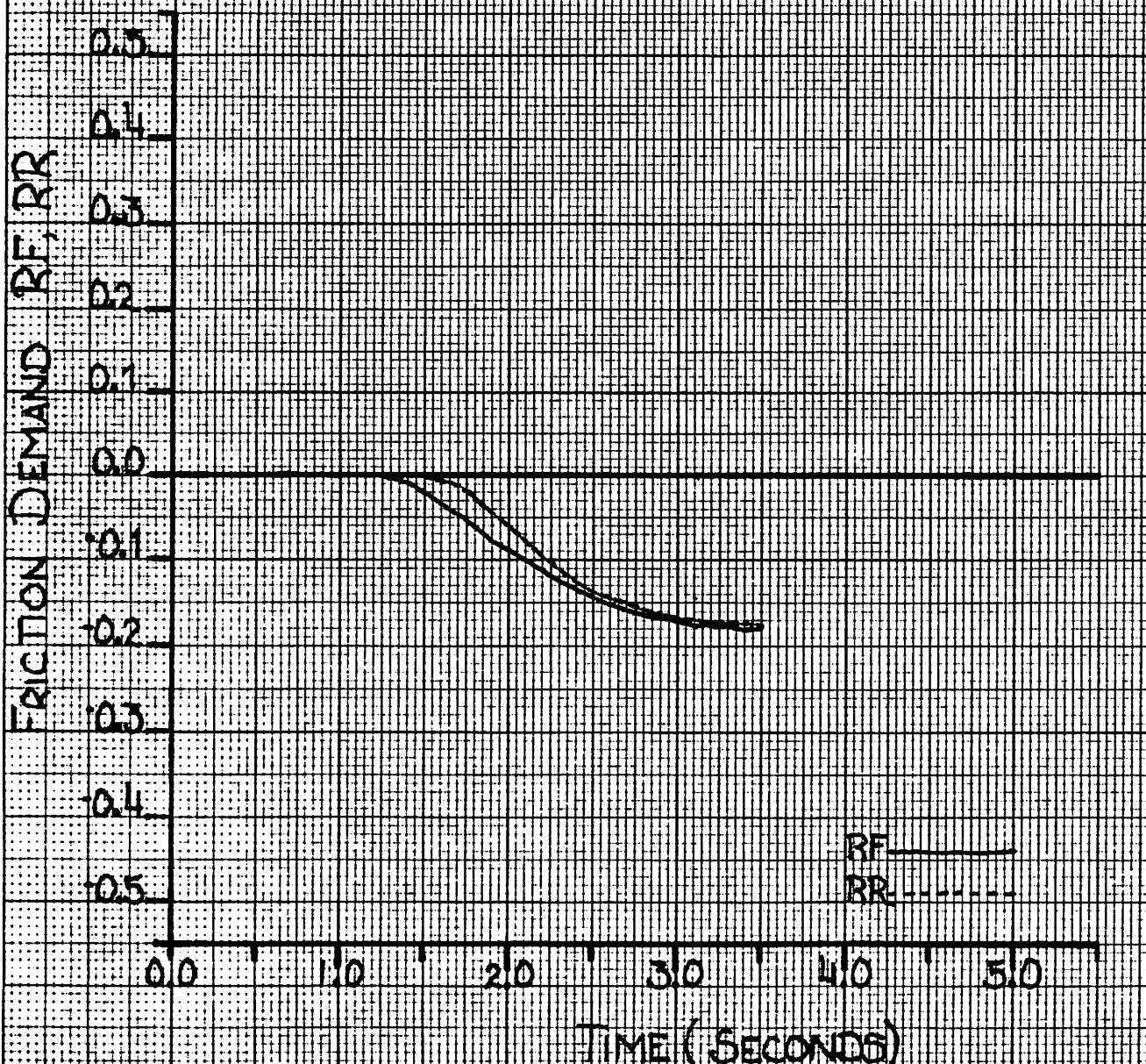
DATA: 40 METER RADIUS PATH

TERRAIN: FLAT SURFACE

SPEED: 120 Kph

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RF RR FRICTION DEMAND VS TIME



CSP2-HVOSM

FLAT SURFACE CORNERING MANEUVER

VEHICLE: 1974 WHITE TRUCK

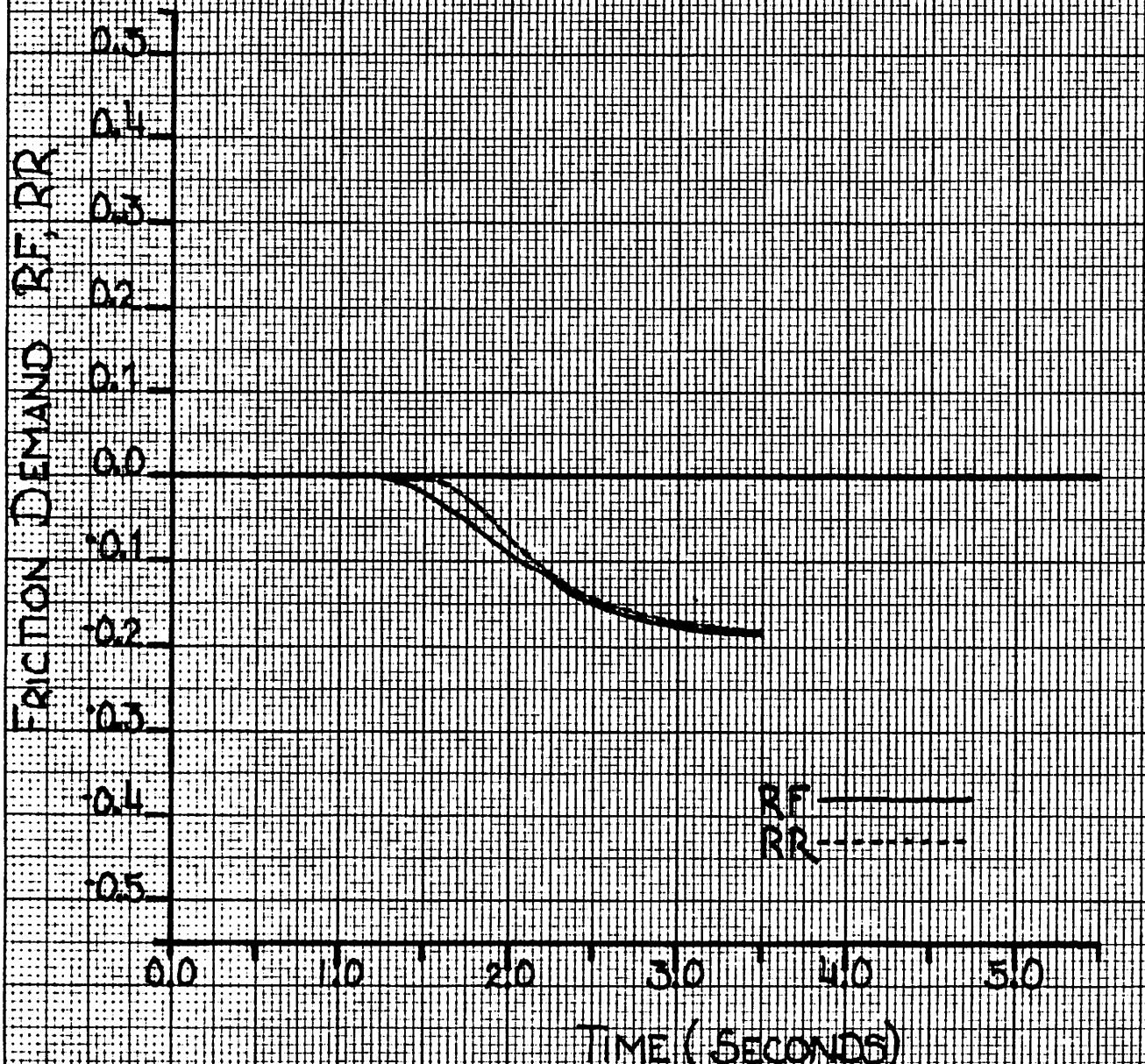
PATH: 410 METER RADIUS CURVE

TERRAIN: FLAT SURFACE

SPEED: 120 kph

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RF RR FRICTION DEMAND VS TIME

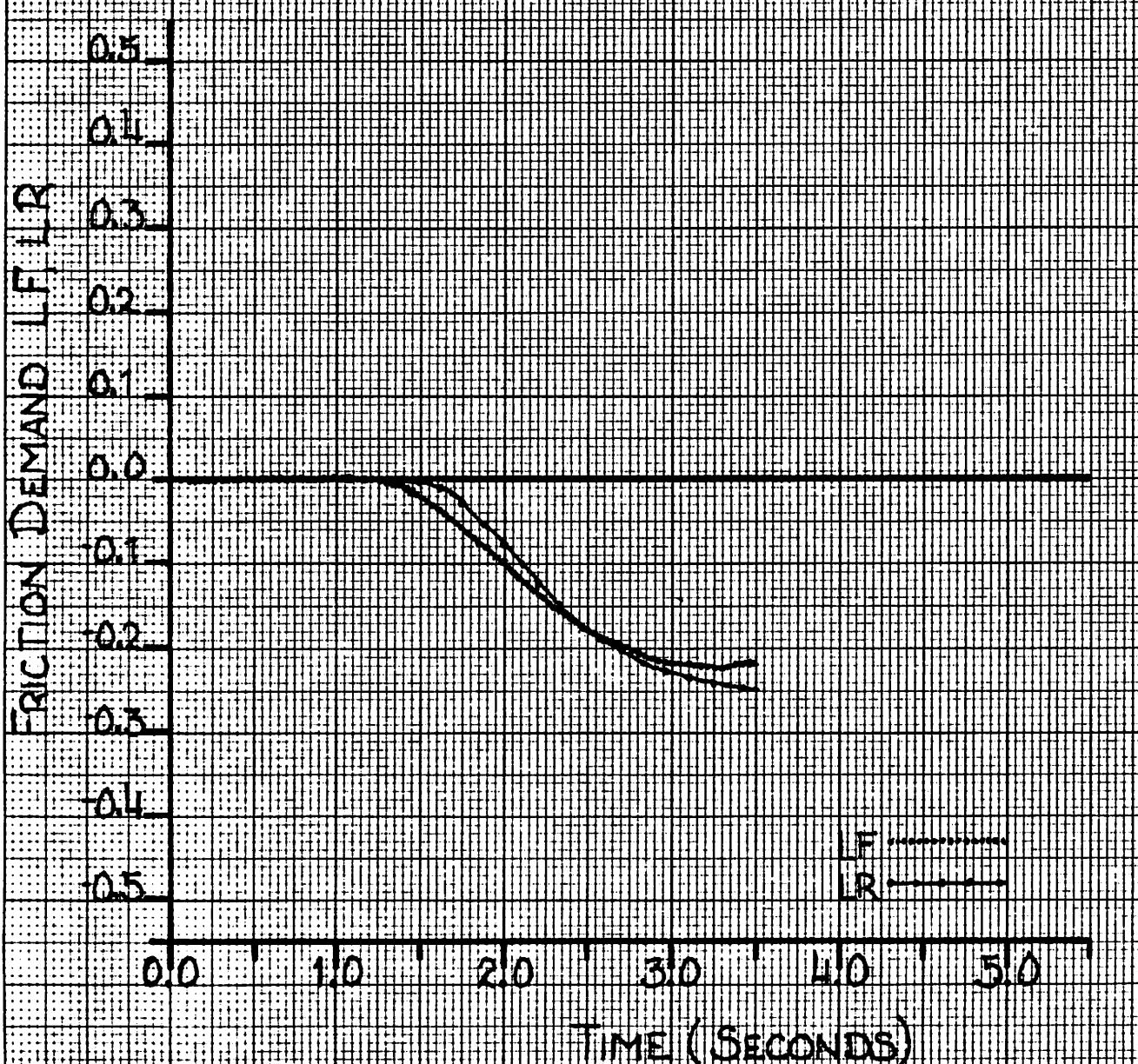


CSP2 - PHASE4
FLAT SURFACE CORNERING MANEUVER

VEHICLE: 1974 WHITE TRUCK
PATH: 410 METER RADIUS CURVE
TERRAIN: FLAT SURFACE
SPEED: 120 kph

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LF, LR FRICTION DEMAND VS TIME



CSP2-HvOSM

FLAT SURFACE CORNERING MANEUVER

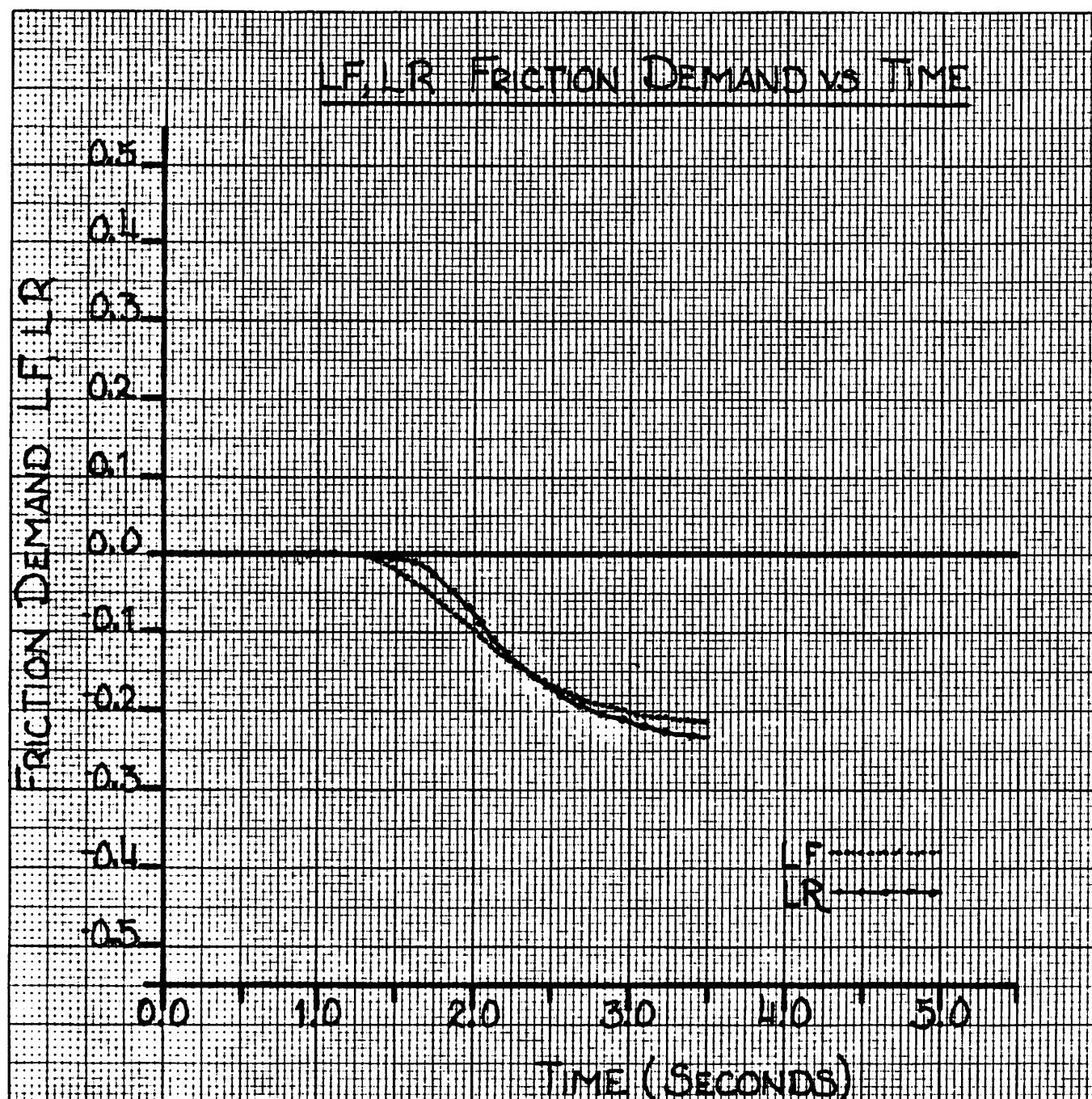
VEHICLE: 1974 WHITE TRUCK

PATH: 410 METER RADIUS CURVE

TERRAIN: FLAT SURFACE

SPEED: 120 kph

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CSP2- PHASE4

FLAT SURFACE CORNERING MANEUVER

VEHICLE: 1974 WHITE TRUCK

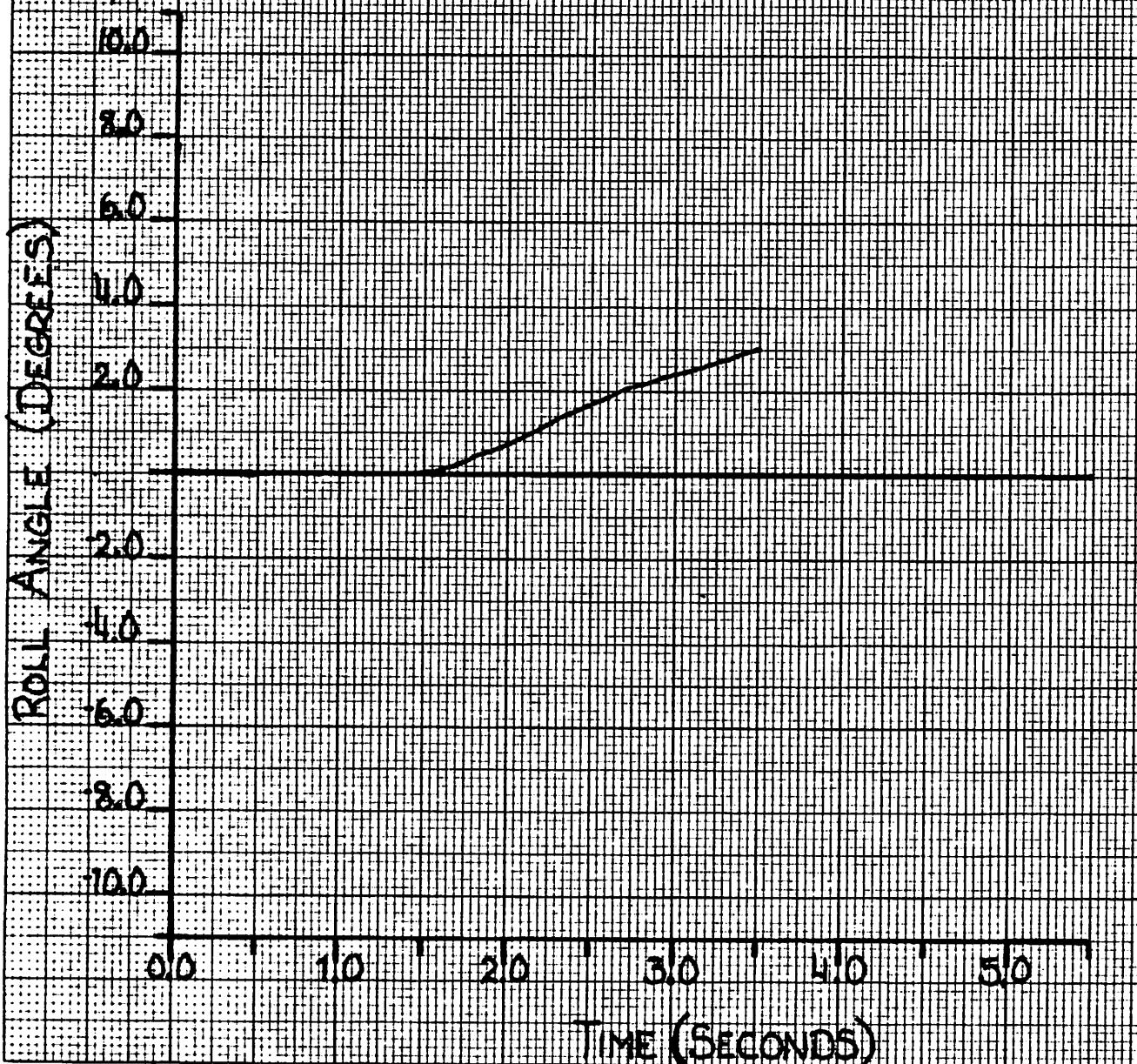
PATH: 410 METER RADIUS CURVE

TERRAIN: FLAT SURFACE

SPEED: 120 kph

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ROLL ANGLE VS TIME



CSP2-HUDSM

FLAT SURFACE CORNERING MANEUVER

VEHICLE: 1974 WHITE TRUCK

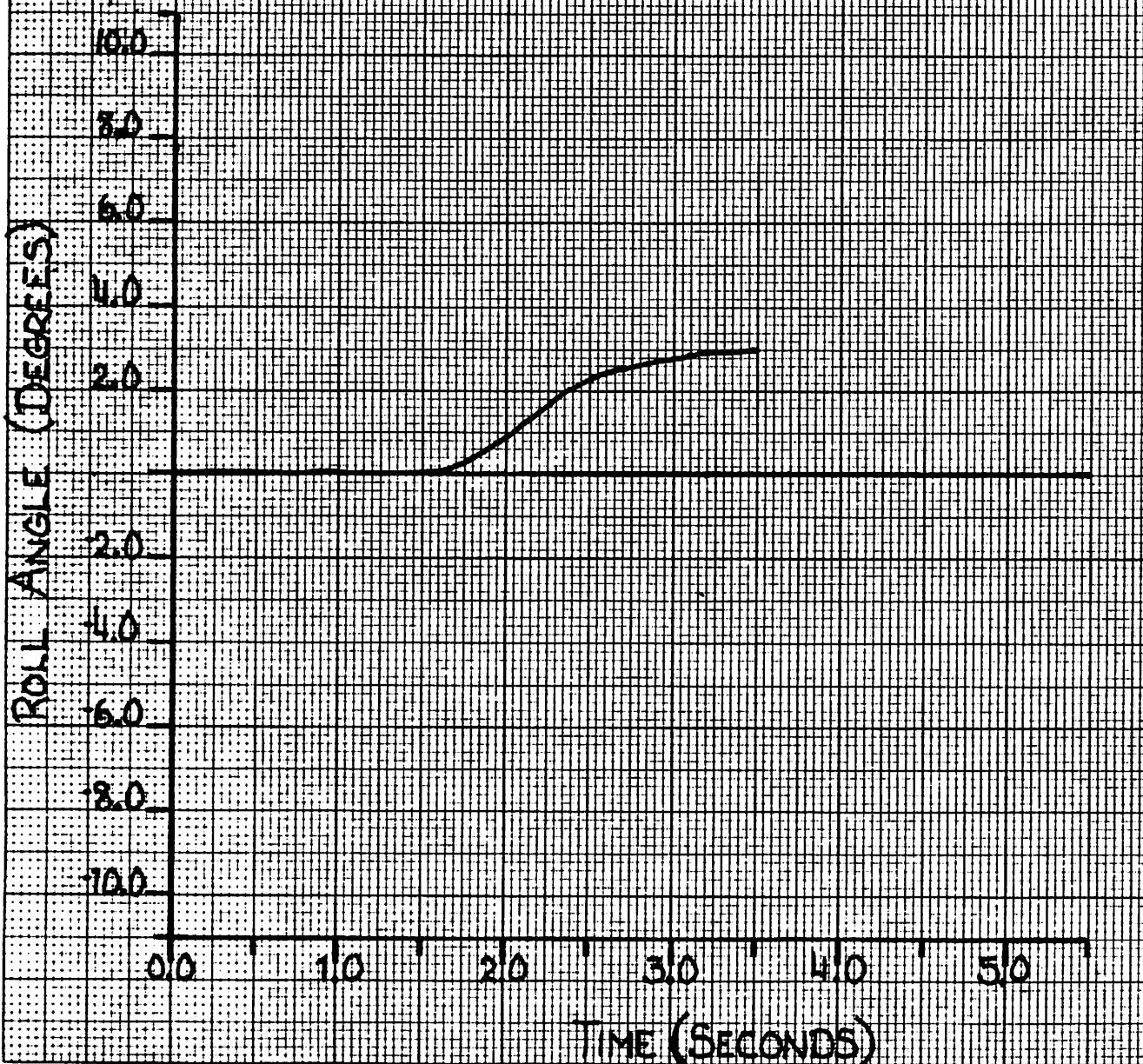
PATH: 410 METER RADIUS CURVE

TERRAIN: FLAT SURFACE

SPEED: 120 kph

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ROLL ANGLE VS TIME



CSP2- PHASE4

FLAT SURFACE CORNERING MANEUVER

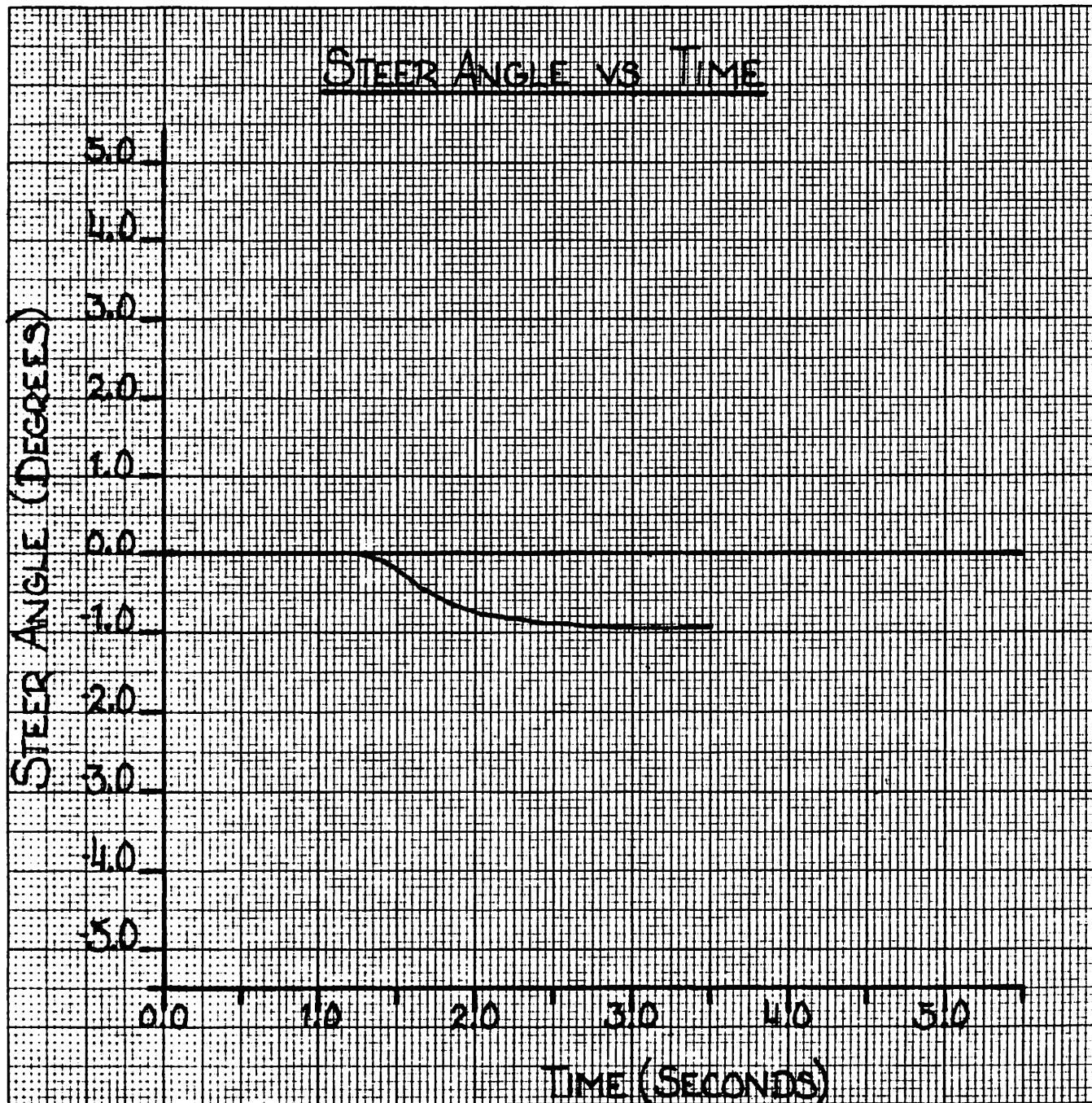
VEHICLE: 1974 WHITE TRUCK

PATH : 410 METER RADIUS CURVE

TERRAIN: FLAT SURFACE

SPEED: 120 kph

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CSP2-HVOSM
FLAT SURFACE CORNERING MANEUVER

VEHICLE: 1974 WHITE TRUCK

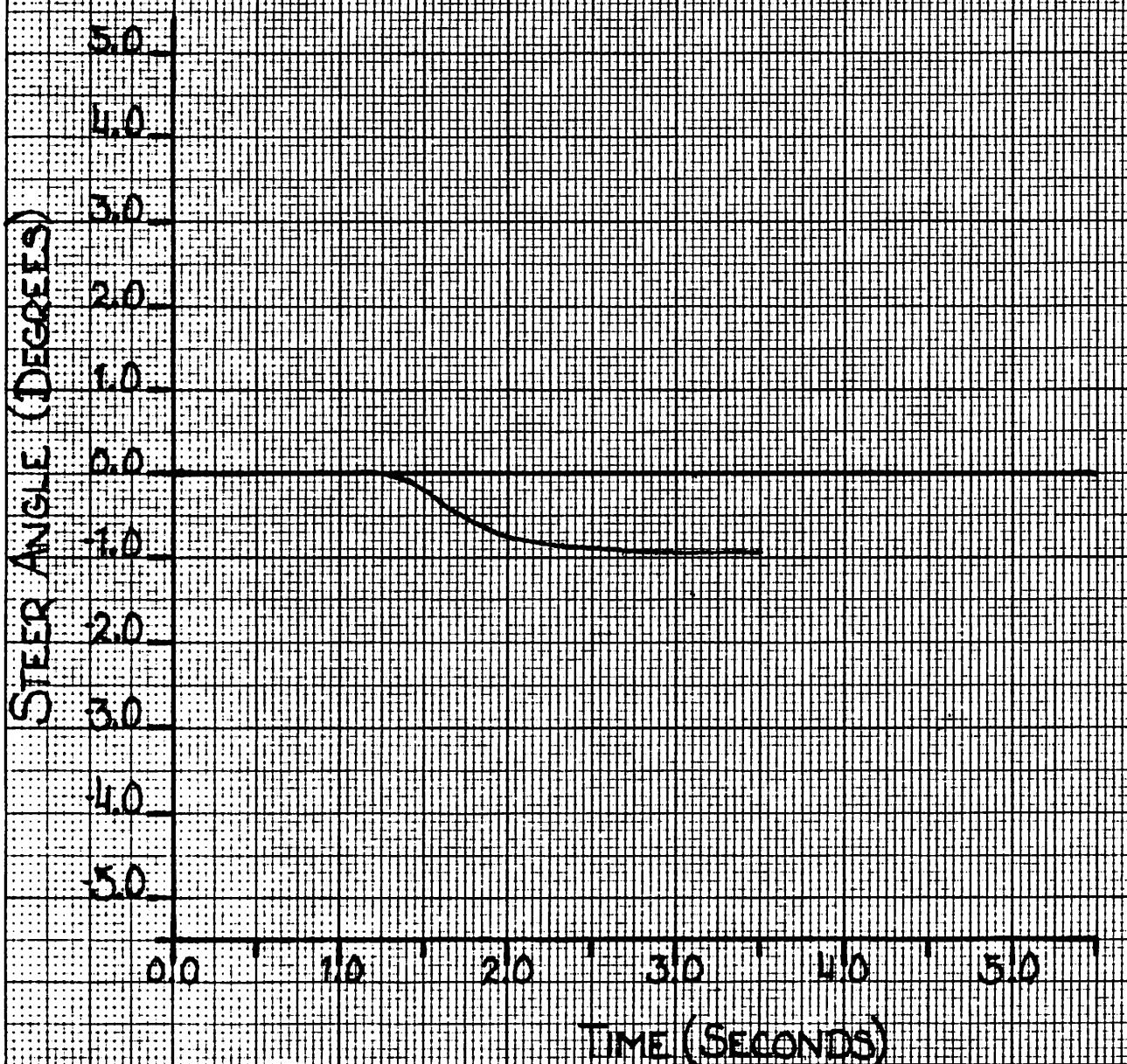
PATH: 90 METER RADIUS CURVE

TERRAIN: FLAT SURFACE

SPEED: 120 Kph

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STEER ANGLE VS TIME



CSP2 - PHASE4

FLAT SURFACE CORNERING MANEUVER

VEHICLE: 1974 WHITE TRUCK

PATH: 410 METER RADIUS PATH

TERRAIN: FLAT SURFACE

SPEED: 120 Kph

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6.2 CPS3 - Superelevated Curve Entry Run

RUN SPECIFICATIONS: Path: 410 Meter Radius Curve

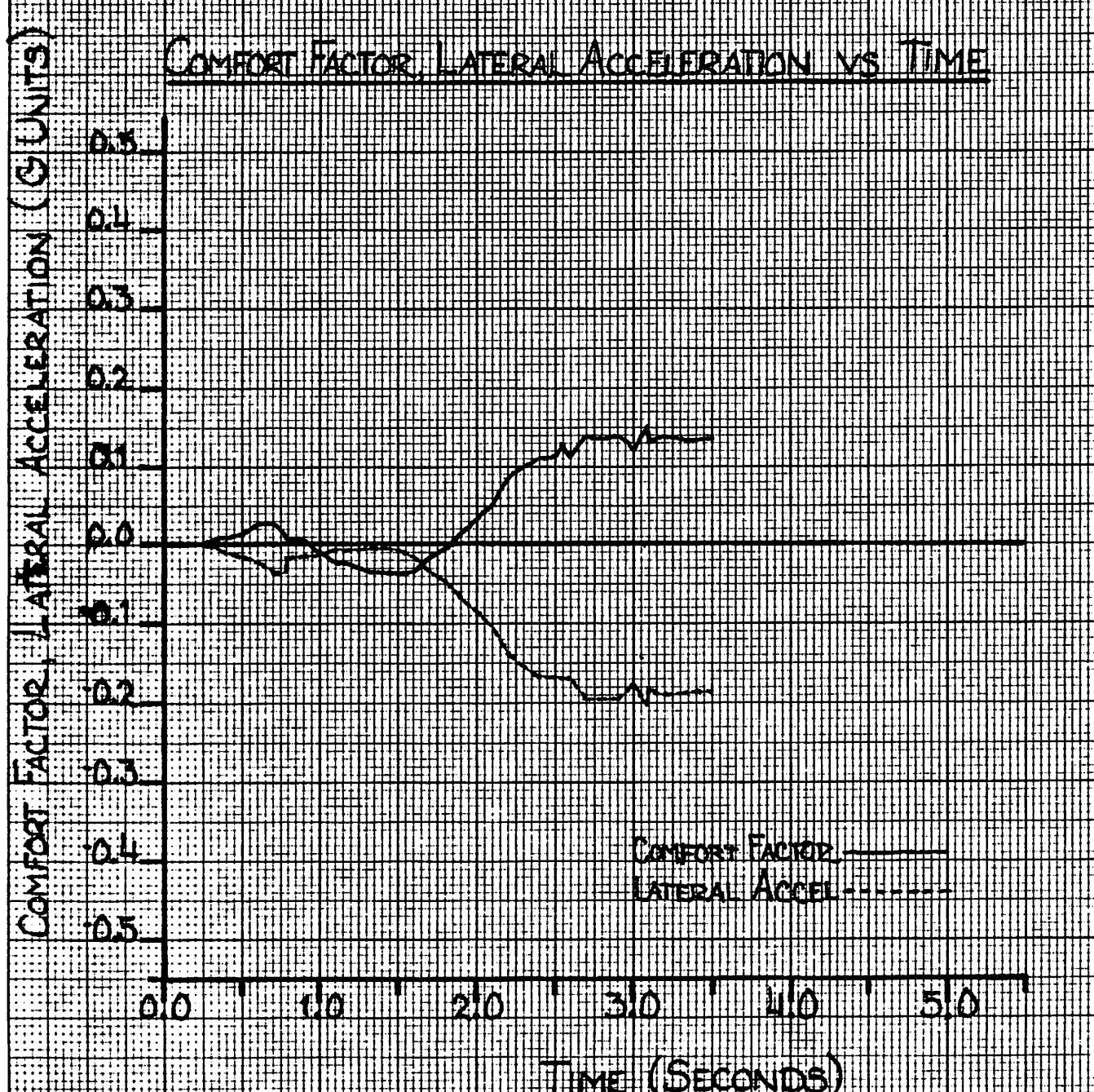
Terrain: 410 Meter Radius Curve

8% SE

74 M Runoff

A curve entry run similar to the runs performed for Task E of the contract (ref. 7) was performed with both simulation programs. Identical terrain definitions were permitted as the result of the installation of the HVOSM terrain table option routines into the PHASE4 program as part of Task B of the subject subcontract (see section 7.2).

The PHASE4 path follower was again tested to determine if its resultant steer responses would correlate with the HVOSM. As a result of this test run, there appeared to be a lack of correlation of the two path-followers; therefore, the HVOSM DRIVER MODEL-PATH FOLLOWER was installed in the PHASE4 program (see section 7.2).



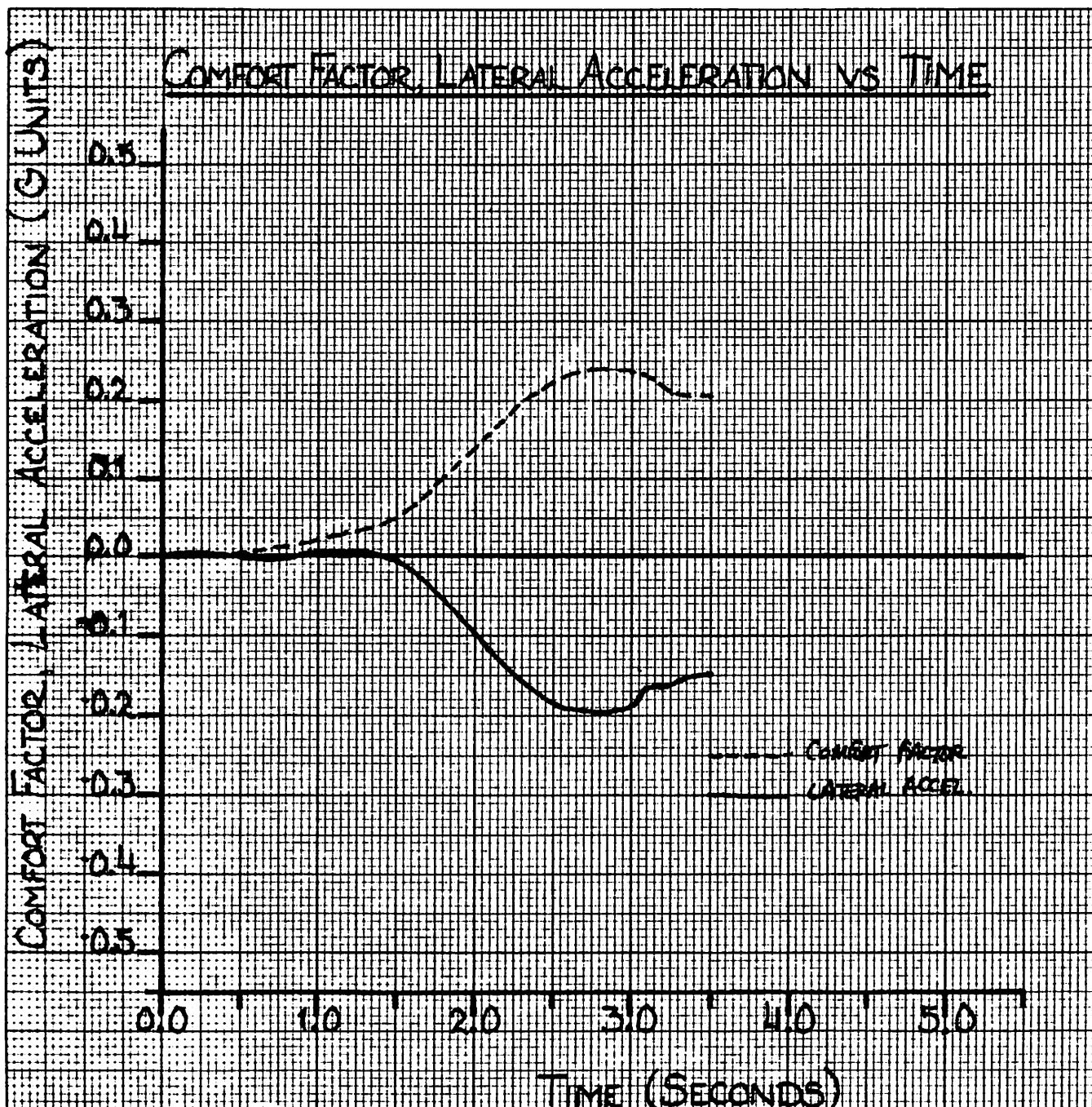
CSP3 - HVOSM
SUPERELEVATED CURVE ENTRY RUN

VEHICLE: 1974 WHITE TRUCK

ROAD: 410 M RADIUS
8% SE
74M RUNOFF

PATH: 410 M RADIUS

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CSP3-PHASE4
SUPERELEVATED CURVE ENTRY RUN

VEHICLE: 1974 WHITE TRUCK

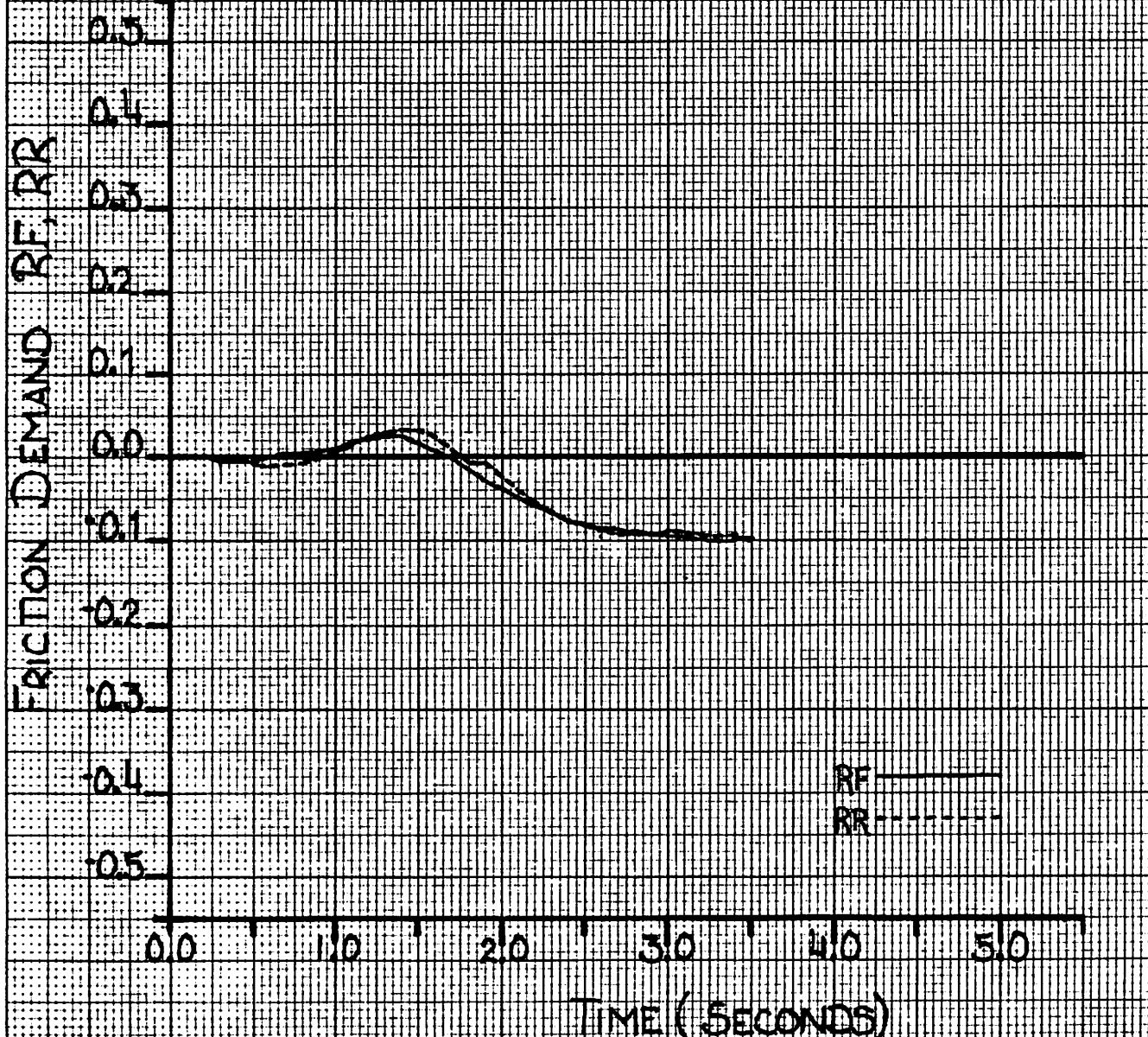
ROAD: 410 M RADIUS
8% SE
74 M RUNOFF

PATH: 410 M RADIUS

PHASE4 PATH FOLLOWER

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RF/RR FRICTION DEMAND VS TIME



CSP3-HVOSM

SUPERELEVATED CURVE ENTRY RUN

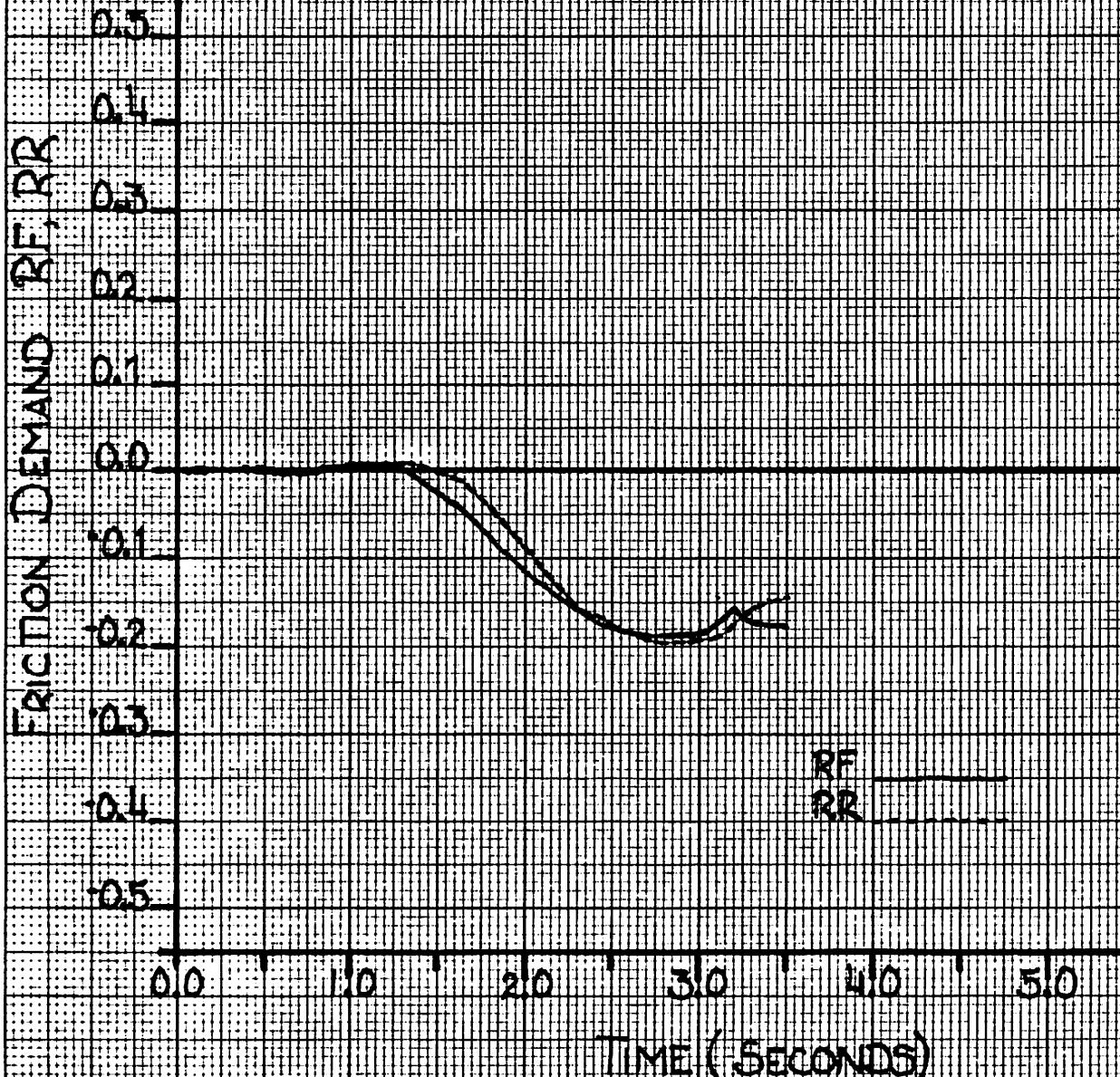
VEHICLE: 1974 WHITE TRUCK

ROAD: 410 M RADIUS
8% SE
74M RUNOFF

PATH: 410 M RADIUS

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RF, RR FRICTION DEMAND VS TIME



CSP3 - PHASE4

SUPERELEVATED CURVE ENTRY RUN

VEHICLE: 1974 WHITE TRUCK

ROAD: 410 M RADIUS CURVE

8% SE

74 M RUNOFF

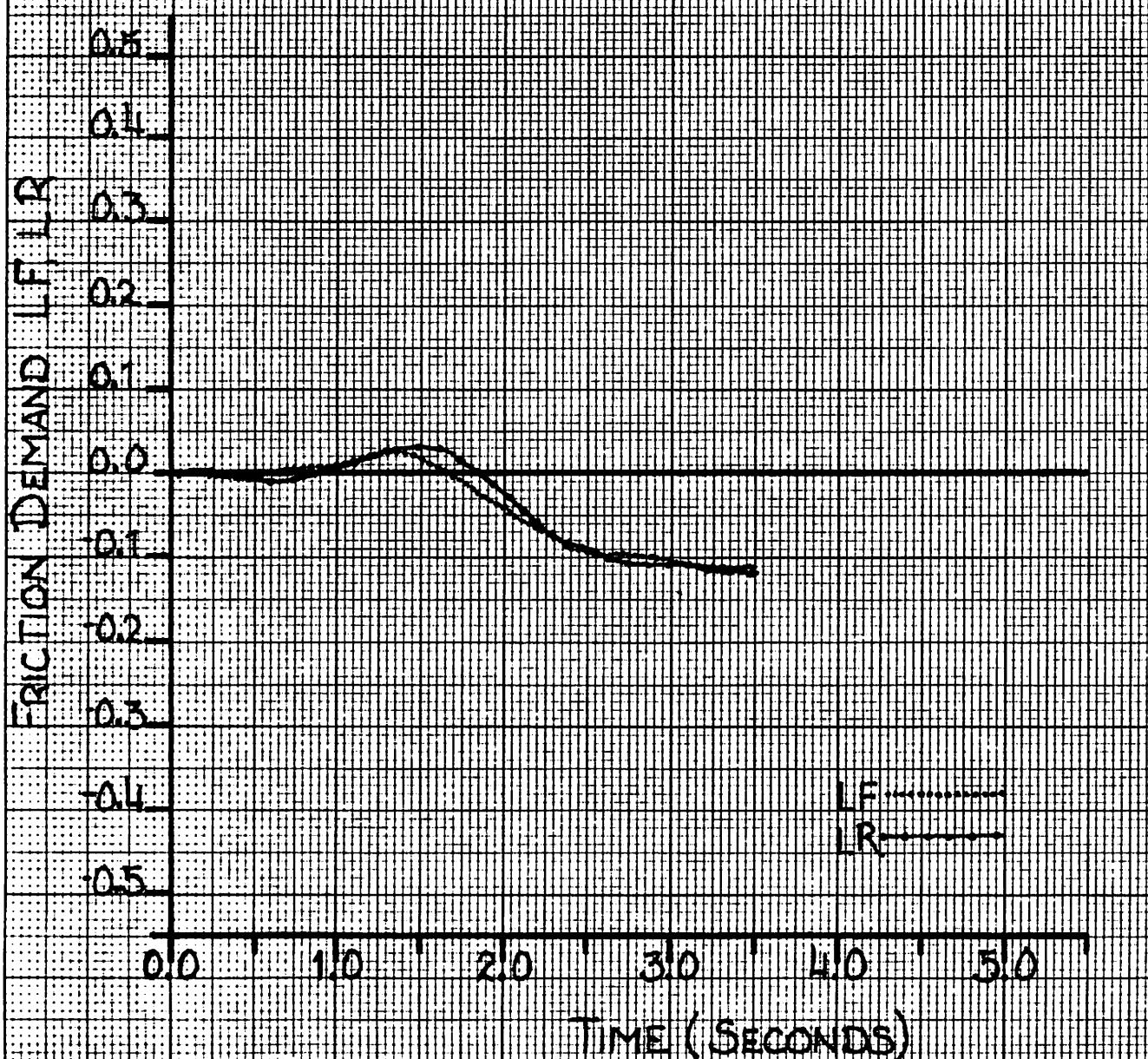
PATH: 410 M RADIUS

PHASE4 PATH FOLLOWER

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CSP3 - PHASE4

LF & R FRICTION DEMAND VS TIME



CSP3 - HVOSM

SUPERELEVATED CURVE ENTRY RUN

VEHICLE: 1974 WHITE TRUCK

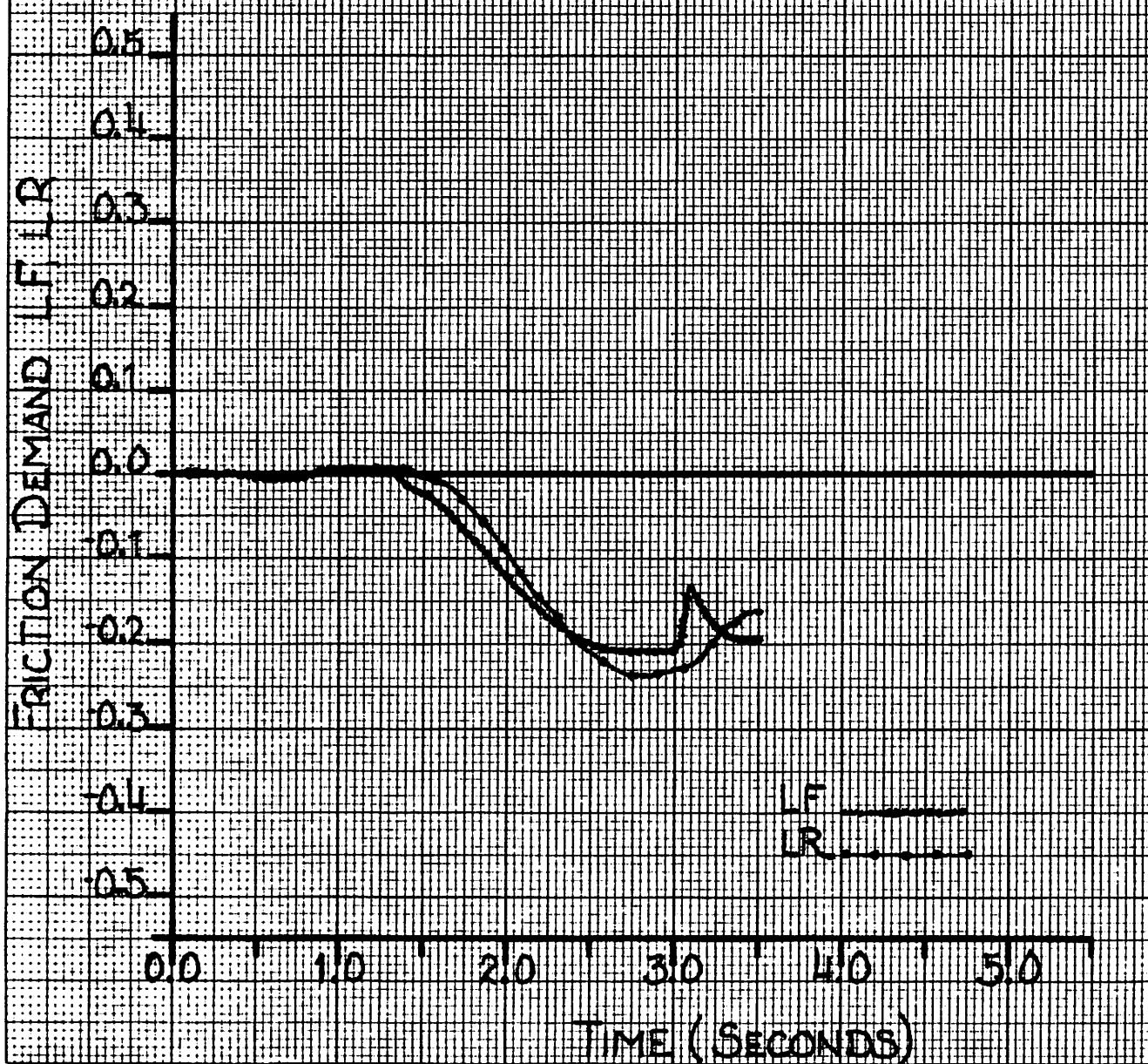
ROAD: 410 M RADIUS
8% SE
74 M RUNOFF

PATH: 410 M RADIUS

Contract DOT-FH-11-9575
"Effectiveness of Geometric Design
Criteria for Rural Highways"
Modification No. 3
"Study of Centerline Crown"
McHenry Consultants, Inc.
MCI File No. 82-1207

CSP3 - HVOSM

LF, LR FRICITION DEMAND VS TIME



CSP3 - PHASE4

SUPERELEVATED CURVE ENTRY RUN

VEHICLE: 1974 WHITE TRUCK

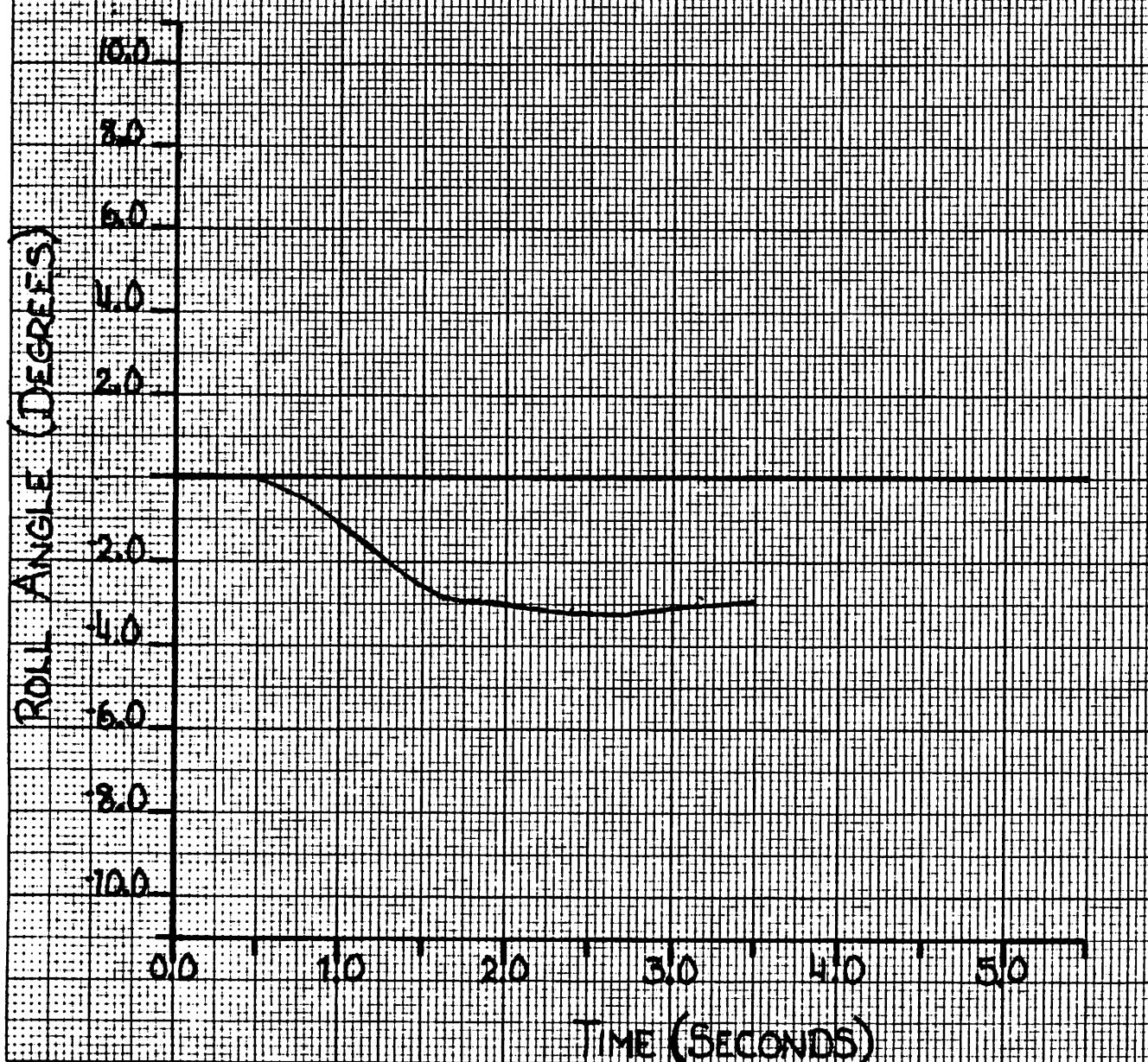
ROAD: 410 m RADIUS CURVE
8% SE
74 m RUNOFF

PATH: 410 m RADIUS

PHASE4 PATH FOLLOWER

Contract DOT-FH-11-9575
"Effectiveness of Geometric Design
Criteria for Rural Highways"
Modification No. 3
"Study of Centerline Crown"
McHenry Consultants, Inc.
MCI File No. 82-1207

ROLL ANGLE VS TIME



CSP3 - HVO/SM
SUPERELEVATED CURVE ENTRY RUN

VEHICLE: 1974 WHITE TRUCK

ROAD: 410 M RADIUS

8% SE

74M RUNOFF

PATH: 410 M RADIUS

Contract DOT-FH-11-9575
"Effectiveness of Geometric Design
Criteria for Rural Highways"
Modification No. 3 -
"Study of Centerline Crown"
McHenry Consultants, Inc.
MCI File No. 82-1207

ROLL ANGLE VS TIME



CSP3 - PHASE4

SUPERELEVATED CURVE ENTRY RUN

VEHICLE: 1974 WHITE TRUCK

ROAD: 410M RADIUS CURVE

8% SE

74M RUNOFF

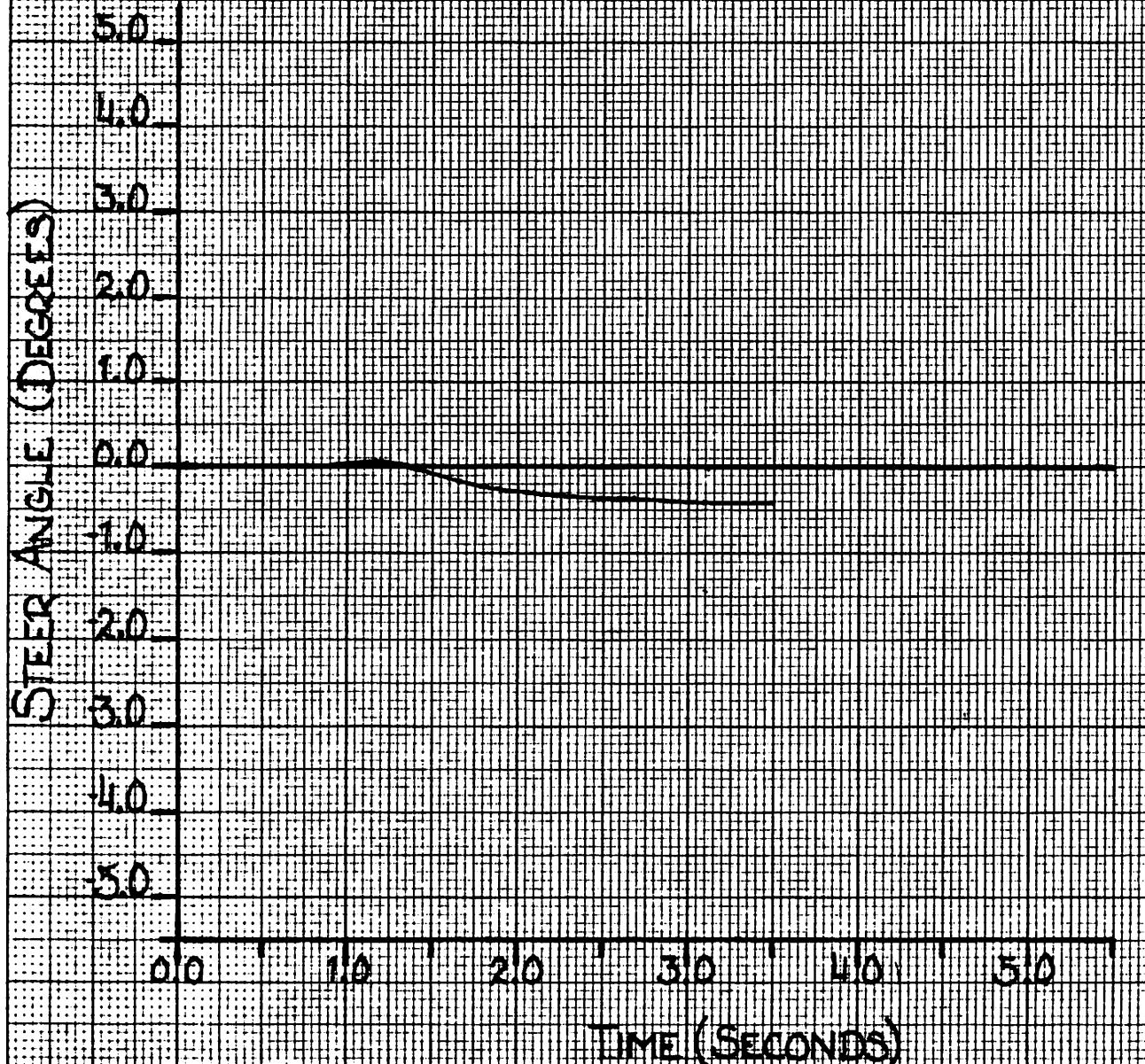
PATH: 410 M RADIUS

PHASE4 PATH FOLLOWER

Contract DOT-FH-11-9575
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"Study of Centerline Crown"
McHenry Consultants, Inc.
MCI File No. 82-1207

CSP3-PHASE4

STEER ANGLE VS TIME



CSP3-Hvošm

SUPERELEVATED CURVE ENTRY RUN

VEHICLE: 1974 WHITE TRUCK

ROAD: 410 M RADIUS

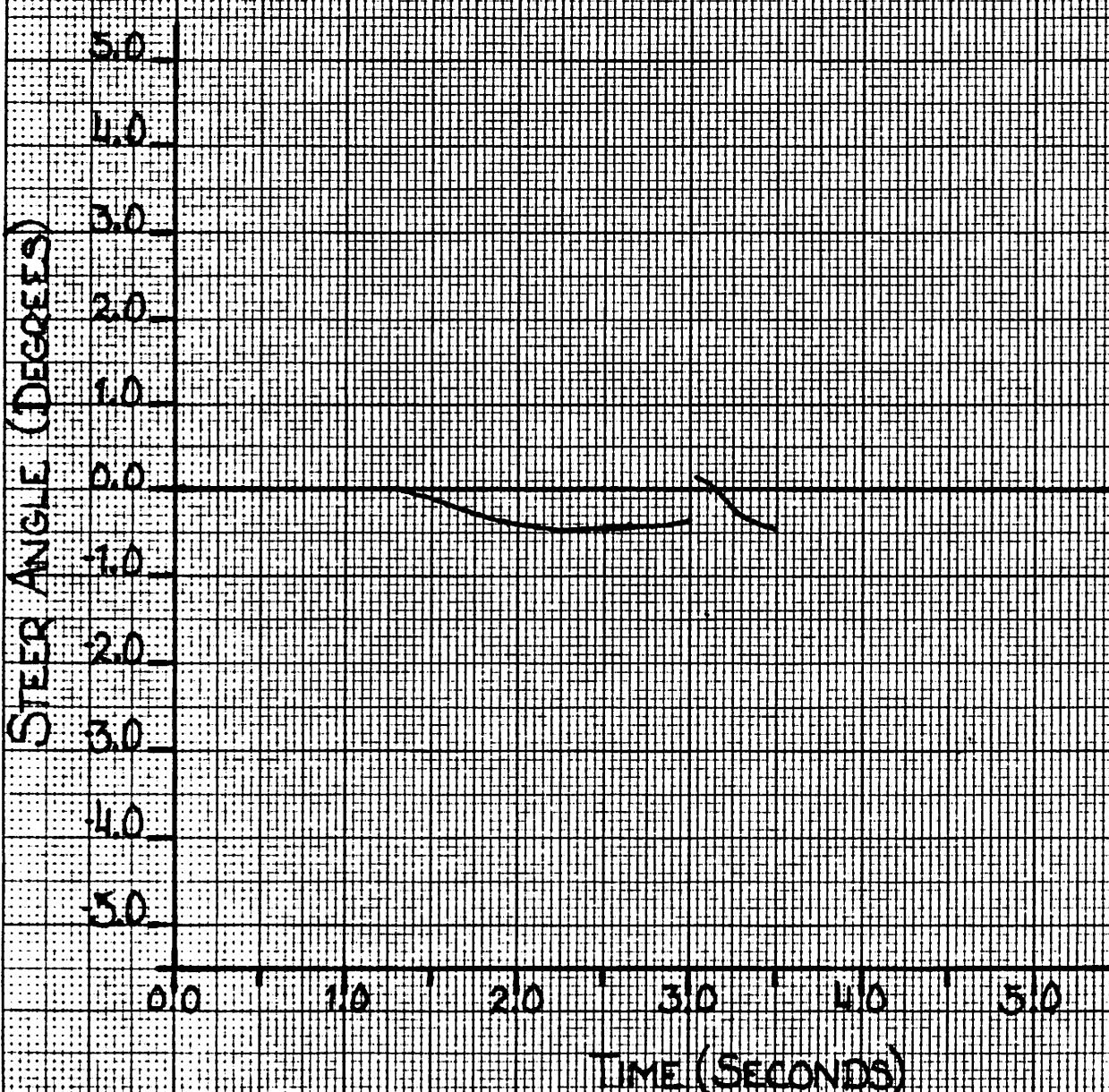
8% SE

74 M RUNOFF

PARTH: 410 M RADIUS

Contract DOT-FH-11-9575
"Effectiveness of Geometric Design
Criteria for Rural Highways"
Modification No. 3 -
"Study of Centerline Crown"
McHenry Consultants, Inc"
MCI File No. 82-1207

STEER ANGLE VS TIME



CSP3 - PHASE4
SUERELEVATED CURVE ENTRY RUN

VEHICLE: 1974 WHITE TRUCK

ROAD: 410 M RADIUS CURVE
8% SE
74M RONOFF

PATH: 410 M RADIUS

PHASE4 PATH FOLLOWER

Contract DOT-FH-11-9575
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"Study of Centerline Crown"
McHenry Consultants, Inc"
MCI File No. 82-1207

CSP3 - PHASE4 46

6.4 CCS9 - Crossover Crown Passing Maneuver

RUN SPECIFICATIONS:

Design Speed: 120 kph

Initial Speed: 104 kph

Road: Crown: 2% (per side)

Lanes: 12 ft

Path: Segment Lengths $L_1 = 29.1$ m

$L_2 = 16.2$ m, radius = 345 m

$L_3 = 58.0$ m

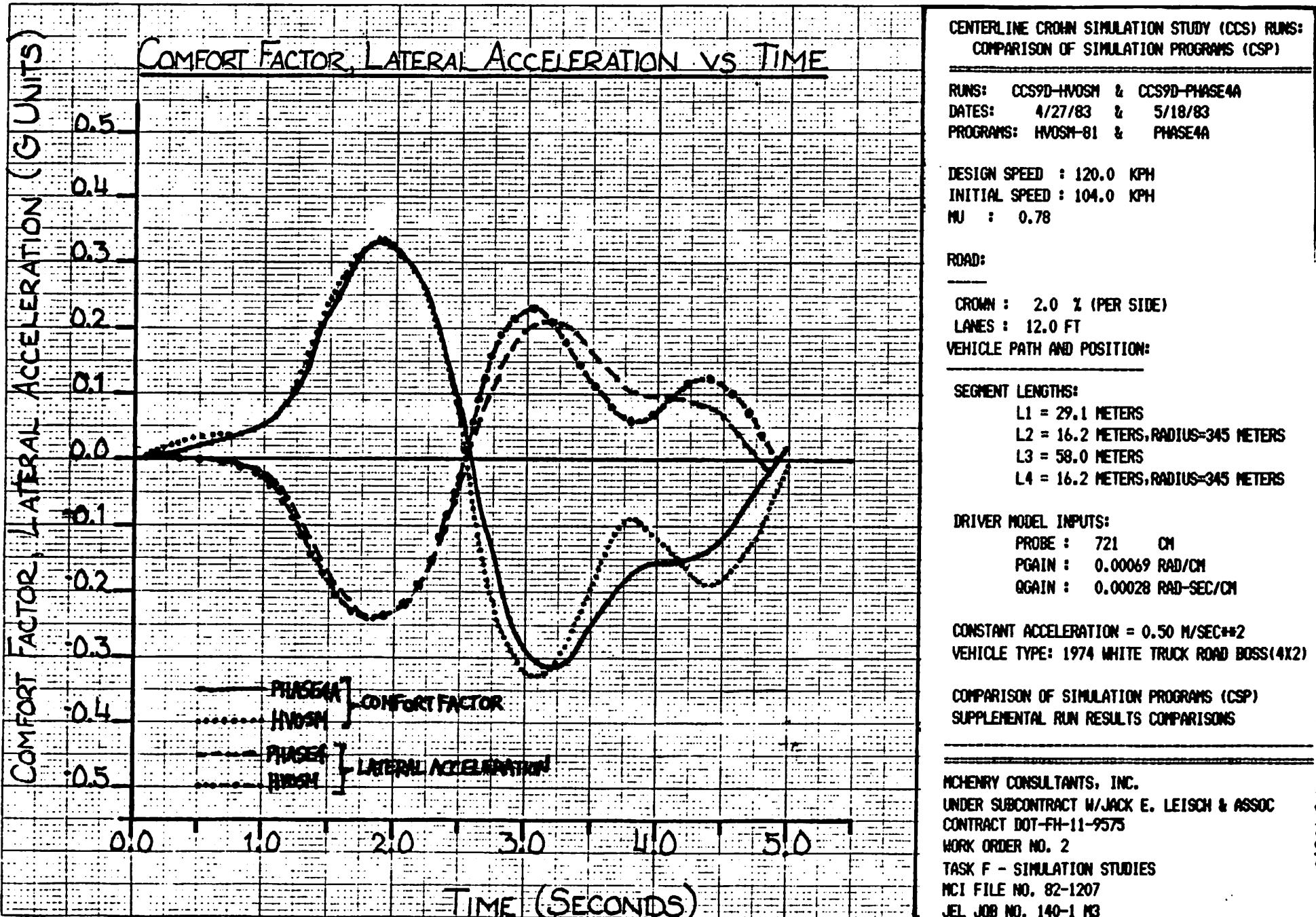
$L_4 = 16.2$ m, radius = 345 m

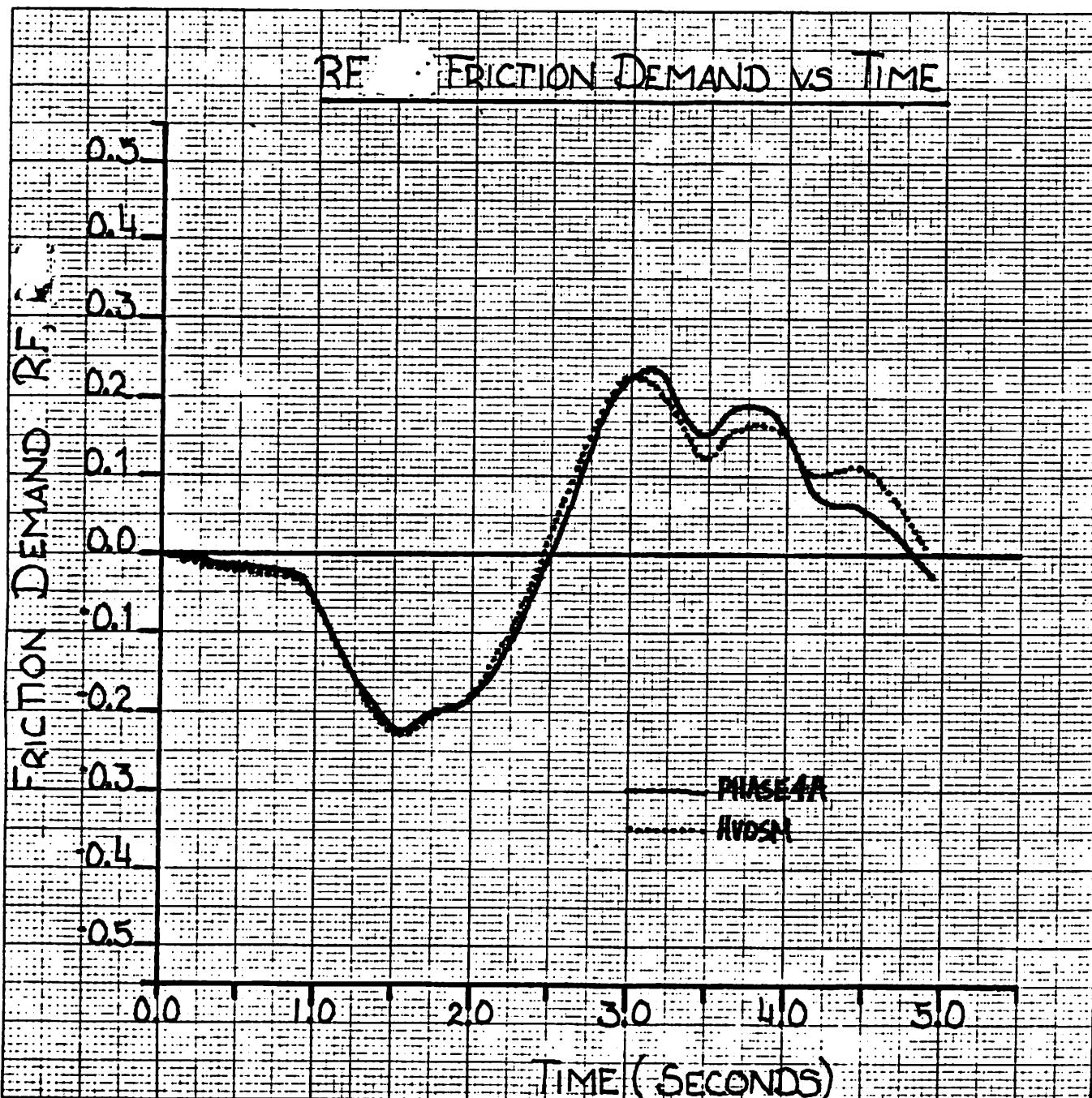
Driver Model: Probe Length = 1153 μ m

PGAIN = 0.00043 rad/cm

QGAIN = 0.00017 rad-sec/cm

A crossover crown simulation run was performed with the PHASE4 and HVOSM programs. The run required the use of both the Driver Model Path Follower and Terrain Table Options in both programs. A comparison of the results reveals an adequate correlation of the results between the two simulation programs.





CENTERLINE CROWN SIMULATION STUDY (CCS) RUNS:
COMPARISON OF SIMULATION PROGRAMS (CSP)

RUNS: CCS9D-HVOSM & CCS9D-PHASE4A
DATES: 4/27/83 & 5/18/83
PROGRAMS: HVOSM-81 & PHASE4A

DESIGN SPEED : 120.0 KPH
INITIAL SPEED : 104.0 KPH
MU : 0.78

ROAD:

CROWN : 2.0 % (PER SIDE)
LANES : 12.0 FT
VEHICLE PATH AND POSITION:

SEGMENT LENGTHS:
L₁ = 29.1 METERS
L₂ = 16.2 METERS, RADIUS=345 METERS
L₃ = 58.0 METERS
L₄ = 16.2 METERS, RADIUS=345 METERS

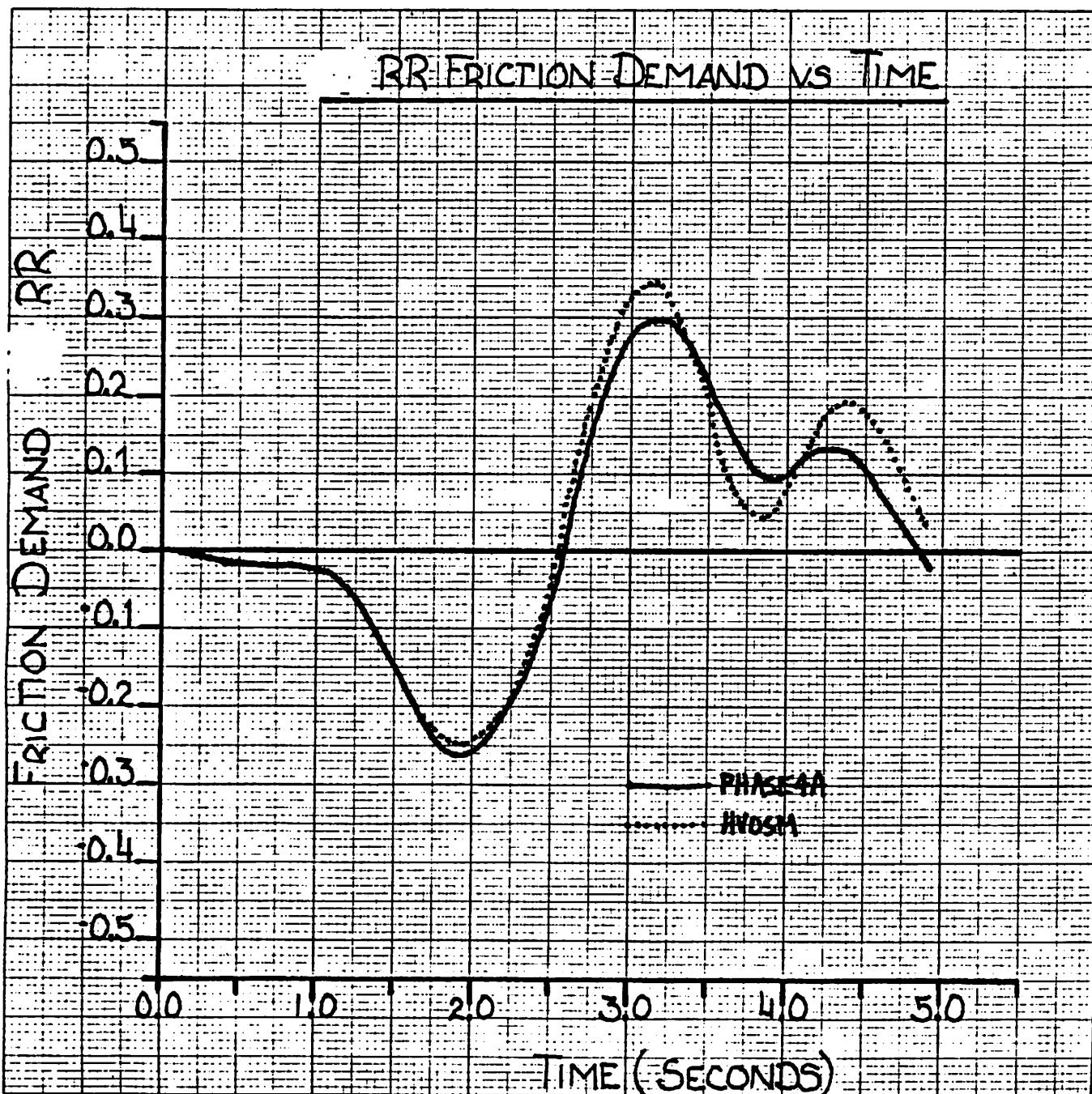
DRIVER MODEL INPUTS:

PROBE : 721 CM
PGAIN : 0.00069 RAD/CM
QGAIN : 0.00028 RAD-SEC/CM

CONSTANT ACCELERATION = 0.50 M/SEC²
VEHICLE TYPE: 1974 WHITE TRUCK ROAD BOSS(4X2)

COMPARISON OF SIMULATION PROGRAMS (CSP)
SUPPLEMENTAL RUN RESULTS COMPARISONS

MCHENRY CONSULTANTS, INC.
UNDER SUBCONTRACT W/JACK E. LEISCH & ASSOC
CONTRACT DOT-FH-11-9573
WORK ORDER NO. 2
TASK F - SIMULATION STUDIES
MCI FILE NO. 82-1207
JEL JOB NO. 140-1 M3



CENTERLINE CROWN SIMULATION STUDY (CCS) RUNS:
COMPARISON OF SIMULATION PROGRAMS (CSP)

RUNS: CCS9D-HVOSM & CCS9D-PHASE4A
DATES: 4/27/83 & 5/18/83
PROGRAMS: HVOSM-81 & PHASE4A

DESIGN SPEED : 120.0 KPH
INITIAL SPEED : 104.0 KPH
MU : 0.78

ROAD:

CROWN : 2.0 % (PER SIDE)
LANES : 12.0 FT

VEHICLE PATH AND POSITION:

SEGMENT LENGTHS:

L1 = 29.1 METERS
L2 = 16.2 METERS, RADIUS=345 METERS
L3 = 58.0 METERS
L4 = 16.2 METERS, RADIUS=345 METERS

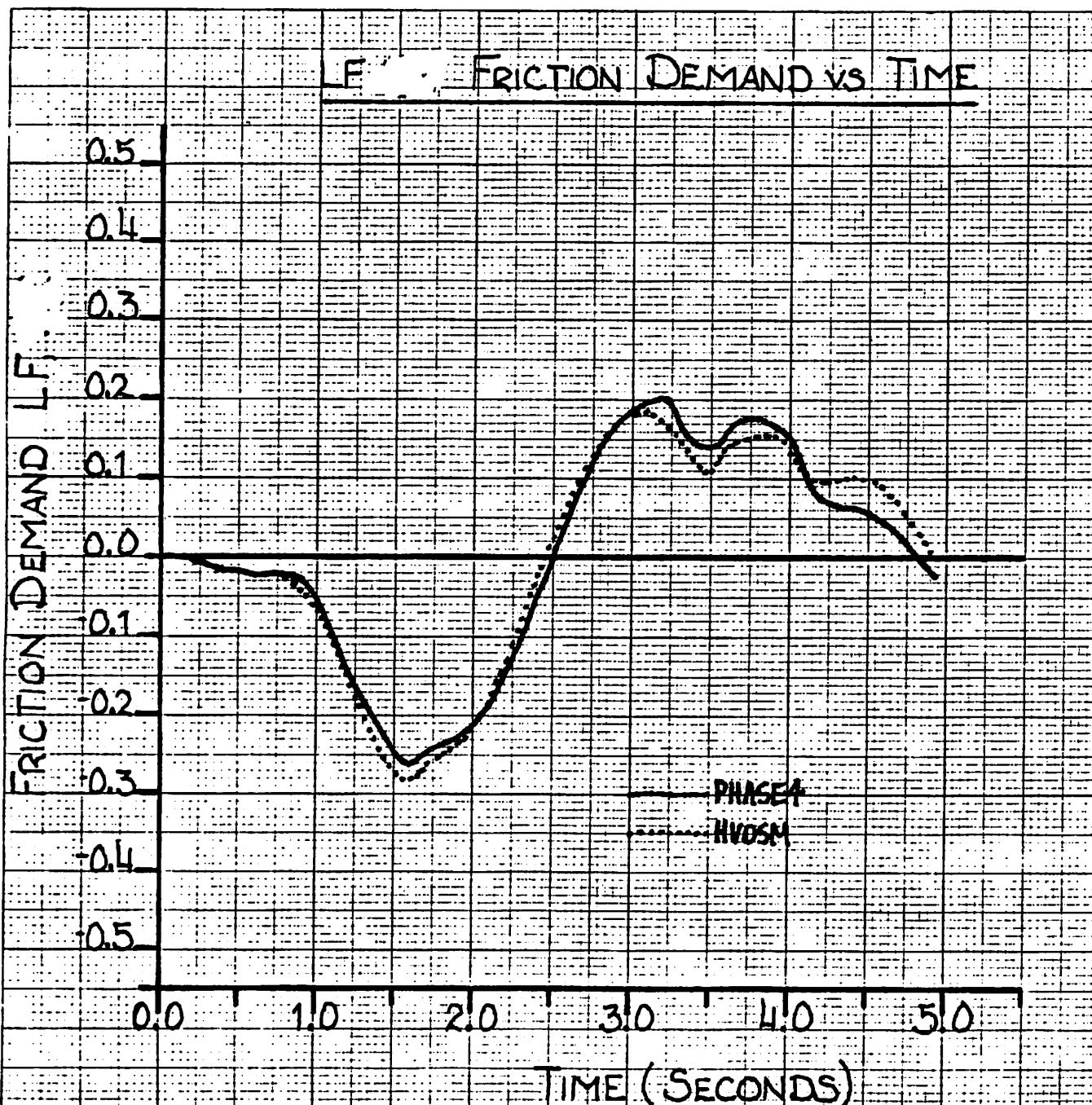
DRIVER MODEL INPUTS:

PROBE : 721 CM
PGAIN : 0.00069 RAD/CM
RGAIN : 0.00028 RAD-SEC/CM

CONSTANT ACCELERATION = 0.50 M/SEC²
VEHICLE TYPE: 1974 WHITE TRUCK ROAD BOSS(4X2)

COMPARISON OF SIMULATION PROGRAMS (CSP)
SUPPLEMENTAL RUN RESULTS COMPARISONS

MHENRY CONSULTANTS, INC.
UNDER SUBCONTRACT W/JACK E. LEISCH & ASSOC
CONTRACT DOT-FH-11-9575
WORK ORDER NO. 2
TASK F - SIMULATION STUDIES
MCI FILE NO. 82-1207
JEL JOB NO. 140-1 M3



CENTERLINE CROWN SIMULATION STUDY (CCS) RUNS:
COMPARISON OF SIMULATION PROGRAMS (CSP)

RUNS: CCS9D-HVOSM & CCS9D-PHASE4A
DATES: 4/27/83 & 5/18/83
PROGRAMS: HVOSM-81 & PHASE4A

DESIGN SPEED : 120.0 KPH
INITIAL SPEED : 104.0 KPH
MU : 0.78

ROAD:

CROWN : 2.0 % (PER SIDE)
LANES : 12.0 FT
VEHICLE PATH AND POSITION:

SEGMENT LENGTHS:
L1 = 29.1 METERS
L2 = 16.2 METERS, RADIUS=345 METERS
L3 = 58.0 METERS
L4 = 16.2 METERS, RADIUS=345 METERS

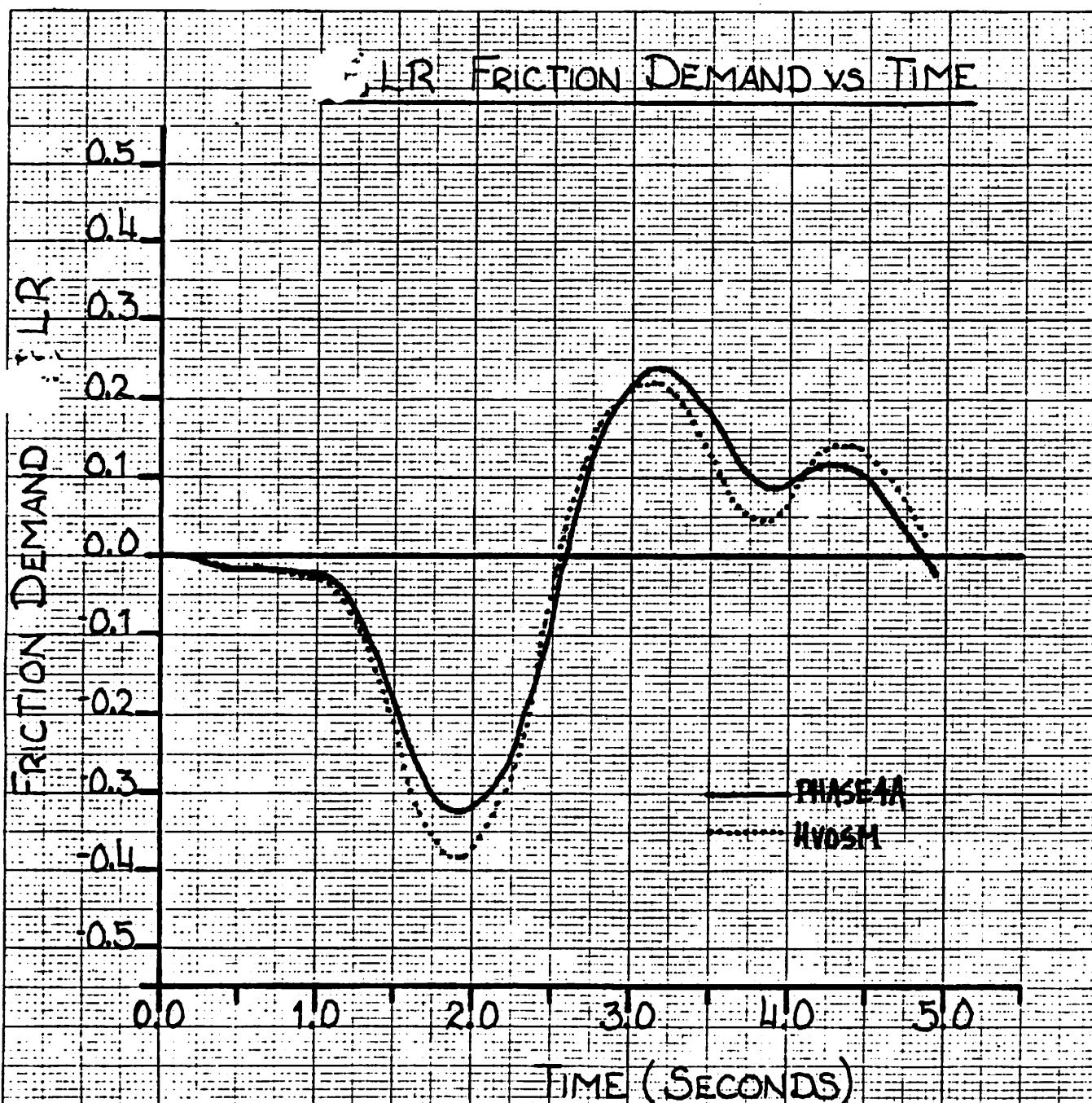
DRIVER MODEL INPUTS:

PROBE : 721 CM
PGAIN : 0.00069 RAD/CM
RGAIN : 0.00028 RAD-SEC/CM

CONSTANT ACCELERATION = 0.50 M/SEC²
VEHICLE TYPE: 1974 WHITE TRUCK ROAD BOSS(4X2)

COMPARISON OF SIMULATION PROGRAMS (CSP)
SUPPLEMENTAL RUN RESULTS COMPARISONS

MCHENRY CONSULTANTS, INC.
UNDER SUBCONTRACT W/JACK E. LEISCH & ASSOC
CONTRACT DOT-FH-11-9575
WORK ORDER NO. 2
TASK F - SIMULATION STUDIES
MCI FILE NO. 82-1207
JEL JOB NO. 140-1 M3



**CENTERLINE CROWN SIMULATION STUDY (CCS) RUNS:
COMPARISON OF SIMULATION PROGRAMS (CSP)**

RUNS: CCS9D-HVOSM & CCS9D-PHASE4A
DATES: 4/27/83 & 5/18/83
PROGRAMS: HVOSM-81 & PHASE4A

DESIGN SPEED : 120.0 KPH
INITIAL SPEED : 104.0 KPH
MU : 0.78

ROAD:

CROWN : 2.0 % (PER SIDE)
LANES : 12.0 FT

VEHICLE PATH AND POSITION:

SEGMENT LENGTHS:
L1 = 29.1 METERS
L2 = 16.2 METERS, RADIUS=345 METERS
L3 = 58.0 METERS
L4 = 16.2 METERS, RADIUS=345 METERS

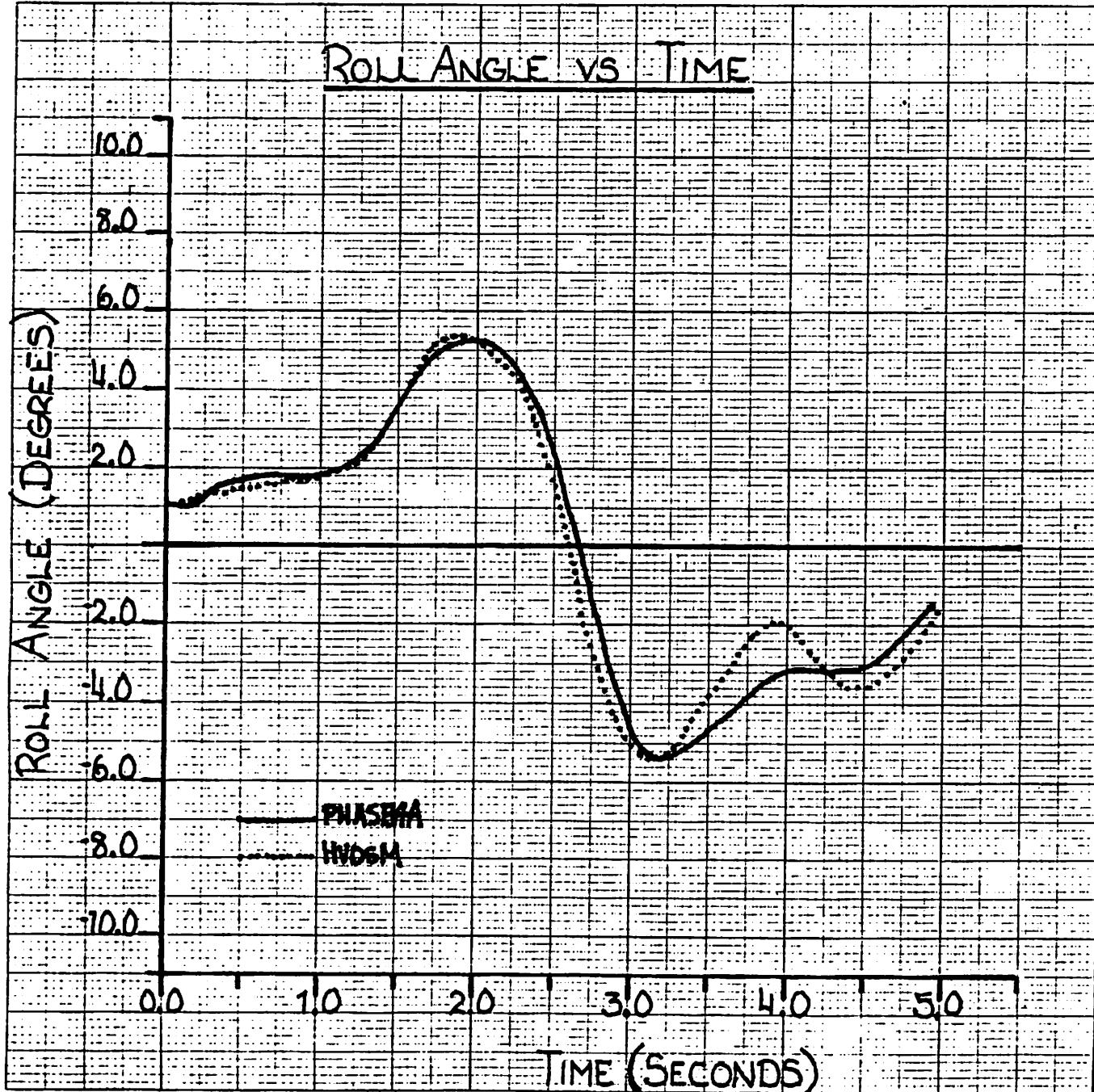
DRIVER MODEL INPUTS:

PROBE : 721 CM
PGAIN : 0.00069 RAD/CM
RGAIN : 0.00028 RAD-SEC/CM

CONSTANT ACCELERATION = 0.50 M/SEC²
VEHICLE TYPE: 1974 WHITE TRUCK ROAD BOSS(4X2)

COMPARISON OF SIMULATION PROGRAMS (CSP)
SUPPLEMENTAL RUN RESULTS COMPARISONS

MCHENRY CONSULTANTS, INC.
UNDER SUBCONTRACT W/JACK E. LEISCH & ASSOC
CONTRACT DOT-FH-11-9575
WORK ORDER NO. 2
TASK F - SIMULATION STUDIES
NCI FILE NO. 82-1207
JEL JOB NO. 140-1 M3



**CENTERLINE CROWN SIMULATION STUDY (CCS) RUNS:
COMPARISON OF SIMULATION PROGRAMS (CSP)**

RUNS: CCS9D-HVOSM & CCS9D-PHASE4A
DATES: 4/27/83 & 5/18/83
PROGRAMS: HVOSM-81 & PHASE4A

DESIGN SPEED : 120.0 KPH
INITIAL SPEED : 104.0 KPH
MU : 0.78

ROAD:

CROWN : 2.0 % (PER SIDE)
LANES : 12.0 FT

VEHICLE PATH AND POSITION:

SEGMENT LENGTHS:

L1 = 29.1 METERS
L2 = 16.2 METERS, RADIUS=345 METERS
L3 = 58.0 METERS
L4 = 16.2 METERS, RADIUS=345 METERS

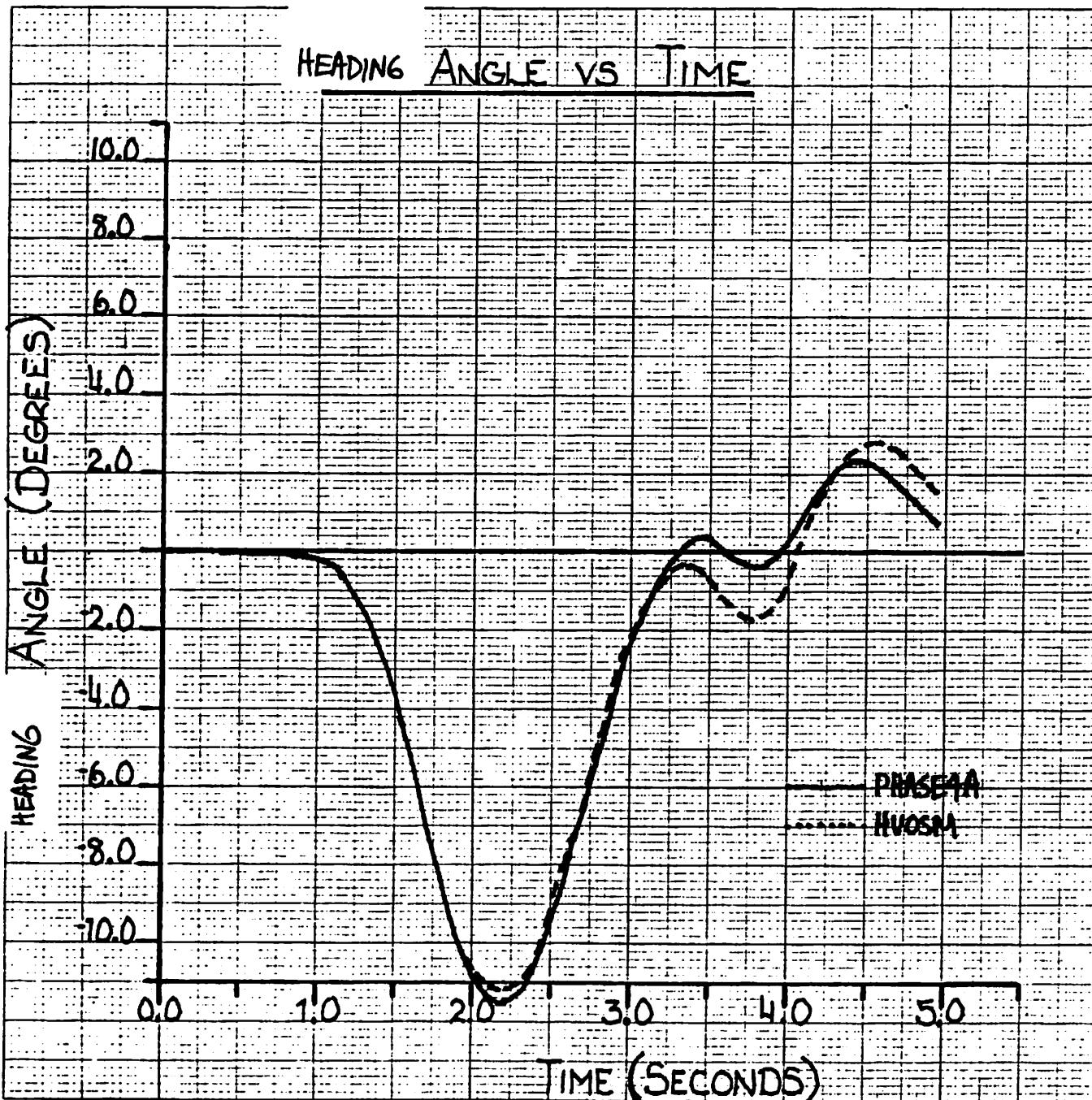
DRIVER MODEL INPUTS:

PROBE : 721 CM
PGAIN : 0.00069 RAD/CM
RGAIN : 0.00028 RAD-SEC/CM

CONSTANT ACCELERATION = 0.50 M/SEC²
VEHICLE TYPE: 1974 WHITE TRUCK ROAD BOSS(4x2)

COMPARISON OF SIMULATION PROGRAMS (CSP)
SUPPLEMENTAL RUN RESULTS COMPARISONS

MCHENRY CONSULTANTS, INC.
UNDER SUBCONTRACT W/JACK E. LEISCH & ASSOC
CONTRACT DOT-FH-11-9575
WORK ORDER NO. 2
TASK F - SIMULATION STUDIES
MCI FILE NO. 82-1207
JEL JOB NO. 140-1 M3


**CENTERLINE CROWN SIMULATION STUDY (CCS) RUNS:
COMPARISON OF SIMULATION PROGRAMS (CSP)**

RUNS: CCS90-HVOSM & CCS90-PHASE4A
DATES: 4/27/83 & 5/18/83
PROGRAMS: HVOSM-81 & PHASE4A

DESIGN SPEED : 120.0 KPH
INITIAL SPEED : 104.0 KPH
MU : 0.78

ROAD:

CROWN : 2.0 % (PER SIDE)
LANES : 12.0 FT
VEHICLE PATH AND POSITION:

SEGMENT LENGTHS:

L1 = 29.1 METERS
L2 = 16.2 METERS, RADIUS=345 METERS
L3 = 58.0 METERS
L4 = 16.2 METERS, RADIUS=345 METERS

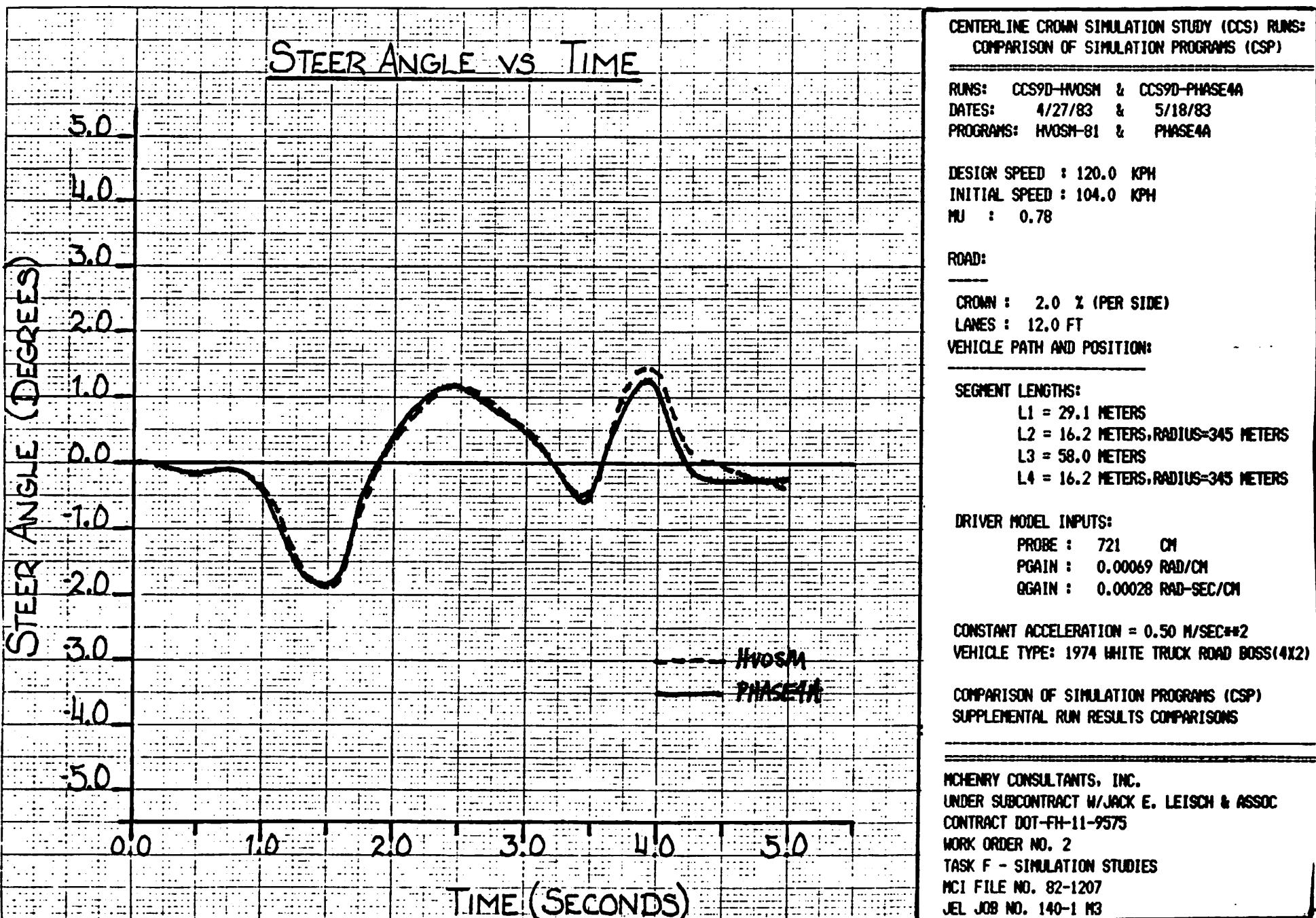
DRIVER MODEL INPUTS:

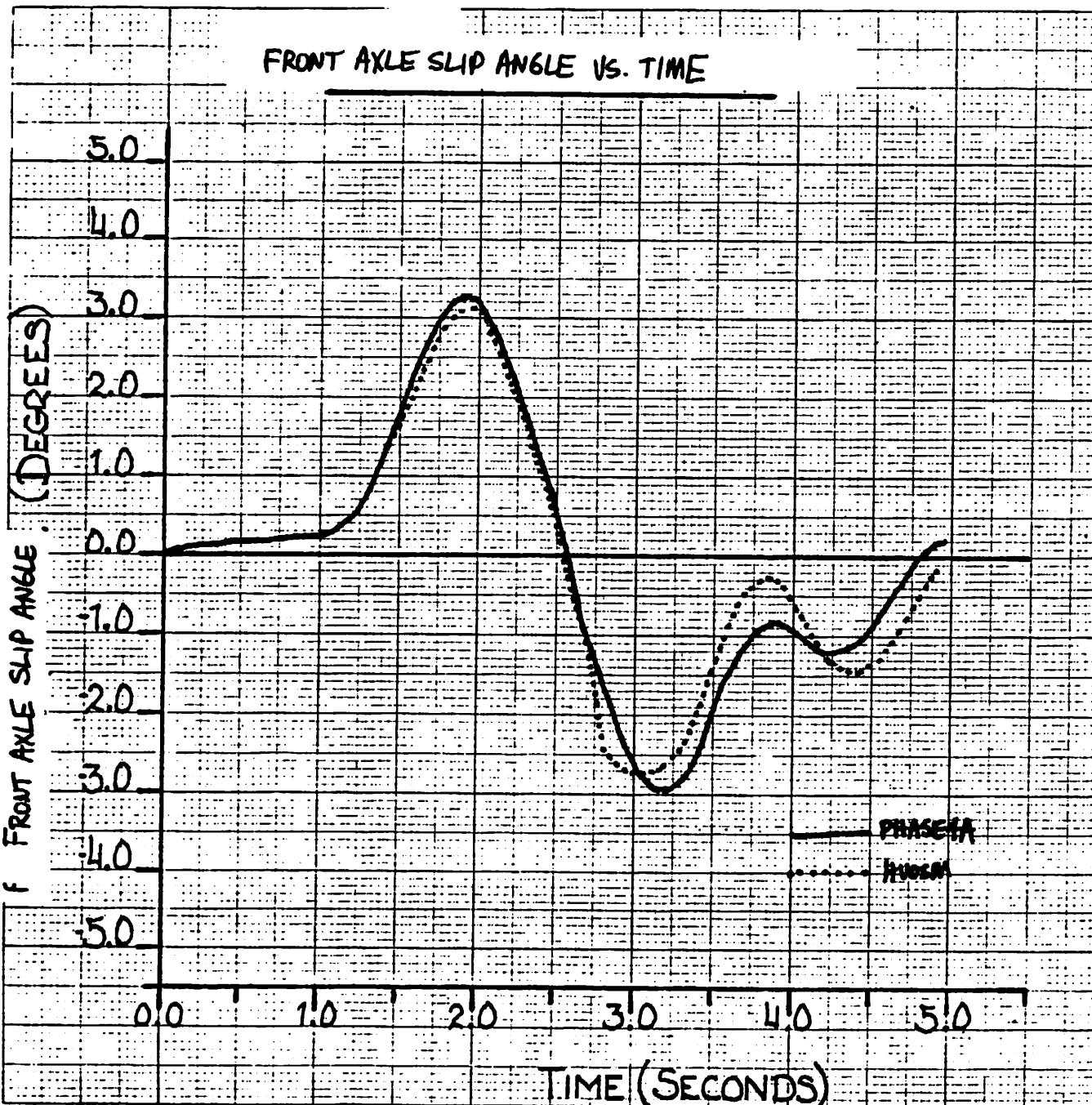
PROBE : 721 CM
PGAIN : 0.00069 RAD/CM
RGAIN : 0.00028 RAD-SEC/CM

CONSTANT ACCELERATION = 0.50 M/SEC²
VEHICLE TYPE: 1974 WHITE TRUCK ROAD BOSS(4x2)

**COMPARISON OF SIMULATION PROGRAMS (CSP)
SUPPLEMENTAL RUN RESULTS COMPARISONS**

MCHENRY CONSULTANTS, INC.
UNDER SUBCONTRACT W/JACK E. LEISCH & ASSOC
CONTRACT DOT-FH-11-9575
WORK ORDER NO. 2
TASK F - SIMULATION STUDIES
NCF FILE NO. 82-1207
JEL JOB NO. 140-1 M3





**CENTERLINE CROWN SIMULATION STUDY (CCS) RUNS:
COMPARISON OF SIMULATION PROGRAMS (CSP)**

RUNS: CCS9D-HVOSM & CCS9D-PHASE4A

DATES: 4/27/83 & 5/18/83

PROGRAMS: HVOSM-81 & PHASE4A

DESIGN SPEED : 120.0 KPH

INITIAL SPEED : 104.0 KPH

MU : 0.78

ROAD:

CROWN : 2.0 % (PER SIDE)

LANES : 12.0 FT

VEHICLE PATH AND POSITION:

SEGMENT LENGTHS:

L1 = 29.1 METERS

L2 = 16.2 METERS, RADIUS=345 METERS

L3 = 58.0 METERS

L4 = 16.2 METERS, RADIUS=345 METERS

DRIVER MODEL INPUTS:

PROBE : 721 CM

PGAIN : 0.00069 RAD/CM

RGAIN : 0.00028 RAD-SEC/CM

CONSTANT ACCELERATION = 0.50 M/SEC²

VEHICLE TYPE: 1974 WHITE TRUCK ROAD BOSS(4X2)

**COMPARISON OF SIMULATION PROGRAMS (CSP)
SUPPLEMENTAL RUN RESULTS COMPARISONS**

MCHENRY CONSULTANTS, INC.

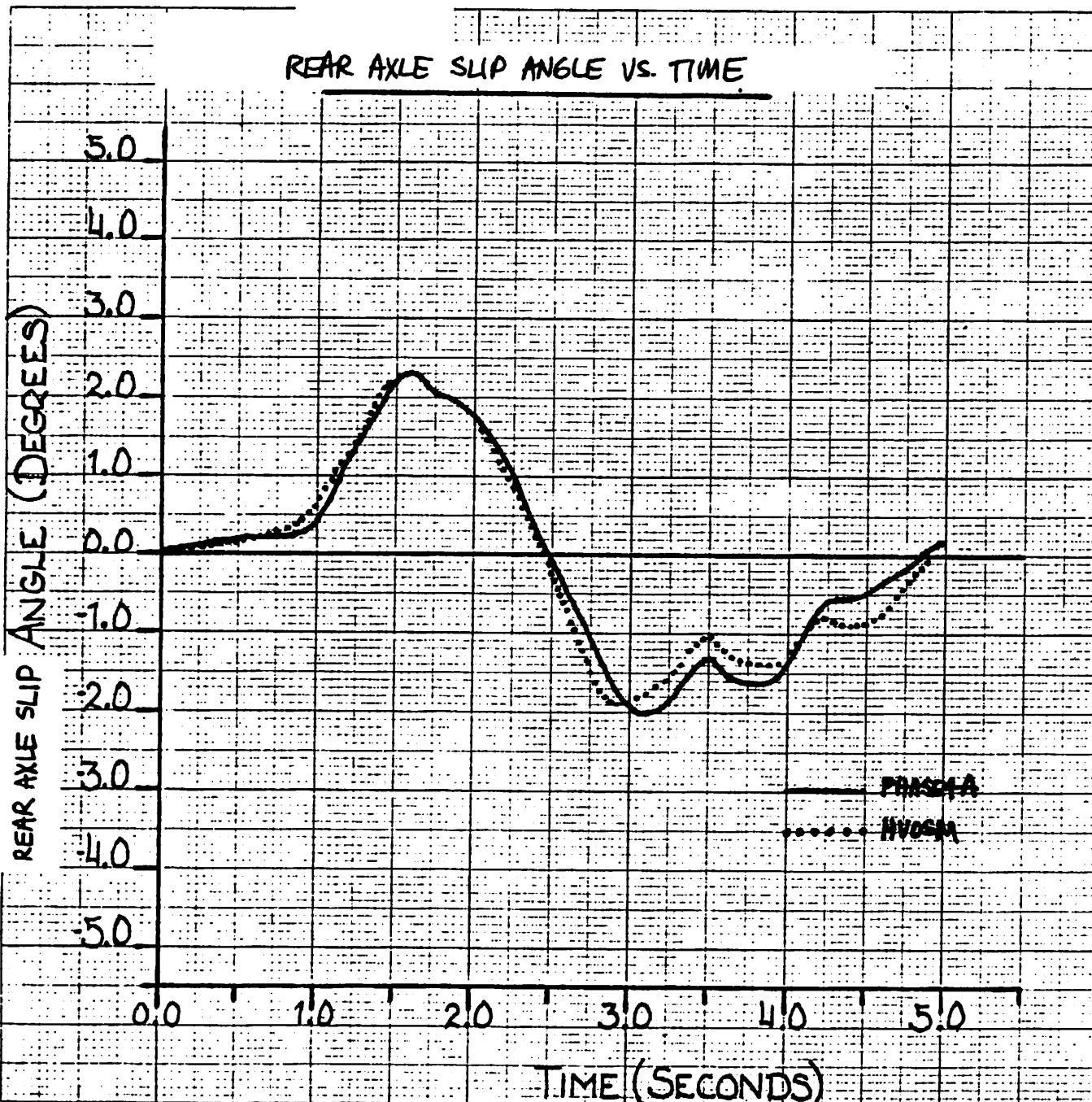
UNDER SUBCONTRACT W/JACK E. LEISCH & ASSOC
CONTRACT DOT-FH-11-9575

WORK ORDER NO. 2

TASK F - SIMULATION STUDIES

MCI FILE NO. 82-1207

JEL JOB NO. 140-1 M3



**CENTERLINE CROWN SIMULATION STUDY (CCS) RUNS:
COMPARISON OF SIMULATION PROGRAMS (CSP)**

RUNS: CCS9D-HVOSM & CCS9D-PHASE4A
DATES: 4/27/83 & 5/18/83
PROGRAMS: HVOSM-81 & PHASE4A

DESIGN SPEED : 120.0 KPH
INITIAL SPEED : 104.0 KPH
MU : 0.78

ROAD:

CROWN : 2.0 % (PER SIDE)
LANES : 12.0 FT
VEHICLE PATH AND POSITION:

SEGMENT LENGTHS:

L1 = 29.1 METERS
L2 = 16.2 METERS, RADIUS=345 METERS
L3 = 58.0 METERS
L4 = 16.2 METERS, RADIUS=345 METERS

DRIVER MODEL INPUTS:

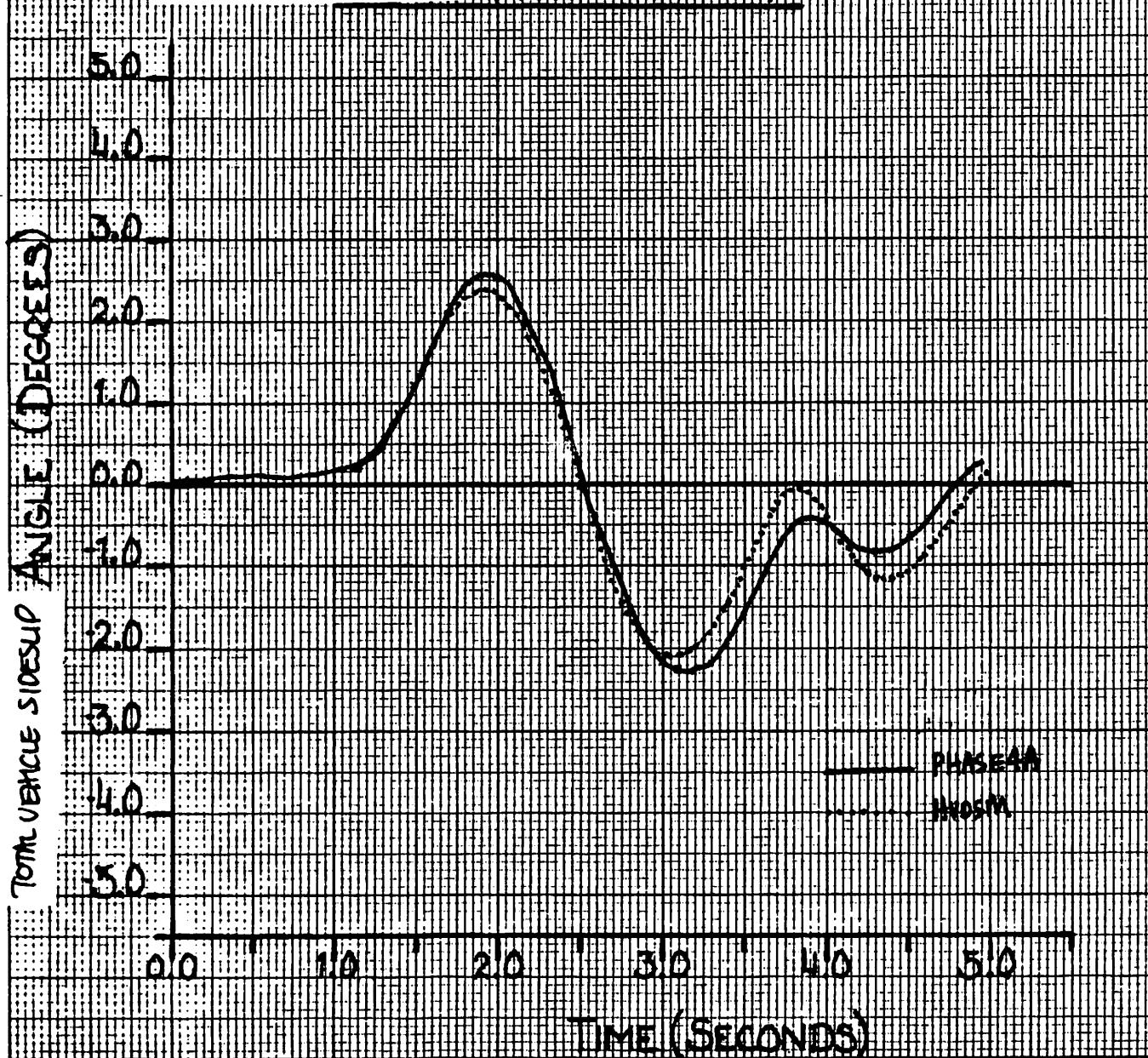
PROBE : 721 CM
PGAIN : 0.00069 RAD/CM
QGAIN : 0.00028 RAD-SEC/CM

CONSTANT ACCELERATION = 0.50 M/SEC²
VEHICLE TYPE: 1974 WHITE TRUCK ROAD BOSS(4X2)

**COMPARISON OF SIMULATION PROGRAMS (CSP)
SUPPLEMENTAL RUN RESULTS COMPARISONS**

MCHENRY CONSULTANTS, INC.
UNDER SUBCONTRACT W/JACK E. LEISCH & ASSOC
CONTRACT DOT-FH-11-9575
WORK ORDER NO. 2
TASK F - SIMULATION STUDIES
MCI FILE NO. 82-1207
JEL JOB NO. 140-1 M3

TOTAL VEHICLE SIDESLIP ANGLE VS TIME



CENTERLINE CROWN SIMULATION STUDY (CCS) RUNS:
COMPARISON OF SIMULATION PROGRAMS (CSP)

RUNS: CCS9D-HVOSM & CCS9D-PHASE4A

DATES: 4/27/83 & 5/18/83

PROGRAMS: HVOSM-81 & PHASE4A

DESIGN SPEED : 120.0 KPH

INITIAL SPEED : 104.0 KPH

MU : 0.78

ROAD:

CROWN : 2.0 % (PER SIDE)

LANES : 12.0 FT

VEHICLE PATH AND POSITION:

SEGMENT LENGTHS:

L1 = 29.1 METERS

L2 = 16.2 METERS, RADIUS=345 METERS

L3 = 58.0 METERS

L4 = 16.2 METERS, RADIUS=345 METERS

DRIVER MODEL INPUTS:

PROBE : 721 CM

PGAIN : 0.00069 RAD/CM

BGAIN : 0.00028 RAD-SEC/CM

CONSTANT ACCELERATION = 0.50 M/SEC²

VEHICLE TYPE: 1974 WHITE TRUCK ROAD BOSS(4x2)

COMPARISON OF SIMULATION PROGRAMS (CSP)
SUPPLEMENTAL RUN RESULTS COMPARISONS

MCHENRY CONSULTANTS, INC.

UNDER SUBCONTRACT W/JACK E. LEISCH & ASSOC

CONTRACT DOT-FH-11-9575

WORK ORDER NO. 2

TASK F - SIMULATION STUDIES

MCI FILE NO. 82-1207

JEL JOB NO. 140-1 M3

7.0 PROGRAM MODIFICATIONS

Several modifications and/or enhancements of the PHASE4 and HVOSM simulation programs were found to be required during the performance of the subject research project. Appendix C contains the source code for the new and revised subroutines. A discussion of the modifications is presented in the following paragraphs.

7.1 HVOSM Modifications

Dual Tires: To permit the comparison simulation runs to be performed, the HVOSM program had to be modified to enable the simulation of dual rear tires such as are found in many single-unit trucks. The modification required to simulate dual rear tires consisted of a modification to subroutine TIRFRC to double the tire forces at the rear when the option is chosen. While a more elaborate definition of dual rear tires could be pursued, the selected approach was most efficient and equivalent to that used in the PHASE4 program.

7.2 New Routines Added to PHASE4 Program

Several new routines were added to the PHASE4 simulation program to permit the use of identical terrain definitions and/or driver model path-following in the PHASE4 and HVOSM simulation programs. The routines added to the PHASE4 program are essentially routines from either the HVOSM-76 (ref. 2) or the HVOSM-81 (routines previously added or modified within this contract).

The routines added to the PHASE4 program are as follows:

7.2.1 New Routines for PHASE4

INPUT2 PURPOSE:

- (1) OBTAINS CARD INPUTS FROM FORTRAN UNIT 7 FOR TERRAIN TABLE AND/OR DRIVER MODEL OPTION(S).
- (2) PRINTS CARD INPUTS.

SUBROUTINE CALLED FROM: INPUT

SUBROUTINES CALLED: BLK04, BLK05, PATH, IDOUT

ORIGIN: MODIFIED VERSION OF SUBROUTINE INPUT FROM HVOSM-76

BLK04 PURPOSE: ASSIGNS INPUT VALUES OF SIMULATION DRIVER MODEL DATA

SUBROUTINE CALLED FROM: INPUT2

SUBROUTINE CALLED: NONE

ORIGIN: MODIFIED VERSION OF SUBROUTINE BLK04 FROM HVOSM-76

BLK05 PURPOSE: ASSIGNS INPUT VALUES OF SIMULATION TERRAIN TABLE DATA

SUBROUTINE CALLED FROM: INPUT2

SUBROUTINE CALLED: TEREAD

ORIGIN: MODIFIED VERSION OF SUBROUTINE BLK05 FROM HVOSM-76

TEREAD PURPOSE: READS TERRAIN TABLE INPUT CARDS

SUBROUTINE CALLED FROM: BLK04

SUBROUTINES CALLED: NONE

ORIGIN: SUBROUTINE TEREAD FROM HVOSM-76

PATH PURPOSE: INITIALIZES THE FIRST POINT AND COMPUTES THE INITIAL
TANGENT FROM A SPECIFIED HEADING ANGLE

SUBROUTINE CALLED FROM: IDOUT

SUBROUTINE(S) CALLED: SETD, PATH6
ORIGIN: SUBROUTINE PATH FROM HVOSM-81

SETD PURPOSE: PRODUCES A SET OF DEGREE OF CURVES FROM A GROSS
 DESCRIPTION OF THE PATH SUCH THAT A SET OF EQUALLY
 SPACED POINTS DESCRIBING THE PATH MAY BE COMPUTED
SUBROUTINE CALLED FROM: PATH
SUBROUTINES CALLED: NONE
ORIGIN: SUBROUTINE SETD FROM HVOSM-81

PATH6 PURPOSE: COMPUTES THE PATH COORDINATES FROM THE DEGREE OF
 CURVES
SUBROUTINE CALLED FROM: PATH
SUBROUTINES CALLED: NONE
ORIGIN: SUBROUTINE PATH6 FROM HVOSM-81

IDOUT PURPOSE: PRINTS TERRAIN TABLE INPUTS WITH UNITS AND HEADINGS
SUBROUTINE CALLED FROM: INPUT2
SUBROUTINES CALLED: PTHOUT, ROADDZ
ORIGIN: MODIFIED VERSION OF SUBROUTINE IDOUT FROM HVOSM-76

PTHOUT PURPOSE: PRINTS DRIVER MODEL INPUTS WITH UNITS AND HEADINGS
SUBROUTINE CALLED FROM: IDOUT
SUBROUTINES CALLED: NONE
ORIGIN: SUBROUTINE PTHOUT FROM HVOSM-81

ROAD PURPOSE: CALCULATES THE ELEVATION AND SLOPES OF THE X,Y
 COORDINATES PASSED TO THE ROUTINE

SUBROUTINES CALLED FROM: IDOUT, FCT1, OUTPUT

SUBROUTINES CALLED: NONE

ENTRY POINTS: ROADDZ, ROAD

ORIGIN: MODIFIED VERSION OF SUBROUTINE INTRPS FROM HVOSM-76

DRIVE1 PURPOSE: COMPUTES THE FRONT WHEEL STEER ANGLE FROM THE DRIVER

MODEL AND PATH DESCRIPTOR INPUTS

SUBROUTINE CALLED FROM: FCT1

SUBROUTINES CALLED: PROBE, CGERR

ENTRY POINTS: DRIVER, DRIVE2

ORIGIN: MODIFIED VERSION OF SUBROUTINE DRIVER FROM HVOSM-81

PROBE PURPOSE: CALCULATES THE ERROR OF AN ARBITRARY POINT ON THE

VEHICLE FROM THE DESIRED PATH

SUBROUTINES CALLED FROM: DRIVE1

SUBROUTINES CALLED: NONE

ORIGIN: SUBROUTINE PROBE FROM HVOSM-81

CGERR PURPOSE: CALCULATES THE ERROR OF THE VEHICLE CENTER OF GRAVITY

FROM THE DESIRED PATH

SUBROUTINES CALLED FROM: DRIVE1

SUBROUTINES CALLED: NONE

ORIGIN: SUBROUTINE CGERR FROM HVOSM-81

7.2.2 Modified Routines for the PHASE4

Two routines for the PHASE4 program had to be modified to enable the use of the new routines with the program. The modified routines are as follows:

INPUT PURPOSE: READS CARD INPUTS AND ECHO'S INPUT PARAMETERS WITH
UNITS AND HEADINGS AND INITIALIZES VARIABLES

MODIFICATIONS:

- (1) PRINT CARD INPUTS PRIOR TO ECHO
- (2) CALL TO INPUT2 TO INPUT AND PROCESS TERRAIN TABLE AND/OR
DRIVER MODEL INPUTS

MAIN PURPOSE: ASSIGN I/O DEVICES, INITIALIZE VARIABLES, AND ACT
AS PROGRAM SUPERVISOR

MODIFICATIONS:

- (1) INPUT AND INITIALIZE INITIAL HEADING ANGLE
- (2) PERMIT THE SETTING OF INITIAL CONDITIONS CAUSED BY ROAD
WHEN TERRAIN TABLE OPTION USED

APPENDIX A

CARD INPUTS AND PARAMETER ECHO
FOR CSP2-HVOSM

82-1207, COMPARISON OF SIMULATION PROGRAMS TEST RUN: MCICSP2
 0.000 3.48 0.0050 0.025 70. 0.0 0.0 0.0
 2.0 0.0 0.0 0.0100 0.0 0.0100
 1
 1974 WHITE TRUCK ROAD BOSS (4X2) 1 1 1 1 1 1
 65.5 4.513 5.368 40509. 221814. 225312. 0.0 4458. 3748.
 104.42 51.576 79.9 71.25 0.0 38.25 0.0 32.50
 .0 0.0 0.0 0.0 0.0 0.0 31.87 31.83
 300. 1560. 0.0 7020. 0.0 1.0 -4.0 4.0
 5000. 5000. 0.0 0.0 0.0 1.0 -4.0 4.0
 0.0 900. 0.10 2200. 0.10
 0.0 0.0 0.14
 UNIROYAL FLEETMASTER TRIPLE-TREAD 10X20F
 1.0 1.0 1.0 1.0 6.0 0.50 1.0
 7000. 4.0 3.0 4400. 9.26 15000. 0.0 1.0 1.00
 0.61 0.0 0.0 0.0 20.5 0.0 0.0 0.0 0.0
 410 M PATH RERUN OF MCS#8 W/TRUCK
 1.0 1.0 1.0 0.05 0.00905 0.000 0.0
 4.0 50. 0.0 0.0 1.5708 120. 0
 0.0 0.0 0.0 1920. -3525 2040. -3525 12000.
 0.0 0.1 792. 0.0 0.5 400. 0.00130 0.000130
 FLAT TERRAIN
 100 KPH
 0.0 0.0 90. 0.0 0.0 0.0
 0.0 0.0 -51.65 1056. 0.0 0.0
 0.0 0.0 0.0 0.0 0.0 0.0 0.0

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82-1207, COMPARISON OF SIMULATION PROGRAMS TEST RUN: MCICSP2 03/02/83
1974 WHITE TRUCK ROAD BOSS (4X2) UNIRROYAL FLEETMASTER TRIPLE-TREAD 10X20F410 M PATH, RERUN OF HCS#8 M/TRUCK
FLAT TERRAIN 100 KPH

```

P R O G R A M   C O N T R O L   D A T A
START TIME      TO    =    0.0     SEC
END TIME       T1    =  3.4800   SEC
INTEGRATION INCREMENT DTCOMP =  0.0050   SEC
INTEGRATION MODE      MODE = 1      -1= VARIABLE STEP ADAMS-MOULTON
                                         -2= RUNGA-KUTTA
                                         -3= FIXED STEP ADAMS-MOULTON
PRINT INTERVAL DTPRNT = 0.0250 SEC
SUSPENSION OPTION ISUS = 2      -1= INDEPENDENT FRONT SUSPENSION, SOLID REAR AXLE
                                         -2= INDEPENDENT FRONT AND REAR SUSPENSION
                                         -3= SOLID FRONT AND REAR AXLES
                                         -4= NO CURB, NO STEER DEGREE OF FREEDOM
CURB/STEER OPTION INDCRB = 0      -1= CURB
                                         -2= STEER DEGREE OF FREEDOM, NO CURB
CURB INTEGRATION INCR. DELTC = 0.01000 SEC
                                         -1= NO BARRIER
                                         -2= RIGID BARRIER, FINITE VERT. DIM.
                                         -3= DEFORM. "", INFINITE " "
                                         -4= DEFORM. "", FINITE " "
BARRIER OPTION INDB = 0      -1= NO BARRIER
                                         -2= RIGID BARRIER, FINITE VERT. DIM.
                                         -3= DEFORM. "", INFINITE " "
                                         -4= DEFORM. "", FINITE " "
BARRIER INTEGRATION INCR. DELTB = 0.01000 SEC

```

INITIAL CONDITIONS

SPRUNG MASS C.G. POSITION	XCOP	0.0	INCHES	SPRUNG MASS LINEAR VELOCITY	UD	1056.00	IN/SEC
	YCOP	0.0	INCHES		VO	0.0	IN/SEC
	ZCOP	-51.65	INCHES		HO	0.0	IN/SEC
SPRUNG MASS ORIENTATION	PHIO	0.0	DEGREES	SPRUNG MASS ANGULAR VELOCITY	PO	0.0	DEG/SEC
	THETAO	0.0	DEGREES		QO	0.0	DEG/SEC
	PSIO	90.00	DEGREES		RO	0.0	DEG/SEC
UNSPRUNGED MASS POSITIONS	DEL10	0.0	INCHES	UNSPRUNGED MASS VELOCITIES	DEL10D	0.0	IN/SEC
	PHIFO	0.0	DEGREES		PHIFOD	0.0	DEG/SEC
	DEL30	0.0	INCHES		DEL30D	0.0	IN/SEC
	PHIRO	0.0	DEGREES		PHIROD	0.0	DEG/SEC
STEER ANGLE	PSIFIO	0.0	DEGREES	STEER VELOCITY	PSIFDO	0.0	DEG/SEC

82-1207, COMPARISON OF SIMULATION PROGRAMS TEST RUN: MCICSP2
 1974 WHITE TRUCK ROAD BOSS (4X2) UNIROYAL FLEETMASTER TRIPLE-TREAD 10X20F410 M PATH, RERUN OF MCS#8 W/TRUCK 03/02/83
 FLAT TERRAIN 100 KPH

SPRUNG MASS	XMS	=	65.500 LB-SEC**2/IN	FRONT WHEEL X LOCATION	A	=	104.420 INCHES	
FRONT UNSPRUNG MASS	XMF	=	4.513 LB-SEC**2/IN	REAR WHEEL X LOCATION	B	=	51.576 INCHES	69
REAR UNSPRUNG MASS	XMR	=	5.368 LB-SEC**2/IN	FRONT WHEEL Z LOCATION	ZF	=	31.870 INCHES	
X MOMENT OF INERTIA	XIX	=	40509.000 LB-SEC**2-IN	REAR WHEEL Z LOCATION	ZR	=	31.830 INCHES	
Y MOMENT OF INERTIA	XYI	=	221814.000 LB-SEC**2-IN	FRONT WHEEL TRACK	TF	=	79.900 INCHES	
Z MOMENT OF INERTIA	XIZ	=	225312.000 LB-SEC**2-IN	REAR WHEEL TRACK	TR	=	71.250 INCHES	
XZ PRODUCT OF INERTIA	XIXZ	=	0.0 LB-SEC**2-IN	FRONT ROLL AXIS	RHOF	=	0.0 INCHES	
FRONT AXLE MOMENT OF INERTIA	XIF	=	3748.000 LB-SEC**2-IN	REAR ROLL AXIS	RHO	=	0.0 INCHES	
REAR AXLE MOMENT OF INERTIA	XIR	=	4458.000 LB-SEC**2-IN	FRONT SPRING TRACK	TSF	=	32.500 INCHES	
GRAVITY	G	=	386.400 IN/SEC**2	REAR SPRING TRACK	TS	=	38.250 INCHES	
ACCELEROMETER 1 POSITION	X1	=	0.0 INCHES	FRONT AUX ROLL STIFFNESS	RF	=	0.0 LB-IN/RAD	
	Y1	=	0.0 INCHES	REAR AUX ROLL STIFFNESS	RR	=	0.0 LB-IN/RAD	
	Z1	=	0.0 INCHES	REAR ROLL-STEER COEF.	AKRS	=	0.1400 RAD/RAD	
ACCELEROMETER 2 POSITION	X2	=	0.0 INCHES		AKDS	=	0.0 NOT USED	
	Y2	=	0.0 INCHES		AKDS1	=	0.0 NOT USED	
	Z2	=	0.0 INCHES		AKDS2	=	0.0 NOT USED	
					AKDS3	=	0.0 NOT USED	

S T E R E I N G S Y S T E M								
MOMENT OF INERTIA	XIPS	=	0.0 LB-SEC**2-IN					
COULOMB FRICTION TORQUE	CPSP	=	0.0 LB-IN					
FRICTION LAG	EPSP	=	0.0 RAD/SEC					
ANGULAR STOP RATE	AKPS	=	0.0 LB-IN/RAD					
ANGULAR STOP POSITION	OMGPS	=	0.0 RADIANS					
PNEUMATIC TRAIL	XPS	=	0.0 INCHES					

	FRONT SUSPENSION		REAR SUSPENSION
SUSPENSION RATE	AKF	=	1300.000 LB/IN
COMPRESSION STOP COEFS.	AKFC	=	1560.000 LB/IN
EXTENSION STOP COEFS.	AKFCP	=	0.0 LB/IN**3
COMPRESSION STOP LOCATION	AKFE	=	7020.000 LB/IN
EXTENSION STOP LOCATION	AKFEP	=	0.0 LB/IN**3
STOP ENERGY DISSIPATION FACTOR	OMEGFC	=	-4.000 INCHES
VISCOSUS DAMPING COEF.	OMEGFE	=	4.000 INCHES
COULOMB FRICTION	XLAMF	=	1.000
FRICTION LAG	CF	=	0.0 LB-SEC/IN
	CFP	=	900.000 LB
	EPSF	=	0.100 IN/SEC
			AKR = 5000.000 LB/IN
			AKRC = 5000.000 LB/IN
			AKRCP = 0.0 LB/IN**3
			AKRE = 0.0 LB/IN
			AKREP = 0.0 LB/IN**3
			OMEGRC = -4.000 INCHES
			OMEGRE = 4.000 INCHES
			XLAMR = 1.000
			CR = 0.0 LB-SEC/IN
			CRP = 2200.000 LB
			EPSR = 0.100 IN/SEC

82-1207, COMPARISON OF SIMULATION PROGRAMS TEST RUN: MCICSP2
 1974 WHITE TRUCK ROAD BOSS (4X2) UNIROYAL FLEETMASTER TRIPLE-TREAD 10X20F410 M PATH, RERUN OF MCS#8 W/TRUCK 03/02/83
 FLAT TERRAIN 100 KPH

	RF	TIRE DATA	RR	LR
TIRE LINEAR SPRING RATE	AKT	=	7000.000	7000.000
DEFL. FOR INCREASED RATE	SIGT	=	4.000	4.000
SPRING RATE INCREASING FACTOR	XLAMT	=	3.000	3.000
	A0	=	4400.000	4400.000
	A1	=	9.260	9.260
SIDE FORCE COEFFICIENTS	A2	=	15000.000	15000.000
	A3	=	0.0	0.0
	A4	=	1.000	1.000
TIRE OVERLOAD FACTOR	OMEGT	=	1.000	1.000
TIRE UNDEFLECTED RADIUS	RH	=	20.500	20.500
TIRE / GROUND FRICTION COEF.	AMU	=	0.610	0.610
DUAL REAR TIRES OPTION USED, IDUAL = 1				INCHES

NO ANTI-PITCH TABLES

82-1207, COMPARISON OF SIMULATION PROGRAMS TEST RUN: MCICSP2 03/02/83
 1974 WHITE TRUCK ROAD BOSS (4X2) UNIROYAL FLEETMASTER TRIPLE-TREAD 10X20F410 M PATH, RERUN OF HCS#8 M/TRUCK
 FLAT TERRAIN 100 KPH

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PATH DESCRIPTORS
 NUMBER OF PATH DESCRIPTORS IPATH = 1
 NUMBER OF POINTS ON PATH KLI = 4
 DISTANCE BETWEEN POINTS NPTS = 50
 COORDINATES OF 1ST PATH POINTS: DELL = 120.000 INCHES
 XINIT = 0.0 INCHES
 YINIT = 0.0 INCHES
 INITIAL ROADWAY HEADING PSA = 90.00 DEGREES

PATH CURVATURE DESCRIPTORS:

DEGREE OF CURVATURE DI(1) = 0.0 DEGREES
 DISTANCE ALONG PATH RLI(1) = 0.0 INCHES

DEGREE OF CURVATURE DI(2) = 0.0 DEGREES
 DISTANCE ALONG PATH RLI(2) = 1920.00 INCHES

DEGREE OF CURVATURE DI(3) = -4.2300 DEGREES
 DISTANCE ALONG PATH RLI(3) = 2040.00 INCHES

DEGREE OF CURVATURE DI(4) = -4.2300 DEGREES
 DISTANCE ALONG PATH RLI(4) = 12000.00 INCHES

MAGON TONGUE STEER DESCRIPTORS
 INITIAL PROBE SAMPLE TIME IIMAGN = 1
 TIME INCREMENT BETWEEN SAMPLES TPRB = 0.0 SECONDS
 LENGTH OF PROBE DPRB = 0.100 SECONDS
 PLGTH = 792.00 INCHES
 MINIMUM ACCEPTABLE ERROR PMIN = 0.0 INCHES
 MAXIMUM OCCUPANT ACCELERATION PMAX = 0.500 G-UNITS
 STEER CORRECTION FACTOR PGAIN = .0013000 RAD/IN
 STEER CORRECTION DAMPING FACTOR QGAIN = .0001300 RAD-SEC/IN
 MAXIMUM STEERING WHEEL RATE PSIFD = 400.000 DEG/SEC

FILTER DESCRIPTORS
 TIME LAG OF FILTER IFILT = 1
 TIME LEAD OF FILTER TIL = 0.050000 SECONDS
 TIME DELAY OF FILTER TI = 0.009050 SECONDS
 TAUF = 0.0 SECONDS

82-1207, COMPARISON OF SIMULATION PROGRAMS TEST RUN: MCICSP2 03/02/83
 1974 WHITE TRUCK ROAD BOSS (4X2) UNIROYAL FLEETMASTER TRIPLE-TREAD 10X20F410 M PATH, RERUN OF HCS#8 M/TRUCK
 FLAT TERRAIN 100 KPH

N	PATH COORDINATES		TANGENT VECTORS		DEGREE OF CURVATURE D(N) (DEG)
	X(N) (FT)	Y(N) (FT)	DX(N) (DEG)	DY(N) (DEG)	
1	0.0	0.0	90.000	90.000	0.0
2	-0.000	10.000	90.000	90.000	0.0
3	-0.000	20.000	90.000	90.000	0.0
4	-0.000	30.000	90.000	90.000	0.0
5	-0.000	40.000	90.000	90.000	0.0
6	-0.000	50.000	90.000	90.000	0.0
7	-0.000	60.000	90.000	90.000	0.0
8	-0.000	70.000	90.000	90.000	0.0
9	-0.000	80.000	90.000	90.000	0.0
10	-0.000	90.000	90.000	90.000	0.0
11	-0.000	100.000	90.000	90.000	0.0
12	-0.000	110.000	90.000	90.000	0.0
13	-0.000	120.000	90.000	90.000	0.0
14	-0.000	130.000	90.000	90.000	0.0
15	-0.000	140.000	90.000	90.000	0.0
16	-0.001	150.000	90.000	90.000	0.0
17	-0.001	160.000	90.000	90.000	0.0
18	-0.001	170.000	90.000	90.000	-4.230
19	0.036	180.000	89.577	89.577	-4.230
20	0.147	189.399	89.154	89.154	-4.230
21	0.332	199.398	88.731	88.731	-4.230
22	0.590	209.994	88.308	88.308	-4.230
23	0.922	219.989	87.885	87.885	-4.230
24	1.328	229.980	87.462	87.462	-4.230
25	1.808	239.969	87.039	87.039	-4.230
26	2.361	249.953	86.616	86.616	-4.230
27	2.988	259.934	86.193	86.193	-4.230
28	3.689	269.309	85.770	85.770	-4.230
29	4.463	279.879	85.347	85.347	-4.230
30	5.311	289.843	84.924	84.924	-4.230
31	6.233	299.800	84.501	84.501	-4.230
32	7.228	309.750	84.078	84.078	-4.230
33	8.296	319.693	83.655	83.655	-4.230
34	9.438	329.627	83.232	83.232	-4.230
35	10.653	339.553	82.809	82.809	-4.230
36	11.941	349.469	82.386	82.386	-4.230
37	13.303	359.376	81.963	81.963	-4.230
38	14.737	369.272	81.540	81.540	-4.230
39	16.245	379.157	81.117	81.117	-4.230
40	17.825	389.031	80.694	80.694	-4.230
41	19.479	398.894	80.271	80.271	-4.230
42	21.205	408.743	79.848	79.848	-4.230
43	23.004	418.580	79.425	79.425	-4.230
44	24.875	428.403	79.002	79.002	-4.230
45	26.819	438.211	78.579	78.579	-4.230
46	28.835	448.006	78.156	78.156	-4.230
47	30.924	457.785	77.733	77.733	-4.230
48	33.085	467.548	77.310	77.310	-4.230
49	35.317	477.295	76.887	76.887	-4.230
50	37.622	487.026	76.464	76.464	-4.230

APPENDIX B

CARD INPUTS AND PARAMETER ECHO

FOR CSP2-PHASE4

ECHO OF CARD INPUTS AS FOLLOWS:

1974 WHITE TRUCK 4X2 ROAD BOSS 82-1207,
VEH
VEL 60 MPH
STEER TIME HISTORY FROM HVOSH RUN

0.0 0.0
1.0 0.0
1.225 -0.01
1.30 -0.09
1.4 -0.21
1.5 -0.35
1.6 -0.50
1.75 -0.75
1.82 -0.87
1.87 -0.89
1.90 -0.90
1.92 -0.92
1.93 -0.93
1.95 -0.95
1.955 -0.955
1.94 -0.94
0.000
0.48
0.025
0.0
1110110
156.0
10096.
19031.0
51.65
40909.0
221814.
225312.
0.0
-1.0
05
-28600.
-5200.
0.0
5200.
83200.
0.01
900.
3748.
19.78
0.00
0.0
32.5
79.9
1743.8
0.0
0.0
03
2715.0 5430.0 7000.

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TIMF
TINC
IROAD
OUTPUT KEYS
MHBS(1)
SN(1,1)
SN(1,2)
DETA(1)
VJ(1,1)
VJ(1,2)
VJ(1,3)
PN(1)
F.SUSPENSION SPRING TABLE NO.

-10.
-4.
0.0
2.0
10.
SUSP. VISCOS DAMPING
SUSP. COULOMB DAMPING
FRONT AXLE I
FRONT AXLE ROLL CENTER HGT
FRONT ROLL STEER COEFF.,SET=0.0,
F. AUX ROLL STIFFNESS
DISTANCE BETWEEN F. SPRINGS
FRONT TRACK
FRUNSPRUNG WEIGHT
STEERING GEAR RATION,SET=0,NOT USED
TRUCK FRONT TIRES & WHEELS TABLE
3 VERTICAL LOADS
LOAD VALUES

01
80.66
06
0.0
1.0
2.0
4.0
8.0
12.0
06
0.0
1.0
2.0
4.0
8.0
12.0
06
0.0
1.0
2.0
4.0
8.0
12.0
02
0.0
0.1
0.2
0.0
20.0
1.0
1.0
0.35
0.35
1. VELOCITY VALUE
VEL VALUE
LOAD#1, VEL#1 TABLE, ALPHA'S
ALPHA VS. MU

LOAD#2, VEL#1

LOAD#3, VEL#1

ROLL OFF TABLE

01
2500.
01
0.0
0.0
LOADS
VELOCITIES
SLIP VALUES

ROLL-OFF TABLE

0.0
0.0
7000.0
19.78
244.60
00
12.0
08
110000.
-20000.
0.0
1.0
1.0
CAMBER STIFFNESS
ALIGNING MOMENT
F. TIRE SPRING RATE
F. TIRE LOADED RADIUS
POLAR MOMENT OF INERTIA
KEY(1,2) *** TRACTOR REAR ***
R. SUSP. SPRING RATE TABLE

-10.
-4.0
0.0

20000.0
 50000.
 0.01
 2200.0
 4458.0
 19.82
 -14
 0.0
 38.25
 38.25
 2074.0
 13.2
 -3.0
 -4.
 0.0
 0.0
 7000.0
 19.82
 344.6
 00
 00
 R. SUSP. VISCOSUS DAMPING
 R. SUSP. COULOMB DAMPING
 R. AXLE MOMENT OF INERTIA
 R. AXLE ROLL CENTER HEIGHT
 R. AXLE ROLL STEER COEFF
 R. AXLE AUX. ROLL STIFFNESS
 R. AXLE DIST. BETWEEN SPRINGS
 R. TRACK WIDTH
 R. UNSPRUNG WEIGHT
 TRUCK REAR TIRE DUAL SEPARATION DIST.
 TIRE DATA TABLE INDICATOR
 LONG. STIFFNESS TABLE INDICATOR
 CAM
 CAT
 R. TIRE SPRING RATE
 SRAD R. TIRE LOADED RADIUS
 NHEEL
 NO ANTILOCK
 END RUN

*** END OF CARD INPUTS ***

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HSRI/NVMA BRAKING AND HANDLING SIMULATION OF TRUCKS, TRACTOR-SEMITAILERS, DOUBLES, AND TRIPLES - PHASE 4.
1974 WHITE TRUCK 4X2 ROAD BOSS, 82-1207,

INPUT PAGE NO. 1

SIMULATION OPERATION PARAMETERS:

VEHICLE CONFIGURATION (NUMBER OF TRAILERS - ENTER 0 FOR A STRAIGHT TRUCK)

INITIAL VELOCITY (FT/SEC)

STEER TABLE (NUMBER OF LINES): POSITIVE - STEER ANGLE TABLE

Negative - Path Follower Table

0 88.00

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TABLE ENTRIES:

TIME (SEC)	LEFT WHEEL (DEG)	RIGHT WHEEL (DEG)
0.0	0.0	0.0
1.00	0.0	0.0
1.23	0.0	0.0
1.30	-0.01	-0.01
1.40	-0.09	-0.09
1.50	-0.21	-0.21
1.60	-0.35	-0.35
1.80	-0.60	-0.60
2.00	-0.75	-0.75
2.20	-0.82	-0.82
2.50	-0.87	-0.87
2.60	-0.89	-0.89
2.70	-0.90	-0.90
2.80	-0.92	-0.92
2.80	-0.93	-0.93
3.00	-0.95	-0.95
3.10	-0.95	-0.95
3.20	-0.95	-0.95
3.30	-0.95	-0.95
3.40	-0.94	-0.94
3.50	-0.94	-0.94

TREADLE PRESSURE TABLE (NUMBER OF LINES)

* ZERO ENTRY INDICATES NO FURTHER TABLE DATA IS NECESSARY - THE FOLLOWING TABLE IS ASSIGNED INTERNALLY *

TABLE ENTRIES:

TIME (SEC)	PRESSURE (PSI)
0.0	0.0

MAXIMUM SIMULATION TIME (SEC)
TIME INCREMENT OF OUTPUT (SEC)

3.48
0.02

ROAD KEY = 0 : FLAT ROAD.

OUTPUT PAGE OPTION KEYS: 0 DELETES PAGES

SPRUNG MASS POSITION	SPRUNG MASS VELOCITY	SPRUNG MASS ACCELERATION	TIRE FORCES PAGES	BRAKE SUMMARY PAGES	LATERAL PAGES	UNSPRUNGED MASS PAGES	TEMP PAGES
1	1	1	1	0	1	1	0

TRUCK PARAMETERS

WHEELBASE - DISTANCE FROM FRONT AXLE TO CENTER OF REAR SUSPENSION (IN)	156.00	74
BASE VEHICLE CURB WEIGHT ON FRONT SUSPENSION (LB)	10096.00	
BASE VEHICLE CURB WEIGHT ON REAR SUSPENSION (LB)	19031.00	
SPRUNG MASS CG HEIGHT (IN ABOVE GROUND)	21.65	
SPRUNG MASS ROLL MOMENT OF INERTIA (IN-LB-SEC**2)	40509.00	
SPRUNG MASS PITCH MOMENT OF INERTIA (IN-LB-SEC**2)	221814.00	
SPRUNG MASS YAW MOMENT OF INERTIA (IN-LB-SEC**2)	225312.00	
PAYOUT WEIGHT (LB)	0.0	

*** ZERO ENTRY INDICATES NO PAYLOAD ***

*** FIVE PAYLOAD DESCRIPTION PARAMETERS ARE NOT ENTERED ***

TRUCK FRONT SUSPENSION AND AXLE PARAMETERS

	LEFT SIDE	RIGHT SIDE
SUSPENSION SPRING RATE (LB/IN/SIDE/AXLE)	-1.00	-1.00
*** NEGATIVE ENTRY INDICATES TABLE ENTERED ***		
*** ECHO WILL APPEAR ON TABLE INDEX PAGE ***		
SUSPENSION VISCOUS DAMPING (LB-SEC/IN/SIDE/AXLE)	0.01	0.01
COULOMB FRICTION (LB/SIDE/AXLE)	900.00	900.00
AXLE ROLL MOMENT OF INERTIA (IN-LB-SEC**2)	3748.00	
ROLL CENTER HEIGHT (IN, ABOVE GROUND)	19.78	
ROLL STEER COEFFICIENT (DEG. STEER/DEG. ROLL)	0.0	
AUXILIARY ROLL STIFFNESS (IN-LB/DEG/AXLE)	0.0	
LATERAL DISTANCE BETWEEN SUSPENSION SPRINGS (IN)	32.50	
TRACK WIDTH (IN)	75.90	
UNSPRUNG WEIGHT (LB)	1743.80	
STEERING GEAR RATIO (DEG STEERING WHEEL/DEG ROAD WHEEL)	0.0	
*** NEGATIVE OR ZERO ENTRY INDICATES NO STEERING SYSTEM ***		
*** STEERING SYSTEM PARAMETERS NOT TO BE ENTERED ***		

TRUCK FRONT TIRES AND WHEELS

	LEFT SIDE	RIGHT SIDE
CORNERING STIFFNESS (LB/DEG/TIRE)	-3.00	-3.00
*** NEGATIVE ENTRY INDICATES TABLE ENTERED ***		
*** ECHO WILL APPEAR ON TABLE INDEX PAGE ***		
LONGITUDINAL STIFFNESS (LB/SLIP/TIRE)	-4.00	-4.00
*** NEGATIVE ENTRY INDICATES TABLE ENTERED ***		
*** ECHO WILL APPEAR ON TABLE INDEX PAGE ***		
CAMBER STIFFNESS (LB/DEG/TIRE)	0.0	0.0
ALIGNING MOMENT (IN-LB/DEG/TIRE)	0.0	0.0
TIRE SPRING RATE (LB/IN/TIRE)	7000.00	7000.00
TIRE LOADED RADIUS (IN)	19.78	19.78
POLAR MOMENT OF INERTIA (IN-LB-SEC**2/WHEEL)	244.60	244.60

TRUCK REAR SUSPENSION AND AXLE PARAMETERS

	LEFT SIDE	RIGHT SIDE
SUSPENSION KEY - 0 INDICATES SINGLE AXLE, 1 INDICATES FOUR SPRING, 2 WALKING BEAM	0	
SUSPENSION SPRING RATE (LB/IN/SIDE/AXLE)	-2.00	-2.00
*** NEGATIVE ENTRY INDICATES TABLE ENTERED ***		
*** ECHO WILL APPEAR ON TABLE INDEX PAGE ***		
SUSPENSION VISCOUS DAMPING (LB-SEC/IN/SIDE/AXLE)	0.01	0.01
COULOMB FRICTION (LB/SIDE/AXLE)	2200.00	2200.00
AXLE ROLL MOMENT OF INERTIA (IN-LB-SEC**2)	4458.00	
ROLL CENTER HEIGHT (IN, ABOVE GROUND)	19.82	
ROLL STEER COEFFICIENT (DEG. STEER/DEG. ROLL)	-0.14	
AUXILIARY ROLL STIFFNESS (IN-LB/DEG/AXLE)	0.0	
LATERAL DISTANCE BETWEEN SUSPENSION SPRINGS (IN)	38.25	
TRACK WIDTH (IN)	71.25	
UNSPRUNG WEIGHT (LB)	2074.00	

TRUCK REAR TIRES AND WHEELS

	LEFT SIDE	RIGHT SIDE
DUAL TIRE SEPARATION (IN)	13.20	13.20
CORNERING STIFFNESS (LB/DEG/TIRE)	-3.00	-3.00
*** NEGATIVE ENTRY INDICATES TABLE ENTERED ***		
*** ECHO WILL APPEAR ON TABLE INDEX PAGE ***		
LONGITUDINAL STIFFNESS (LB/SLIP/TIRE)	-4.00	-4.00
*** NEGATIVE ENTRY INDICATES TABLE ENTERED ***		
*** ECHO WILL APPEAR ON TABLE INDEX PAGE ***		
CAMBER STIFFNESS (LB/DEG/TIRE)	0.0	0.0
ALIGNING MOMENT (IN-LB/DEG/TIRE)	0.0	0.0
TIRE SPRING RATE (LB/IN/TIRE)	7000.00	7000.00
TIRE LOADED RADIUS (IN)	19.82	19.82
POLAR MOMENT OF INERTIA (IN-LB-SEC**2/WHEEL)	244.60	244.60

*** ZERO LINES IN TREADLE PRESSURE TABLE INDICATES NO BRAKING ***
** THREE BRAKE PARAMETERS PER AXLE ARE DELETED AT THIS POINT ***

ANTILOCK KEY: 1 INDICATES ANTILOCK WILL BE USED

0

TRUCK	PAYOUT =	0.0 LBS	EMPTY	LOADED
DISTANCE FROM TRUCK	SPRUNG MASS CENTER TO REAR SUSPENSION (IN)		51.481	51.481
DISTANCE FROM TRUCK	SPRUNG MASS CENTER TO GROUND (IN)		51.650	51.650
ROLL MOMENT OF INERTIA OF TRUCK	SPRUNG MASS (IN-LB-SEC**2)		40509.000	40509.000
PITCH MOMENT OF INERTIA OF TRUCK	SPRUNG MASS (IN-LB-SEC**2)		221814.000	221814.000
YAH MOMENT OF INERTIA OF TRUCK	SPRUNG MASS (IN-LB-SEC**2)		225312.000	225312.000

75

THE STATIC LOADS ON THE AXLES ARE:

AXLE NUMBER	LOAD
NS(1,1,1)	10095.996
NS(1,2,1)	19031.000
TOTAL	29126.996

THE TRUCK TOTAL MASS CENTER IS 101.927 INCHES BEHIND THE FRONT AXLE
THE TOTAL YAH MOMENT OF INERTIA IS 296602.687 IN-LB-SEC**2HSRI/MVMA BRAKING AND HANDLING SIMULATION OF TRUCKS, TRACTOR-SEMITAILERS, DOUBLES, AND TRIPLES - PHASE 4.
1974 WHITE TRUCK 4X2 ROAD BOSS, 82-1207,

SPRING TABLES

<u>NO. OF LINES</u>	<u>FORCE (LB)</u>	<u>DEFLECTION (IN)</u>	<u>TABLE NO.</u>
5	-28600.00	-10.00	-1
	-5200.00	-4.00	
	0.0	0.0	
	5200.00	4.00	
	83200.00	10.00	
SPRING STATIC EQUILIBRIUM CONDITION:	4176.10 LB,	3.21 INCHES.	UNIT 1 SUSP 1 AXLE 1
5	-110000.00	-10.00	-2
	-20000.00	-4.00	
	0.0	0.0	
	20000.00	4.00	
	50000.00	10.00	
SPRING STATIC EQUILIBRIUM CONDITION:	8478.50 LB,	1.70 INCHES.	UNIT 1 SUSP 2 AXLE 1

HSRI/NVMA BRAKING AND HANDLING SIMULATION OF TRUCKS, TRACTOR-SEMITAILERS, DOUBLES, AND TRIPLES - PHASE 4.
1974 WHITE TRUCK 4X2 ROAD BOSS, 82-1207,

MU-Y VS ALPHA TABLES

NO. OF LOADS NO. OF VELOCITIES

VELOCITY = 80.66 FT/SEC LOAD =
ALPHA (DEG) MU - Y
0.0 0.0
1.00 0.13
2.00 0.25
4.00 0.43
8.00 0.63
12.00 0.69

VELOCITY = 80.66 FT/SEC LOAD =
ALPHA (DEG) MU - Y
0.0 0.0
1.00 0.12
2.00 0.21
4.00 0.38
8.00 0.55
12.00 0.58

VELOCITY = 80.66 FT/SEC LOAD =
ALPHA (DEG) MU - Y
0.0 0.0
1.00 0.09
2.00 0.18
4.00 0.33
8.00 0.63
12.00 0.69

TABLE NO.
-3

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ROLL-OFF TABLE

ALPHA	0.0	SLIP	0.10
0.0	1.00		0.35
20.00	1.00		0.35

HSRI/NVMA BRAKING AND HANDLING SIMULATION OF TRUCKS, TRACTOR-SEMITAILERS, DOUBLES, AND TRIPLES - PHASE 4.
1974 WHITE TRUCK 4X2 ROAD BOSS, 82-1207,

MU-X VS. SLIP TABLES

NO. OF LOADS NO. OF VELOCITIES

VELOCITY = 57.00 FT/SEC LOAD =
SLIP MU - X
0.0 0.0
0.10 0.90
0.20 0.80
0.40 0.70
1.00 0.54

TABLE NO.
-4

ROLL-OFF TABLE

ALPHA	0.0	SLIP	1.00
0.0	1.00		1.00
20.00	1.00		1.00