REPORT NO. FRA-OR&D - FRA/ORD-78/05

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RRD-11

USERS' MANUAL FOR ASYMMETRIC WHEEL/RAIL CONTACT CHARACTERIZATION PROGRAM

by

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DECEMBER 1977

INTERIM REPORT

Document is available to the public through the National Technical Information Service; Springfield, Virginia, 22161

Prepared for:

U.S. DEPARTMENT OF TRANSPORTATION

Federal Railroad Administration

Office of Research and Development

Washington, D.C. 20590

02-Track-Train Dynamics

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1. Report No. FRA/ORD-78/05	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle USERS' MANUAL FOR ASYMMETRIC WHEEL/RAIL CONTACT CHARACTERIZATION PROGRAM		5. Report Date December 1977 6. Performing Organization Code
7. Authors R. Heller, N. K. Cooperrider		8. Performing Organization Report No.
9. Performing Organization Name and Address Clemson University, Dept. of Mech. Engr., Clemson, SC 29631 Arizona State University, Dept. of Mech. Engr., Tempe, Arizona 85281		10. Work Unit No. (TRAIS) 11. Contract of Grant No. DOT-OS-40018
12. Sponsoring Agency Name and Address U.S. Department of Transportation Federal Railroad Administration Washington, D.C.		13. Type of Report and Period Covered Interim 14. Sponsoring Agency Code FRA/RRD-11

15. Supplementary Notes

Prepared in cooperation with Association of American Railroads Research Center, Chicago, Illinois.

16. Abstract

Wheel/rail geometric constraint relationships, such as the effective conicity and gravitational stiffness, strongly influence the lateral dynamics of railway vehicles. The principal curvatures of wheel and rail profiles are important parameters in the determination of creep coefficients used in rail vehicle models. In general, these geometric constraints and profile curvatures are nonlinear functions of the wheelset lateral displacement. This report is a users' manual for a computer program written in FORTRAN IV that uses iterative procedures to determine these nonlinear functions for arbitrary wheel and rail profiles. The program computes the wheel/rail contact positions, geometric constraint functions, and profile curvatures for any given wheel profile, rail profile, rail cant angle, and rail gauge for an asymmetric wheelset on asymmetric rails. Analytical methods used and program input and output are described. Results are in the form of printout, punched cards and drum plotter plots. The users' manual includes program listings, sample deck set-ups, and sample run output.

17. Key Words - wheel/rail geometry, rail vehicle, wheelset, profile principal curvature, wheel profile, rail profile, quasi-linearization	18. Distribution Statement Document is available to the public through the National Technical Information Service, Springfield, Virginia 22151		
19. Security Classif. (of this report) UNCLASSIFIED	20. Security Classif. (of this page) UNCLASSIFIED	21. No. of Pages 103	22. Price

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A. INTRODUCTION AND PURPOSE

The Asymmetric Wheel/Rail Contact Characterization Program, WHRAILA, and associated subroutines compute the wheel/rail contact positions, geometric constraint functions and profile curvatures for any given wheel profile, rail profile, rail cant angle and rail gauge for an asymmetric wheelset on asymmetric rails. The program is an extension of the WHRAIL program for symmetric wheelsets on symmetric rails developed under U.S. Department of Transportation Contract Number DOT-OS-40018 and documented in [1]. Much of the material in this manual parallels directly the description of the WHRAIL program in Appendix A of [1]. Major differences between the two programs are given in Section D. A flow chart of the WHRAILA program is shown in Figure 2.

B. PROGRAM DESCRIPTION

1) Usage: The program consists of a main program and sixteen subroutines. Input is coordinated by the main program, WHRAILA, and subroutine PRFLE. Printed output is from the main program, subroutine PRFLE, and subroutine DCRFCN. Punched card output is from the main program. Plotted output is from subroutines PLOT1 and PLOT2. The bulk of the communication is in COMMON storage. All floating-point computations are done in double precision.

The main program, WHRAILA, coordinates the input and calculations. Subroutine PRFLE reads in the digitized profiles and fits a series of 4th order polynomials to the data using subroutines CRVFT, ORTHLS, and COEFS. The main program prints-out and punches on cards the curve-fit results. Subroutine PLOT1 plots the profile data points and the curve-fits using subroutine GTPTS to calculate the fitted points and using the plotting routines [3] associated with the CALCOMP 936 digital drum plotter to produce the plots. Subroutine EQSOLV coordinates subroutines CHECK, FIBON, CHOOSE, and RADII to find the contact point locations. Subroutine EQSUB2, using subroutines CHOOSE and RADII, calculates values of

the constraint parameters which are plotted by subroutine PLOT2, using the CALCOMP plotter routines. The main program, WHRAILA, coordinates entry points PRFLES and PRFLEP in subroutine PRFLE and the subroutines SPLINE and SPI to find profile curvatures. The main program outputs contact point, constraint parameter, and profile curvature results on the line printer and on punched cards. Profile curvature results are printed both as a function of wheelset lateral position and as a function of position on the profile.

The user has the option to suppress punched card output and plotter output. He can use the program for either symmetric configurations of the wheelset, rails, and rail cant angles or asymmetric configurations. For an asymmetric wheelset, an option is available to adjust the left wheel profile points so that the left wheel flange top is at the same height as the right wheel flange top. The program can be optionally used to only generate wheel and rail profile principal transverse curvatures.

2) Subroutines Required: SUBROUTINE PRFLE (NW, XW, YW, NC, RR, XB, INC, IW), the profile fitting routine, reads in data points describing a profile, divides each profile into a series of regions, and fits a 4th order polynomial to each region. Uses subroutines CRVFT, ORTHLS, and COEFS. Contains entry points PRFLES and PRFLEP to set up arrays for the spline fit calculation of profile curvatures.

SUBROUTINE CRVFT (N, L, X, Y, W, A) finds the coefficients of the 4th order polynomial that best fits an array of data points. Uses subroutines ORTHLS and COEFS.

SUBROUTINES ORTHLS (X, Y, W, N, L, J, C, ALPHA, BETA, K, T1, T2, T3, IND1) computes parameters for a fourth order polynomial using a least-squares procedure. From the Univac MATHPAC [2].

SUBROUTINE COEFS (J, C, ALPHA, BETA, KC, A, T1, T2, T3, IND2) computes the five coefficients for a fourth order polynomial. From the Univac MATHPAC [2].

SUBROUTINE PLOT1 (ICTR, ICTL, IWG, IRG) plots the wheel and rail profiles with a symbol at every other data point and draws a line representing the curve-fit. Uses subroutine GTPTS and the CALCOMP plotter routines [3].

SUBROUTINE GTPTS (XMAX, XMIN, RR, B, NC, AXW, AR1, S1, NU) calculates an array of points on the curves fitted to a profile.

SUBROUTINE EQSOLV (NUMBR, XWINC) coordinates the search for the contact points. For symmetric wheelsets and rails, it transposes positive wheelset lateral displacement results to get values for negative wheelset displacement. Uses subroutine CHECK.

SUBROUTINE CHECK (XW, DXW, WR, XOLD) uses a Fibonacci search procedure [4] to find the contact point locations. Uses subroutines CHOOSE, RADII, and FIBON.

SUBROUTINE CHOOSE (X1, X2, X3, X4) chooses the curves which represent the wheel and rail profiles at the instantaneous points of interest.

SUBROUTINE RADII (RR, YR, RL, YL, X1, X2, X3, X4, R1, R2, R3, R4) finds the functions of four fourth order polynomials for four inputs.

SUBROUTINE FIBON (N, AX, XMAXW, XMAXR, XMINW, XMINR, SBX, NCA, NCB, BA, BB, R, Y, SIGN, X1, X2, Y1) uses the Fibonacci single direction minimization search procedure [4] to find candidate contact point locations.

SUBROUTINE EQSUB2 (NUMBR) calculates the geometric constraint relations by substituting the contact point locations into the defining equations. Uses subroutines RADII and CHOOSE.

SUBROUTINE PLOT2 (NUMBR, ICTR, ICTL) plots the results. Uses the CALCOMP plotter and associated routines[3].

SUBROUTINE SPLINE (N, X, Y, C, IPRINT) computes parameters for a cubic spline curve-fit of profile data points.

SUBROUTINE SPI (N, X, Y, S, XP, YP, D1, D2, RC, CV, IER) interpolates along the profile spline curve to find values of the profile ordinate, first and second derivatives, radius of curvature, and curvature. ENTRY point SPIC (N, X, Y, S, XP, CV) is used to just find the curvature.

SUBROUTINE DCRFCN (N, AXW, AR5, AM3, AW1, AR) performs quasilinearization using describing function techniques for a sinusoidal input for symmetrical wheelsets on symmetrical rails.

3) Description of Parameters:

Main Program WHRAILA - Input parameters

XWINC	Lateral increment of wheelset at which calculations are made, inches.
ISYM	For asymmetric wheels and/or rails ISYM = 0. (All four wheel and rail input decks required.) For symmetric case ISYM = 1. (One wheel and one rail profile input deck required.) For symmetric case, but with different rail cants ISYM = 2. (Same decks as ISYM = 1.)
IPUNCH	For punched results on cards IPUNCH = 1.
IPLOT	To bypass CALCOMP plotting routines, IPLOT = 0.
ICURV	To only perform profile curvature calculations, ICURV = 1 (bypass contact point and geometric constraint calculations).
IFLANG	For asymmetric wheelsets, for adjusting the left wheel profile points so that right and left wheel flange top heights coincide, set IFLANG = 1.
NUMB	Number of points to be calculated, $\leq$ 121. The amplitude of wheelset lateral displacement = (NUMB - 1)*XWINC inches.
INC	Number of data points per curve-fit zone, 3 $\leq$ INC $\leq$ M/3, where M = number of data points.
WG	Wheel gauge measured from flangeback to flangeback, inches.
RG	Rail gauge measured from inside one rail at a point 5/8" from the top of the rail to the corresponding point on the other rail, inches.

BR	Cant of right rail, radians (positive cant to the inside).
BL	Cant of left rail, radians (positive cant to the inside).
IWHLR, IWHLL	Label for right and left wheels, alphanumeric.
DTFR, DTFL	Distances from tapeline to flangeback for right and left wheels, inches.
NWR, NWL	Number of right and left wheel profile data points, $9 \leq NW \leq 200$.
XW1,YW1,XW3,YW3	Arrays of data points for wheel profiles, dimensions NWR and NWL: XW1(I), XW3(I) = distances from tapeline for right and left wheels, positive out, inches. YW1(I), YW3(I) = right and left wheel radii at XW1(I), XW3(I), inches.
IRAILR, IRAILL	Label for right and left rails, alphanumeric
DRWR, DRWL	Distances from rail head centerline to a point on the inside of the rail 5/8" down from the top of the rail for right and left rails, inches.
NYR, NYL	Number of right and left rail profile data points, $9 \leq NW \leq 200$.
XW2,YW2,XW4,YW4	Arrays of data points for rail profiles, dimensions NYR and NYL: XW2(I), XW4(I) = distances from centerline for right and left rails, positive out, inches. YW2(I), YW4(I) = heights of right and left rails at XW2(I), XW4(I), inches.
ITWO	If the input profile data cards contain one (X,Y) data point per card, ITWO = 0. For two data points per card, ITWO = 1.
INEG	If the Y coordinates of the input profile data cards are positive, INEG = 0. If they are negative, INEG = 1.

4) Input Formats: Sample deck set-ups are listed in Section F. The program requires the wheel and rail profile data, rail cant, rail gauge, wheel gauge and certain program control information in the following format:

Card #	Col. #	Contents	Format
1	any	XWINC	( ) - unspecified, real number
2 2	1-3 4-6	ISYM IPUNCH	(2I3)
3 3	1-3 4-6	IPLOT ICURV	(2I3)
4	1-3	IFLANG	(I3)
5 5	1-3 4-6	NUMB INC	(2I3)
6 6 6 6	any any any any	WG RG BR BL	( ) - unspecified, real numbers, in order, separated by commas or blanks
7	1-52	IWHLR (start right wheel input data)	(13A4)
8	any	DTFR	( ) - real
9	any	NWR	( ) - integer
10 10	any any	ITWO INEG	( ) - integers, in order, separated by a comma or blank
11 to end of right wheel profile data (ED1)	11-25 26-40	for ITWO = 0 XW1(I), YW1(I)	(10X,2D15.7)
		or	
	any	for ITWO = 1 XW1(I), YW1(I), XW1(I+1), YW1(I+1)	( ) - real 4D15.7 numbers, in order, separated by commas or blanks

Card #	Col. #	Contents	Format
ED1 + 1	1-52	IRAILR (start right rail input data)	(13A4)
ED1 + 2	any	DRWR	( ) - real
ED1 + 3	any	NYR	( ) - integer
ED1 + 4 ED1 + 4	any any	ITWO INEG	( ) - integers, in order, separated by a comma or blank
ED1 + 5 to end of right rail profile data (ED2)	11-25 26-40	for ITWO = 0 XW2(I), YW2(I)	(10X, 2D15.7)
		or	
	any	for ITWO = 1 XW2(I), YW2(I), XW2(I+1), YW2(I+1)	( ) - real 4D15.7 numbers, in order, separated by commas or blanks
For asymmetric case, add the following data decks: 1) Left wheel input data (identical format to right wheel input data starting with card #7) 2) Left rail input data (identical format to right rail input data starting with card # (ED1 + 1)			
END-3	1-52	ICTR (Right Rail Cant)*	(13A4)
END-2	1-52	ICTL (Left Rail Cant)*	(13A4)
END-1	1-52	IRG (Rail Gauge)*	(13A4)
END	1-52	IWG (Wheel Gauge)*	(13A4)

* Character labels appearing on CALCOMP plots.

5) Output: For a sample output, see Section F. The main program, WHRAILA, first prints out the selected user options followed by a printout of the profile input cards. The wheel and rail descriptions and coefficients of the polynomials used to fit the profiles are printed. Two tables are then printed that contain all the contact point, geometric constraint, and profile curvature results as a function of the wheelset lateral position. For symmetric configurations, sinusoidal describing functions of certain of the results are printed by the DCRFCN subroutine. Finally, the main program prints tables of wheel and rail profile curvatures as a function of position on the profile. If selected, the results as a function of wheelset lateral position are punched by WHRAILA. If selected, the input profiles and the contact point and geometric constraint results are plotted by subroutines PLOT1 and PLOT2.

The FORTRAN names used in the program output are the following:

AMP	Amplitude of wheelset lateral motion, inches.
ALAM	Describing function of the nondimensional difference in rolling radii, $(r_L - r_R)/2a$, as a function of nondimensional wheelset lateral position, x_w/a_w.
DELM	Describing function of one half the difference in contact angles as a function of nondimensional wheelset lateral position, x_w/a_w.
WSRL	Describing function of the wheelset roll angle as a function of nondimensional wheelset lateral position, x_w/a_w.
XW	Wheelset lateral displacement, positive to the left, inches.
X1, X3	Contact locations on the right and left wheels, positive out from tapeline, inches.
X2, X4	Contact locations on the right and left rails, positive out from centerline, inches.
RR, RL	Rolling radii, right and left wheels, inches
YR, YL	Rail head profile height, right and left rails, inches.
MR, ML	Contact angles on the right and left wheel with respect to the axle, radians.
WR	Wheelset roll angle with respect to the horizontal (positive up on left), radians.

YCG — Vertical displacement of wheelset centroid from nominal position, inches.

RR CRV — Principal rolling curvature, right wheel, 1/inches.

RL CRV — Principal rolling curvature, left wheel, 1/inches.

(RL-RR)/2A — Normalized difference in rolling radii.

(ML-MR)/2 — Normalized difference in contact angles, radians.

CWR, CWL — Principal transverse curvature, right and left wheel profiles, positive for center of curvature within wheel, 1/inches.

CYR, CYL — Principal transverse curvature, right and left rail profiles, positive for center of curvature within rail, 1/inches.

XWR, XWL — Distance from the tapeline on the right and left wheels, positive out from the tapeline, inches.

XRR, XRL — Distance from the centerline on the right and left rails, positive out from the centerline, inches.

6) Summary of User Requirements and Recommendations:

All input data is on cards with the formats shown. The maximum allowable points per wheel or rail profile is 200 points. For asymmetric wheels and/or asymmetric rails, ISYM = 0, and two each wheel and two each rail input decks are required. For completely symmetric configurations, ISYM = 1, and only one wheel and one rail input deck are needed. For symmetric wheels and rails, but with different rail cant angles, ISYM = 2, with one wheel and one rail input deck required.

For punched results on cards, specify IPUNCH = 1 (otherwise, specify IPUNCH = 0). To bypass CALCOMP plotting routines, specify IPLOT = 0. To bypass all calculations except profile curvature calculations, select ICURV = 1. For asymmetric wheel profiles, to adjust left wheel data points so that right and left wheel flange top heights are identical, select IFLANG = 1 (otherwise, select IFLANG = 0).

To pick values for NUMB, the number of points to be calculated, and XWINC, the lateral increment of the wheelset at which points are calculated, note that NUMB and XWINC determine the range of the wheelset lateral positions, i.e., the maximum wheelset amplitude = (NUMB - 1)XWINC inches. If calculations are made for too large a wheelset lateral displacement, then plotted results may extend

past the borders of the graphs. The suggested value for XWINC is 0.01 inch. However, XWINC = .02 inch is completely acceptable and the WHRAILA execution time is almost cut in half. When larger values of XWINC are selected, the wheelset location at which the contact point jumps from the wheel tread to the flange is less accurately defined. Suggested values for NUMB (with XWINC = .01 inch) are (1) for wide gauge take NUMB = 121 (the maximum allowed), (2) normal gauge take NUMB = 101, and (3) narrow gauge take NUMB = 81. INC determines the data points per curve-fit zone. If INC is small then the fitted curve will fit the points more closely. If INC is larger, more numerical smoothing will be done. Take INC = 6 for a start. If the curves do not fit the profiles well enough (this is determined from the plot where the profile data points and curve-fits are plotted together) then decrease INC. The maximum number of curve-fit regions allowed is 30. The maximum number of increments of the wheelset in the positive direction is 121.

Remember to input the profile data points (wheel and rail) in a sequence that starts with the largest "X" value and moves toward the smallest. This is necessary because the program separates the profiles into zones assuming this order. A message is printed if any of the "X" coordinates are out of order. There are a few other error messages in the program which are self-explanatory. There is also a warning printed when the wheelset roll angle iteration does not converge. When IFLANG = 1, for asymmetric wheels, a message is printed noting the amount that the left wheel profile "Y" values were adjusted.

C. METHOD

The computations carried out in this program can be divided into five sections:

(1) Mathematical Description of Rail and Wheel Profiles
(2) Calculation of Contact Point Locations
(3) Quantitative Description of Geometric Constraint Relations
(4) Calculation of Wheel and Rail Profile Curvatures
(5) Quasi-linearization

The computational procedures and mathematical representations used in these five sections, respectively, are described below. A program listing for each subroutine may be found in Section F. Additional information on the theory behind the approach and methods used in the WHRAILA programs can be found in Chapter 4 of [1].

1) Mathematical Description of Rail and Wheel: The inputs to the program are:
   (a) parameters specifying the size of regions to be curve-fit and the amplitude of wheelset lateral displacement allowed
   (b) wheel and rail gauges
   (c) tabular wheel and rail profile data
   (d) tapeline to flangeback distance and one-half head rail width

   The rail and wheel profiles are described by fourth order polynomials fitted to sub-intervals of the profiles. The sub-intervals consist of a specified number of data points with an overlap of three data points on each adjoining interval. The tabular profile data is read into a subroutine, PRFLE, that separates the data into the regions and then calls another subroutine, CRVFT, to fit a fourth order polynomial to each region. The curve-fitting is accomplished in subroutines ORTHLS and COEFS [2] that use an orthogonal polynomial, least-squares curve-fitting approach.

   The output of the profile subroutine for each profile is: (1) the input profile data cards, (2) a set of fourth order polynomials with each polynomial fitting a certain interval of the profile, and (3) the limits defining each interval of the profile.

2) Calculation of Contact Point Locations: The numerical procedure to find the contact point locations is conducted in the manner described in Chapter 4 of [1] with the following exceptions:
   (a) To handle asymmetric wheels and rails, the contact point search is conducted both for the wheelset displaced in the positive and negative directions.
   (b) The contact points are found for XWINC inch increments (user selectable) of the wheelset lateral position.

(c) The iterative search procedures are conducted using multiple Fibonacci minimization searches [4] rather than an exhaustive search for each contact point over the entire wheel and rail profiles.

The iteration and sweeping procedures described there are performed in subroutine CHECK. Subroutine EQSOLV increment increases the wheelset lateral displacement and calls on the CHECK subroutine to find the contact points. Several geometric relations are used in subroutine CHECK. The first is the equation describing the correspondence between points on the wheel and points on the rail. The equations that express the requirement that the wheel and rail contact at the same lateral positions are, on the right

$$a_r + x_{r_R} = -x_w + (a_w + x_{w_R}) \cos \phi_w - r_R \sin \phi_w \qquad (1)$$

and, on the left

$$a_r + x_{r_L} = x_w + (a_w + x_{w_L}) \cos \phi_w + r_L \sin \phi_w \qquad (2)$$

The variables in these equations are shown in Figures 1 and 2. The equations equate the lateral distance of corresponding wheel and rail points from the track centerline. They are used in subroutine CHECK and FIBON to find corresponding points on the wheel and rail to check for the minimum separation distance. Recall that the minimum separation distance indicates a contact point.

The heights that are required in calculating the minimum separation distance are computed from the following four equations, one set for the wheels and one set for the rails.

$$h_{\text{right wheel}} = -r_R \cos \phi_w - (a_w + x_{w_R}) \sin \phi_w \qquad (3)$$

$$h_{\text{left wheel}} = -r_L \cos \phi_w + (a_w + x_{w_L}) \sin \phi_w \qquad (4)$$

$$h_{\text{right rail}} = y_R + x_{r_R} \sin \beta_R \qquad (5)$$

$$h_{\text{left rail}} = y_L + x_{r_L} \sin \beta_L \qquad (6)$$

The datum used for the wheel heights is a horizontal line through the wheelset centroid. Distances above the line are positive. The datum used for rail heights is the horizontal line through the base of the rails. Rail cant is assumed to tilt only the top of the rail head about its midpoint, in accordance with the standard practice of measuring the rail gauge after the rail has been canted. The actual datums used for the wheel or rail are arbitrary, as we are only interested in the minimum separation.

Wheelset roll angle is calculated from

$$\phi_w = \frac{(y_L - y_R) + x_{r_L} \sin \beta_L - x_{r_R} \sin \beta_R + (r_L - r_R) \cos \phi_w}{(2\, a_w + x_{w_R} + x_{w_L}) \cos \phi_w} \qquad (7)$$

where the variables are again shown in Figures 1 and 2. Note that ϕ_w is defined in terms of itself. In the program, an iterative scheme was used to solve this equation. In case of difficulties with convergence of the contact point search, print statements have been left in the coding for debugging. The variable IPRT is set to IPRT = 0 in the beginning of the main program to suppress contact point search printout. To print information (7000 lines) during the search this variable can be set to IPRT = 1. To print values of the Fibonacci search procedure, set IPRT = 2 (produces more than 20,000 lines).

3) Quantitative Description of Geometric Constraint Relations: The defining equations used to calculate the geometric constraint relations are evaluated in subroutine EQSUB2. EQSUB2 calls subroutines CHOOSE and RADII to choose the applicable curve-fits and to evaluate them at the contact locations determined from the value of wheelset lateral position under consideration. The defining equations for these constraint relations follow below. See Figure 2 for an illustration of the variables appearing in the equations.

1. Rolling radii and rail heights

   r_R, y_R, r_L, y_L - evaluated from curve-fits

2. Contact angles

$$\delta_R = \arctan\left[\frac{d}{dx_{w_R}}(r_R)\right]$$
$$\delta_L = \arctan\left[\frac{d}{dx_{w_L}}(r_L)\right] \tag{8}$$

3. Normalized difference in rolling radii

$$\Delta r = \frac{r_L - r_R}{2\,a_r} \tag{9}$$

4. Normalized difference in contact angles

$$\Delta\delta = \frac{\delta_L - \delta_R}{2} \tag{10}$$

5. Roll angle

$$\phi_w = \arctan \frac{(y_L + x_{r_L} \sin\beta_L + r_L \cos\phi_w) - (y_R + x_{r_R} \sin\beta_R + r_R \cos\phi_w)}{(2\,a_w + x_{w_R} + x_{w_L})\cos\phi_w} \tag{11}$$

6. Vertical displacement of wheelset c.g.

$$y_{cg} = \left[\frac{y_L + y_R + x_{r_L} \sin\beta_L + x_{r_R} \sin\beta_R + (r_L + r_R)\cos\phi_w}{2}\right] - \left[\frac{y_L + y_R + x_{r_L} \sin\beta_L + x_{r_R} \sin\beta_R + (r_L + r_R)\cos\phi_w}{2}\right]_{x_w = 0} \tag{12}$$

4) Calculation of the Wheel and Rail Profile Curvatures: Curvature of the wheel and rail profile shapes are important parameters in the calculation of creep coefficients as a function of wheelset position. The main program, WHRAILA, coordinates the calculation of wheel and rail profile curvatures by calling subroutine SPLINE,

ENTRY points PRFLES and PRFLEP in subroutine PRFLE, and ENTRY point SPIC in subroutine SPI. The main program selects the range of profile points over which curvatures are calculated and calls the ENTRY PRFLES routine to select the data points through which a profile spline curve-fit is passed (explained below). The subroutine SPLINE is then called to fit a spline through these points. The ENTRY SPIC in subroutine SPI is called to interpolate for curvatures at the contact points found on each wheel and rail profile. The main program prints and punches on cards profile curvatures for the right wheel, right rail, left wheel, and left rail as a function of wheelset lateral position. The main program uses the ENTRY PRFLEP routine and the ENTRY SPIC routine to interpolate for profile curvature as a function of distance in 0.05 inch increments along each profile and prints the results in a table.

Curvature at any point on a wheel or rail profile is computed from a curve fitted to the profile data points. The curvature of a function y of one variable x is defined as

$$\alpha(x) = \frac{\frac{d^2y(x)}{dx^2}}{[1 + (\frac{dy(x)}{dx})^2]^{3/2}} \qquad (13)$$

For any x, $\frac{d^2y}{dx^2}$ and $\frac{dy}{dx}$ can be found by interpolating on the fitted curve for second and first derivatives of $y(x)$, respectively, and $\alpha(x)$ can be found from equation (13).

Profile data points may be fitted with a single, high-order polynomial. However, the inevitable wiggles of such a polynomial fit would give inaccurate values for the first and second derivatives. A sequence of low-order polynomials for sub-intervals could be used to fit the data points. This technique, using fourth order polynomials in least-squares fits over sub-intervals, was used in PRFLE and gives good results for interpolating function values $y(x)$. However, since first and second derivatives are not required to agree as we shift from one sub-interval polynomial to the next, discontinuities in $\frac{d^2y(x)}{dx^2}$ and $\frac{dy(x)}{dx}$ and thus in $\alpha(x)$ occur at the boundary between sub-intervals.

To cope with this problem, a composite interpolation technique called the cubic spline fit was used. In cubic spline interpolation, a set of cubics is passed through the points in sub-intervals along the profile and the function value, first derivative, and second derivative are required to be the same at the ends of the sub-intervals where one cubic meets the next. Thus we have a continuous second derivative (and a continuous curvature) throughout the whole range of interpolation. Each data point through which the spline fit passes is called a joint and defines the boundary between two adjacent sub-intervals. In computing the coefficients for the cubic in each sub-interval, the function value, the first derivative, and the second derivative at each joint are used in a set of n x n simultaneous equations for n joints. Thus the location of each joint affects the entire spline fit. The values of the second derivatives at the end points must be specified by the spline user.

Fitting profiles with joints at each data point resulted in curvature values that oscillated excessively between joints. This is due to at least three problems.

a) In the recording of profile data points (done by digitization of profile plots or some other means), minor data point deviations from a "smooth" curve inevitably result. These small deviations are amplified in the calculation of derivatives of a curve passed through these points. In a spline fit, each joint (located at a data point) affects the entire curve-fit. The cumulative affects of small deviations of the data points from a smooth curve may cause large oscillations in the curvature. A solution to this problem is to select only a few of the data points for spline joints, which will tend to smooth out the fit and the curvature results.

b) A cubic spline will fit a cubic (3rd degree polynomial) exactly to joints located on a cubic curve. However, when fitting joints lying in a straight line, oscillations or wiggles in the curve-fit occur between joints. This problem is particularly noticable in the fitting of the straight taper of the new AAR wide flange wheel tread. The problem can be minimized by selecting joints at widely spaced data points along the wheel profile tread.

c) A very large range in the first and second derivatives between data points causes the curvature of a spline passed through the points to oscillate excessively. This was noticed in the fitting of a new standard AAR rail profile. When points on the vertical gauge and field sides of the rail were included in the spline fit, large oscillations in the curve-fit occurred along the top of the rail. This problem was solved by only including the contact portion of the rail in the spline fit.

Thus the procedure of selecting locations of spline joints from profile data points is important in obtaining accurate curvature results. The main program limits the range of profile data points for candidate joints to the range of contact points on the wheels and rails. The ENTRY PRFLES routine is called to select joint locations for the spline fit. End joints for the wheel curve-fits are located on the top of the flange and at either the furthest contact point from the tapeline on the tread or one inch from the tapeline (whichever is larger). Approximate joint spacing is 0.15 inch on the flange, 0.30 inch on the flange root, and 0.50 inch on the tread. This selection defines the curvature better on the flange and minimizes curve-fit oscillations on the tread. End joints for the rail curve-fits are located at the contact point closest to the centerline between rails and at either the furthest contact point from the rail centerline to the field side or one inch from the centerline (whichever is larger). Joint spacing is 0.1 to 0.2 inches on the gauge side of the rail and 0.4 inch on the rail head. This selection defines the curvature accurately on the rail gauge edge, while avoiding curve-fit oscillations on the rail head.

After selection of joint locations, the main program calls subroutine SPLINE to solve the set of simultaneous equations associated with a spline fit. Then the ENTRY SPIC routine is called for each wheel and rail profile to interpolate for profile curvatures at contact point locations. The main program prints and punches on cards the curvature results as a function of wheelset lateral position.

A separate printout of lateral profile principal curvatures as a function of distance along the profiles (in 0.05 inch increments), is furnished by the main program by calling the ENTRY

PRFLEP routine and the ENTRY SPIC routine. The coordinate systems used are given in Figure 1. This printout can be generated by itself by use of the user option ICURV = 1 (contact point search and geometric constraint calculations are bypassed).

The principal lateral profile curvature computation procedure was verified by comparing spline fit results of digitized profile data against design curvatures of the following profiles: New AAR rail, new AAR wide flange wheel for freight vehicles, new modified Heumann wheel, and new Canadian National Profile A wheel.

The principal rolling curvatures of the right and left wheels are computed for each location x_w of the wheelset by the equations

$$\text{RR CRV}(x_w) = \frac{\cos(\delta_R(x_w))}{r_R(x_w)}$$

$$\text{RL CRV}(x_w) = \frac{\cos(\delta_L(x_w))}{r_L(x_w)} \qquad (14)$$

Limitations to the accuracy of principal lateral curvatures of wheel and rail profiles should be remembered:

a) Inaccuracies or noise in the taking of profile data points can cause oscillation inaccuracies in the interpolated curvature values.

b) Curvature values may oscillate slightly in the wheel tread region, particularly for a straight taper tread.

c) Curvatures interpolated from the end spline sub-intervals can be in error. This is due to the assumption that the second derivative at the end joints is a linear extrapolation of the second derivative values of the adjacent two spline joints.

5) Quasi-linearization: The quasi-linearization method described here assumes that we have symmetric wheels on symmetric rails. The sinusoidal input describing function is defined by the following equation:

$$Y_q = \frac{1}{\pi A^2} \int_0^{2\pi} F(A \sin\phi) A \sin\phi \, d\phi. \quad (15)$$

The relations to quasi-linearize are the following:

$$\Delta r \equiv \frac{r_L - r_R}{2a_r}; \quad \Delta\delta \equiv \frac{\delta_L - \delta_R}{2}; \quad \text{and } \phi_w.$$

These are non-dimensional and non-hysteretic. Also, due to the symmetry of the wheel and rail profiles, they are odd functions of the wheelset lateral position, i.e. $\Delta r(x_w) = -\Delta r(-x_w)$. If these properties are applied, the describing function can be re-written as:

$$Y_q = \frac{4}{\pi A^2} \int_0^{\pi/2} F(A \sin\phi) A \sin\phi \, d\phi. \quad (16)$$

This equation is numerically integrated in the program. To do this, the integration increment, $d\phi$, was expressed as a function of x, because the functions to be quasi-linearized were tabulated as functions of x. The substitution was made by letting

$$x = A \sin\phi \quad (17)$$

or

$$\phi = \sin^{-1}\frac{x}{A}, \; 0 \leq \phi \leq \pi/2 \quad (18)$$

and thus

$$\Delta\phi_n = \phi_n - \phi_{n-1}$$

$$= \sin^{-1}\left(\frac{x_n}{A}\right) - \sin^{-1}\left(\frac{x_{n-1}}{A}\right) \quad (19)$$

Substitution of this result into the describing function equation (15) gives

$$Y_q = \frac{4}{\pi A^2} \int_0^{\pi/2} F(x)x \; d\phi(x) \tag{20}$$

When we let $f(x) = F(x)x$ and numerically integrate using the trapezoidal rule, we obtain

$$\begin{aligned} Y_q \simeq & \frac{4}{\pi A^2} \frac{f(x_1) + f(x_2)}{2} \left(\sin^{-1} \frac{x_2}{A} - \sin^{-1} \frac{x_1}{A}\right) \\ & + \frac{f(x_2) + f(x_3)}{2} \left(\sin^{-1} \frac{x_3}{A} - \sin^{-1} \frac{x_2}{A}\right) + \ldots \\ & + \frac{f(x_{n-1}) + f(x_n)}{2} \left(\sin^{-1} \frac{x_n}{A} - \sin^{-1} \frac{x_{n-1}}{A}\right) \end{aligned} \tag{21}$$

where $x_1 = 0$ and $x_n = A$.

This equation was programmed in subroutine DCRFCN. It was multiplied, in the subroutine, by a_r to non-dimensionalize the describing function for the parameters considered.

D. MAJOR DIFFERENCES BETWEEN WHRAILA AND WHRAIL PROGRAMS

1) The program can calculate wheel/rail contact points and geometric constraint functions for any given asymmetric wheelset, asymmetric rails, and asymmetric rail cant angles as well as the case of a symmetric wheelset on symmetric rails.

2) Execution time of the contact point search procedure, where most of the computer time is spent, has been reduced by about a factor of 10 by replacing the exaustive search with a Fibonacci search procedure.

3) Execution time has been streamlined in several other places, particularly in CHECK, CHOOSE, EQSOLV, and EQSUB2. For example, redundant IF statements, redundant variable calculations and unneeded array processing have been removed.

4) Principal profile curvatures of the wheels and rails are calculated using cubic spline fits.

5) Options for suppressing punched card and plotter outputs have been introduced.

6) The plotting routines allow wheel rolling radii of any diameter and allow any rail height.

7) Processing of all real variables is in double precision.

E. TEST PROBLEMS

The following test problems are given to demonstrate the WHRAILA program. The calculations were performed on a IBM 370/3165-II computer. With the plot and punch options selected, CPU execution time was less than 10 seconds for the symmetric problem and less than 15 seconds for the asymmetric problem.

1) Symmetric Problem:

Profiles: New AAR Wheel
New AAR Rail

Gauges: Rail gauge - nominal, 56.5 inches
Wheel gauge - nominal, 53 inches

Rail Cant: 0.025 radians (1.4324 degrees)

Maximum Allowed Wheelset Lateral Displacement: 1 inch

2) Asymmetric Problem:

Profiles: Right wheel - Moderately Worn AAR Wheel
Right rail - New AAR Rail
Left wheel - Slightly Worn AAR Wheel
Left rail - Worn AAR Rail

Gauges: Rail gauge - wide, 57.5 inches
Wheel gauge - nominal, 53 inches

Rail Cants: Right rail - 0.025 radians
Left rail - 0.025 radians

Maximum Allowed Wheelset Lateral Displacement: 1.2 inch

The program listing, card input, printer output, plotter output, and punched card output listing for these problems are contained in the following section.

F. PROGRAM LISTINGS WITH INPUTS AND OUTPUTS FOR TEST PROBLEMS

1) Program Listings

2) Symmetric Problem:

   a) Listing of input cards
   b) Printer output
   c) CALCOMP plotter output
   d) Partial listing of punched card output

3) Asymmetric Problem:

   a) Listing of input cards
   b) Printer output
   c) CALCOMP plotter output
   d) Partial listing of punched card output

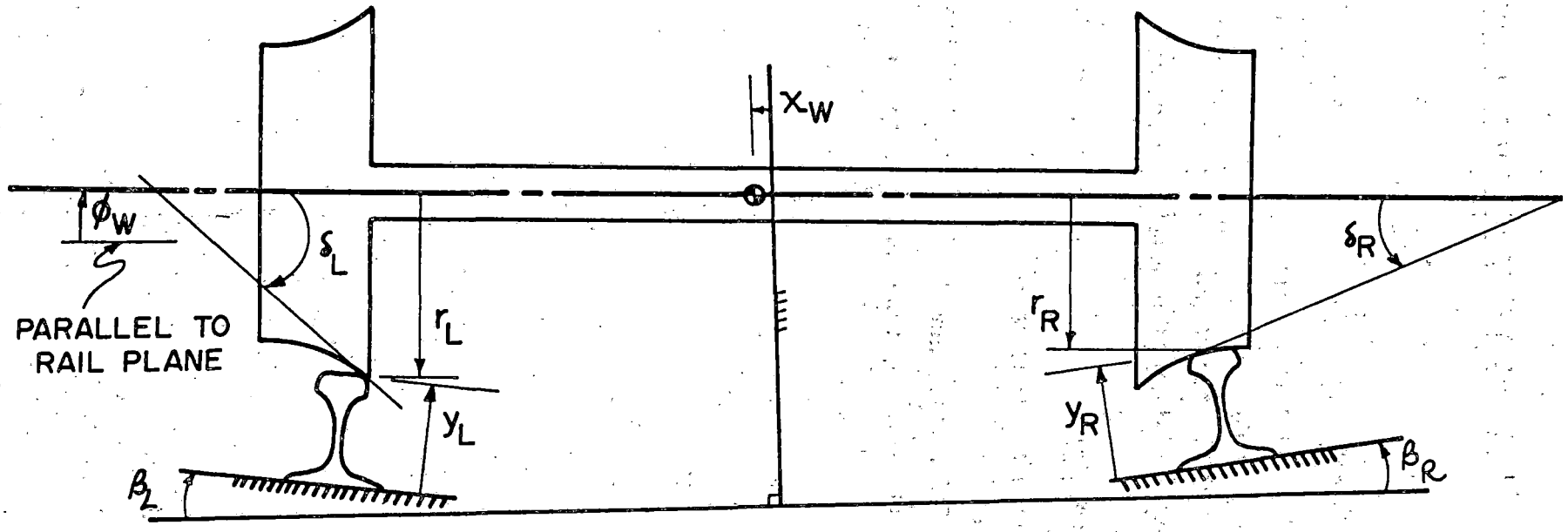
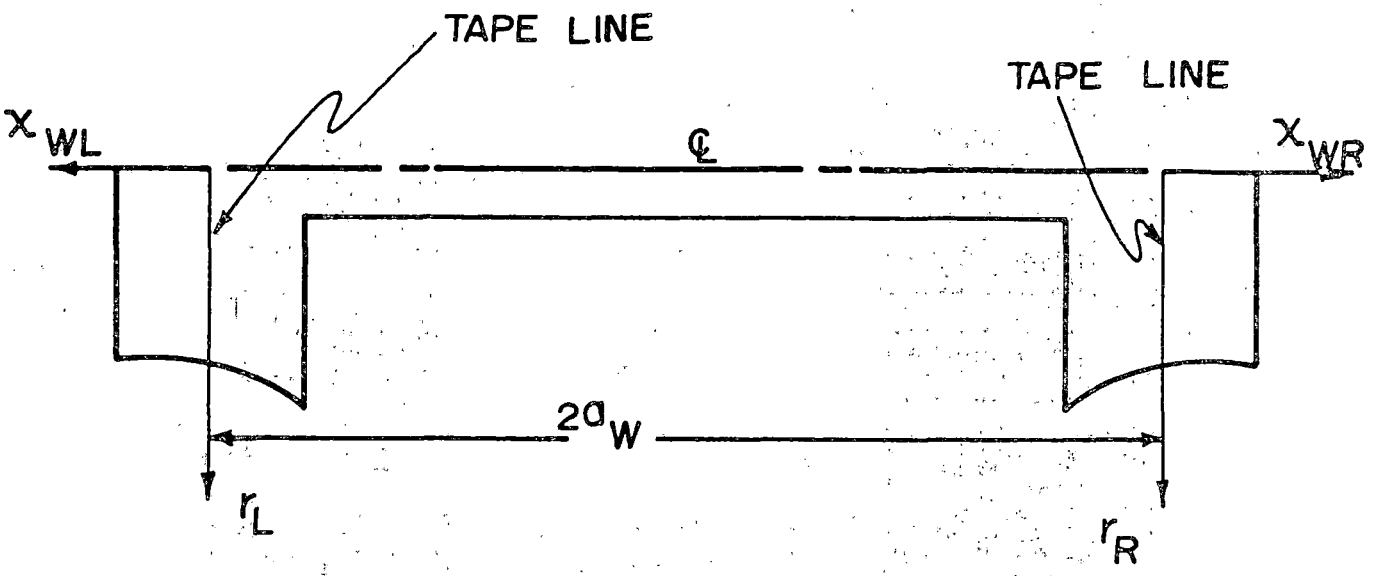
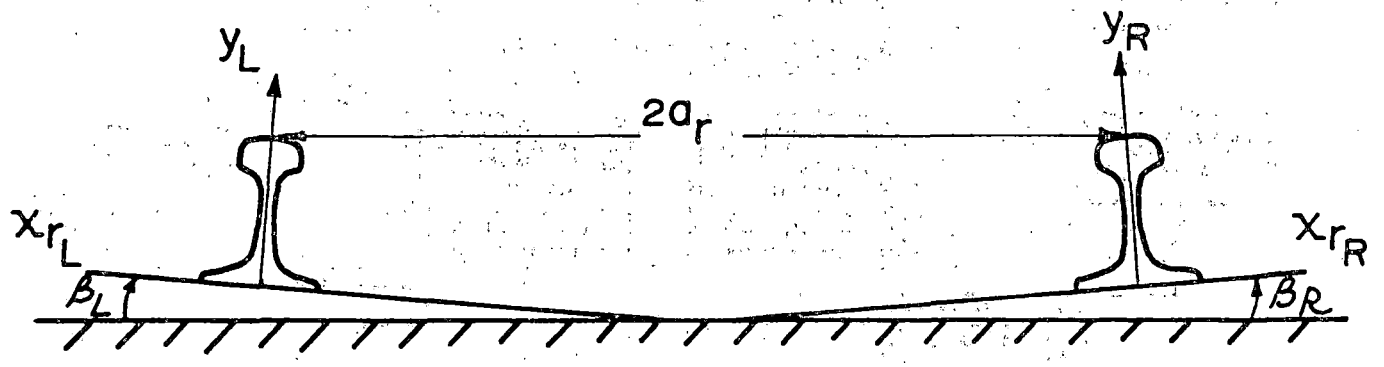


FIGURE 1A WHEEL/RAIL PARAMETERS, REAR VIEW [From Ref. 1]



WHEEL COORDINATE SYSTEMS
REAR VIEW



RAIL COORDINATE SYSTEMS
REAR VIEW

FIGURE 1B WHEEL/RAIL COORDINATE SYSTEMS [From Ref. 1]

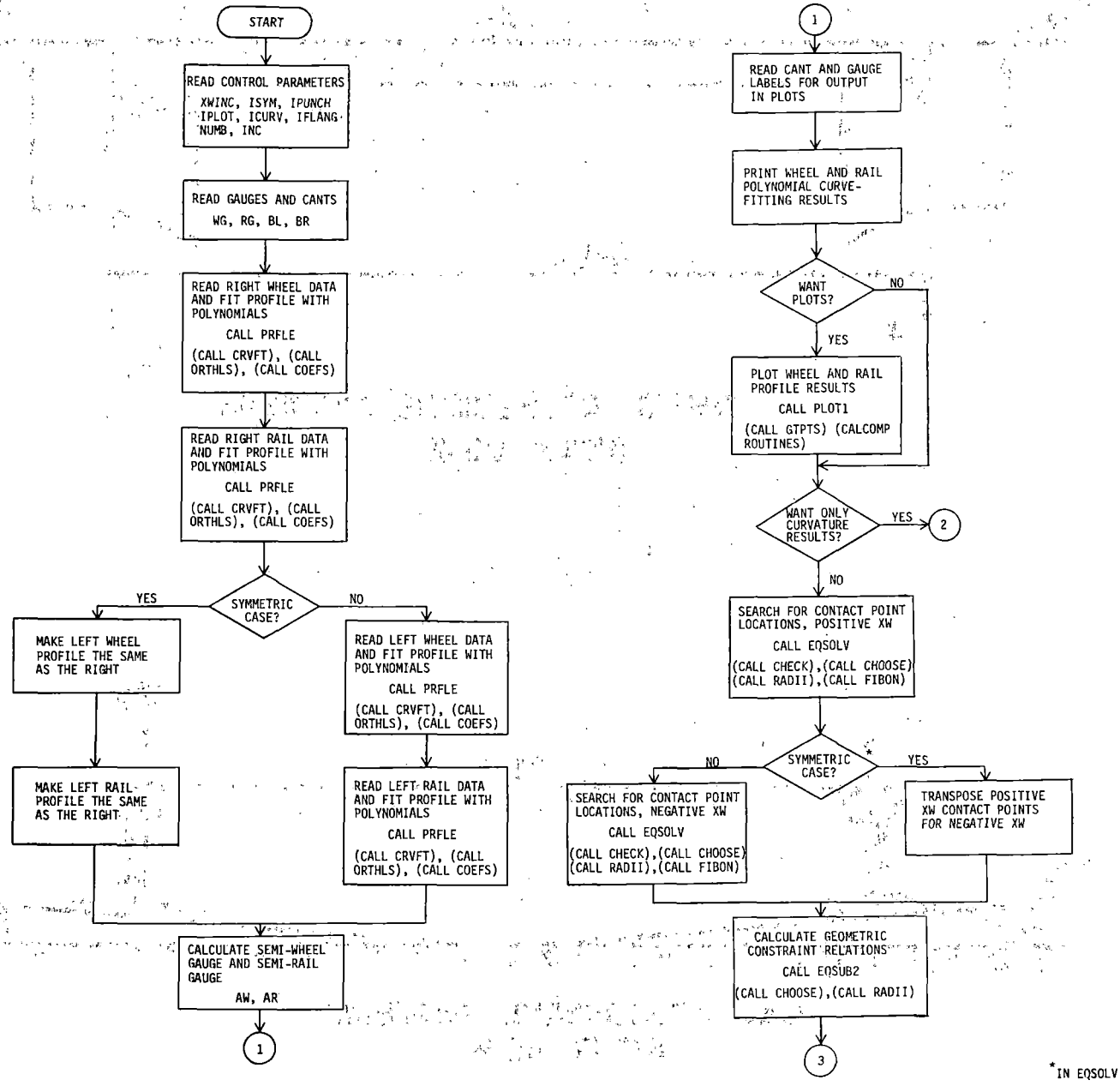


FIGURE 2. FLOWCHART, ASYMMETRIC WHEEL/RAIL CONTACT CHARACTERIZATION PROGRAM

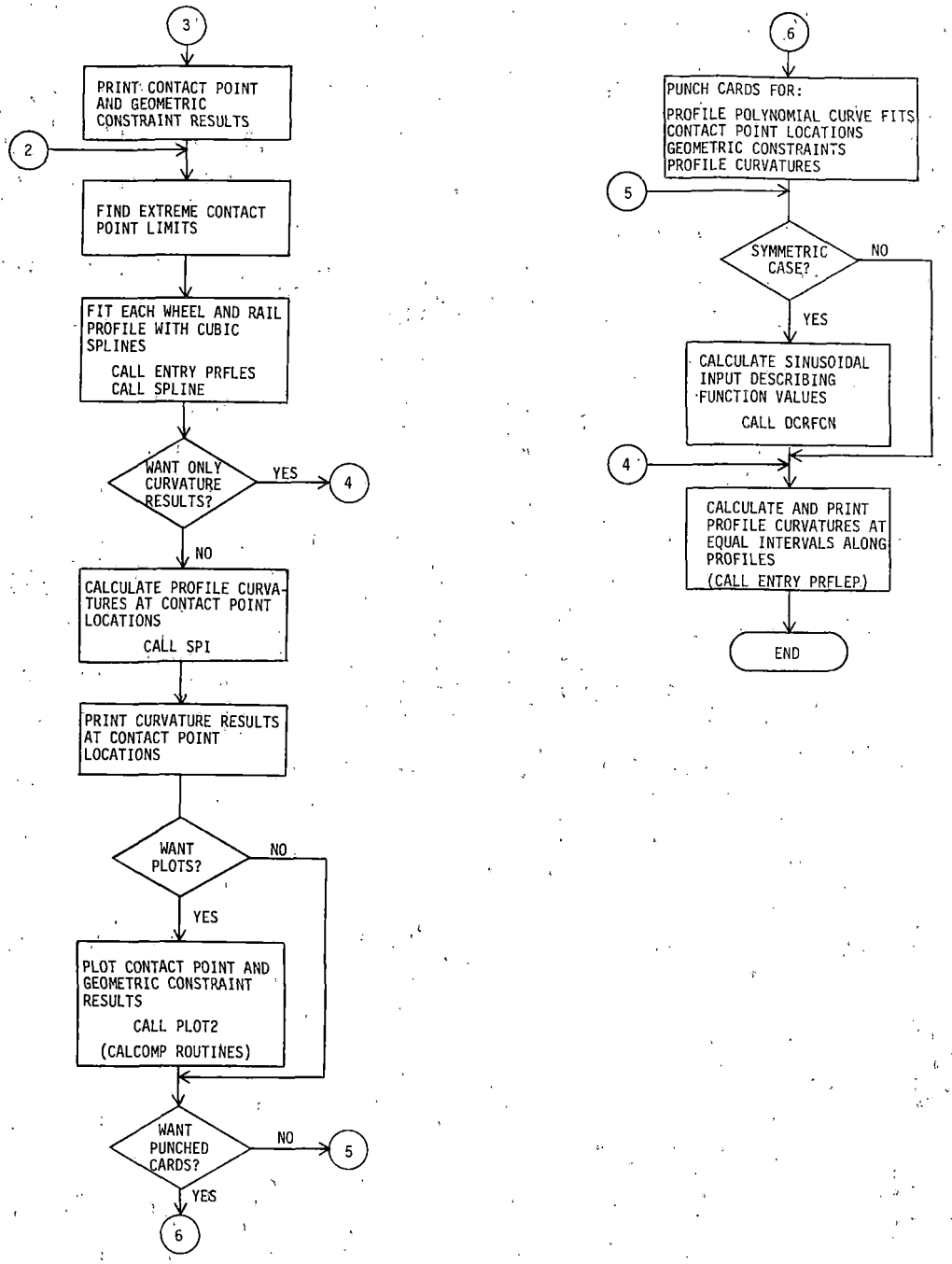


FIGURE 2 (continued). FLOWCHART, ASYMMETRIC WHEEL/RAIL CONTACT CHARACTERIZATION PROGRAM

PROGRAM LISTINGS

```
C  THE ASYMMETRIC WHEEL/RAIL CHARACTERIZATION PROGRAM - WHRAILA
C
C  WRITTEN AT ARIZONA STATE UNIVERSITY BY R. HULL, N. K. COOPERRIDER
C  REWRITTEN AT CLEMSON UNIVERSITY BY R. HELLER, C. H. CSTLING
C
C  SUPPORTED BY U. S. DEPT. OF TRANSPORTATION/FED. RAIL ADMINISTRATION
C  CONTRACT DOT-US-40018, PROGRAM DIRECTOR, E. HARRY LAW, CLEMSON UNIV.
C
C  FOR DESCRIPTION REFER TO:
C   1) HELLER, R., N. K. COOPERRIDER, "USERS' MANUAL FOR  ASYMMETRIC
C      WHEEL/RAIL CONTACT CHARACTERIZATION PROGRAM", FRA REPORT, AUG 1977
C   2) COOPERRIDER, N. K., E. H. LAW, R. HULL, P. S. KADALA, J. M. TUTEN,
C      "ANALYTICAL AND EXPERIMENTAL DETERMINATION OF NONLINEAR WHEEL/RAIL
C      GEOMETRIC CONSTRAINTS", REPORT NO. FRA-ORD 76-244, DEC 1975
C
C  FIBONACCI SEARCH VERSION
C  INCLUDES CALCOMP PLOTTING
C  INCLUDES PROFILE SPLINE FIT RADIUS OF CURVATURE CALCULATIONS
C  MODIFIED TO ALLOW MORE RUN OPTIONS
C  MODIFIED TO RUN WITH DOUBLE PRECISION
C
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION IRG(13),IWG(13),ICTR(13),ICTL(13)
      DIMENSION AR1C(244),AR2C(244),AR3C(244),AR4C(244),
     1 ARR1C(244),ARR3C(244),XI05(140)
      DIMENSION XJ1(50),YJ1(50),SJ1(50),XJ2(50),YJ2(50),SJ2(50),
     1 XJ3(50),YJ3(50),SJ3(50),XJ4(50),YJ4(50),SJ4(50)
C
      COMMON /COMA/ AW,AR,BR,BL,RR(30,5),YR(30,5),RL(30,5),YL(30,5),
     1 B1(30,2),B2(30,2),B3(30,2),B4(30,2),S1(5),S2(5),S3(5),S4(5),
     1AXW(244),AX1(244),AX2(244),AX3(244),AX4(244),AR1(244),AR2(244),
     1 AR3(244),AR4(244),AR5(244),AM1(244),AM2(244),AM3(244),AW1(244),
     1 AY1(244),NC1,NC2,NC3,NC4,ISYM
      COMMON /COMB/ YW1M,IFLANG
      COMMON /COMC/ IWHLR(13),IWHLL(13),IRAILR(13),IRAILL(13)
      COMMON /COMD/ XW1(200),YW1(200),XW2(200),YW2(200),NWR,NYR,
     1 XW3(200),YW3(200),XW4(200),YW4(200),NWL,NYL
      COMMON /COME/ XMINWR,XMINRR,XMINWL,XMINRL,XMAXWR,XMAXRR,
     1 XMAXWL,XMAXRL
      COMMON /COMF/ M1,M2,M3,M4,M5,M6,STEP,IPRT
C
      DATA XJ1,YJ1,SJ1,XJ2,YJ2,SJ2,XJ3,YJ3,SJ3,XJ4,YJ4,SJ4/600*0.0D0/
C
C*****MAXIMUM PROFILE PTS 200
C*****MAXIMUM NUMBER OF CURVE FITS 30
C*****MAXIMUM INCREMENTS OF XW IN POSITIVE DIRECTION 121
      PRINT 801
801   FORMAT(' THE ASYMMETRIC WHRAIL/RAIL CONTACT CHARACTERIZATION PROGR
     1AM'//' RUN OPTIONS SELECTED'/)
C
      READ(1,*)XWINC
      WRITE(3,1)XWINC
1     FORMAT(' ',T10,'XWINC=',F8.4/)
C  XWINC IS LATERAL INCREMENT OF WHEELSET CENTROID
C  NUMB OF PTS TO BE CALC MUST TAKE XWINC INTO ACCOUNT
C
      READ 30,ISYM,IPUNCH
      WRITE(3,2) ISYM,IPUNCH
 2    FORMAT(' ',T10,'ISYM=',I3,T25,'IPUNCH=',I2/)
 30   FORMAT(3I3)
C  ISYM=1 FOR SYMMETRIC CASE
C  ISYM=2 FOR SAME PROFILES ON BOTH WHEELS AND RAILS, BUT WITH
C  DIFFERENT RAIL CANTS.
C  IPUNCH=1 FOR PUNCH RESULTS
C
      READ 30,IPLOT,ICURV
      WRITE(3,33)IPLOT,ICURV
33    FORMAT(' ',T10,'IPLOT=',I2,T25,'ICURV=',I2/)
C  IPLOT=0 FOR NO CALCOMP PLOTTING (BYPASS PLOTTING ROUTINES)
C  ICURV=1 FOR ONLY PERFORMING PROFILE CURVATURE CALC (BYPASS CONTACT
C  POINT,GEOM CALC)
C
```

```
      READ 30,IFLANG
      WRITE(3,34)IFLANG
34    FORMAT(' ',T10,'IFLANG =',I2/)
C  IFLANG = 1 TO ADJUST LT WHEEL DATA SUCH THAT TOP OF FLANGE
C            ON LT WHEEL = RT WHEEL
C
      READ 30,NUMB,INC
      WRITE(3,31) NUMB,INC
31    FORMAT(' ',T10,'NUMB=',I3,T25,'INC=',I2)
      NUMBR=2.*NUMB
C NUMBR=NO OF PTS TO BE CALCULATED
C * NO OF PTS TO BE CALCULATED MUST BE LT 400, XW IS + OR - NUMBR*.01/2.
C * FIT A CURVE EVERY INC DATA PTS (SUGGEST INC=5)
C
      STEP=0.01
      IPRT=0
      M1=12
      M2=9
      M3=9
      M4=12
      M5=9
      M6=11
C     WRITE(3,3)STEP,IPRT,M1,M2,M3,M4,M5,M6
  3   FORMAT(/' ',T10,'STEP=',F8.4,T25,'IPRT=',I2//
     1 ' ',T10,'M1=',I3,9X,'M2=',I3,9X,'M3=',I3/
     1 ' ',T10,'M4=',I3,9X,'M5=',I3,9X,'M6=',I3)
C STEP = INCREMENT ALONG WHEEL PRFLE DURING CONTACT PT SEARCH
C        (SUGGEST STEP=0.01)
C M1, ... ,M6 ARE SIZES OF FIBONACCI SEARCHES
C A CHANGE TO STEP REQUIRES CORRESPONDING CHANGES TO M1,...M6.
C   STEP=.01  M1,...M6 =  12 9 9 12 9 11
C   STEP=.005 M1,...M6 =  14 10 10 14 10 12
C IPRT PRINTOUT SHOULD BE USED ONLY FOR PARTIAL RUNS (TESTING PURPOSES)
C IPRT=1 TO PRINT INFORMATION DURING CONTACT PT SEARCH (7000 LINES)
C IPRT=2 TO PRINT FIBONACCI CONTACT PT SEARCH PROCEDURE (>20000 LINES)
C
C WG=WHEEL GAGE, RG=RAIL GAGE, BR=BL=CANT OF RAILS
      READ(1,*)WG,RG,BR,BL
      PRINT 802
802   FORMAT(/' WHEEL GAUGE (IN), RAIL GAUGE (IN), RIGHT RAIL CANT (RAD)
     1, LEFT RAIL CANT (RAD)')
      WRITE(3,4)WG,RG,BR,BL
  4   FORMAT(/4F11.5/)
C
C *** READ A ONE LINE LABEL FOR THE TYPE OF RIGHT WHEEL
      READ 10,(IWHLR(I),I=1,13)
   10 FORMAT(13A4)
      PRINT 803
803   FORMAT(/' RIGHT WHEEL PROFILE INPUT DATA ',85('*')/)
      WRITE(3,12) (IWHLR(I),I=1,13)
   12 FORMAT(1X,13A4)
      READ(1,*)DTFR
      WRITE(3,5) DTFR
C ** DTFR=DIST FROM TAPELINE TO FLANGEBACK ON RIGHT WHEEL
      CALL PRFLE(NWR,XW1,YW1,NC1,RR,B1,INC,1)
      IF(ISYM.EQ.1.OR.ISYM.EQ.2) IFLANG  = 0
      IF(IFLANG.NE.1) GO TO 15
C FIND TOP OF FLANGE FOR RT WHEEL
      YW1M = YW1(1)
      DO 14 I = 2, NWR
      IF(YW1(I)-YW1M) 14,14,13
13    YW1M = YW1(I)
14    CONTINUE
15    CONTINUE
C
C *** READ A ONE LINE LABEL FOR TYPE OF RIGHT RAIL
      READ 10,(IRAILR(I),I=1,13)
      PRINT 804
804   FORMAT(//' RIGHT RAIL PROFILE INPUT DATA ',85('*')/)
      WRITE(3,12) (IRAILR(I),I=1,13)
      READ(1,*)DRWR
      WRITE(3,5) DRWR
```

```
C *** DRWR=1/2 RIGHT RAIL WIDTH AT 5/8 IN DOWN
      CALL PRFLE(NYR,XW2,YW2,NC2,YR,B2,INC,0)
C
C CHECK FOR SYMMETRIC CASE
      IF ((ISYM.NE.1).AND.(ISYM.NE.2)) GO TO 25
C USE THE SAME WHEEL PROFILE ON EITHER END OF THE WHEELSET
      NC3=NC1
      DO 60 I=1,NC1
      DO 50 J=1,5
      RL(I,J)=RR(I,J)
   50 CONTINUE
      B3(I,1)=B1(I,1)
      B3(I,2)=B1(I,2)
   60 CONTINUE
C USE THE SAME RAIL PROFILE ON EITHER SIDE OF THE TRACK
      NC4=NC2
      DO 80 I=1,NC2
      DO 70 J=1,5
      YL(I,J)=YR(I,J)
   70 CONTINUE
      B4(I,1)=B2(I,1)
      B4(I,2)=B2(I,2)
   80 CONTINUE
      NWL=NWR
      DO 90 I=1,NWR
      XW3(I)=XW1(I)
      YW3(I)=YW1(I)
   90 CONTINUE
      NYL=NYR
      DO 91 I=1,NYR
      XW4(I)=XW2(I)
      YW4(I)=YW2(I)
   91 CONTINUE
      DTFL=DTFR
      DRWL=DRWR
      DO 92 I=1,13
      IWHLL(I)=IWHLR(I)
      IRAILL(I)=IRAILR(I)
   92 CONTINUE
      GO TO 45
C
C *** READ A ONE LINE LABEL FOR THE TYPE OF LEFT WHEEL
   25 READ 10,(IWHLL(I),I=1,13)
      PRINT 805
805   FORMAT(//' LEFT WHEEL PROFILE INPUT DATA ',85('*')/)
      WRITE(3,12) (IWHLL(I),I=1,13)
      READ (1,*) DTFL
      WRITE(3,5) DTFL
      CALL PRFLE(NWL,XW3,YW3,NC3,RL,B3,INC,2)
C
C *** READ A ONE LINE LABEL FOR TYPE OF LEFT RAIL
      READ 10,(IRAILL(I),I=1,13)
      PRINT 806
806   FORMAT(//' LEFT RAIL  PROFILE INPUT DATA ',85('*')/)
      WRITE(3,12) (IRAILL(I),I=1,13)
      READ(1,*)DRWL
      WRITE(3,5) DRWL
      CALL PRFLE(NYL,XW4,YW4,NC4,YL,B4,INC,0)
    5 FORMAT(2F11.5)
C
C *** AW=SEMI WHEEL GAGE=1/2 DIST BETWEEN TAPE LINES
   45 AW=(WG+DTFR+DTFL)/2.
C *** AR=1/2 DIST FROM CENTER OF ONE RAIL TO CENTER OF THE OTHER
      AR=(RG+DRWR+DRWL)/2.
C
      XMINWR=XW1(NWR)
      XMINRR=XW2(NYR)
      XMINWL=XW3(NWL)
      XMINRL=XW4(NYL)
      XMAXWR=XW1(1)
      XMAXRR=XW2(1)
      XMAXWL=XW3(1)
      XMAXRL=XW4(1)
```

```
C
C  READ THE CANT, WHEEL GAGE, AND RAIL GAGE FOR USE ON CN OUTPUTTING
C  THEM IN THE PLOTTING ROUTINES
      READ(1,10)(ICTR(I),I=1,13)
      READ(1,10)(ICTL(I),I=1,13)
      READ(1,10)(IRG(I),I=1,13)
      READ(1,10)(IWG(I),I=1,13)
      WRITE(3,11) ICTL
      WRITE(3,11) ICTR
      WRITE(3,11) IRG
      WRITE(3,11) IWG
11    FORMAT(' ',13A4)
C
C  PRINT RESULTS OF PROFILE CURVE-FITTING
      PRINT 190
  190 FORMAT(1H1,21X,'*************** RESULTS *************** ')
      PRINT 195
  195 FORMAT(// 34X,'RIGHT SIDE'/)
C
C  PRINT MATHEMATICAL DESCRIPTIONS OF WHEELSET AND TRACK
      PRINT 200,IWHLR,WG,AW,INC
  200  FORMAT(12X,'WHEEL/RAIL CONTACT CHARACTERIZATION'// 9X,13A4/
     1 2X,'WHEEL GAGE=',F6.3/2X,'1/2 DIST BETWEEN TAPE LINES=',F6.3//
     1 5X,'CURVE FITS',3X,I2,' PTS/CURVE FIT ZONE'//14X,'0TH',12X,'1ST',
     1 12X,'2ND',12X,'3RD',12X,'4TH')
C
      DO 210 I=1,NC1
      PRINT 205,I,(RR(I,J),J=1,5),B1(I,1),B1(I,2)
  205 FORMAT(2X,I3,3X,5(D13.6,2X),3X,'FROM ',F8.4,' TO ',F7.4)
  210  CONTINUE
C
      PRINT 220,IRAILR,RG,AR,BR,INC
  220 FORMAT(//9X,13A4,//2X,'RAIL GAGE=',F6.3/2X,'1/2 DIST BETWEEN RAIL
     1 CENTERS=',F6.3,/2X,'RAIL CANT= ',F6.3,
     1      //5X,'CURVE FITS',3X,I2,' PTS/CURVE FIT ZONE'//14X,'0TH',
     1 12X,'1ST',12X,'2ND',12X,'3RD',12X,'4TH')
C
      DO 230 I=1,NC2
      PRINT 205,I,(YR(I,J),J=1,5),B2(I,1),B2(I,2)
  230 CONTINUE
      PRINT 231
  231 FORMAT (1H1,35X,'LEFT SIDE'/)
      PRINT 200,IWHLL,WG,AW,INC
      DO 234 I=1,NC3
      PRINT 205,I,(RL(I,J),J=1,5),B3(I,1),B3(I,2)
  234 CONTINUE
      PRINT 220,IRAILL,RG,AR,BL,INC
      DO 238 I=1,NC4
      PRINT 205,I,(YL(I,J),J=1,5),B4(I,1),B4(I,2)
  238 CONTINUE
C
C  PLOT TABULAR WHEEL AND RAIL DATA AND FITTED CURVES
      IF(IPLOT.EQ.0 .OR. ICURV.EQ.1) GO TO 236
      CALL PLOTS(0,0,0)
      CALL PLOT(0.,0.,3)
      CALL PLOTI(ICTR,ICTL,IWG,IRG)
236   CONTINUE
C
      IF(ICURV.EQ.1) GO TO 301
C  FINDS THE CONTACT PT LOCATIONS
      CALL EQSOLV(NUMBR,XW,INC)
C  FINDS THE GEOMETRIC CONSTRAINT RELATIONS
      CALL EQSUB2(NUMBR)
C
C  PRINT A TABLE OF MOST OF THE RESULTS
C
C  FOR ROLLING RADII CURVATURE PRINTOUT
      DO 239 I=1,NUMBR
      ARR1C(I)=DCOS(AM1(I))/AR1(I)
      ARR3C(I)=DCOS(AM2(I))/AR3(I)
239   CONTINUE
      PRINT 240
  240 FORMAT(1H1   2X,'*************** DATA POINTS ***************'/ )
```

```
      PRINT 810
810   FORMAT(' CONTACT POINTS, GEOMETRIC CONSTRAINTS, AND PROFILE CURVAT
     1URES'/' AS A FUNCTION OF WHEELSET LATERAL DISPLACEMENT'//
     1' XW = WHEELSET LATERAL, POSITIVE TO THE LEFT (IN)'/
     1' X1 = CONTACT LOCATION ON RIGHT WHEEL, POSITIVE OUT FROM TAPELINE
     1 (IN)'/
     1' X2 = CONTACT LOCATION ON RIGHT RAIL, POSITIVE OUT FROM CENTERLIN
     1E (IN)'/
     1' X3 = CONTACT LOCATION ON LEFT WHEEL, POSITIVE OUT FROM TAPELINE
     1 (IN)'/
     1' X4 = CONTACT LOCATION ON LEFT RAIL, POSITIVE OUT FROM CENTERLINE
     1 (IN)'/
     1' RR = ROLLING RADII, RIGHT WHEEL (IN)'/
     1' YR = RAIL HEAD PROFILE HEIGHT, RIGHT RAIL (IN)'/
     1' RL = ROLLING RADII, LEFT WHEEL (IN)'/
     1' YL = RAIL HEAD PROFILE HEIGHT, LEFT RAIL (IN)'/
     1' MR = CONTACT ANGLE W.R.T. AXLE, RIGHT WHEEL (RAD)'/
     1' ML = CONTACT ANGLE W.R.T. AXLE, LEFT WHEEL (RAD)')
      PRINT 815
815   FORMAT(' RR CRV = PRINCIPAL ROLLING CURVATURE OF RIGHT WHEEL PROFI
     1LE (1/IN)'/
     1' RL CRV = PRINCIPAL ROLLING CURVATURE OF LEFT WHEEL PROFILE (1/IN
     1)')
      PRINT 245
  245 FORMAT(/4X,'XW',7X,'X1',6X,'X2',6X,'X3',6X,'X4',7X,'RR',7X,'YR',
     1 7X,'RL',7X,'YL',9X,'MR',8X,'ML',7X,'RR CRV',4X,'RL CRV'/
     1 3X,'(IN)',5X,3('(IN)',4X),5('(IN)',5X),2X,
     1 2('(RAD)',5X),2('(1/IN)',4X)/)
      PRINT 250,(AXW(I),AX1(I),AX2(I),AX3(I),AX4(I),AR1(I),AR2(I),
     1 AR3(I),AR4(I),AM1(I),AM2(I),ARR1C(I),ARR3C(I),I=1,NUMBR)
  250 FORMAT(2X,F6.3,2X,F7.4,1X,F7.4,1X,F7.4,1X,F7.4,2X,F8.5,1X,F8.5,
     1 1X,F8.5,1X,F8.5,2X,F9.6,1X,F9.6,F11.6,F10.6)
C
C  CALCULATE PROFILE CURVATURES USING SPLINE FITS
C
C  FIND LTMOST (MOST NEG) & RTMOST (MOST POS) CP LOCATIONS
      AX1R = AX1(1)
      AX2L = AX2(1)
      AX2R = AX2(1)
      AX3R = AX3(1)
      AX4L = AX4(1)
      AX4R = AX4(1)
      DO 300 I = 2, NUMBR
      IF(AX1(I).GT.AX1R) AX1R = AX1(I)
      IF(AX2(I).LT.AX2L) AX2L = AX2(I)
      IF(AX2(I).GT.AX2R) AX2R = AX2(I)
      IF(AX3(I).GT.AX3R) AX3R = AX3(I)
      IF(AX4(I).LT.AX4L) AX4L = AX4(I)
      IF(AX4(I).GT.AX4R) AX4R = AX4(I)
  300 CONTINUE
      GO TO 303
C
C  SET THE LEFTMOST & RIGHTMOST PTS FOR CURV CALC WHEN ICURV=1
C  WHEEL: SET RT CURVE-FIT LIMIT AT 1ST PT LT OF 2.2 INCH
301   DO 701 I=1,NWR
      IF(XW1(I).LT.2.2) GO TO 702
701   CONTINUE
702   AX1R=XW1(I)
      DO 703 I=1,NWL
      IF(XW3(I).LT.2.2) GO TO 704
703   CONTINUE
704   AX3R=XW3(I)
C  RAIL: SET RT CURVE-FIT LIMIT AT 1ST PT WITH SLOPE LT 2.
C  RAIL: SET LT CURVE-FIT LIMIT AT 1ST PT BEFORE SLOPE GT 6.
      NR=NYR-1
      NL=NYL-1
      DO 705 I=1,NR
      IF(DABS((YW2(I+1)-YW2(I))/(XW2(I+1)-XW2(I))).LT.2.) GO TO 706
705   CONTINUE
706   AX2R=XW2(I)
      DO 707 I=1,NR
      IF(DABS((YW2(I+1)-YW2(I))/(XW2(I+1)-XW2(I))).GT.6.) GO TO 708
```

```
707   CONTINUE
      I=NYR
708   AX2L=XW2(I)
      DO 709 I=1,NL
      IF(DABS((YW4(I+1)-YW4(I))/(XW4(I+1)-XW4(I))).LT.2.) GO TO 710
709   CONTINUE
710   AX4R=XW4(I)
      DO 711 I=1,NL
      IF(DABS((YW4(I+1)-YW4(I))/(XW4(I+1)-XW4(I))).GT.6.) GO TO 712
711   CONTINUE
      I=NYL
712   AX4L=XW4(I)
303   CONTINUE
C
C FIT PROFILES WITH CUBIC SPLINES
C RIGHT WHEEL SPLINE FIT
      CALL PRFLES(NWR,XW1,YW1,NJ1,XJ1,YJ1,1,AX1R,AX1R)
      CALL SPLINE(NJ1,XJ1,YJ1,SJ1,0)
C RIGHT RAIL SPLINE FIT
      CALL PRFLES(NYR,XW2,YW2,NJ2,XJ2,YJ2,0,AX2R,AX2L)
      CALL SPLINE(NJ2,XJ2,YJ2,SJ2,0)
C LEFT WHEEL SPLINE FIT
      CALL PRFLES(NWL,XW3,YW3,NJ3,XJ3,YJ3,1,AX3R,AX3R)
      CALL SPLINE(NJ3,XJ3,YJ3,SJ3,0)
C LEFT RAIL SPLINE FIT
      CALL PRFLES(NYL,XW4,YW4,NJ4,XJ4,YJ4,0,AX4R,AX4L)
      CALL SPLINE(NJ4,XJ4,YJ4,SJ4,0)
302   CONTINUE
      IF(ICURV.EQ.1) GO TO 401
C
C INTERPOLATE ALONG SPLINE FITS TO FIND PRFLE CRV AT THE CONTACT PT LOC
C CURVATURES ARE POSITIVE IF CENTER OF CURVATURE IS WITHIN BODY
      DO 304 I=1,NUMBR
      CALL SPLC(NJ1,XJ1,YJ1,SJ1,AX1(I),AR1C(I))
      CALL SPLC(NJ2,XJ2,YJ2,SJ2,AX2(I),AR2C(I))
      CALL SPLC(NJ3,XJ3,YJ3,SJ3,AX3(I),AR3C(I))
      CALL SPLC(NJ4,XJ4,YJ4,SJ4,AX4(I),AR4C(I))
304   CONTINUE
C
      PRINT 820
820   FORMAT('1(RL-RR)/2A = NORMALIZED DIFFERENCE IN ROLLING RADII (IN/I
     1N)'/
     1' (ML-MR)/2 = NORMALIZED DIFFERENCE IN CONTACT ANGLES (RAD)'/
     1' WR        = WHEELSET ROLL ANGLE W.R.T. HORIZONTAL, POSITIVE UP O
     1N LEFT (RAD)'/
     1' YCG       = VERTICAL DISPLACEMENT OF WHEELSET CENTROID FROM NOMI
     1NAL POS. (IN)')
      PRINT 830
830   FORMAT(' CWR         = PRINCIPAL TRANSVERSE CURVATURE OF RIGHT WHEE
     1L PROFILE,'/13X,'POSITIVE FOR CURVATURE CENTER IN BODY (1/IN)'/
     1' CYR       = PRINCIPAL TRANSVERSE CURVATURE OF RIGHT RAIL PROFILE
     1,'/13X,'POSITIVE FOR CURVATURE CENTER IN BODY (1/IN)'/
     1' CWL       = PRINCIPAL TRANSVERSE CURVATURE OF LEFT WHEEL PROFILE
     1,'/13X,'POSITIVE FOR CURVATURE CENTER IN BODY (1/IN)'/
     1' CYL       = PRINCIPAL TRANSVERSE CURVATURE OF LEFT RAIL PROFILE,
     1' /13X,'POSITIVE FOR CURVATURE CENTER IN BODY (1/IN)'/)
      PRINT 255
  255 FORMAT(  4X,'XW',4X,'(RL-RR)/2A',1X,'(ML-MR)/2',
     1 6X,'WR',8X,'YCG',8X,'CWR',8X,'CYR',8X,'CWL',8X,'CYL'/
     1 3X,'(IN)',4X,'(IN/IN)',5X,'(RAD)',7X,'(RAD)',6X,
     1 '(IN)',6X,4('(1/IN)',5X)/)
      DO 256 I=1,NUMBR
      PRINT 260,AXW(I),AR5(I),AM3(I),AW1(I),AY1(I),
     1 AR1C(I),AR2C(I),AR3C(I),AR4C(I)
  256 CONTINUE
  260 FORMAT(2X,F6.3,8F11.6)
C
      IF(IPLOT.EQ.0)                    GO TO 265
C PLOT THE C.P. LOCATIONS AND THE GEOMETRIC CONSTRAINT RELATIONS
      CALL PLOT2(NUMBR,ICTR,ICTL)
C PLOTTER CONTROL CARD, VARIES WITH COMPUTER
      CALL PLOT(0.,0.,999)
```

```
C
265   CONTINUE
      IF(IPUNCH.NE.1) GO TO 400
C OUTPUT RESULTS ON CARDS
      PUNCH 345,WG,AW,RG,AR,BR,BL
      PUNCH 18
18    FORMAT(/' COEFFICIENTS FOR PROFILE CURVE FITS')
      PUNCH 19,(IWHLR(I),I=1,13)
19    FORMAT(/13A4)
      PUNCH 335,NC1
      DO 322 I=1,NC1
      PUNCH 340 ,I,(RR(I,J),J=1,5),B1(I,1),B1(I,2)
  322 CONTINUE
      PUNCH 19,(IRAILR(I),I=1,13)
      PUNCH 335,NC2
      DO 323 I=1,NC2
      PUNCH 340,I,(YR(I,J),J=1,5),B2(I,1),B2(I,2)
  323 CONTINUE
      PUNCH 19,(IWHLL(I),I=1,13)
      PUNCH 335,NC3
      DO 324 I=1,NC3
      PUNCH 340,I,(RL(I,J),J=1,5),B3(I,1),B3(I,2)
  324 CONTINUE
      PUNCH 19,(IRAILL(I),I=1,13)
      PUNCH 335,NC4
      DO 325 I=1,NC4
      PUNCH 340,I,(YL(I,J),J=1,5),B4(I,1),B4(I,2)
  325 CONTINUE
      PUNCH 398
398   FORMAT(/'THE DATA IS ORDERED AS FOLLOWS:'/)
      PUNCH 810
      PUNCH 820
      PUNCH 815
      PUNCH 830
      PUNCH 30 ,NUMBR,INC
      PUNCH 330,(AXW(I),AX1(I),AX2(I),AX3(I),AX4(I),AR1(I),AR2(I),
     1 AR3(I),AR4(I),AM1(I),AM2(I),AR5(I),AM3(I),AW1(I),AY1(I),
     1 ARR1C(I),ARR3C(I),AR1C(I),AR2C(I),AR3C(I),AR4C(I),I=1,NUMBR)
  330 FORMAT(6E13.6/6E13.6/3E13.6/6E13.6)
  335 FORMAT(I3)
  340 FORMAT(I3,5E13.6/2E13.6)
345   FORMAT(6E12.5)
  400 CONTINUE
C
C COMPUTE DESCRIBING FUNCTIONS OF SOME OF THE RELATIONS AND PRINT
C RESULTS.  ONLY VALID FOR SYMMETRICAL CASE.
      IF(ISYM.NE.1) GO TO 401
      CALL DCRFCN(NUMBR,AXW,AR5,AM3,AW1,AR)
401   CONTINUE
C
C PRINT CURVATURES AT EQUAL INTERVALS ALONG PROFILES
      XI05(1) = -3.50 D0
      DO 410 I = 2, 140
410   XI05(I) = XI05(I-1) + 0.05 D0
C ZERO OUT AX1,...,AX4 ARRAYS TO REUSE
      DO 411 I=1,244
      AX1(I)=0.0D0
      AX2(I)=0.0D0
      AX3(I)=0.0D0
      AX4(I)=0.0D0
411   CONTINUE
C FIND POINTS AT 0.05" INCREMENTS ALONG PROFILES
      CALL PRFLEP(NWR,XW1,XI05,AX1)
      CALL PRFLEP(NYR,XW2,XI05,AX2)
      CALL PRFLEP(NWL,XW3,XI05,AX3)
      CALL PRFLEP(NYL,XW4,XI05,AX4)
C INTERPOLATE TO FIND PRFLE CRV'S AT THESE POINTS
      DO 412 I = 1, NWR
412   CALL SPIC(NJ1,XJ1,YJ1,SJ1,AX1(I),AR1C(I))
      DO 414 I = 1, NYR
414   CALL SPIC(NJ2,XJ2,YJ2,SJ2,AX2(I),AR2C(I))
      DO 416 I = 1,NWL
```

```
      CALL SPLC(NJ3,XJ3,YJ3,SJ3,AX3(I),AR3C(I))
      DO 418 I = 1,NYL
418   CALL SPLC(NJ4,XJ4,YJ4,SJ4,AX4(I),AR4C(I))
C ZERO OUT UNUSED PORTION OF CURVATURE ARRAYS
      DO 420 I = 1,100
      AR1C(NWR + I) = 0.0D0
      AR2C(NYR + I) = 0.0D0
      AR3C(NWL + I) = 0.0D0
      AR4C(NYL + I) = 0.0D0
420   CONTINUE
C PRINT OUT PROFILE CURVATURE ARRAYS
      N = NWR
      IF(NYR.GT.N) N = NYR
      IF(NWL.GT.N) N = NWL
      IF(NYL.GT.N) N = NYL
      PRINT 840
840   FORMAT('1PROFILE PRINCIPAL TRANSVERSE CURVATURES (1/IN)'//
     1' XWR= LOCATION ON RIGHT WHEEL, POSITIVE OUT FROM TAPELINE (IN)'/
     1' XRR= LOCATION ON RIGHT RAIL, POSITIVE OUT FROM CENTERLINE (IN)'/
     1' XWL= LOCATION ON LEFT WHEEL, POSITIVE OUT FROM TAPELINE (IN)'/
     1' XRL= LOCATION ON LEFT RAIL, POSITIVE OUT FROM CENTERLINE (IN)')
      PRINT 830
      PRINT 430
430   FORMAT(//6X,'XWR',7X,'CWR',9X,'XRR',7X,'CYR',
     1 9X,'XWL',7X,'CWL',9X,'XRL',7X,'CYL'/
     1 6X,'(IN)',5X,'(1/IN)',3(7X,'(IN)',5X,'(1/IN)')/)
      PRINT 440,(AX1(I),AR1C(I),AX2(I),AR2C(I),
     1 AX3(I),AR3C(I),AX4(I),AR4C(I),I=1,N)
440   FORMAT(4(3X,F8.5,F11.6))
      STOP
      END
```

```
      SUBROUTINE PRFLE(NW,XW,YW,NC,RR,XB,INC,IW)
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION XW(1),YW(1),RR(30,1),XB(30,1),
     1 F1(200),F2(200),F3(200),SS(5)
      DIMENSION XJ(1),YJ(1)
      DIMENSION XI(1),AX(1)
      COMMON /COMB/ YW1M,IFLANG
C
C     INPUT
C    NW=NO OF DATA PTS
C    DATA MUST BE IN ORDER STARTING WITH POSITIVE X
C ITWO=1 FOR TWO (X,Y) COORDINATES PER INPUT CARD
C INEG=1 FOR CHANGING SIGN OF INPUT Y COORDINATE
C IW = 0 IS RAIL, IW = 1 IS RT WHEEL, IW = 2 IS LT WHEEL
10    FORMAT(1X,3I3)
15    FORMAT(10X,2D15.7)
      READ(1,*) NW
      WRITE(3,10) NW
C DECIDE WHICH FORMAT FOR INPUT CARDS
      READ(1,*)ITWO,INEG
21    WRITE(3,*)ITWO,INEG
      IF(ITWO.EQ.1) GO TO 3
      READ 15,(XW(I),YW(I),I=1,NW)
      GO TO 6
3     DO 4 I=1,NW,2
      M=I+1
4     READ(1,*)  XW(I),YW(I),XW(M),YW(M)
      IF(INEG.NE.1) GO TO 6
      DO 7 I=1,NW
7     YW(I)=-YW(I)
6     CONTINUE
C CHECK IF PRFLE CARDS ARE IN ORDER
      NW1 = NW - 1
      DO 31 I = 1, NW1
      IF(XW(I+1).GT.XW(I))GO TO 32
31    CONTINUE
      GO TO 34
32    JJ=I+1
      WRITE(3,33) XW(JJ)
33    FORMAT(//25('*'),'  WARNING  ',25('*')/
     1 5('*'),' PROFILE INPUT CARDS NOT IN DECENDING ',
     2'ORDER AT X COORDINATE =',F12.6,5('*')/
     3 5('*'),' INVALID CURVE FIT IN THE CURVE FIT REGION CONTAINING ',
     4'THAT POINT ',5('*')//)
34    CONTINUE
      IF(IFLANG.NE.1) GO TO 17
      IF(IW.NE.2) GO TO 17
C FOR ASYMMETRIC CASE, MAKE TOP OF FLANGE ON LT WH = RT WH
C FIND TOP OF FLANGE OF LT WHEEL
      YW3M = YW(1)
      DO 13 I = 2,NW
      IF(YW(I) - YW3M) 13,13,12
12    YW3M = YW(I)
13    CONTINUE
C ADJUST LT WH DATA AND PRINT NOTE
      YWD = YW1M - YW3M
      DO 14 I = 1,NW
14    YW(I) = YW(I) + YWD
      WRITE(3,16) YWD
16    FORMAT(' TO EQUATE TOP OF WHEEL FLANGES ON LEFT ',
     1'AND RIGHT, LEFT WHEEL ROLLING RADII DATA HAVE BEEN ',
     1'ADJUSTED BY',F11.6,' INCH')
17    CONTINUE
      WRITE(3,19) (I,XW(I),YW(I),I=1,NW)
19    FORMAT(I4,4X,2D15.7)
C    DECIDE THE NO OF CURVE FITS, NC, TO USE
C    FIT A CURVE EVERY INC DATA PTS
      NC=NW/INC
      IF((NW-INC*NC).GE.3)NC=NC+1
      IF(NC.LT.3) PRINT 18
   18 FORMAT(2X,'*** ERROR *** TOO LARGE AN INCREMENT OR NOT ENOUGH DATA
     1 PTS')
```

```
C     FIT FIRST CURVE
C     XB(I,1)=UPPER LIMIT OF CURVEFIT
C     XB(I,2)=LOWER LIMIT
        XB(1,1)=200.
        XB(1,2)=XW(INC)
        J=INC+3
        DO 20 I=1,J
        F1(I)=XW(I)
        F2(I)=YW(I)
   20 CONTINUE
        CALL CRVFT(J,0,F1,F2,F3,SS)
        DO 25 I=1,5
        RR(1,I)=SS(I)
   25 CONTINUE
C     FIT OTHER CURVES
        NC1=NC-1
        DO 100 II=2,NC1
        J=II-1
        XB(II,1)=XB(J,2)
        J=INC*II
        XB(II,2)=XW(J)
        J=(II-1)*INC-2
        K=II*INC+3
        L=0
        DO 40 I=J,K
        L=L+1
        F1(L)=XW(I)
        F2(L)=YW(I)
   40 CONTINUE
        CALL CRVFT(L,0,F1,F2,F3,SS)
        DO 45 I=1,5
        RR(II,I)=SS(I)
   45 CONTINUE
  100 CONTINUE
C     FIT LAST CURVE
        XB(NC,1)=XB(NC1,2)
        XB(NC,2)=XW(NW)
        K=0
        J=NC1*INC-2
        DO 150 I=J,NW
        K=K+1
        F1(K)=XW(I)
        F2(K)=YW(I)
  150 CONTINUE
        CALL CRVFT(K,0,F1,F2,F3,SS)
        DO 155 I=1,5
        RR(NC,I)=SS(I)
  155 CONTINUE
        RETURN
C
C  SET UP JT ARRAYS FOR SPLINE FIT CALC OF RAD OF CURV
C
        ENTRY PRFLES(NP,XW,YW,NJ,XJ,YJ,IW,XR,XL)
C  REARRANGE PRFLE PTS SO THAT XW(I) < XW(I+1)
C  F1,F2 USED AS TEMP STORAGE ARRAYS
        DO 50 I=1,NP
        J = 1 + NP - I
        F1(I) = XW(J)
   50 F2(I) = YW(J)
        DO 55 I=1,NP
        XW(I) = F1(I)
   55 YW(I) = F2(I)
C
        IF(IW.EQ.0) GO TO 80
C  TOP OF FLANGE SEARCH
        YWM=YW(1)
        M=1
        DO 65 I=2,NP
        IF(YW(I)-YWM) 65,65,60
60      YWM=YW(I)
        XWM=XW(I)
        M=I
```

```
65      CONTINUE
C USE ONLY CONTACT PORTION OF WHEEL PROFILE FOR SPLINE FIT
        DO 70 I=1,NP
        XW(I)=XW(M)
        YW(I)=YW(M)
        IF(XW(I).GE.XW(NP)) GO TO 75
        IF(XW(I).GT.XR.AND.XW(I).GT.2.00) GO TO 75
70      M=M+1
75      NP=I
C SPECIFY REGIONS AND INCREMENTS ALONG WHEEL PRFLE TO PLACE JOINTS
        XREG1=-1.6000
        XREG2=-0.9500
        XJINC1=0.1500
        XJINC2=0.3000
        XJINC3=0.5000
        GO TO 99
C USE ONLY CONTACT PORTION OF RAIL  PROFILE FOR SPLINE FIT
80      DO 85 I=1,NP
        IF(XL.LT.XW(I)) GO TO 90
85      CONTINUE
90      L=I-1
        DO 95 I=1,NP
        XW(I)=XW(L)
        YW(I)=YW(L)
        IF(XW(I).GE.XW(NP)) GO TO 96
        IF(XW(I).GT.XR.AND.XW(I).GT.1.00) GO TO 96
95      L=L+1
96      NP=I
C SPECIFY REGIONS AND INCREMENTS ALONG RAIL  PRFLE TO PLACE JOINTS
        XREG1=-1.2000
        XREG2=-0.7000
        XJINC1=0.1000
        XJINC2=0.2000
        XJINC3=0.4000
C
99      CONTINUE
        NP1=NP+1
        DO 101 I=NP1,200
        XW(I)=0.000
101     YW(I)=0.000
C
C SET UP SPLINE JOINT COORDINATES
        DO 106 I=1,99
        XJ(I)=0.000
106     YJ(I)=0.000
        J=1
        DO 110 I=1,NP
        XJ(I)=XW(J)
        YJ(I)=YW(J)
        XJNEXT=XJ(I)+XJINC1
        IF(XJNEXT.GE.XREG1) XJNEXT=XJ(I)+XJINC2
        IF(XJNEXT.GE.XREG2) XJNEXT=XJ(I)+XJINC3
        IF(XJNEXT.GE.XW(NP)) GO TO 120
        SMDIF=100.
        DO 116 K=1,NP
        DIFXJ=DABS(XW(J+K)-XJNEXT)
        IF(DIFXJ-SMDIF) 115,117,117
115     SMDIF=DIFXJ
116     CONTINUE
117     J=J+K-1
110     CONTINUE
120     K=I+1
        IF(XJ(I).EQ.XW(NP)) K=I
        XJ(K)=XW(NP)
        YJ(K)=YW(NP)
        NJ=K
        RETURN
C
```

```
C  SET UP X PRINT ARRAY FOR FINAL PRT OF PRFLE CRV
C
      ENTRY PRFLEP(NP,XW,XI,AX)
      DO 151 I = 1,140
      IF(XW(1).LE.XI(I)) GO TO 160
151   CONTINUE
160   AX(1) = XW(1)
      DO 170 J = 2,140
      AX(J) = XI(I)
      IF(AX(J).GE.XW(NP)) GO TO 180
170   I = I + 1
180   AX(J) = XW(NP)
      NP = J
      RETURN
      END
```

```
      SUBROUTINE CRVFIT(N,L,X,Y,W,A)
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION X(1),Y(1),W(1),A(1)
      DIMENSION C(5),ALPHA(4),BETA(4),T1(402),T2(402),T3(402)
      J=0
      K=4
C  FIT CURVE
      CALL ORTHLS(X,Y,W,N,L,J,C,ALPHA,BETA,K,T1,T2,T3,IND1)
C  GET COEFFICIENTS OF THE CURVE
      CALL COEFS(J,C,ALPHA,BETA,K,A,T1,T2,T3,IND2)
      RETURN
      END
```

```
      SUBROUTINE ORTHLS (X,Y,W,N,L,J,C,ALPHA,BETA,K,T1,T2,T3,IND1)
      IMPLICIT REAL*8(A-H,O-Z)
C-----------------------------------------------------------------------
C     THIS SUBROUTINE COMPUTES THE COEFFICIENTS OF THE POLYNOMIAL
C     EQUATION OF DEGREE K AND THE ALPHA AND BETA PARAMETERS.
C-----------------------------------------------------------------------
      DIMENSION X(N),Y(N),W(N),C(K),ALPHA(K),BETA(K),T1(N),T2(N),T3(N)
C-----------------------------------------------------------------------
C     PROGRAM INITIALIZATION.
C-----------------------------------------------------------------------
      KJ1=K-J+1
      IF (KJ1.LE.0) GO TO 16
      SUM=0.0
      IF (L.EQ.1) GO TO 3
      DO 2 I=1,N
      T3(I)=X(I)
      IF (J.GT.0) GO TO 1
      SUM=SUM+1.0
      GO TO 2
    1 SUM=SUM+X(I)**(2*J)
    2 W(I)=1.0
      GO TO 7
    3 DO 6 I=1,N
      T3(I)=X(I)
      IF (J.GT.0) GO TO 4
      SUM=SUM+W(I)
      GO TO 5
    4 SUM=SUM+W(I)*X(I)**(2*J)
    5 X(I)=W(I)*X(I)
    6 Y(I)=W(I)*Y(I)
    7 B=0.0
      RC=SUM
      DO 9 I=1,N
      IF (J.GT.0) GO TO 8
      T2(I)=1.0
      GO TO 9
    8 T2(I)=T3(I)**J
    9 T1(I)=0.0
C-----------------------------------------------------------------------
C     BEGIN COMPUTATION.
C-----------------------------------------------------------------------
      II=1
   10 S=0.0
      DO 11 I=1,N
   11 S=S+Y(I)*T2(I)
C-----------------------------------------------------------------------
C     COMPUTATION OF A COEFFICIENT IN THE POLYNOMIAL EQUATION.
C-----------------------------------------------------------------------
      C(II)=S/RC
      IF (II.GE.KJ1) GO TO 15
C-----------------------------------------------------------------------
C     COMPUTATION OF AN ALPHA FOR THE POLYNOMIAL EQUATION.
C-----------------------------------------------------------------------
      SUMXPS=0.0
      DO 12 I=1,N
   12 SUMXPS=SUMXPS+X(I)*T2(I)*T2(I)
      ALPHA(II)=SUMXPS/RC
C-----------------------------------------------------------------------
C     COMPUTATION OF A NEW POLYNOMIAL.
C-----------------------------------------------------------------------
      DO 13 I=1,N
      TEMP=T2(I)
      T2(I)=(T3(I)-ALPHA(II))*T2(I)-B*T1(I)
   13 T1(I)=TEMP
C-----------------------------------------------------------------------
C     COMPUTATION OF A BETA FOR THE POLYNOMIAL EQUATION.
C-----------------------------------------------------------------------
      R=0.0
      DO 14 I=1,N
   14 R=R+W(I)*T2(I)*T2(I)
      BETA(II)=R/RC
      RC=R
```

```
      B=BETA(II)
      II=II+1
      GO TO 10
C-----------------------------------------------------------------------
C     SUCCESSFUL RETURN.
C-----------------------------------------------------------------------
   15 IND1=+1
      RETURN
C-----------------------------------------------------------------------
C     ERROR RETURN.  SET ALL C COEFFICIENTS, ALPHA AND BETA TO ZERO.
C-----------------------------------------------------------------------
   16 DO 17 II=1,K
      C(II)=0.0
      ALPHA(II)=0.0
   17 BETA(II)=0.0
      C(K+1)=0.0
      IND1=-1
      RETURN
      END
```

```
      SUBROUTINE COEFS (J,C,ALPHA,BETA,KC,A,T1,T2,T3,IND2)
      IMPLICIT REAL*8(A-H,O-Z)
C-----------------------------------------------------------------------
C     THIS SUBROUTINE COMPUTES THE A COEFFICIENTS FOR A POLYNOMIAL
C     OF DEGREE KC WHERE KC IS LESS THAN OR EQUAL TO K.
C-----------------------------------------------------------------------
      DIMENSION C(KC),ALPHA(KC),BETA(KC),A(KC),T1(KC),T2(KC),T3(KC)
C-----------------------------------------------------------------------
C     PROGRAM INITIALIZATION.
C-----------------------------------------------------------------------
      KCJ1=KC-J+1
      IF(KCJ1.LE.0) GO TO 9
      B=0.0
      DO 1 NN=1,KCJ1
      A(NN)=C(NN)
      T1(NN)=0.0
      T2(NN)=0.0
    1 T3(NN)=0.0
      IF (KC.LE.J) GO TO 5
      II=2
C-----------------------------------------------------------------------
C     BEGIN COMPUTATION.
C-----------------------------------------------------------------------
    2 T2(II)=1.0
      DO 3 NN=2,II
      T3(NN)=T2(NN-1)-T2(NN)*ALPHA(II-1)-B*T1(NN)
C-----------------------------------------------------------------------
C     COMPUTATION OF AN A COEFFICIENT.
C-----------------------------------------------------------------------
    3 A(NN-1)=A(NN-1)+C(II)*T3(NN)
      IF (II.GE.KCJ1) GO TO 5
C-----------------------------------------------------------------------
C     RESETTING THE VECTORS FOR THE NEXT COEFFICIENT.
C-----------------------------------------------------------------------
      DO 4 NN=1,II
      T1(NN)=T2(NN)
    4 T2(NN)=T3(NN)
      B=BETA(II-1)
      II=II+1
      GO TO 2
    5 IF (J.LE.0) GO TO 8
C-----------------------------------------------------------------------
C      ARRANGE COEFFICIENTS PROPERLY IF J IS NON ZERO.
C-----------------------------------------------------------------------
      DO 6 NN=1,KCJ1
      N1=KCJ1-NN+1
      N2=N1+J
    6 A(N2)=A(N1)
      DO 7 NN=1,J
    7 A(NN)=0.0
C-----------------------------------------------------------------------
C     SUCCESSFUL RETURN.
C-----------------------------------------------------------------------
    8 IND2=+2
      RETURN
C-----------------------------------------------------------------------
C      ERROR RETURN.  SET ALL THE A COEFFICIENTS EQUAL TO ZERO.
C-----------------------------------------------------------------------
    9 DO 10 NN=1,KC
   10 A(NN)=0.0
      A(KC+1)=0.0
      IND2=-2
      RETURN
      END
```

```
      SUBROUTINE PLOT1(ICTR,ICTL,IWG,IRG)
      IMPLICIT REAL*8(A-H,O-Z)
C
      REAL SAXW(244),SAX1(244),SAX2(244),SAX3(244),SAX4(244),
     1SXW1(244),SXW2(244),SXW3(244),SXW4(244),
     1SYW1(244),SYW2(244),SYW3(244),SYW4(244),
     1SAR1(244),SAR2(244),SAR3(244),SAR4(244)
      COMMON /COMA/ AW,AR,BR,BL,RR(30,5),YR(30,5),RL(30,5),YL(30,5),
     1 B1(30,2),B2(30,2),B3(30,2),B4(30,2),S1(5),S2(5),S3(5),S4(5),
     1 AXW(244),AX1(244),AX2(244),AX3(244),AX4(244),AR1(244),AR2(244),
     1 AR3(244),AR4(244),AR5(244),AM1(244),AM2(244),AM3(244),AW1(244),
     1 AY1(244),NC1,NC2,NC3,NC4
      DIMENSION ICTR(13),ICTL(13),IWG(13),IRG(13)
C
      COMMON /COMC/ IWHLR(13),IWHLL(13),IRAILR(13),IRAILL(13)
C
      COMMON /COMD/ XW1(200),YW1(200),XW2(200),YW2(200),NWR,NYR,
     1 XW3(200),YW3(200),XW4(200),YW4(200),NWL,NYL
C
C CALCULATE AN ARRAY OF PTS FROM POLYNOMIALS FIT TO WHEEL PROFILE
      CALL GTPTS(XW1(1),XW1(NWR),RR,B1,NC1,AX1,AR1,S1,NUR)
      CALL GTPTS(XW3(1),XW3(NWL),RL,B3,NC3,AX3,AR3,S3,NUL)
C CALCULATE AN ARRAY OF PTS FROM POLYNOMIALS FIT TO RAIL PROFILE
      CALL GTPTS(XW2(1),XW2(NYR),YR,B2,NC2,AX2,AR2,S2,NBR)
      CALL GTPTS(XW4(1),XW4(NYL),YL,B4,NC4,AX4,AR4,S4,NBL)
C
C DEFINE STARTING AND DELTX VALUES FOR PLOTS
      NWR1=NWR+1
      NWR2=NWR+2
      NYR1=NYR+1
      NYR2=NYR+2
      NWL1=NWL+1
      NWL2=NWL+2
      NYL1=NYL+1
      NYL2=NYL+2
      XW1(NWR1)=0.
      YW1(NWR1)=0.
      XW2(NYR1)=0.
      YW2(NYR1)=0.
      XW1(NWR2)=1.
      YW1(NWR2)=1.
      XW2(NYR2)=1.
      YW2(NYR2)=1.
      XW3(NWL1)=0.
      YW3(NWL1)=0.
      XW4(NYL1)=0.
      YW4(NYL1)=0.
      XW3(NWL2)=1.
      YW3(NWL2)=1.
      XW4(NYL2)=1.
      YW4(NYL2)=1.
      NBR1=NBR+1
      NBR2=NBR+2
      NUR1=NUR+1
      NUR2=NUR+2
      NUL1=NUL+1
      NUL2=NUL+2
      NBL1=NBL+1
      NBL2=NBL+2
      AX1(NUR1)=0.
      AR1(NUR1)=0.
      AR2(NBR1)=0.
      AX2(NBR1)=0.
      AX1(NUR2)=1.
      AR1(NUR2)=-1.
      AR2(NBR2)=1.
      AX2(NBR2)=1.
      AX3(NUL1)=0.
      AR3(NUL1)=0.
      AR4(NBL1)=0.
      AX4(NBL1)=0.
      AX3(NUL2)=1.
```

```
      AR3(NUL2)=-1.
      AR4(NBL2)=1.
      AX4(NBL2)=1
C
C  SUBTRACT CONSTANT TERMS FROM DATA POINTS TO REDUCE MAGNITUDES
      CSTW=DBLE((AINT(SNGL(AR1(NUR/2)*10.)))/10.)
      CSTR=DBLE((AINT(SNGL(AR2(NBR/2)*10.)))/10.)
      DO 10 I=1,NUR
      AR1(I)=AR1(I)-CSTW
   10 CONTINUE
      DO 11 I=1,NUL
      AR3(I)=AR3(I)-CSTW
   11 CONTINUE
      DO 15 I=1,NBR
      AR2(I)=AR2(I)-CSTR
   15 CONTINUE
      DO 16 I=1, NBL
      AR4(I)=AR4(I)-CSTR
   16 CONTINUE
      DO 20 I=1,NWR
      YW1(I)=-YW1(I)+CSTW
   20 CONTINUE
      DO 21 I=1, NWL
      YW3(I)=-YW3(I)+CSTW
   21 CONTINUE
      DO 30 I=1,NYR
      YW2(I)=YW2(I)-CSTR
   30 CONTINUE
      DO 31 I=1,NYL
      YW4(I)=YW4(I)-CSTR
   31 CONTINUE
C
C  ** CHANGE DOUBLE PRECISION ARRAYS TO SINGLE PRECISION FOR PLOTTING
      DO 40 I=1,244
      SAXW(I)=SNGL(AXW(I))
      SAX1(I)=SNGL(AX1(I))
      SAX2(I)=SNGL(AX2(I))
      SAX3(I)=SNGL(AX3(I))
      SAX4(I)=SNGL(AX4(I))
      SAR1(I)=SNGL(AR1(I))
      SAR2(I)=SNGL(AR2(I))
      SAR3(I)=SNGL(AR3(I))
      SAR4(I)=SNGL(AR4(I))
40    CONTINUE
      DO 50 I=1,200
      SXW1(I)=SNGL(XW1(I))
      SXW2(I)=SNGL(XW2(I))
      SXW3(I)=SNGL(XW3(I))
      SXW4(I)=SNGL(XW4(I))
      SYW1(I)=SNGL(YW1(I))
      SYW2(I)=SNGL(YW2(I))
      SYW3(I)=SNGL(YW3(I))
      SYW4(I)=SNGL(YW4(I))
50    CONTINUE
C  PLOT THE PROFILES AND LABEL THEM
      CALL PLOT(39.,17.5,-3)
      CALL AXIS(-2.,.75,11HRIGHT WHEEL,-11,4.,0.,-2.,1.)
      CALL LINE(SAX1,SAR1,NUR,1,0,3)
      CALL LINE(SXW1,SYW1,NWR,1,-2,3)
      CALL SYMBOL(-2.,-.4,.14,IWHLR,0.,52)
      CALL PLOT(5.5,0.,-3)
      CALL AXIS(-2.,.75,10HRIGHT RAIL,-10,4.,0.,-2.,1.)
      CALL LINE(SAX2,SAR2,NBR,1,0,3)
      CALL LINE(SXW2,SYW2,NYR,1,-2,3)
      CALL SYMBOL(-2.,-.4,.14,IRAILR,0.,52)
      CALL SYMBOL(-6.0,-1.4,.14,IWG,0.,52)
      CALL SYMBOL(-6.0,-1.63,.14,IRG,0.,52)
      CALL NUMBER(-4.0,-1.63,.14,RG,0.,2)
      CALL SYMBOL(-2.48,-1.4,.14,ICTR,0.,52)
      CALL PLOT (-5.5,-13.25,-3)
      CALL AXIS(-2.,.75,'LEFT WHEEL',-10,4.,0.,-2.,1.)
      CALL LINE(SAX3,SAR3,NUL,1,0,3)
```

```
      CALL LINE(SXW3,SYW3,NWL,1,-2,3)
      CALL SYMBOL(-2.,-.4,.14,IWHLL,C.,52)
      CALL PLOT(5.5,0.,-3)
      CALL AXIS(-2.,.75,'LEFT RAIL',-9,4.,C.,-2.,1.)
      CALL LINE(SAX4,SAR4,NBL,1,0,3)
      CALL LINE(SXW4,SYW4,NYL,1,-2,3)
      CALL SYMBOL(-2.,-.4,.14,IRAILL,0.,52)
      CALL SYMBOL(-2.48,-1.4,.14,ICTL,C.,52)
      CALL PLOT(-44.5,-4.25,-3)
      DO 60 I=1,NWR
60    YW1(I)=-YW1(I)+CSTW
      DO 61 I=1,NWL
61    YW3(I)=-YW3(I)+CSTW
      DO 70 I=1,NYR
70    YW2(I)=YW2(I)+CSTR
      DO 71 I=1,NYL
71    YW4(I)=YW4(I)+CSTR
      RETURN
      END
```

```
      SUBROUTINE GTPTS(XMAX,XMIN,RR,B,NC,AXW,AR1,S1,NU)
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION AXW(1),AR1(1),S1(1),RR(30,1),B(30,1)
C DEFINE STARTING VALUES
      X=XMAX
      IJ=1
C LOOP TO FIND EACH PT.
      DO 6 I=1,400
      NU=I
C CHOOSE THE POLYNOMIAL VALID FOR THE SPECIFIC X
      DO 2 J=IJ,NC
      IF(B(J,2).LE.X.AND.B(J,1).GT.X) GO TO 3
    2 CONTINUE
    3 IJ=J
C STORE THE POLY COEFS
      DO 4 K=1,5
      S1(K)=RR(J,K)
    4 CONTINUE
      AXW(I)=X
C CALCULATE THE Y VALUE
      AR1(I)=S1(1)+S1(2)*X+S1(3)*X**2+S1(4)*X**3+S1(5)*X**4
C INCREMENT X BY -.025 INCHES
      X=X-.025
C CHECK FOR END OF PROFILE
      IF(X.LT.XMIN) GO TO 7
    6 CONTINUE
    7 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE EQSOLV(NUMBR,XWINC)
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON /COMA/ AW,AR,BR,BL,RR(30,5),YR(30,5),RL(30,5),YL(30,5),
     1 B1(30,2),B2(30,2),B3(30,2),B4(30,2),S1(5),S2(5),S3(5),S4(5),
     1AXW(244),AX1(244),AX2(244),AX3(244),AX4(244),AR1(244),AR2(244),
     1 AR3(244),AR4(244),AR5(244),AM1(244),AM2(244),AM3(244),AW1(244),
     1 AY1(244),NC1,NC2,NC3,NC4,ISYM
      COMMON /COMF/ M1,M2,M3,M4,M5,M6,STEP,IPRT
      COMMON /COMH/ IFLAG,IFLAGA
C
      DIMENSION XOLD(4)
C  INITIALIZE WHEELSET DISPLACEMENT, INCREMENTS OF DISPLACEMENT, AND ROLL
      XW=0.
      XWI=0.
      WR=0.
      IFLAG=0
      IFLAGA=0
C  COMPUTE 1/2 THE NUMBER OF DATA PTS DESIRED
      NHALF=NUMBR/2
C  COMPUTE C.P. LOCATIONS AS WHEELSET IS LATERALED INCREMINTALLY IN THE
C  POSITIVE DIRECTION
      ISTART=NHALF+1
      DO 250 NUMB=ISTART,NUMBR
C  ROUTINE THAT FINDS CONTACT PT LOCATIONS
      CALL CHECK(XW,XWI,WR,XOLD)
C  XW  IS INCREMENTED WITHIN CHECK
      M3=9
      IF(XW.LE.0.45) M3=10
      IF(XW.LE.0.15) M3=12
C  STORE CONTACT PTS AND WHEELSET LATERAL
      AXW(NUMB)=XW
      AX1(NUMB)=XOLD(1)
      AX2(NUMB)=XOLD(2)
      AX3(NUMB)=XOLD(3)
      AX4(NUMB)=XOLD(4)
      IF(IPRT.EQ.1.OR.IPRT.EQ.2) WRITE(3,1) (XOLD(J),J=1,4)
C  XWI=SIZE OF WHEELSET LATERAL INCREMENTS
      XWI=XWINC
  250 CONTINUE
C  FOR SYMMETRIC CASE FORCE SAME VALUES AT XW=0.
      IF(ISYM.EQ.1) AX1(ISTART) = AX3(ISTART)
      IF(ISYM.EQ.1) AX2(ISTART) = AX4(ISTART)
    1 FORMAT(/4F13.7)
C
C   CHECK FOR SYMMETRIC CASE
      IF(ISYM.EQ.1) GO TO 301
C
C   NEGATIVE DIRECTION
      XW=0.
      XWI=0.
      WR=0.
      IFLAG=0
      IFLAGA=1
      M1=M4
      M2=M5
      M3=M6
      M4=M1
      M5=M2
      M6=M3
      ISTART=NHALF
      DO 300 NUMB=1,ISTART
      CALL CHECK(XW,XWI,WR,XOLD)
C  XW  IS INCREMENTED WITHIN CHECK
      M6=9
      IF(XW.GE.-.45) M6=10
      IF(XW.GE.-.15) M6=12
C  STORE CONTACT PTS AND WHEELSET LATERAL
      AXW(1-NUMB+ISTART)=XW
      AX1(1-NUMB+ISTART)=XOLD(1)
      AX2(1-NUMB+ISTART)=XOLD(2)
      AX3(1-NUMB+ISTART)=XOLD(3)
      AX4(1-NUMB+ISTART)=XOLD(4)
```

```
      IF(IPRT.EQ.1.OR.IPRT.EQ.2) WRITE(3,1) (XCLD(J),J=1,4)
C XWI=SIZE OF WHEELSET LATERAL INCREMENTS
      XWI=-XWINC
  300 CONTINUE
C FORCE SAME VALUES AT Xb = 0.
      AX1(NHALF+1)=AX1(NHALF)
      AX2(NHALF+1)=AX2(NHALF)
      AX3(NHALF+1)=AX3(NHALF)
      AX4(NHALF+1)=AX4(NHALF)
      RETURN
C
  301 NUMB1=ISTART
      DO 311 NUMB=ISTART,NUMBR
      NUMB1=NUMB1-1
      AXW(NUMB1)=-AXW(NUMB)
      AX1(NUMB1)=AX3(NUMB)
      AX2(NUMB1)=AX4(NUMB)
      AX3(NUMB1)=AX1(NUMB)
      AX4(NUMB1)=AX2(NUMB)
  311 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE CHECK(XW,DXW,WR,XOLD)
      IMPLICIT REAL*8(A-H,C-Z)
      COMMON /COMA/ AW,AR,BR,BL,RR(30,5),YR(30,5),RL(30,5),YL(30,5),
     1 B1(30,2),B2(30,2),B3(30,2),B4(30,2),S1(5),S2(5),S3(5),S4(5),
     1 Z(3660) ,NC1,NC2,NC3,NC4,ISYM
      COMMON /COME/ XMINWR,XMINRR,XMINWL,XMINRL,XMAXWR,XMAXRR,
     1 XMAXWL,XMAXRL
      COMMON /COMF/ M1,M2,M3,M4,M5,M6,STEP,IP
      COMMON /COMG/ XXW,C,S
      COMMON /COMH/ IFLAG,IFLAGA
      DIMENSION XOLD(1)
C
C  INCREMENT WHEELSET LATERAL
      XW=XW+DXW
      XXW=XW
      IF(IP.EQ.1.OR.IP.EQ.2) WRITE(3,300)XW
  300 FORMAT(///' XW =',F8.4)
CFOR EACH INCREMENT OF XW, CHOOSE STARTING PTS
      IF (IFLAG.EQ.1) GO TO 1
      A1 = XMINWR+ 0.4
47    IF (A1.GT.-1.6) GO TO 48
      A1 = A1 + STEP
      GO TO 47
48    CONTINUE
      A3 = A1
      IFLAG = 1
      STEPBK=10.*STEP
1     A1 = A1 + DXW - STEPBK
      A3 = A3 - DXW - STEPBK
      IF (A3.LT.XMINWL)A3 = XMINWL
      SBR =DSIN(BR)
      SBL =DSIN(BL)
      SP1=1.0D0
      SN1=-1.0D0
C  ITERATION LOOP ON WHEELSET ROLL ANGLE
      DO 120 IJK=1,8
      IF(IP.EQ.1.OR.IP.EQ.2) WRITE(3,400)IJK
  400 FORMAT(/'  IJK =',I2/)
C  CHOOSE PTS, ON INSIDE EDGES, FROM WHICH TO START SEARCH
      AX1=A1
      AX3=A3
      C=DCOS(WR)
      S=DSIN(WR)
C  LOCATE INSIDE EDGE OF RT RAIL
      DO 10 IB1 = 1,300
      DO 11 I = 1,NC1
      IF (B1(I,2).LE.AX1) GO TO 12
11    CONTINUE
12    R1=RR(I,1)+AX1*(RR(I,2)+AX1*(RR(I,3)+AX1*(RR(I,4)+AX1*RR(I,5))))
      AX2=-XW-AR+(AW+AX1)*C      -R1*S
      IF(IP.EQ.1.OR.IP.EQ.2) WRITE(3,500)IB1,AX1,AX2
500   FORMAT(I6,2(F9.4))
      IF(AX2.GE.XMINRR) GO TO 15
10    AX1=AX1+STEP
15    CONTINUE
      IF(IP.EQ.1.OR.IP.EQ.2) WRITE(3,900)
900   FORMAT(' ')
C  LOCATE INSIDE EDGE OF LT RAIL
      DO 20 IB1=1,300
      DO 21 I=1,NC3
      IF (B3(I,2).LE.AX3) GO TO 22
21    CONTINUE
22    R3=RL(I,1)+AX3*(RL(I,2)+AX3*(RL(I,3)+AX3*(RL(I,4)+AX3*RL(I,5))))
      AX4=XW-AR+(AW+AX3)*C      +R3*S
      IF(IP.EQ.1.OR.IP.EQ.2) WRITE(3,500)IB1,AX3,AX4
      IF(AX4.GE.XMINRL) GO TO 40
20    AX3=AX3+STEP
   40 CONTINUE
C  SAVE CURRENT STARTING VALUES
      A1=AX1
      A3=AX3
C  THREE INTERVAL FIBONACCI SEARCH TO FIND CANDIDATE CONTACT PTS
```

```
C M1,...M6 ARE CHANGED IN EQSOLV
C IFLAGA=1 FOR XW INCREMENTED IN NEG DIR
C FIND CONTACT POINT ON THE RIGHT
      CALL FIBON(M1,AX1,XMINWR,XMAXWR,XMINRR,XMAXRR,SBR,NC1,NC2,B1,B2,
     1 RR,YR,SN1 ,X1,X2,Y1)
      AX1=X1-0.65D0
      IF(IFLAGA.EQ.1) AX1=A1
      CALL FIBON(M2,AX1,XMINWR,XMAXWR,XMINRR,XMAXRR,SBR,NC1,NC2,B1,B2,
     1 RR,YR,SN1 ,X1A,X2A,Y1A)
      AX1=X1+0.10D0
      IF(IFLAGA.EQ.1) AX1=A1+1.5D0
      CALL FIBON(M3,AX1,XMINWR,XMAXWR,XMINRR,XMAXRR,SBR,NC1,NC2,B1,B2,
     1 RR,YR,SN1 ,X1B,X2B,Y1B)
      IF(Y1-Y1A) 2,2,4
2     IF(Y1-Y1B) 6,6,3
3     X1=X1B
      X2=X2B
      GO TO 6
4     IF(Y1A-Y1B) 5,5,3
5     X1=X1A
      X2=X2A
6     CONTINUE
C FIND CONTACT POINT ON THE LEFT
      CALL FIBON(M4,AX3,XMINWL,XMAXWL,XMINRL,XMAXRL,SBL,NC3,NC4,B3,B4,
     1 RL,YL,SP1,X3,X4,Y1)
      AX3=A3
      IF(IFLAGA.EQ.1) AX3=X3-0.65D0
      CALL FIBON(M5,AX3,XMINWL,XMAXWL,XMINRL,XMAXRL,SBL,NC3,NC4,B3,B4,
     1 RL,YL,SP1,X1A,X2A,Y1A)
      AX3=A3+1.5D0
      IF(IFLAGA.EQ.1) AX3=X3+0.10D0
      CALL FIBON(M6,AX3,XMINWL,XMAXWL,XMINRL,XMAXRL,SBL,NC3,NC4,B3,B4,
     1 RL,YL,SP1,X1B,X2B,Y1B)
      IF(Y1-Y1A) 7,7,9
7     IF(Y1-Y1B) 19,19,8
8     X3=X1B
      X4=X2B
      GO TO 19
9     IF(Y1A-Y1B) 18,18,8
18    X3=X1A
      X4=X2A
19    CONTINUE
      IF(IP.EQ.1.OR.IP.EQ.2) WRITE(3,200)X1,X2,X3,X4
200   FORMAT(/4(F9.4)/)
C KEEP PREVIOUS ROLL ANGLE
  110 WR2=WR
C COMPUTE NEW ROLL ANGLE
      CALL CHOOSE(X1,X2,X3,X4)
      CALL RADII(S1,S2,S3,S4,X1,X2,X3,X4,R1,R2,R3,R4)
      WR=(R4-R2+X4*SBL      -X2*SBR      +(R3-R1)*C        )/
     1 ((2.*AW+X1+X3)*C          )
      IF(IP.EQ.1.OR.IP.EQ.2) WRITE(3,600) WR2,WR
 600  FORMAT('   WR2 = ',F15.7/'   WR = ',F15.7)
C CHECK FOR CONVERGENCE BY COMPAIRING ROLL ANGLES
      IF(DABS(WR-WR2).LE..00001   ) GO TO 125
  120 CONTINUE
  125 CONTINUE
C ERROR CHECK
      ER=WR-WR2
      IF(IJK.GE.8) PRINT 130,ER,XW
  130 FORMAT( 4X,'*** WARNING ***  WHEELSET ROLL ANGLE CONVERGED ONLY WI
     1THIN  WR(NEW)-WR(OLD)=',F9.5,'  AT XW=',F6.3)
C STORE THE CONTACT PT LOCATIONS
      XOLD(1)= X1
      XOLD(2)= X2
      XOLD(3)= X3
      XOLD(4)= X4
      RETURN
      END
```

```
      SUBROUTINE CHOOSE(X1,X2,X3,X4)
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON /COMA/ AW,AR,BR,BL,RR(30,5),YR(30,5),RL(30,5),YL(30,5),
     1 B1(30,2),B2(30,2),B3(30,2),B4(30,2),S1(5),S2(5),S3(5),S4(5),
     1AXW(244),AX1(244),AX2(244),AX3(244),AX4(244),AR1(244),AR2(244),
     1 AR3(244),AR4(244),AR5(244),AM1(244),AM2(244),AM3(244),AW1(244),
     1 AY1(244),NC1,NC2,NC3,NC4
C
C CHOOSE THE CURVEFIT VALID FOR PT X1 ON THE RT WHEEL
      DO 20 I=1,NC1
        IF(B1(I,2).LE.X1) GO TO 25
   20 CONTINUE
   25 DO 30 J=1,5
        S1(J)=RR(I,J)
   30 CONTINUE
C
C CHOOSE THE CURVEFIT VALID FOR PT X2 ON THE RT RAIL
      DO 40 I=1,NC2
        IF(B2(I,2).LE.X2) GO TO 45
   40 CONTINUE
   45 DO 50 J=1,5
        S2(J)=YR(I,J)
   50 CONTINUE
C
C CHOOSE THE CURVEFIT VALID FOR PT X3 ON THE LEFT WHEEL
      DO 60 I=1,NC3
        IF(B3(I,2).LE.X3) GO TO 65
   60 CONTINUE
   65 DO 70 J=1,5
        S3(J)=RL(I,J)
   70 CONTINUE
C
C CHOOSE THE CURVEFIT VALID FOR PT X4 ON THE LEFT RAIL
      DO 80 I=1,NC4
        IF(B4(I,2).LE.X4) GO TO 85
   80 CONTINUE
   85 DO 90 J=1,5
        S4(J)=YL(I,J)
   90 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE RADII(RR,YR,RL,YL,X1,X2,X3,X4,R1,R2,R3,R4)
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION RR(1),YR(1),RL(1),YL(1)
C COMPUTES THE VALUES OF FOUR 4TH ORDER POLYNOMIALS AT THE GIVEN
C PTS, RESPECTIVELY
      R1=RR(1)+X1*(RR(2)+X1*(RR(3)+X1*(RR(4)+X1*RR(5))))
      R2=YR(1)+X2*(YR(2)+X2*(YR(3)+X2*(YR(4)+X2*YR(5))))
      R3=RL(1)+X3*(RL(2)+X3*(RL(3)+X3*(RL(4)+X3*RL(5))))
      R4=YL(1)+X4*(YL(2)+X4*(YL(3)+X4*(YL(4)+X4*YL(5))))
      RETURN
      END
```

```
      SUBROUTINE FIBON(N,AX,XMINW,XMAXW,XMINR,XMAXR,SBX,NCA,NCB,BA,BB,
     1 R,Y,SIGN,X1,X2,Y1)
C
C FIBONACCI SEARCH TO FIND CONTACT POINTS.
C LOOKING FOR PROFILE PTS WITH MIN IN HGT BETWEEN WH & RAIL.
C
C N = N PT FIB SEARCH, AX = AX1,AX3, STEP = X INCREM ALONG WH PROFILE
C C = COS(WR), S = SIN(WR), SBX = SBL,SBR, SIGN = + OR - 1. IN EQNS
C 1) SIGN=-1. FOR AX1 CALLS, 2) SIGN=1. FOR AX3 CALLS: IP=PRINT FLAG
C ARRAYS: BA = B1,B3, BB = B2,B4, R = RR,RL, Y = YR,YL
C OUTPUT OF SUBR; CANDIDATE CONTACT PTS: X1 = X1,X3, X2 = X2,X4
C                 ; MINIMUM HEIGHT AT CONTACT PT = Y1
C
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION F(15),BA(30,2),BB(30,2),R(30,5),Y(30,5)
      COMMON /COMA/ AW,AR,BR,BL
      COMMON /COMF/ M1,M2,M3,M4,M5,M6,STEP,IP
      COMMON /COMG/  XW,C,S
      DATA F/1.,2.,3.,5.,8.,13.,21.,34.,55.,89.,144.,
     1 233.,377.,610.,987./
C
C SKIP LINE FOR FIB SEARCH PRINTOUT
      IF(IP.NE.2) GO TO 601
      WRITE(3,600)
600   FORMAT(' ')
601   CONTINUE
C
C SET UP FIRST FIBONACCI SEARCH INTERVAL
      N1 = N - 1
      XL = AX
      XR = AX + F(N)*STEP
      XFIB = F(N1 )*STEP
      X1 = XR - XFIB
      X2 = XL + XFIB
C
C FIBONACCI SEARCH PROCEDURE, (N-1) INTERVALS
      DO 100 IFIB = 2,N
C CALC FUNCTION VALUES (HEIGHTS)
C FOR THE LEFT  FIBONACCI POINT, X1
      IF(X1.GT.XMAXW)X1=XMAXW
      IF(X1.LT.XMINW)X1=XMINW
      DO 10 I = 1,NCA
      IF (BA(I,2).LE.X1)GO TO 11
10    CONTINUE
11    R1 = R(I,1) +X1*(R(I,2) +X1*(R(I,3) +X1*(R(I,4) +X1*R(I,5))))
      XZ = SIGN*XW - AR + (AW+X1)*C+ SIGN*R1*S
      IF(XZ.GT.XMAXR) GO TO 15
      IF(XZ.LT.XMINR) GO TO 15
      DO 12 I = 1,NCB
      IF (BB(I,2).LE.XZ) GO TO 13
12    CONTINUE
13    R2 = Y(I,1) + XZ*(Y(I,2) + XZ*(Y(I,3) + XZ*(Y(I,4) + XZ*Y(I,5))))
      H1 = -R1*C + SIGN*(AW+X1)*S
      H2 = R2 + XZ*SBX
      Y1 = H1 - H2
      X1AX2 = XZ
      GO TO 19
15    Y1=1000.
19    CONTINUE
C FOR THE RIGHT FIBONACCI POINT, X2
      IF(X2.GT.XMAXW)X2=XMAXW
      IF(X2.LT.XMINW)X2=XMINW
      DO 20 I = 1,NCA
      IF (BA(I,2).LE.X2)GO TO 21
20    CONTINUE
21    R1 = R(I,1) +X2*(R(I,2) +X2*(R(I,3) +X2*(R(I,4) +X2*R(I,5))))
      XZ = SIGN*XW - AR + (AW+X2)*C+ SIGN*R1*S
      IF(XZ.GT.XMAXR) GO TO 25
      IF(XZ.LT.XMINR) GO TO 25
      DO 22 I = 1,NCB
      IF (BB(I,2).LE.XZ) GO TO 23
22    CONTINUE
23    R2 = Y(I,1) + XZ*(Y(I,2) + XZ*(Y(I,3) + XZ*(Y(I,4) + XZ*Y(I,5))))
```

```
      H1 = -R1*C + SIGN*(AW+X2)*S
      H2 = R2 + XZ*SBX
      Y2 = H1 - H2
      GO TO 29
25    Y2=1000.
29    CONTINUE
C AT THIS PT WE HAVE X1,X2,Y1,Y2, & X1AX2,X2AX2.
C
C PRINT OUT RESULTS OF IFIB DO LOOP
      IF(IP.NE.2) GO TO 501
      WRITE (3,500)IFIB,XFIB,XL,X1,Y1,X2,Y2,XR,X1AX2,XZ
500   FORMAT(I3,3F9.4,F13.7,F9.4,F13.7,3F9.4)
501   CONTINUE
C
      IF(IFIB.EQ.N) GO TO 9
      XFIB = F(N - IFIB)*STEP
9     IF (Y1 - Y2) 1,2,2
C MIN FROM X2 TO THE LEFT
1     XR = X2
      X2 = X1
      X1 = XR - XFIB
      IF(IFIB.EQ.N1) X1 = XL
      GO TO 100
C MIN FROM X1 TO THE RIGHT
2     XL = X1
      X1 = X2
      X2 = XL + XFIB
      IF (IFIB.EQ.N1) X2 = XR
100   CONTINUE
C
C STORE CANDIDATE CONTACT POINTS
      IF (Y1 - Y2) 3,4,4
C MIN AT PT ON LEFT: AX1MIN=X2, AX2MIN=X1AX2, MIN VAL Y1
3     X1 = X2
      X2 = X1AX2
      GO TO 5
C MIN AT PT ON RIGHT: AX1MIN=X1, AX2MIN=X2AX2=XZ, MIN VAL Y2
4     X2 = XZ
      Y1 = Y2
5     RETURN
      END
```

```
      SUBROUTINE EQSUB2(NUMBR)
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON /COMA/ AW,AR,BR,BL,RR(30,5),YR(30,5),RL(30,5),YL(30,5),
     1 B1(30,2),B2(30,2),B3(30,2),B4(30,2),S1(5),S2(5),S3(5),S4(5),
     1AXW(244),AX1(244),AX2(244),AX3(244),AX4(244),AR1(244),AR2(244),
     1 AR3(244),AR4(244),AR5(244),AM1(244),AM2(244),AM3(244),AW1(244),
     1 AY1(244),NC1,NC2,NC3,NC4
C
C CALCULATE THE CONSTRAINT RELATIONS AT EACH OF THE INCREMENTS OF
C WHEELSET LATERAL
      SBR=DSIN(BR)
      SBL=DSIN(BL)
      AWT2=2.*AW
      ART2=2.*AR
      DO 100 I=1,NUMBR
C CHOOSE THE CURVE FITS VALID AT THE POINTS
      CALL CHOOSE(AX1(I),AX2(I),AX3(I),AX4(I))
C CALCULATE THE ROLLING RADII AND HEIGHT OF THE RAIL AT THE POINTS
      CALL RADII(S1,S2,S3,S4,AX1(I),AX2(I),AX3(I),AX4(I),AR1(I),
     1  AR2(I),AR3(I),AR4(I))
C CALCULATE WHEELSET ROLL ANGLE
      AW1(I)=(AR4(I)-AR2(I)+AX4(I)*SBL      -AX2(I)*SBR      +AR3(I)
     1-AR1(I))/(AWT2 +AX1(I)+AX3(I))
      AW1(I)=DATAN(AW1(I))
      AW1(I)=(AR4(I)-AR2(I)+AX4(I)*SBL      -AX2(I)*SBR      +(AR3(I)-
     1 AR1(I))*DCOS(AW1(I)))/((AWT2 *AX1(I)+AX3(I))*DCOS(AW1(I)))
      AW1(I)=DATAN(AW1(I))
C CALCULATE RIGHT CONTACT ANGLE
      AM1(I)=-(S1(2)+2.*S1(3)*AX1(I)+3.*S1(4)*AX1(I)**2+4.*S1(5)*
     1  AX1(I)**3)
      AM1(I)=DATAN(AM1(I))
C CALCULATE LEFT CONTACT ANGLE
      AM2(I)=-(S3(2)+2.*S3(3)*AX3(I)+3.*S3(4)*AX3(I)**2+4.*S3(5)*
     1  AX3(I)**3)
      AM2(I)=DATAN(AM2(I))
C CALCULATE NORMALIZED DIFFERENCE IN CONTACT ANGLES
      AM3(I)=(AM2(I)-AM1(I))/2.
C CALCULATE NORMALIZED DIFFERENCE IN ROLLING RADII
      AR5(I)=(AR3(I)-AR1(I))/ART2
C CALCULATE VERTICAL DISPLACEMENT OF WHEELSET
      AY1(I)=(AR4(I)+AR2(I)+AX4(I)*SBL      +AX2(I)*SBR      +(AR3(I)
     1 +AR1(I))*DCOS(AW1(I))) /2.
  100 CONTINUE
C NORMALIZE VERTICAL DISPLACEMENT TO ZERO AT XW=0
      N=NUMBR/2
      Y=AY1(N)
      DO 110 I=1,NUMBR
      AY1(I)=AY1(I)-Y
  110 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE PLOT2(NUMBR,ICTR,ICTL)
      IMPLICIT REAL*8(A-H,O-Z)
      REAL SAXW(244),SAM1(244),SAM2(244),SAM3(244),SAR1(244),
     CSAR3(244),SAR5(244),SAW1(244),SAX1(244),SAX2(244),SAX3(244),
     CSAX4(244)
      COMMON /COMA/ AW,AR,BR,BL,RR(30,5),YR(30,5),RL(30,5),YL(30,5),
     1 B1(30,2),B2(30,2),B3(30,2),B4(30,2),S1(5),S2(5),S3(5),S4(5),
     1AXW(244),AX1(244),AX2(244),AX3(244),AX4(244),AR1(244),AR2(244),
     1 AR3(244),AR4(244),AR5(244),AM1(244),AM2(244),AM3(244),AW1(244),
     1 AY1(244),NC1,NC2,NC3,NC4
C
      COMMON /COMC/ IWHLR(13),IWHLL(13),IRAILR(13),IRAILL(13)
C
      DIMENSION ICTR(13),ICTL(13)
C
C COMPUTE SCALING FACTORS
      AN=NUMBR
      XW=-AN*.005  +.01
      NI=-XW/.01+1.
      N1=NUMBR+1
      N2=NUMBR+2
      NI1=NI+1
      NI2=NI+2
      AXW(N1)=-1.2
      AXW(N2)=.3
      AR1(N1)=DBLE((AINT(SNGL((AR1(NUMBR/2)-.9)*10.)))/10.)
      AR1(N2)=.4
      AR3(N1)=AR1(N1)
      AR3(N2)=AR1(N2)
      AR5(N1)=-.05
      AR5(N2)=.01
C
      AW1(N1)=-.025
      AW1(N2)=.005
C
C
      AM1(N1)=-.2
      AM1(N2)=.2
      AM2(N1)=AM1(N1)
      AM2(N2)=AM1(N2)
      AM3(N1)=-1.
      AM3(N2)=.2
C
C
C ** CHANGE DOUBLE PRECISION ARRAYS TO SINGLE PRECISION FOR PLOTTING
      DO 50 I=1,244
      SAXW(I)=SNGL(AXW(I))
      SAM1(I)=SNGL(AM1(I))
      SAM2(I)=SNGL(AM2(I))
      SAM3(I)=SNGL(AM3(I))
      SAR1(I)=SNGL(AR1(I))
      SAR3(I)=SNGL(AR3(I))
      SAR5(I)=SNGL(AR5(I))
      SAW1(I)=SNGL(AW1(I))
50    CONTINUE
C PLOT DIFF IN CONTACT ANGLES
      CALL PLOT(.5,5.,-3)
      CALL SYMBOL(.5,10.2,.21,'ONE HALF CONTACT ANGLE DIFFERENCE',0.,33)
      CALL GRID(0.,0.,.5,.5,16,20)
      CALL AXIS(0.,0.,21HWHEELSET LATERAL (IN),-21,8.,0.,AXW(N1),
     1 AXW(N2))
      CALL LINE(SAXW,SAM3,NUMBR,1,+1,5)
      CALL AXIS(4.0,0.,46H1/2 DIFF. IN CONTACT ANGLES W.R.T. AXLE, LT-RT
     1,46,9.9,90.,AM3(N1),AM3(N2))
C PLOT DIFF IN ROLLING RADII
      CALL PLOT(0.,11.5,-3)
      CALL SYMBOL(.3,10.2,.21,'NORMALIZED ROLLING RADII DIFFERENCE',0.,
     1 35)
      CALL GRID(0.,0.,.5,.5,16,20)
      CALL AXIS(0.,0.,21HWHEELSET LATERAL (IN),-21,8.,0.,AXW(N1),
     1 AXW(N2))
      CALL LINE(SAXW,SAR5,NUMBR,1,+1,5)
```

```
      CALL AXIS(4.0,0.,39HDIFF. IN ROLLING RADII/RAIL GAGE, LF-RT,
     1 39,9.9,90.,AR5(N1),AR5(N2))
C
C PLOT ROLLING RADII
      CALL PLOT(9.,0.,-3)
      CALL SYMBOL(2.6,10.2,.21,'ROLLING RADII',0.,13)
      CALL GRID(0.,0.,.5,.5,16,20)
      CALL AXIS(0.,0.,21HWHEELSET LATERAL (IN),-21,8.,0.,AXW(N1),
     1 AXW(N2))
      CALL AXIS(4.0,0.,35HROLLING RADIUS, +=RIGHT,*=LEFT, IN.,35,9.9,
     1 90.,AR1(N1),AR1(N2))
      CALL LINE(SAXW,SAR1,NUMBR,1,+1,3)
      CALL LINE(SAXW,SAR3,NUMBR,1,+1,11)
C
CPLOT CONTACT ANGLES
      CALL PLOT(0.,-11.5,-3)
      CALL SYMBOL(2.5,10.2,.21,'CONTACT ANGLES',0.,14)
      CALL GRID(0.,0.,.5,.5,16,20)
      CALL AXIS(0.,0.,21HWHEELSET LATERAL (IN),-21,8.,0.,AXW(N1),
     1 AXW(N2))
      CALL AXIS(4.0,0.,37HCONTACT ANGLE W.R.T. AXLE, +=RT, *=LT,37,
     1 9.9,90.,AM1(N1),AM1(N2))
      CALL LINE(SAXW,SAM1,NUMBR,1,+1,3)
      CALL LINE(SAXW,SAM2,NUMBR,1,+1,11)
C
C PLOT WHEELSET ROLL ANGLES
      CALL PLOT(9.,0.,-3)
      CALL SYMBOL(2.6,10.2,.21,'WHEELSET ROLL',0.,13)
      CALL GRID(0.,0.,.5,.5,16,20)
      CALL AXIS(0.,0.,21HWHEELSET LATERAL (IN),-21,8.,0.,AXW(N1),
     1 AXW(N2))
      CALL AXIS(4.0,0.,13HWHEELSET ROLL,13,9.9,90.,AW1(N1),AW1(N2))
      CALL LINE(SAXW,SAW1,NUMBR,1,+1,5)
C
C TITLES
      CALL SYMBOL(.5,21.,.21,'RIGHT SIDE',0.,10)
      CALL SYMBOL(1.0,20.,.21,IWHLR,0.,52)
      CALL SYMBOL(1.0,19.5,.21,IRAILR,0.,52)
      CALL SYMBOL(1.0,19.,.21,ICTR,0.,52)
      CALL SYMBOL(.5,18.0,.21,'LEFT SIDE',0.,9)
      CALL SYMBOL(1.0,17.0,.21,IWHLL,0.,52)
      CALL SYMBOL(1.0,16.5,.21,IRAILL,0.,52)
      CALL SYMBOL(1.0,16.0,.21,ICTL,0.,52)
C
C
C SCALING FACTORS
      AX1(N1)=0.
      AX1(N2)=1.
      AX2(N1)=0.
      AX2(N2)=1.
      AX3(N1)=0.
      AX3(N2)=1.
      AX4(N1)=0.
      AX4(N2)=1.
C ** CHANGE DOUBLE PRECISION VALUES TO SINGLE PRECISION FOR PLOTTING
      DO 60 I=1,244
      SAX1(I)=SNGL(AX1(I))
      SAX2(I)=SNGL(AX2(I))
      SAX3(I)=SNGL(AX3(I))
      SAX4(I)=SNGL(AX4(I))
60    CONTINUE
C PLOT RIGHT WHEEL CONTACT PTS
      CALL PLOT(20.5,13.25,-3)
      CALL AXIS(0.,0.,21HWHEELSET LATERAL (IN),21,7.9,90.,-1.2,.3)
      CALL SYMBOL(-2.5,8.2,.21,'WHEEL CONTACT POSITION',0.,22)
      CALL GRID(-2.5,0.,.5,.5,10,16)
      CALL LINE(SAX1,SAX4,NUMBR,1,+1,5)
C PLOT RIGHT RAIL CONTACT PTS
      CALL PLOT(5.5,0.,-3)
      CALL AXIS(0.,0.,21HWHEELSET LATERAL (IN),21,7.9,90.,-1.2,.3)
      CALL SYMBOL(-2.0,8.2,.21,'RAIL CONTACT POSITION',0.,21)
      CALL GRID(-2.,0.,.5,.5,8,16)
```

```
      CALL LINE(SAX2,SAXH,NUMBR,1,+1,5)
C PLOT LEFT RAIL CONTACT PTS
      CALL PLOT(0.,-13.25,-3)
      CALL AXIS(0.,0.,21HWHEELSET LATERAL (IN),21,7.9,90.,-1.2,.3)
      CALL SYMBOL(-2.0,8.2,.21,'RAIL CONTACT POSITION',0.,21)
      CALL GRID(-2.,0.,.5,.5,8,16)
      CALL LINE(SAX4,SAXH,NUMBR,1,1,5)
C  PLOT LEFT WHEEL CONTACT PTS
      CALL PLOT (-5.5,0.,-3)
      CALL AXIS(0.,0.,21HWHEELSET LATERAL (IN),21,7.9,90.,-1.2,.3)
      CALL SYMBOL(-2.5,8.2,.21,'WHEEL CONTACT POSITION',0.,22)
      CALL GRID(-2.5,0.,.5,.5,10,16)
      CALL LINE(SAX3,SAXH,NUMBR,1,1,5)
      RETURN
      END
```

```
C   CUBIC SPLINE FITTING ROUTINE
C
C   PURPOSE:
C      SOLVE BASIC SIMULTANEOUS SET OF N SPLINE LINEAR EQUATIONS
C      FOR SECOND DERIVATIVES S(I) AT SPLINE JOINTS.  RESULTS STORED IN
C      VECTOR C.  ROUTINE CAN ACCOMODATE UP TO N=200 SPLINE JOINTS.
C
C   VARIABLES:
C      N = NUMBER OF SPLINE JOINTS (INPUT)
C      X = N X 1 VECTOR OF ABSCISSA JOINT COORDINATES (INPUT)
C      Y = N X 1 VECTOR OF ORDINATE JOINT COORDINATES (INPUT)
C      C = N X 1 VECTOR OF S(I) 2ND DERIV SOLNS (OUTPUT)
C       IPRINT = PRINT FLAG, 0=NO PRINT, 1=PRINT (INPUT)
C      H(I) = X(I+1) - X(I) = DIST BETWEEN ADJACENT JOINTS
C
C   TRIDIAGONAL SYSTEM:
C      SYSTEM IS TRIDIAGONAL ALLOWING QUICK SOLUTION OF A LARGE NUMBER
C      OF EQUATIONS.
C      B(I) = ELEMENTS BELOW DIAGONAL
C      D(I) = ELEMENTS ON DIAGONAL
C      A(I) = ELEMENTS ABOVE DIAGONAL
C      C(I) = CONSTANT RIGHT HAND SIDE ELEMENTS
C      THE N SIMULTANEOUS EQNS IN 2ND DERIVATIVES S(I) HAVE BEEN REDUCED
C      TO (N-2) EQNS TO TAKE ADVANTAGE OF THE RAPID SOLN OF A TRIDIAGONAL
C      SYSTEM.  THE 1ST EQN HAS BEEN INCORPORATED IN THE 2ND EQN,
C      AND THE NTH IN THE (N-1)ST EQN.
C
C   THE END CONDITIONS:
C      THE END CONDITIONS FOR SPLINE FITTING MUST BE CHOSEN.
C      THE VALUES OF THE 2ND DERIVATIVES AT END
C      JOINTS X(1) AND X(N) ARE ESTIMATED AS A LINEAR EXTRAPOLATION
C      OF THE 2ND DERIVATIVES AT THE TWO ADJACENT JOINTS, RESPECTIVELY
C
C      THIS SUBROUTINE CAN BE CHANGED TO ACCOMODATE OTHER END CONDITIONS
C      BY REPLACING THE CODING LOCATED BETWEEN THE LINES OF ASTERISKS.
C
      SUBROUTINE SPLINE(N,X,Y,C,IPRINT)
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION X(1),Y(1),C(1),B(201),D(201),A(201),H(201)
      N1=N-1
      N2=N-2
      H(1)=X(2)-X(1)
      H(2)=X(3)-X(2)
      H(N1)=X(N)-X(N1)
C
C  THE MODIFIED SECOND SYSTEM EQN (I=2)
      B(2)=0.
C**********************************************************
      D(2)=(2.+H(1)/H(2))*(H(1)+H(2))
      A(2)=H(2)-H(1)*H(1)/H(2)
C**********************************************************
      C(2)=6.*((Y(3)-Y(2))/H(2)-(Y(2)-Y(1))/H(1))
C  THE NEXT (N-4) SYS EQNS (I=3,4,...,N-2)
      DO 10 I=3,N2
      H(I)=X(I+1)-X(I)
      B(I)=H(I-1)
      D(I)=2.*(H(I-1)+H(I))
      A(I)=H(I)
      C(I)=6.*((Y(I+1)-Y(I))/H(I)-(Y(I)-Y(I-1))/H(I-1))
10    CONTINUE
C  THE MODIFIED NEXT TO LAST SYS EQN (I=N-1)
      A(N1)=0.
C**********************************************************
      B(N1)=H(N2)-H(N1)*F(N1)/H(N2)
      D(N1)=(2.+H(N1)/H(N2))*(F(N1)+F(N2))
C**********************************************************
      C(N1)=6.*((Y(N)-Y(N1))/H(N1)-(Y(N1)-Y(N2))/H(N2))
C
C  PRINT RESULTS
      IF(IPRINT.EQ.0) GO TO 15
      WRITE(3,100)
100   FORMAT ('0')
```

```
      WRITE(3,200) (I,B(I),D(I),A(I),C(I),H(I),I=2,N1)
200   FORMAT(I5,5F14.6)
C
C  SOLVE TRIDIAGONAL SYSTEM BY ELIMINATION.
C     STORAGE IS MINIMIZED BY COMPRESSING COEFS INTO 4 VECTORS.
C     N-2 EQNS IN N-2 UNKNOWNS
C
C  COMPUTE NEW MATRIX.  VALS OF VAR WILL BE STORED IN C ARRAY.
15    DO 20 I=3,N1
      R=B(I)/D(I-1)
      D(I)=D(I)-R*A(I-1)
20    C(I)=C(I)-R*C(I-1)
C  BACK SUBSTITUTION.
      C(N1)=C(N1)/D(N1)
      DO 30 I=2,N2
      J=N1-I+1
30    C(J)=(C(J)-A(J)*C(J+1))/D(J)
C
C  CALCULATE THE SOLUTION VALUES FOR I=1 AND I=N
C**************************************************************
      C(1)=((H(1)+H(2))*C(2)-C(3)*H(1))/H(2)
      C(N)=((H(N2)+H(N1))*C(N1)-C(N2)*H(N1))/H(N2)
C**************************************************************
C
C  PRINT RESULTS
      IF(IPRINT.EQ.0) GO TO 40
      WRITE(3,100)
      WRITE(3,300) (I,C(I),I=1,N)
300   FORMAT(I5,F14.6)
C
40    RETURN
      END
```

```
C   CUBIC SPLINE INTERPOLATION ROUTINE
C
C   PURPOSE:
C      INTERPOLATE TO FIND Y ORDINATE VALUE BETWEEN JOINTS
C      AND FIND VALUES OF 1ST DERIV, 2ND DERIV, RADIUS OF
C      CURVATURE, AND CURVATURE AT THIS Y VALUE.
C      THIS ROUTINE IS USED IN CONJUNCTION WITH THE SPLINE
C      ROUTINE WHICH FINDS THE VALUES OF 2ND DERIV S(I) AT JOINTS.
C
C   VARIABLES:
C      N  = NUMBER OF JOINTS
C      X  = INPUT VECTOR OF JOINT COORDINATES - ABSCISSAS
C      Y  = INPUT VECTOR OF JOINT COORDINATES - ORDINATES
C      S  = INPUT VECTOR OF 2ND DERIVATIVES AT JOINTS
C      XP = INPUT X VALUE
C      YP = OUTPUT Y VALUE
C      D1 = OUTPUT 1ST DERIVATIVE
C      D2 = OUTPUT 2ND DERIVATIVE
C      RC = OUTPUT RADIUS OF CURVATURE
C      CV = OUTPUT CURVATURE = 1./RC
C      IER= ERROR FLAG, 0=NO ERROR, 1=X VALUE INPUT ERROR
C
      SUBROUTINE    SPI(N,X,Y,S,XP,YP,D1,D2,RC,CV,IER)
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION X(1),Y(1),S(1)
      ENTRY SPIC(N,X,Y,S,XP,CV)
C
C   CHECK FOR X INPUT ERROR.
      IER=0
1     IF(XP.GE.X(1).AND.XP.LE.X(N)) GO TO 10
      IF(IER.EQ.1) GO TO 5
      IER=1
      XPI=0.000001
      IF(XP.GT.0.0) XPI=-0.000001
      XP=XP+XPI
      GO TO 1
5     WRITE( 3,100) XP
100   FORMAT(' THE INPUT X VALUE X =',F12.6,
     1 ' IS OUTSIDE JOINT RANGE **************')
      RETURN
C
C   LOCATE WHICH INTERVAL XP IS IN.
10    DO 20 L=2,N
      IF(X(L).GE.XP) GO TO 30
20    CONTINUE
30    I=L-1
C
C   CALCULATE CUBIC COEFFICIENTS ON ITH INTERVAL
      H=X(L) -X(I)
      AP=(S(L) -S(I))/(6.*H)
      BP=S(I)/2.
      CP=(Y(L) -Y(I))/H-(S(L) +2.*S(I))*H/6.
      XD=XP-X(I)
C
C   CALC YP VALUE, DERIVATIVES, AND RAD OF CURV FOR THIS XP.
      YP=AP*XD**3+BP*XD*XD+CP*XD+Y(I)
      D1=3.*AP*XD*XD+2.*BP*XD+CP
      D2=6.*AP*XD+2.*BP
      RC=((1.+D1*D1)**1.5)/D2
C NEGATE THE CURVATURE FOR WHRAIL PROFILES
      CV=-1./RC
      RETURN
      END
```

```
      SUBROUTINE DCRFCN(N,AXW,AR5,AM3,AW1,AR)
      IMPLICIT REAL*8(A-H,C-Z)
      DIMENSION AXW(1),AR5(1),AM3(1),AW1(1)
C LINEARIZATION USING DESCRIBING FUNCTIONS WITH A SINUSIODAL INPUT
C AMP=AMP OF MOTION=A
C ALAM=SLOPE OF (RL-RR)/2AR=AN2
C DELM=SLOPE OF (ML-MR)/2=AN1
C WSRL=SLOPE OF WHEELSET ROLL ANGLE DATA =AN3
      PRINT 10
   10 FORMAT(////2X,'LINEARIZATION USING DESCRIBING FCNS'/3X,'AMP',
     1 5X,'ALAM',5X,'DELM',5X,'WSRL'/)
C COMPUTE POINT IN ARRAYS CORRESPONDING TO START OF Xw GT 0
      N2=N/2+2
C COMPUTE FOR EACH AMPLITUDE
      DO 100 IJK=1,30
      AI=IJK
      A=.05*AI
C CHECK LIMIT OF ARRAY
      IF(A.GT.AXW(N)+.002) GO TO 200
C DEFINE OR INITIALIZE PARAMETERS
      AK=4./(3.14159*A**2.)
      AN1=0
      AN2=0
      AN3=0
C USE TRAPAZOIDAL RULE TO NUMERICALLY INTEGRATE EQUATIONS
      DO 40 I=N2,402
      I1=I-1
C**********************************************************************
C ** ROUND-UP ROUTINE FOR ARCSIN ARGUMENT GREATER THAN ONE
      TEST1=AXW(I)/A
      TEST2=AXW(I1)/A
      IF(TEST1.GT.1.0000CC.AND.TEST1.LT.1.00CC1)GOTO 1
      GOTO 2
1     TEST1=1.0000000000CC000D+00
2     IF(TEST2.GT.1.0000C0.AND.TEST2.LT.1.CCCC1)GOTO 3
      GOTO 4
3     TEST2=1.0000000000CCCCCD+C0
4     CONTINUE
C ** IF ARGUMENT OF ARSIN IS GREATER THEN 1.00001
C ** THE PROGRAM WILL TERMINATE ABNORMALLY
C ** END OF ARGUMENT PROTECTION ROUTINE
C**********************************************************************
      S1=DARSIN(TEST1)-DARSIN(TEST2)
      AN1=AN1+(AM3(I)*AXW(I)+AM3(I1)*AXW(I1))*S1/2.
      AN2=AN2+(AR5(I)*AXW(I)+AR5(I1)*AXW(I1))*S1/2.
      AN3=AN3+(AW1(I)*AXW(I)+AW1(I1)*AXW(I1))*S1/2.
C CHECK TO SEE IF AMPLITUDE REACHED
      IF((AXW(I)-A).GE.-.002) GO TO 50
   40 CONTINUE
C COMBINE TERMS AND NORMALIZE
   50 AN1=AN1*AK*AR
      AN2=AN2*AK*AR
      AN3=AN3*AK*AR
C OUTPUT
      PRINT 60,AXW(I),AN2,AN1,AN3
   60 FORMAT(   F7.3,3(   F9.4))
  100 CONTINUE
  200 CONTINUE
      RETURN
      END
```

LISTING OF INPUT CARDS - SYMMETRIC PROBLEM

```
.01
0010001
0010000
000
1010005
53.0 56.5 .025 .025
 NEW AAR WHEEL    DATA 026
3.0625
0072
1 1
```

0.2849992E+01	-0.1517651E+02	0.2563899E+01	-0.1605087E+02
0.2482374E+01	-0.1637062E+02	0.2379514E+01	-0.1638278E+02
0.2298308E+01	-0.1638788E+02	0.2210096E+01	-0.1639655E+02
0.2121566E+01	-0.1640149E+02	0.2004057E+01	-0.1641267E+02
0.1900559E+01	-0.1642101E+02	0.1819672E+01	-0.1642586E+02
0.1724455E+01	-0.1642905E+02	0.1621276E+01	-0.1642966E+02
0.1518735E+01	-0.1643260E+02	0.1423199E+01	-0.1643344E+02
0.1334988E+01	-0.1643835E+02	0.1224484E+01	-0.1644630E+02
0.1105657E+01	-0.1645422E+02	0.1003796E+01	-0.1645920E+02
0.9082613E+00	-0.1646436E+02	0.8050820E+00	-0.1646925E+02
0.6802480E+00	-0.1647444E+02	0.5627390E+00	-0.1647919E+02
0.4522360E+00	-0.1648421E+02	0.3493760E+00	-0.1649142E+02
0.2388720E+00	-0.1649667E+02	0.1286880E+00	-0.1650182E+02
0.2582800E-01	-0.1650694E+02	-0.7735097E-01	-0.1651505E+02
-0.1732060E+00	-0.1652180E+02	-0.2980390E+00	-0.1652998E+02
-0.4085430E+00	-0.1653506E+02	-0.5040790E+00	-0.1654015E+02
-0.5996140E+00	-0.1654073E+02	-0.7094800E+00	-0.1654124E+02
-0.7976910E+00	-0.1654204E+02	-0.8859030E+00	-0.1655125E+02
-0.9601030E+00	-0.1655791E+02	-0.1062963E+01	-0.1657082E+02
-0.1136845E+01	-0.1658423E+02	-0.1204040E+01	-0.1660268E+02
-0.1270916E+01	-0.1662659E+02	-0.1338110E+01	-0.1665831E+02
-0.1391294E+01	-0.1668880E+02	-0.1459127E+01	-0.1674220E+02
-0.1512948E+01	-0.1679153E+02	-0.1536196E+01	-0.1681941E+02
-0.1567407E+01	-0.1686533E+02	-0.1599255E+01	-0.1691809E+02
-0.1623141E+01	-0.1696332E+02	-0.1647346E+01	-0.1700359E+02
-0.1686200E+01	-0.1707988E+02	-0.1703718E+01	-0.1711224E+02
-0.1735567E+01	-0.1718874E+02	-0.1760090E+01	-0.1723038E+02
-0.1790982E+01	-0.1728351E+02	-0.1822830E+01	-0.1732303E+02
-0.1868690E+01	-0.1737601E+02	-0.1914549E+01	-0.1741570E+02
-0.1960089E+01	-0.1745094E+02	-0.2012954E+01	-0.1748557E+02
-0.2073144E+01	-0.1752026E+02	-0.2125690E+01	-0.1754588E+02
-0.2177917E+01	-0.1756200E+02	-0.2244155E+01	-0.1757417E+02
-0.2325361E+01	-0.1757899E+02	-0.2398605E+01	-0.1758299E+02
-0.2464843E+01	-0.1757506E+02	-0.2529806E+01	-0.1755930E+02
-0.2609099E+01	-0.1752475E+02	-0.2688073E+01	-0.1747803E+02
-0.2758766E+01	-0.1742532E+02	-0.2829459E+01	-0.1735641E+02

```
 NEW RAIL DATA 025
1.5
 072
0 0
```

0.14329410 01	0.61061130 01
0.14291980 01	0.61597160 01
0.14256830 01	0.62024020 01
0.14221670 01	0.62558520 01
0.14188780 01	0.62999160 01
0.14115450 01	0.64077960 01
0.14084830 01	0.64595930 01
0.14052700 01	0.65026490 01
0.13848190 01	0.66204050 01
0.13772590 01	0.66489650 01
0.13566820 01	0.67203300 01
0.13270590 01	0.67767390 01
0.12887660 01	0.68278590 01
0.12460500 01	0.68722490 01
0.12031830 01	0.59068200 01
0.11558180 01	0.69354830 01
0.11040300 01	0.69586720 01
0.10392000 01	0.69851670 01
0.97879400 00	0.70091350 01
0.93127700 00	0.70256050 01
0.88361000 00	0.70380430 01
0.83594200 00	0.70459280 01
0.78385200 00	0.70525030 01
0.71872000 00	0.70597570 01
0.65366300 00	0.70683340 01
0.59295400 00	0.70750920 01
0.53644100 00	0.70799950 01
0.44957300 00	0.70834930 01
0.38436600 00	0.70858620 01
0.31915800 00	0.70883990 01
0.24967900 00	0.70912570 01
0.19316600 00	0.70935360 01
0.14534700 00	0.70957540 01
0.93256980-01	0.70967250 01
0.36668000-01	0.70966410 01
-0.37310000-01	0.70929160 01
-0.98246010-01	0.70913560 01
-0.15910600 00	0.70909650 01
-0.21561900 00	0.70933440 01
-0.27640400 00	0.70930600 01
-0.34176300 00	0.70901480 01
-0.38096300 00	0.70872740 01
-0.47667600 00	0.70784160 01
-0.51602750 00	0.70773310 01
-0.57246510 00	0.70720110 01
-0.62478230 00	0.70704020 01
-0.68571830 00	0.70615160 01
-0.72941680 00	0.70554230 01
-0.78608120 00	0.70413460 01
-0.82985530 00	0.70346050 01

```
          -0.89948560 00   0.70233440 01
          -0.94745560 00   0.70174310 01
          -0.99107850 00   0.70067760 01
          -0.10479700 01   0.69881620 01
          -0.11092840 01   0.69678310 01
          -0.11660240 01   0.69449910 01
          -0.12143720 01   0.69243820 01
          -0.12582220 01   0.68990890 01
          -0.12978000 01   0.68719200 01
          -0.13331820 01   0.68444620 01
          -0.13728350 01   0.68047690 01
          -0.14040220 01   0.67669180 01
          -0.14308610 01   0.67112460 01
          -0.14403870 01   0.66880750 01
          -0.14586070 01   0.66212080 01
          -0.14681330 01   0.65845440 01
          -0.14775830 01   0.65141430 01
          -0.14785660 01   0.65070630 01
          -0.14833940 01   0.64519760 01
          -0.14929690 01   0.63953160 01
          -0.14937250 01   0.63817730 01
          -0.15031750 01   0.63237230 01
RAIL CANT FOR RIGHT RAIL .025
RAIL CANT FOR LEFT RAIL .025
 RAIL GAUGE 56.5 (IN)
WHEEL GAUGE 53.0 (IN)
```

PRINTER OUTPUT - SYMMETRIC PROBLEM

```
THE ASYMMETRIC WHEEL/RAIL CONTACT CHARACTERIZATION PROGRAM
RUN OPTIONS SELECTED
        XWINC=  0.0100
        ISYM=  1        IPUNCH= 1
        IPLOT= 1        ICURV= 0
        IFLANG = 0
        NUMB=101        INC= 5
WHEEL GAUGE (IN), RAIL GAUGE (IN), RIGHT RAIL CANT (RAD), LEFT RAIL CANT (RAD)
  53.00000   56.50000    0.02500    0.02500

RIGHT WHEEL PROFILE INPUT DATA ************************************************
 NEW AAR WHEEL    DATA 026
   3.06250
 72
          1              1
  1      0.2849992D+01   0.1517651D+02
  2      0.2563899D+01   0.1605087D+02
  3      0.2482374D+01   0.1637062D+02
  4      0.2379514D+01   0.1638278D+02
  5      0.2298308D+01   0.1638788D+02
  6      0.2210096D+01   0.1639655D+02
  7      0.2121566D+01   0.1640149D+02
  8      0.2004057D+01   0.1641267D+02
  9      0.1900559D+01   0.1642101D+02
 10      0.1819672D+01   0.1642586D+02
 11      0.1724455D+01   0.1642905D+02
 12      0.1621276D+01   0.1642966D+02
 13      0.1518735D+01   0.1643260D+02
 14      0.1423199D+01   0.1643344D+02
 15      0.1334988D+01   0.1643835D+02
 16      0.1224484D+01   0.1644630D+02
 17      0.1106657D+01   0.1645422D+02
 18      0.1003796D+01   0.1645920D+02
 19      0.9082613D+00   0.1646436D+02
 20      0.8050820D+00   0.1646925D+02
 21      0.6802480D+00   0.1647444D+02
 22      0.5627390D+00   0.1647919D+02
 23      0.4522360D+00   0.1648421D+02
 24      0.3493760D+00   0.1649142D+02
 25      0.2388720D+00   0.1649667D+02
 26      0.1286880D+00   0.1650182D+02
 27      0.2628000D-01   0.1650694D+02
 28     -0.7735097D-01   0.1651505D+02
 29     -0.1732060D+00   0.1652218D+02
 30     -0.2980390D+00   0.1652998D+02
 31     -0.4085430D+00   0.1653506D+02
 32     -0.5043790D+00   0.1654015D+02
 33     -0.5996140D+00   0.1654673D+02
 34     -0.7094830D+00   0.1654124D+02
 35     -0.7976910D+00   0.1654204D+02
 36     -0.8859030D+00   0.1655125D+02
 37     -0.9601030D+00   0.1655751D+02
 38     -0.1062963D+01   0.1657182D+02
 39     -0.1136845D+01   0.1658423D+02
 40     -0.1204040D+01   0.1660268D+02
 41     -0.1270916D+01   0.1662659D+02
 42     -0.1338110D+01   0.1665831D+02
 43     -0.1391294D+01   0.1668880D+02
 44     -0.1459127D+01   0.1674220D+02
 45     -0.1512948D+01   0.1679153D+02
 46     -0.1586196D+01   0.1681941D+02
 47     -0.1567497D+01   0.1686533D+02
 48     -0.1599255D+01   0.1691809D+02
 49     -0.1623141D+01   0.1696332D+02
 50     -0.1647346D+01   0.1700359D+02
 51     -0.1686200D+01   0.1707588D+02
 52     -0.1703718D+01   0.1711224D+02
 53     -0.1735567D+01   0.1718874D+02
 54     -0.1760399D+01   0.1723038D+02
 55     -0.1790982D+01   0.1728351D+02
 56     -0.1822830D+01   0.1732303D+02
 57     -0.1866690D+01   0.1737661D+02
 58     -0.1914549D+01   0.1741570D+02
 59     -0.1960089D+01   0.1745094D+02
 60     -0.2012954D+01   0.1748557D+02
 61     -0.2073144D+01   0.1752026D+02
 62     -0.2125690D+01   0.1754588D+02
 63     -0.2177917D+01   0.1756200D+02
 64     -0.2244155D+01   0.1757417D+02
 65     -0.2325361D+01   0.1757899D+02
 66     -0.2398605D+01   0.1758299D+02
 67     -0.2464843D+01   0.1757506D+02
 68     -0.2529806D+01   0.1755930D+02
 69     -0.2609099D+01   0.1752475D+02
 70     -0.2688073D+01   0.1747803D+02
 71     -0.2758766D+01   0.1742532D+02
 72     -0.2829459D+01   0.1735641D+02
```

RIGHT RAIL PROFILE INPUT DATA **********

NEW AAR RAIL DATA 025
1.5000
72

	0	0
1	0.1432941D+01	C.6106113D+C1
2	0.1429198D+01	0.6159716D+01
3	0.1425083D+01	C.6202402D+C1
4	0.1422167D+01	0.6255852D+C1
5	0.1418878D+01	C.6299516D+C1
6	0.1411545D+01	0.6407596D+01
7	0.1408483D+01	0.6459593D+01
8	0.1405270D+01	C.6502649D+01
9	0.1384819D+01	0.6620405D+01
10	0.1377259D+01	0.6648965D+C1
11	0.1356582D+01	0.6720330D+01
12	0.1327059D+01	C.6776739D+C1
13	0.1288766D+01	0.6827859D+C1
14	0.1246050D+01	C.6872249D+C1
15	0.1203183D+01	0.6906820D+01
16	0.1155818D+01	C.6935483D+C1
17	0.1104030D+01	C.6958672D+C1
18	0.1039200D+01	C.6985167D+01
19	0.9787940D+00	C.7009135D+C1
20	C.9312770D+00	0.7025605D+01
21	C.8836100D+00	C.7038043D+C1
22	0.8359420D+00	0.7045928D+01
23	C.7838520D+00	C.7052503D+C1
24	0.7187200D+00	0.7059757D+01
25	C.6536630D+00	C.7068334D+C1
26	0.5929540D+00	C.7075092D+01
27	C.5364410D+00	0.7079995D+01
28	0.4495730D+00	C.7083493D+C1
29	C.3843660D+00	0.7085862D+01
30	0.3191580D+00	C.7088399D+C1
31	0.2496790D+00	0.7091257D+C1
32	C.1931660D+00	C.7093536D+C1
33	0.1453470D+00	0.7095754D+01
34	C.9325698D-01	C.7096725D+01
35	0.3666800D-01	0.7096641D+01
36	-C.3731000D-01	C.7092916D+C1
37	-C.9824601D-01	C.7091356D+C1
38	-C.1591060D+00	C.7090965D+01
39	-0.2156190D+00	0.7093244D+C1
40	-0.2764040D+00	C.7093060D+01
41	-0.3417630D+00	C.7090148D+C1
42	-0.3809630D+00	0.7087274D+01
43	-0.4766760D+00	C.7078416D+C1
44	-0.5160275D+00	0.7077331D+01
45	-C.5724651D+00	C.7072011D+C1
46	-0.6247823D+00	0.7070402D+01
47	-0.6857183D+00	C.7061516D+01
48	-0.7294168D+00	C.7055423D+C1
49	-0.7860812D+00	0.7041346D+C1
50	-0.8298553D+00	C.7034605D+C1
51	-0.8994856D+00	0.7023344D+C1
52	-0.9474556D+00	C.7017431D+C1
53	-0.9910785D+00	0.7006776D+01
54	-0.1047970D+01	C.6988162D+C1
55	-0.1109284D+01	0.6967831D+01
56	-0.1166024D+01	C.6944591D+C1
57	-0.1214372D+01	C.6924382D+C1
58	-0.1258222D+01	0.6899089D+01
59	-0.1297800D+01	0.6871920D+C1
60	-0.1333182D+01	0.6844462D+01
61	-0.1372835D+01	C.6804769D+C1
62	-0.1404022D+01	0.6766918D+C1
63	-0.1430861D+01	0.6711246D+C1
64	-C.1440387D+01	0.6688075D+C1
65	-0.1458607D+01	0.6621208D+01
66	-0.1468133D+01	0.6584544D+01
67	-0.1477583D+01	C.6514143D+C1
68	-0.1478566D+01	0.6507063D+01
69	-0.1483594D+01	C.6451976D+01
70	-0.1492969D+01	0.6385316D+01
71	-C.1493725D+01	0.6381773D+C1
72	-0.1503175D+01	0.6323723D+C1

RAIL CANT FOR LEFT RAIL .025
RAIL CANT FOR RIGHT RAIL .025
RAIL GAUGE 56.5 (IN)
WHEEL GAUGE 53.0 (IN)

LEFT SIDE

WHEEL/RAIL CONTACT CHARACTERIZATION

NEW AAR WHEEL DATA 026

WHEEL GAGE=53.000
1/2 DIST BETWEEN TAPE LINES=29.563

CURVE FITS 5 PTS/CURVE FIT ZONE

	0TH	1ST	2ND	3RD	4TH				
1	0.4405190D+03	-0.7104370D+03	0.4421820D+03	-0.1210410D+03	0.1227390D+02	FROM	200.0000	TO	2.2983
2	0.1555370D+02	0.1575400D+01	-0.1006580D+01	0.2731350D+00	-0.2813760D-01	FROM	2.2983	TO	1.8197
3	0.1570280D+02	0.2427170D+01	-0.2778270D+01	0.1344880D+01	-0.2368990D+00	FROM	1.8197	TO	1.3350
4	0.1656630D+02	-0.3707880D+00	0.6042870D+00	-0.4639510D+00	0.1241230D+00	FROM	1.3350	TO	0.8051
5	0.1650960D+02	-0.6147290D+01	0.1825800D+01	-0.3133290D+00	-0.3608650D-02	FROM	0.8051	TO	0.2389
6	0.1650960D+02	-0.6166240D+01	0.3217590D+01	-0.1192490D+01	0.1154260D+00	FROM	0.2389	TO	-0.2980
7	0.1650820D+02	-0.8422190D+01	0.1647020D+01	-0.2117730D+00	0.1642800D+00	FROM	-0.2980	TO	-0.7977
8	0.1689900D+02	0.1639960D+01	0.2765980D+01	0.2088070D+01	0.6248470D+00	FROM	-0.7977	TO	-1.2040
9	0.2853000D+02	0.3839280D+02	0.4660830D+02	0.2463610D+02	0.5003670D+01	FROM	-1.2040	TO	-1.5129
10	-0.2695490D+02	-0.1189490D+03	-0.1206460D+03	-0.5360570D+02	-0.8721790D+01	FROM	-1.5129	TO	-1.6473
11	0.5869440D+03	0.1284520D+04	0.1079240D+04	0.4009410D+03	0.5563560D+02	FROM	-1.6473	TO	-1.7910
12	-0.1476490D+03	-0.3212700D+03	-0.2359790D+03	-0.7743020D+02	-0.9558570D+01	FROM	-1.7910	TO	-2.0130
13	0.4288870D+01	-0.1754740D+02	-0.8679330D+01	-0.1954130D+01	-0.1755460D+00	FROM	-2.0130	TO	-2.3254
14	0.5214570D+02	0.5661550D+02	0.3355590D+02	0.8804470D+01	0.8263800D+00	FROM	-2.3254	TO	-2.8295

NEW AAR RAIL DATA 025

RAIL GAGE=56.500
1/2 DIST BETWEEN RAIL CENTERS=29.750
RAIL CANT= 0.025

CURVE FITS 5 PTS/CURVE FIT ZONE

	0TH	1ST	2ND	3RD	4TH				
1	-0.1239710D+07	0.3493540D+07	-0.3691700D+07	0.1733770D+07	-0.3053340D+06	FROM	200.0000	TO	1.4189
2	-0.2234710D+05	0.6678590D+05	-0.7481650D+05	0.3724760D+05	-0.6953560D+04	FROM	1.4189	TO	1.3773
3	-0.2187900D+03	0.7699750D+03	-0.9822300D+03	0.5558040D+03	-0.1178130D+03	FROM	1.3773	TO	1.2032
4	-0.2833060D-01	0.2871520D+02	-0.4321290D+02	0.2858740D+02	-0.7144460D+01	FROM	1.2032	TO	0.9313
5	0.6709010D+01	0.2383070D+01	-0.5439600D+01	0.5314960D+01	-0.1964740D+01	FROM	0.9313	TO	0.6537
6	0.7115480D+01	-0.2075830D+00	0.6369020D+00	-0.9094470D+00	0.3865160D+00	FROM	0.6537	TO	0.3192
7	0.7094790D+01	0.2694400D-01	-0.9564850D-01	-0.4791310D+00	0.9752210D+00	FROM	0.3192	TO	0.0367
8	0.7094520D+01	0.2457210D-01	0.4752250D-02	-0.4734000D+00	-0.1108990D+01	FROM	0.0367	TO	-0.2764
9	0.7031680D+01	-0.6152510D+00	-0.2305770D+01	-0.3374480D+01	-0.1814650D+01	FROM	-0.2764	TO	-0.5725
10	0.6867400D+01	-0.1039940D+01	-0.1636330D+01	-0.8570420D+00	-0.1212760D+00	FROM	-0.5725	TO	-0.8299
11	0.9771550D+01	0.1084690D+02	0.1610840D+02	0.1049630D+02	0.2466900D+01	FROM	-0.8299	TO	-1.1093
12	-0.1452650D+02	-0.7645140D+02	-0.1011520D+03	-0.5929450D+02	-0.1306350D+02	FROM	-1.1093	TO	-1.3332
13	-0.1632580D+04	-0.4911880D+04	-0.5515700D+04	-0.2751820D+04	-0.5147570D+03	FROM	-1.3332	TO	-1.4586
14	0.1787410D+06	0.4888150D+06	0.5012280D+06	0.2283780D+06	0.3901320D+05	FROM	-1.4586	TO	-1.5032

*** WARNING *** WHEELSET ROLL ANGLE CONVERGED ONLY WITHIN WR(NEW)-WR(OLD)= 0.00001 AT XW= 0.380
*** WARNING *** WHEELSET ROLL ANGLE CONVERGED ONLY WITHIN WR(NEW)-WR(OLD)= 0.00001 AT XW= 0.390
*** WARNING *** WHEELSET ROLL ANGLE CONVERGED ONLY WITHIN WR(NEW)-WR(OLD)= 0.00002 AT XW= 0.400
*** WARNING *** WHEELSET ROLL ANGLE CONVERGED ONLY WITHIN WR(NEW)-WR(OLD)= 0.00001 AT XW= 0.410
*** WARNING *** WHEELSET ROLL ANGLE CONVERGED ONLY WITHIN WR(NEW)-WR(OLD)= 0.00001 AT XW= 0.900

********** RESULTS **********

RIGHT SIDE

WHEEL/RAIL CONTACT CHARACTERIZATION

NEW AAR WHEEL DATA 026
WHEEL GAGE=53.000
1/2 DIST BETWEEN TAPE LINES=29.563

CURVE FITS 5 PTS/CURVE FIT ZONE

	0TH	1ST	2ND	3RD	4TH				
1	0.440519D+03	-0.713437D+03	0.442182D+03	-0.121041D+03	0.122735D+02	FROM	200.0000	TO	2.2983
2	0.155537D+02	0.157540D+01	-0.100658D+01	0.273135D+00	-0.281376D-01	FROM	2.2983	TO	1.8197
3	0.157028D+02	0.242717D+01	-0.217821D+01	0.134488D+01	-0.236895D+00	FROM	1.8197	TO	1.3350
4	0.165663D+02	-0.370788D+00	0.604287D+00	-0.463951D+00	0.124123D+00	FROM	1.3350	TO	0.8051
5	0.165096D+02	-0.614729D-01	0.18258CD-01	-0.313329D-02	0.360865D-02	FROM	0.8051	TO	0.2389
6	0.165096D+02	-0.616624D-01	0.321755D-01	0.119249D-01	-0.115426D+00	FROM	0.2389	TO	-0.2980
7	0.165082D+02	-0.842219D-01	0.164702D-01	0.211773D+00	0.164280D+00	FROM	-0.2980	TO	-0.7977
8	0.168990D+02	0.163996D+01	0.276598D+01	0.208807D+01	0.624847D+00	FROM	-0.7977	TO	-1.2040
9	0.285300D+02	0.383928D+02	0.466C6830+02	0.246361D+02	0.500367D+01	FROM	-1.2040	TO	-1.5129
10	-0.269549D+02	-0.118949D+03	-0.120646D+03	-0.536057D+02	-0.872179D+01	FROM	-1.5129	TO	-1.6473
11	0.586944D+03	0.128452D+04	0.1079240+04	0.400941D+03	0.556356D+02	FROM	-1.6473	TO	-1.7910
12	-0.147649D+03	-0.321270D+03	-0.2359790+03	-0.774302D+02	-0.955857D+01	FROM	-1.7910	TO	-2.0130
13	0.428387D+01	-0.175474D+02	-0.867933D+01	-0.195413D+01	-0.175546D+00	FROM	-2.0130	TO	-2.3254
14	0.521457D+02	0.566155D+02	0.335559D+02	0.880447D+01	-0.826380D+00	FROM	-2.3254	TO	-2.8295

NEW AAR RAIL DATA 025

RAIL GAGE=56.500
1/2 DIST BETWEEN RAIL CENTERS=29.750
RAIL CANT= 0.025

CURVE FITS 5 PTS/CURVE FIT ZONE

	0TH	1ST	2ND	3RD	4TH				
1	-0.123971D+07	0.349354D+07	-0.365170D+07	0.173377D+07	-0.305334D+06	FROM	200.0000	TO	1.4189
2	-0.223471D+05	0.667859D+05	-0.748169D+05	0.372476D+05	-0.695358D+04	FROM	1.4189	TO	1.3773
3	-0.218790D+03	0.769975D+03	-0.982230D+03	0.555804D+03	-0.117813D+03	FROM	1.3773	TO	1.2032
4	-0.283166D+01	0.287152D+02	-0.431291D+02	0.285874D+02	-0.714446D+01	FROM	1.2032	TO	0.9313
5	0.670901D+01	0.238307D+01	-0.543960D+01	0.531496D+01	-0.196474D+01	FROM	0.9313	TO	0.6537
6	0.711548D+01	-0.237583D+00	-0.636952D+00	-0.909447D+00	0.386516D+00	FROM	0.6537	TO	0.3192
7	0.709479D+01	0.269440D-01	-0.956485D-01	-0.479131D+00	0.975221D+00	FROM	0.3192	TO	0.0367
8	0.709452D+01	-0.245721D-01	0.479225D-02	-0.473900D+00	-0.110895D+01	FROM	0.0367	TO	-0.2764
9	0.703868D+01	-0.615251D+00	-0.230577D+01	-0.337448D+01	-0.181956D+01	FROM	-0.2764	TO	-0.5725
10	0.686740D+01	-0.103994D+01	-0.163633D+01	-0.857042D+00	-0.121276D+00	FROM	-0.5725	TO	-0.8299
11	0.977150D+01	0.108469D+02	0.161084D+02	0.104963D+02	0.246696D+01	FROM	-0.8299	TO	-1.1093
12	-0.145265D+02	-0.764514D+02	-0.101152D+03	-0.592945D+02	-0.130635D+02	FROM	-1.1093	TO	-1.3332
13	-0.163258D+04	-0.491188D+04	-0.551570D+04	-0.275182D+04	-0.514757D+03	FROM	-1.3332	TO	-1.4586
14	0.178741D+06	0.488819D+06	0.501228D+06	0.228378D+06	0.390132D+05	FROM	-1.4586	TO	-1.5032

********** DATA POINTS **********

CONTACT POINTS, GEOMETRIC CONSTRAINTS, AND PROFILE CURVATURES
AS A FUNCTION OF WHEELSET LATERAL DISPLACEMENT

XW = WHEELSET LATERAL, POSITIVE TO THE LEFT (IN)
X1 = CONTACT LOCATION ON RIGHT WHEEL, POSITIVE OUT FROM TAPELINE (IN)
X2 = CONTACT LOCATION ON RIGHT RAIL, POSITIVE OUT FROM CENTERLINE (IN)
X3 = CONTACT LOCATION ON LEFT WHEEL, POSITIVE OUT FROM TAPELINE (IN)
X4 = CONTACT LOCATION ON LEFT RAIL, POSITIVE OUT FROM CENTERLINE (IN)
RR = ROLLING RADII, RIGHT WHEEL (IN)
YR = RAIL HEAD PROFILE HEIGHT, RIGHT RAIL (IN)
RL = ROLLING RADII, LEFT WHEEL (IN)
YL = RAIL HEAD PROFILE HEIGHT, LEFT RAIL (IN)
MR = CONTACT ANGLE W.R.T. AXLE, RIGHT WHEEL (RAD)
ML = CONTACT ANGLE W.R.T. AXLE, LEFT WHEEL (RAD)
RR CRV = PRINCIPAL ROLLING CURVATURE OF RIGHT WHEEL PROFILE (1/IN)
RL CRV = PRINCIPAL ROLLING CURVATURE OF LEFT WHEEL PROFILE (1/IN)

XW (IN)	X1 (IN)	X2 (IN)	X3 (IN)	X4 (IN)	RR (IN)	YR (IN)	RL (IN)	YL (IN)	MR (RAD)	ML (RAD)	RR CRV (1/IN)	RL CRV (1/IN)
-1.000	-2.1595	-1.0551	1.6405	0.1718	17.55458	6.98795	16.42539	7.09502	0.303139	0.013757	0.054367	0.060861
-0.990	-2.1495	-1.0562	1.6305	0.1729	17.55176	6.98758	16.42953	7.09499	0.320336	0.014123	0.054076	0.060860
-0.980	-2.1495	-1.0674	1.6105	0.1640	17.55176	6.98393	16.42982	7.09523	0.320336	0.015211	0.054076	0.060858
-0.970	-2.1395	-1.0686	1.6005	0.1652	17.54834	6.98352	16.42958	7.09520	0.337575	0.015520	0.053769	0.060857
-0.960	-2.1395	-1.0799	1.1405	-0.2838	17.54834	6.97964	16.45115	7.09291	0.337575	0.066210	0.053769	0.060653
-0.950	-2.1295	-1.0814	1.1305	-0.2824	17.54474	6.97911	16.45182	7.09297	0.354845	0.065893	0.053446	0.060652
-0.940	-2.1295	-1.0927	1.1205	-0.2811	17.54474	6.97504	16.45247	7.09302	0.354845	0.065518	0.053446	0.060651
-0.930	-2.1195	-1.0943	1.1105	-0.2796	17.54093	6.97446	16.45313	7.09309	0.372133	0.065088	0.053107	0.060650
-0.920	-2.1195	-1.1058	1.1005	-0.2781	17.54093	6.97012	16.45378	7.09315	0.372133	0.064606	0.053107	0.060650
-0.910	-2.1095	-1.1074	1.0905	-0.2766	17.53693	6.96950	16.45442	7.09321	0.389429	0.064074	0.052753	0.060649
-0.900	-2.0895	-1.0996	1.0705	-0.2846	17.52831	6.97247	16.45569	7.09287	0.423995	0.062875	0.051999	0.060649
-0.890	-2.1095	-1.1312	1.0605	-0.2829	17.53693	6.95848	16.45632	7.09295	0.389429	0.062213	0.052753	0.060649
-0.880	-2.1095	-1.1429	1.0505	-0.2812	17.53693	6.95367	16.45694	7.09302	0.389429	0.061513	0.052753	0.060650
-0.870	-2.0995	-1.1446	1.0405	-0.2796	17.53272	6.95294	16.45755	7.09309	0.406720	0.060780	0.052383	0.060650
-0.860	-2.0995	-1.1564	1.0305	-0.2778	17.53272	6.94799	16.45816	7.09316	0.406720	0.060014	0.052383	0.060651
-0.850	-2.0995	-1.1679	1.0105	-0.2863	17.53272	6.94310	16.45934	7.09279	0.406720	0.058400	0.052383	0.060652
-0.840	-2.0995	-1.1797	1.0005	-0.2846	17.53272	6.93802	16.45992	7.09287	0.406720	0.057558	0.052383	0.060653
-0.830	-2.0895	-1.1815	0.9905	-0.2829	17.52831	6.93722	16.46049	7.09295	0.423995	0.056696	0.051999	0.060654
-0.820	-2.0895	-1.1934	0.9805	-0.2811	17.52831	6.93200	16.46106	7.09302	0.423995	0.055817	0.051999	0.060655
-0.810	-2.0795	-1.1952	0.9705	-0.2793	17.52370	6.93115	16.46161	7.09310	0.441242	0.054925	0.051600	0.060656
-0.800	-2.0795	-1.2070	0.9605	-0.2775	17.52370	6.92575	16.46216	7.09317	0.441242	0.054021	0.051600	0.060657
-0.790	-2.0795	-1.2188	0.9505	-0.2857	17.52370	6.92017	16.46322	7.09282	0.441242	0.052194	0.051600	0.060659
-0.780	-2.0695	-1.2208	0.9305	-0.2838	17.51887	6.91921	16.46374	7.09290	0.458450	0.051276	0.051187	0.060660
-0.770	-2.0695	-1.2328	0.9205	-0.2819	17.51887	6.91329	16.46425	7.09259	0.458450	0.050359	0.051187	0.060661
-0.760	-2.0595	-1.2349	0.9105	-0.2799	17.51382	6.91224	16.46475	7.09307	0.475606	0.049447	0.050761	0.060662
-0.750	-2.0495	-1.2370	0.9005	-0.2779	17.50857	6.91114	16.46524	7.09316	0.492699	0.048541	0.050322	0.060662
-0.740	-2.0495	-1.2490	0.8805	-0.2859	17.50857	6.90481	16.46619	7.09281	0.492699	0.046762	0.050322	0.060664
-0.730	-2.0395	-1.2513	0.8705	-0.2838	17.50309	6.90358	16.46665	7.09251	0.509718	0.045895	0.049870	0.060665
-0.720	-2.0295	-1.2536	0.8605	-0.2815	17.49738	6.90229	16.46711	7.09301	0.526653	0.045047	0.049407	0.060666
-0.710	-2.0295	-1.2659	0.8505	-0.2793	17.49738	6.89526	16.46756	7.09310	0.526653	0.044221	0.049407	0.060666
-0.700	-2.0195	-1.2684	0.8405	-0.2769	17.49146	6.89382	16.46799	7.09320	0.543491	0.043420	0.048933	0.060667
-0.690	-2.0195	-1.2808	0.8205	-0.2846	17.49146	6.88614	16.46885	7.09287	0.543491	0.041905	0.048933	0.060667
-0.680	-2.0195	-1.2935	0.8105	-0.2818	17.49146	6.87765	16.46926	7.09299	0.543491	0.041196	0.048933	0.060668
-0.670	-1.9995	-1.2864	0.8005	-0.2792	17.47747	6.88251	16.46503	7.09310	0.570654	0.045638	0.048150	0.060657
-0.660	-1.9895	-1.2888	0.8105	-0.2569	17.47097	6.88090	16.46526	7.09172	0.582208	0.041196	0.047808	0.060668
-0.650	-1.9795	-1.2916	0.8105	-0.2443	17.46630	6.87901	16.46526	7.09176	0.594151	0.041196	0.047447	0.060668
-0.640	-1.9695	-1.2944	0.8105	-0.2316	17.45745	6.87703	16.46926	7.09178	0.606612	0.041196	0.047062	0.060668
-0.630	-1.9595	-1.2974	1.0705	0.0445	17.45041	6.87492	16.45569	7.09271	0.619709	0.062875	0.046649	0.060649
-0.620	-1.9495	-1.3006	1.0605	0.0376	17.44316	6.87267	16.45632	7.09276	0.633549	0.062213	0.046205	0.060649
-0.610	-1.9395	-1.3038	1.0405	0.0376	17.43572	6.87028	16.45755	7.09365	0.648210	0.060780	0.045720	0.060650
-0.600	-1.9295	-1.3073	0.7105	-0.2793	17.42802	6.86766	16.47312	7.09310	0.663777	0.045415	0.045196	0.060642
-0.590	-1.9195	-1.3105	0.6905	-0.2862	17.42007	6.86522	16.47403	7.09280	0.680302	0.045461	0.044626	0.060639
-0.580	-1.9095	-1.3141	0.6805	-0.2828	17.41183	6.86239	16.47449	7.09295	0.697822	0.045494	0.044007	0.060637
-0.570	-1.9095	-1.3278	0.6705	-0.2752	17.41183	6.85103	16.47494	7.09310	0.697822	0.045534	0.044007	0.060635
-0.560	-1.8995	-1.3316	0.9805	0.0446	17.40329	6.84766	16.46106	7.09576	0.716353	0.055817	0.043337	0.060655
-0.550	-1.8795	-1.3258	0.9605	0.0385	17.38516	6.85273	16.46216	7.09566	0.756412	0.054021	0.041835	0.060657
-0.540	-1.8695	-1.3302	0.6305	-0.2774	17.37552	6.84891	16.47677	7.09318	0.777867	0.045772	0.041001	0.060628
-0.530	-1.8795	-1.3560	0.9305	0.0386	17.38516	6.81992	16.46374	7.09566	0.756412	0.051276	0.041835	0.060660
-0.520	-1.8395	-1.3302	0.6005	-0.2778	17.34386	6.84885	16.47815	7.09316	0.847061	0.046027	0.038180	0.060622
-0.510	-1.8695	-1.3747	0.9105	0.0470	17.37552	6.80209	16.46475	7.09280	0.777867	0.049447	0.041001	0.060662
-0.500	-1.8595	-1.3795	0.5705	-0.2785	17.36545	6.79726	16.47553	7.09313	0.800188	0.046346	0.040113	0.060616
-0.490	-1.8495	-1.3845	0.5505	-0.2837	17.35491	6.79192	16.48046	7.09251	0.823287	0.046593	0.039171	0.060612
-0.480	-1.8395	-1.3899	0.5405	-0.2786	17.34386	6.78589	16.48093	7.09313	0.847061	0.046727	0.038180	0.060610
-0.470	-1.8295	-1.3957	0.5205	-0.2829	17.33226	6.77870	16.48187	7.09295	0.871391	0.047013	0.037142	0.060606
-0.460	-1.8095	-1.3923	0.5105	-0.2767	17.30724	6.78293	16.48234	7.09321	0.921188	0.047166	0.034949	0.060604
-0.450	-1.7995	-1.3995	0.4905	-0.2758	17.29373	6.77375	16.48329	7.09308	0.946377	0.047490	0.033806	0.060599
-0.440	-1.7895	-1.4080	0.4705	-0.2816	17.27873	6.76140	16.48424	7.09300	0.999408	0.047839	0.031299	0.060555
-0.430	-1.7695	-1.4082	0.4505	-0.2818	17.24556	6.76100	16.48520	7.09299	1.044106	0.048212	0.029147	0.060590
-0.420	-1.7595	-1.4204	0.4305	-0.2800	17.22838	6.73916	16.48617	7.09307	1.062790	0.048607	0.028235	0.060585
-0.410	-1.7295	-1.4145	0.4105	-0.2766	17.17147	6.75049	16.48715	7.09321	1.104383	0.049025	0.026188	0.060580
-0.400	-1.7195	-1.4206	0.3805	-0.2810	17.13086	6.73875	16.48863	7.09303	1.120200	0.049693	0.025422	0.060573
-0.390	-1.6795	-1.4182	0.3505	-0.2841	17.00815	6.74353	16.49013	7.09289	1.124907	0.050147	0.023263	0.060565
-0.380	-1.6495	-1.4148	0.3305	-0.2780	16.00678	6.74985	16.49115	7.09315	1.112315	0.050907	0.026403	0.060560
-0.370	-1.6295	-1.4177	0.3005	-0.2855	16.56970	6.74454	16.49269	7.09283	1.069830	0.051693	0.028302	0.060552
-0.360	-1.5995	-1.4087	0.2805	-0.2848	16.51720	6.76018	16.45373	7.09286	1.031598	0.052246	0.030351	0.060546
-0.350	-0.4595	-0.2851	0.2705	-0.2788	16.53711	7.09285	16.49425	7.09312	0.028967	0.052519	0.060445	0.060544
-0.340	-0.4495	-0.2853	0.2605	-0.2786	16.53682	7.09284	16.45478	7.09313	0.030339	0.052803	0.060443	0.060541
-0.330	-0.4395	-0.2856	0.2305	-0.2983	16.53651	7.09283	16.49690	7.09220	0.031761	0.050546	0.060442	0.060540
-0.320	-0.4295	-0.2859	0.2305	-0.2880	16.53618	7.09281	16.49490	7.09272	0.033230	0.050540	0.060440	0.060540
-0.310	-0.4195	-0.2861	0.2305	-0.2778	16.53584	7.09280	16.49490	7.09316	0.034740	0.050540	0.060438	0.060540
-0.300	-0.4095	-0.2864	0.2205	-0.2775	16.53549	7.09279	16.45741	7.09317	0.036288	0.050639	0.060436	0.060538
-0.290	-0.3895	-0.2766	0.2105	-0.2773	16.53473	7.09321	16.49792	7.09318	0.035484	0.050793	0.060432	0.060536
-0.280	-0.3795	-0.2769	0.2005	-0.2770	16.53433	7.09320	16.49843	7.09319	0.041123	0.050998	0.060429	0.060533
-0.270	-0.3695	-0.2772	0.1905	-0.2767	16.53391	7.09319	16.49894	7.09320	0.042784	0.051251	0.060426	0.060530
-0.260	-0.3595	-0.2774	0.1805	-0.2765	16.53347	7.09318	16.49945	7.09321	0.044464	0.051550	0.060424	0.060528
-0.250	-0.3495	-0.2777	0.1605	-0.2862	16.53302	7.09317	16.50045	7.09280	0.046158	0.052272	0.060421	0.060521
-0.240	-0.3395	-0.2780	0.1505	-0.2859	16.53255	7.09315	16.50102	7.09281	0.047862	0.052690	0.060417	0.060518
-0.230	-0.3295	-0.2783	0.1405	-0.2856	16.53206	7.09314	16.50155	7.09282	0.049573	0.053143	0.060414	0.060515
-0.220	-0.3195	-0.2786	0.1305	-0.2853	16.53155	7.09313	16.50208	7.09284	0.051287	0.053628	0.060411	0.060511
-0.210	-0.3095	-0.2789	0.1205	-0.2850	16.53103	7.09312	16.50262	7.09285	0.052999	0.054141	0.060407	0.060508
-0.200	-0.2995	-0.2792	0.1105	-0.2847	16.53049	7.09310	16.50316	7.09287	0.054705	0.054681	0.060404	0.060504
-0.190	-0.2995	-0.2898	0.1005	-0.2843	16.53049	7.09264	16.50271	7.09288	0.054705	0.055244	0.060404	0.060500
-0.180	-0.2995	-0.3000	0.0905	-0.2840	16.53049	7.09211	16.50427	7.09290	0.054705	0.055827	0.060404	0.060496
-0.170	-0.2995	-0.3104	0.0805	-0.2836	16.53049	7.09153	16.50483	7.09292	0.054705	0.056429	0.060404	0.060492
-0.160	-0.2995	-0.3208	0.0705	-0.2831	16.53049	7.09090	16.50540	7.09294	0.054705	0.057045	0.060404	0.060488
-0.150	-0.2495	-0.2812	0.0605	-0.2827	16.52634	7.09302	16.50597	7.09296	0.068216	0.057674	0.060369	0.060483
-0.140	-0.2395	-0.2816	0.0505	-0.2823	16.52566	7.09300	16.50655	7.09297	0.068574	0.058312	0.060370	0.060479
-0.130	-0.2995	-0.3521	0.0405	-0.2818	16.53049	7.08879	16.50714	7.09299	0.054705	0.058957	0.060404	0.060475
-0.120	-0.2195	-0.2824	0.0305	-0.2816	16.52428	7.09297	16.50774	7.09300	0.069072	0.059606	0.060373	0.060470
-0.110	-0.2095	-0.2827	0.0205	-0.2812	16.52358	7.09295	16.50834	7.09302	0.069218	0.060258	0.060375	0.060466
-0.100	-0.1995	-0.2831	0.0105	-0.2808	16.52289	7.09294	16.50894	7.09304	0.069360	0.060905	0.060377	0.060461
-0.090	-0.1895	-0.2835	0.0005	-0.2804	16.52220	7.09292	16.50955	7.09305	0.069319	0.061550	0.060379	0.060456
-0.080	-0.1795	-0.2839	-0.0095	-0.2800	16.52150	7.09290	16.51017	7.09307	0.069279	0.062187	0.060382	0.060452
-0.070	-0.1695	-0.2843	-0.0195	-0.2797	16.52081	7.09289	16.51080	7.09309	0.069183	0.062815	0.060385	0.060447
-0.060	-0.1595	-0.2846	-0.0295	-0.2793	16.52012	7.09287	16.51143	7.09310	0.069032	0.063430	0.060388	0.060442
-0.050	-0.1495	-0.2850	-0.0395	-0.2789	16.51943	7.09285	16.51207	7.09312	0.068831	0.064030	0.060391	0.060438
-0.040	-0.1395	-0.2854	-0.0495	-0.2785	16.51874	7.09283	16.51271	7.09313	0.068581	0.064612	0.060395	0.060433
-0.030	-0.1295	-0.2858	-0.0595	-0.2781	16.51805	7.09282	16.51336	7.09315	0.068286	0.065173	0.060399	0.060428

-0.020	-0.1195	-0.2862	-0.0695	-0.2777	16.51737	7.09280	16.51402	7.09317	0.067947	0.065710	0.060403	0.060424
-0.010	-0.0995	-0.2766	-0.0795	-0.2773	16.51602	7.09321	16.51468	7.09318	0.067154	0.066221	0.060411	0.060419
0.0	-0.0895	-0.2770	-0.0895	-0.2770	16.51535	7.09320	16.51535	7.09320	0.066703	0.066703	0.060415	0.060415
0.0	-0.0895	-0.2770	-0.0895	-0.2770	16.51535	7.09320	16.51535	7.09320	0.066703	0.066703	0.060415	0.060415
0.010	-0.0795	-0.2773	-0.0995	-0.2766	16.51468	7.09318	16.51602	7.09321	0.066221	0.067154	0.060419	0.060411
0.020	-0.0695	-0.2777	-0.1195	-0.2862	16.51402	7.09317	16.51737	7.09280	0.065710	0.067947	0.060424	0.060403
0.030	-0.0595	-0.2781	-0.1295	-0.2858	16.51336	7.09315	16.51805	7.09282	0.065173	0.068286	0.060428	0.060399
0.040	-0.0495	-0.2785	-0.1395	-0.2854	16.51271	7.09313	16.51874	7.09283	0.064612	0.068581	0.060433	0.060395
0.050	-0.0395	-0.2789	-0.1495	-0.2850	16.51207	7.09312	16.51943	7.09285	0.064030	0.068831	0.060438	0.060391
0.060	-0.0295	-0.2793	-0.1595	-0.2846	16.51143	7.09310	16.52012	7.09287	0.063430	0.069032	0.060442	0.060388
0.070	-0.0195	-0.2797	-0.1695	-0.2843	16.51080	7.09309	16.52081	7.09289	0.062815	0.069183	0.060447	0.060385
0.080	-0.0095	-0.2800	-0.1795	-0.2839	16.51017	7.09307	16.52150	7.09290	0.062187	0.069279	0.060452	0.060382
0.090	0.0005	-0.2804	-0.1895	-0.2835	16.50955	7.09305	16.52220	7.09292	0.061550	0.069315	0.060456	0.060379
0.100	0.0105	-0.2808	-0.1995	-0.2831	16.50894	7.09304	16.52289	7.09294	0.060905	0.069300	0.060461	0.060377
0.110	0.0205	-0.2812	-0.2095	-0.2827	16.50834	7.09302	16.52358	7.09295	0.060256	0.069218	0.060466	0.060375
0.120	0.0305	-0.2816	-0.2195	-0.2824	16.50774	7.09300	16.52428	7.09297	0.059606	0.069072	0.060470	0.060373
0.130	0.0405	-0.2818	-0.2995	-0.3521	16.50714	7.09299	16.53049	7.08879	0.058957	0.054705	0.060475	0.060404
0.140	0.0505	-0.2823	-0.2395	-0.2816	16.50655	7.09297	16.52566	7.09300	0.058312	0.068574	0.060479	0.060370
0.150	0.0605	-0.2827	-0.2495	-0.2812	16.50557	7.09296	16.52634	7.09302	0.057674	0.068216	0.060483	0.060369
0.160	0.0705	-0.2831	-0.2995	-0.3208	16.50540	7.09294	16.53049	7.09050	0.057045	0.054705	0.060488	0.060404
0.170	0.0805	-0.2836	-0.2995	-0.3104	16.50483	7.09292	16.53049	7.09153	0.056429	0.054705	0.060492	0.060404
0.180	0.0905	-0.2840	-0.2995	-0.3000	16.50427	7.09290	16.53049	7.09211	0.055827	0.054705	0.060496	0.060404
0.190	0.1005	-0.2843	-0.2995	-0.2896	16.50371	7.09288	16.53045	7.09264	0.055244	0.054705	0.060500	0.060404
0.200	0.1105	-0.2847	-0.2995	-0.2792	16.50316	7.09287	16.53045	7.09310	0.054681	0.054705	0.060504	0.060404
0.210	0.1205	-0.2850	-0.3095	-0.2789	16.50262	7.09285	16.53103	7.09312	0.054141	0.052999	0.060508	0.060407
0.220	0.1305	-0.2853	-0.3195	-0.2786	16.50208	7.09284	16.53159	7.09313	0.053628	0.051287	0.060511	0.060411
0.230	0.1405	-0.2856	-0.3295	-0.2783	16.50155	7.09282	16.53206	7.09314	0.053143	0.049573	0.060515	0.060414
0.240	0.1505	-0.2859	-0.3395	-0.2780	16.50102	7.09281	16.53255	7.09315	0.052650	0.047862	0.060518	0.060417
0.250	0.1605	-0.2862	-0.3495	-0.2777	16.50049	7.09280	16.53302	7.09317	0.052272	0.046158	0.060521	0.060421
0.260	0.1805	-0.2765	-0.3595	-0.2774	16.49545	7.09321	16.53347	7.09318	0.051550	0.044464	0.060528	0.060424
0.270	0.1905	-0.2767	-0.3695	-0.2772	16.49894	7.09320	16.53391	7.09319	0.051251	0.042784	0.060530	0.060426
0.280	0.2005	-0.2770	-0.3795	-0.2769	16.49843	7.09319	16.53433	7.09320	0.050998	0.041123	0.060533	0.060429
0.290	0.2105	-0.2773	-0.3895	-0.2766	16.49792	7.09318	16.53473	7.09321	0.050793	0.039484	0.060536	0.060432
0.300	0.2205	-0.2775	-0.4095	-0.2864	16.49741	7.09317	16.53545	7.09279	0.050639	0.036288	0.060538	0.060436
0.310	0.2305	-0.2778	-0.4195	-0.2861	16.49690	7.09316	16.53584	7.09280	0.050540	0.034740	0.060540	0.060438
0.320	0.2305	-0.2880	-0.4295	-0.2859	16.49690	7.09272	16.53618	7.09281	0.050540	0.033230	0.060540	0.060440
0.330	0.2305	-0.2983	-0.4395	-0.2856	16.49690	7.09220	16.53651	7.09283	0.050540	0.031761	0.060540	0.060442
0.340	0.2605	-0.2786	-0.4495	-0.2853	16.49678	7.09313	16.53682	7.09284	0.052803	0.030339	0.060541	0.060443
0.350	0.2705	-0.2788	-0.4595	-0.2851	16.49625	7.09312	16.53711	7.09285	0.052519	0.028967	0.060544	0.060445
0.360	0.2805	-0.2848	-1.5995	-1.4087	16.49373	7.09286	16.91720	6.76018	0.052240	1.031598	0.060546	0.030351
0.370	0.3005	-0.2855	-1.6295	-1.4177	16.49269	7.09283	16.96570	6.74454	0.051693	1.069830	0.060552	0.028302
0.380	0.3305	-0.2760	-1.6495	-1.4148	16.49115	7.09315	17.00678	6.74565	0.050907	1.101315	0.060560	0.026663
0.390	0.3505	-0.2841	-1.6795	-1.4182	16.49013	7.09289	17.06815	6.74353	0.050407	1.124987	0.060565	0.025263
0.400	0.3805	-0.2810	-1.7095	-1.4206	16.48863	7.09303	17.13086	6.73875	0.049693	1.126200	0.060573	0.025422
0.410	0.4105	-0.2766	-1.7295	-1.4145	16.48715	7.09321	17.17147	6.75049	0.049025	1.104383	0.060580	0.026188
0.420	0.4305	-0.2800	-1.7595	-1.4204	16.48617	7.09307	17.22838	6.73916	0.048607	1.062790	0.060585	0.028235
0.430	0.4505	-0.2816	-1.7695	-1.4082	16.48520	7.09299	17.24596	6.76100	0.048212	1.044106	0.060590	0.029147
0.440	0.4705	-0.2816	-1.7895	-1.4080	16.48424	7.09300	17.27873	6.76140	0.047839	0.999408	0.060594	0.031259
0.450	0.4905	-0.2798	-1.7995	-1.3995	16.48329	7.09308	17.29373	6.77379	0.047490	0.946377	0.060599	0.033806
0.460	0.5105	-0.2767	-1.8095	-1.3923	16.48234	7.09321	17.30724	6.78293	0.047166	0.921188	0.060604	0.034949
0.470	0.5205	-0.2829	-1.8295	-1.3957	16.48187	7.09295	17.33226	6.77870	0.047013	0.871391	0.060606	0.037142
0.480	0.5405	-0.2786	-1.8395	-1.3899	16.48053	7.09313	17.34386	6.78589	0.046727	0.847061	0.060610	0.038180
0.490	0.5505	-0.2837	-1.8495	-1.3845	16.48046	7.09291	17.35491	6.79192	0.046593	0.823287	0.060612	0.039171
0.500	0.5705	-0.2785	-1.8595	-1.3795	16.47953	7.09313	17.36545	6.79726	0.046346	0.800188	0.060616	0.040113
0.510	0.9105	0.0470	-1.8695	-1.3747	16.46475	7.09580	17.37552	6.80205	0.049447	0.777867	0.060662	0.041001
0.520	0.6005	-0.2778	-1.8395	-1.3302	16.47815	7.09316	17.34386	6.84885	0.046027	0.847061	0.060622	0.038160
0.530	0.9305	0.0386	-1.8795	-1.3560	16.46374	7.09566	17.38516	6.81552	0.051236	0.756412	0.060660	0.041835
0.540	0.6305	-0.2774	-1.8655	-1.3302	16.47677	7.09318	17.37552	6.84851	0.045772	0.777867	0.060628	0.041001
0.550	0.9605	0.0385	-1.8795	-1.3258	16.46216	7.09566	17.38516	6.85273	0.054021	0.756412	0.060657	0.041835
0.560	0.9805	0.0446	-1.8995	-1.3316	16.46106	7.09576	17.40325	6.85766	0.055177	0.716353	0.060655	0.043337
0.570	0.6705	-0.2792	-1.9095	-1.3278	16.47494	7.09310	17.41183	6.85103	0.045534	0.697822	0.060635	0.044007
0.580	0.6805	-0.2828	-1.9295	-1.3141	16.47449	7.09295	17.41183	6.86239	0.045494	0.697822	0.060637	0.044007
0.590	0.6905	-0.2862	-1.9195	-1.3105	16.47403	7.09280	17.42007	6.86522	0.045461	0.680302	0.060639	0.044626
0.600	0.7105	-0.2793	-1.9295	-1.3073	16.47312	7.09310	17.42802	6.86766	0.045419	0.663777	0.060642	0.045156
0.610	1.0405	0.0376	-1.9395	-1.3038	16.45755	7.09565	17.43572	6.87028	0.060780	0.648210	0.060650	0.045720
0.620	1.0605	0.0445	-1.9495	-1.3006	16.45632	7.09576	17.44318	6.87267	0.062213	0.633545	0.060649	0.046263
0.630	1.0705	0.0415	-1.9595	-1.2974	16.45569	7.09571	17.45041	6.87492	0.062875	0.619709	0.060649	0.046649
0.640	0.8105	-0.2316	-1.9695	-1.2944	16.46926	7.09178	17.45745	6.87763	0.041156	0.606612	0.060668	0.047062
0.650	0.8105	-0.2443	-1.9795	-1.2916	16.46526	7.09176	17.46430	6.87901	0.041196	0.594151	0.060668	0.047447
0.660	0.8105	-0.2569	-1.9895	-1.2888	16.46926	7.09172	17.47051	6.88050	0.041196	0.582208	0.060668	0.047808
0.670	0.8005	-0.2792	-1.9995	-1.2864	16.46903	7.09310	17.47747	6.88251	0.045638	0.570654	0.060657	0.048160
0.680	0.8105	-0.2818	-2.0195	-1.2935	16.46926	7.09299	17.49146	6.87765	0.041196	0.543491	0.060668	0.048933
0.690	0.8205	-0.2846	-2.0155	-1.2808	16.46885	7.09287	17.49146	6.88144	0.041905	0.543491	0.060667	0.048933
0.700	0.8405	-0.2769	-2.0195	-1.2654	16.46799	7.09320	17.45146	6.85362	0.043420	0.543491	0.060667	0.048933
0.710	0.8505	-0.2793	-2.0295	-1.2659	16.46756	7.09310	17.49738	6.89526	0.044221	0.526653	0.060666	0.049407
0.720	0.8605	-0.2815	-2.0255	-1.2536	16.46711	7.09301	17.49738	6.90229	0.045047	0.526653	0.060666	0.049407
0.730	0.8705	-0.2838	-2.0355	-1.2513	16.46665	7.09291	17.50309	6.90358	0.045855	0.509718	0.060665	0.049870
0.740	0.8805	-0.2859	-2.0495	-1.2490	16.46619	7.09281	17.50857	6.90481	0.046762	0.492699	0.060664	0.050322
0.750	0.9005	-0.2779	-2.0495	-1.2370	16.46524	7.09316	17.50857	6.91114	0.048541	0.492699	0.060662	0.050322
0.760	0.9105	-0.2799	-2.0595	-1.2349	16.46475	7.09307	17.51382	6.91224	0.049447	0.475606	0.060662	0.050761
0.770	0.9205	-0.2819	-2.0695	-1.2328	16.46425	7.09299	17.51887	6.91329	0.050359	0.458450	0.060661	0.051187
0.780	0.9305	-0.2838	-2.0695	-1.2208	16.46374	7.09290	17.51887	6.91921	0.051276	0.458450	0.060660	0.051187
0.790	0.9405	-0.2857	-2.0795	-1.2188	16.46322	7.09282	17.52370	6.92017	0.052194	0.441242	0.060659	0.051600
0.800	0.9605	-0.2775	-2.0795	-1.2070	16.46216	7.09317	17.52370	6.92575	0.054021	0.441242	0.060657	0.051600
0.810	0.9705	-0.2793	-2.0795	-1.1952	16.46161	7.09310	17.52370	6.93115	0.054925	0.441242	0.060656	0.051600
0.820	0.9805	-0.2811	-2.0895	-1.1933	16.46106	7.09302	17.52831	6.93200	0.055817	0.423995	0.060655	0.051999
0.830	0.9905	-0.2829	-2.0895	-1.1815	16.46049	7.09295	17.52831	6.93722	0.056696	0.423995	0.060654	0.051999
0.840	1.0005	-0.2846	-2.0995	-1.1797	16.45992	7.09287	17.53272	6.93862	0.057558	0.406720	0.060653	0.052383
0.850	1.0105	-0.2863	-2.0995	-1.1679	16.45934	7.09279	17.53272	6.94310	0.058400	0.406720	0.060652	0.052383
0.860	1.0305	-0.2778	-2.0995	-1.1564	16.45816	7.09316	17.53272	6.94759	0.060014	0.406720	0.060651	0.052383
0.870	1.0405	-0.2796	-2.0995	-1.1446	16.45755	7.09309	17.53272	6.95294	0.060780	0.406720	0.060650	0.052383
0.880	1.0505	-0.2812	-2.1095	-1.1429	16.45694	7.09302	17.53693	6.95367	0.061513	0.389429	0.060650	0.052753
0.890	1.0605	-0.2829	-2.1095	-1.1312	16.45632	7.09295	17.53693	6.95848	0.062213	0.389429	0.060649	0.052753
0.900	1.0705	-0.2846	-2.0895	-1.0996	16.45569	7.09287	17.52831	6.97247	0.062875	0.423995	0.060649	0.051999
0.910	1.0905	-0.2766	-2.1095	-1.1074	16.45442	7.09321	17.53693	6.96950	0.064074	0.389429	0.060649	0.052753
0.920	1.1005	-0.2781	-2.1155	-1.1058	16.45378	7.09315	17.54053	6.97012	0.064686	0.372133	0.060650	0.053107
0.930	1.1105	-0.2796	-2.1195	-1.0943	16.45313	7.09309	17.54093	6.97446	0.065088	0.372133	0.060650	0.053107
0.940	1.1205	-0.2811	-2.1295	-1.0927	16.45247	7.09302	17.54474	6.97564	0.065518	0.354845	0.060651	0.053446
0.950	1.1305	-0.2824	-2.1295	-1.0814	16.45182	7.09297	17.54474	6.97911	0.065893	0.354845	0.060652	0.053446
0.960	1.1405	-0.2838	-2.1395	-1.0799	16.45115	7.09291	17.54834	6.97964	0.066210	0.337575	0.060653	0.053769
0.970	1.6005	0.1652	-2.1395	-1.0686	16.42998	7.09520	17.54834	6.98352	0.015920	0.337575	0.060657	0.053769
0.980	1.6105	0.1649	-2.1495	-1.0674	16.42982	7.09523	17.55176	6.98363	0.015211	0.320336	0.060658	0.054076
0.990	1.6305	0.1729	-2.1495	-1.0562	16.42953	7.09499	17.55176	6.98758	0.014123	0.320336	0.060660	0.054076
1.000	1.6405	0.1718	-2.1595	-1.0551	16.42939	7.09502	17.55498	6.98795	0.013757	0.303139	0.060661	0.054367

(RL-RR)/2A = NORMALIZED DIFFERENCE IN ROLLING RADII (IN/IN)
(ML-MR)/2 = NORMALIZED DIFFERENCE IN CONTACT ANGLES (RAD)
WR = WHEELSET ROLL ANGLE W.R.T. HORIZONTAL, POSITIVE UP ON LEFT (RAD)
YCG = VERTICAL DISPLACEMENT OF WHEELSET CENTROID FROM NOMINAL PCS. (IN)
CWR = PRINCIPAL TRANSVERSE CURVATURE OF RIGHT WHEEL PROFILE, POSITIVE FOR CURVATURE CENTER IN BODY (1/IN)
CYR = PRINCIPAL TRANSVERSE CURVATURE OF RIGHT RAIL PROFILE, POSITIVE FOR CURVATURE CENTER IN BODY (1/IN)
CWL = PRINCIPAL TRANSVERSE CURVATURE OF LEFT WHEEL PROFILE, POSITIVE FOR CURVATURE CENTER IN BODY (1/IN)
CYL = PRINCIPAL TRANSVERSE CURVATURE OF LEFT RAIL PROFILE, POSITIVE FOR CURVATURE CENTER IN BODY (1/IN)

XW (IN)	(RL-RR)/2A (IN/IN)	(ML-MR)/2 (RAD)	WR (RAD)	YCG (IN)	CWR (1/IN)	CYR (1/IN)	CWL (1/IN)	CYL (1/IN)
-1.000	-0.018918	-0.144691	-0.016856	0.418599	1.556777	0.969547	-0.009239	0.283165
-0.990	-0.018861	-0.153107	-0.016756	0.416874	1.597991	0.968966	-0.008951	0.282919
-0.980	-0.018856	-0.152563	-0.016723	0.415084	1.597991	0.959366	-0.008374	0.284922
-0.970	-0.018796	-0.160828	-0.016655	0.413251	1.597110	0.958289	-0.008086	0.284659
-0.960	-0.018440	-0.135683	-0.016583	0.415022	1.597110	0.948314	0.005171	0.261169
-0.950	-0.018368	-0.144476	-0.016498	0.413338	1.594137	0.946957	0.005459	0.260523
-0.940	-0.018357	-0.144663	-0.016414	0.411559	1.594137	0.936697	0.005747	0.259941
-0.930	-0.018282	-0.153522	-0.016324	0.409747	1.589087	0.935239	0.006035	0.259262
-0.920	-0.018272	-0.153764	-0.016235	0.407833	1.589087	0.924529	0.006126	0.258577
-0.910	-0.018193	-0.162677	-0.016142	0.405901	1.581985	0.923027	0.006092	0.257893
-0.900	-0.018027	-0.180560	-0.016035	0.403573	1.561789	0.930323	0.006022	0.261505
-0.890	-0.018162	-0.163608	-0.015925	0.400892	1.581985	0.900309	0.005988	0.260737
-0.880	-0.018151	-0.163558	-0.015827	0.398731	1.581985	0.888898	0.005953	0.259992
-0.870	-0.018070	-0.172970	-0.015729	0.396632	1.572865	0.887178	0.005919	0.259244
-0.860	-0.018060	-0.173353	-0.015625	0.394394	1.572865	0.875446	0.005884	0.258427
-0.850	-0.018049	-0.174160	-0.015534	0.392133	1.572865	0.863924	0.005815	0.262284
-0.840	-0.018030	-0.174581	-0.015432	0.389825	1.572865	0.852044	0.005780	0.261507
-0.830	-0.017947	-0.183650	-0.015330	0.387571	1.561789	0.850192	0.005746	0.260727
-0.820	-0.017937	-0.184089	-0.015226	0.385182	1.561789	0.838167	0.005711	0.259932
-0.810	-0.017850	-0.193159	-0.015119	0.382788	1.548805	0.836223	0.005677	0.259119
-0.800	-0.017841	-0.193610	-0.015012	0.380299	1.548805	0.824078	0.005642	0.258306
-0.790	-0.017823	-0.194524	-0.014907	0.377642	1.548805	0.960533	0.005573	0.262025
-0.780	-0.017733	-0.203587	-0.014795	0.375077	1.533973	1.023975	0.005538	0.261172
-0.770	-0.017725	-0.204045	-0.014680	0.372316	1.533973	1.010513	0.005504	0.260288
-0.760	-0.017632	-0.213080	-0.014563	0.369587	1.517366	1.450393	0.005469	0.259356
-0.750	-0.017535	-0.222079	-0.014441	0.366727	1.499093	1.511156	0.005435	0.258479
-0.740	-0.017519	-0.222968	-0.014325	0.363641	1.499093	1.829293	0.005365	0.262102
-0.730	-0.017419	-0.231912	-0.014158	0.360596	1.479249	1.884171	0.005331	0.261131
-0.720	-0.017316	-0.240803	-0.014066	0.357407	1.457937	1.939259	0.005296	0.260124
-0.710	-0.017308	-0.241216	-0.013931	0.354074	1.457937	2.196156	0.005262	0.259056
-0.700	-0.017201	-0.250335	-0.013763	0.350686	1.435261	2.240162	0.005227	0.258048
-0.690	-0.017187	-0.250793	-0.013654	0.346894	1.435261	2.426949	0.005158	0.261493
-0.680	-0.017180	-0.251147	-0.013454	0.342827	1.435261	2.550864	0.005123	0.260270
-0.670	-0.016949	-0.262508	-0.013338	0.338356	1.386268	2.489762	0.005089	0.259051
-0.660	-0.016835	-0.270506	-0.013202	0.334006	1.360179	2.512828	0.005123	0.248986
-0.650	-0.016723	-0.276477	-0.013045	0.329904	1.333183	2.536273	0.005123	0.243231
-0.640	-0.016608	-0.282708	-0.012864	0.325663	1.305396	2.556916	0.005123	0.237428
-0.630	-0.016718	-0.278417	-0.012714	0.319683	1.276933	2.574876	0.006622	0.112642
-0.620	-0.016586	-0.285666	-0.012537	0.315313	1.247907	2.589522	0.005988	0.111966
-0.610	-0.016440	-0.293715	-0.012352	0.310859	1.218427	2.600418	0.005919	0.113526
-0.600	-0.016049	-0.309179	-0.012153	0.308255	1.188599	2.607258	0.004777	0.259058
-0.590	-0.015993	-0.317420	-0.011966	0.303268	1.158525	2.609245	0.004708	0.262243
-0.580	-0.015764	-0.326164	-0.011762	0.298082	1.128298	2.606738	0.004673	0.260688
-0.570	-0.015746	-0.326144	-0.011550	0.292620	1.097996	2.596695	0.004639	0.259073
-0.560	-0.015836	-0.330268	-0.011334	0.285092	1.068138	2.579266	0.005711	0.111535
-0.550	-0.015513	-0.351155	-0.011097	0.279109	1.038118	2.556057	0.005642	0.113306
-0.540	-0.015105	-0.366047	-0.010851	0.274484	1.007844	2.529147	0.004500	0.258267
-0.530	-0.015486	-0.352568	-0.010599	0.263227	1.045118	2.278078	0.005538	0.113297
-0.520	-0.014550	-0.400517	-0.010280	0.259397	1.017616	2.536631	0.004397	0.258466
-0.510	-0.015307	-0.364210	-0.009957	0.250024	1.494044	2.020492	0.005469	0.111387
-0.500	-0.014889	-0.376921	-0.009726	0.244544	1.515186	1.556799	0.004293	0.258775
-0.490	-0.014697	-0.388347	-0.009441	0.236880	1.526570	1.876702	0.002175	0.261121
-0.480	-0.014503	-0.400167	-0.009129	0.228727	1.517616	1.791453	0.000461	0.258800
-0.470	-0.014292	-0.412189	-0.008792	0.219636	1.494055	1.710447	-0.002968	0.260760
-0.460	-0.013864	-0.437311	-0.008417	0.209783	1.411012	1.760668	-0.004682	0.257936
-0.450	-0.013621	-0.449443	-0.008011	0.198792	1.355685	1.655724	-0.000110	0.259344
-0.440	-0.013353	-0.475785	-0.007520	0.185472	1.293883	1.533830	-0.011538	0.260164
-0.430	-0.012786	-0.497947	-0.006930	0.169431	1.158302	1.530277	-0.014965	0.260256
-0.420	-0.012474	-0.507092	-0.006225	0.156188	1.076685	1.363016	-0.018393	0.259437
-0.410	-0.011501	-0.527679	-0.005417	0.128157	0.534541	1.443385	-0.021819	0.257856
-0.400	-0.010794	-0.535253	-0.004685	0.102578	0.303285	1.360344	-0.026958	0.259850
-0.390	-0.009715	-0.537290	-0.003866	0.074356	0.034461	1.392553	-0.032095	0.261271
-0.380	-0.008666	-0.525204	-0.003049	0.047658	-0.222927	1.438833	-0.035519	0.258541
-0.370	-0.008017	-0.509369	-0.001738	0.026948	-0.430500	1.399673	-0.040652	0.261922
-0.360	-0.007117	-0.485679	-0.001085	0.009189	-0.891631	1.523020	-0.044072	0.261586
-0.350	-0.006720	-0.511776	-0.000720	-0.000003	0.198817	0.261723	-0.045782	0.258907
-0.340	-0.000707	0.011232	-0.000706	0.000112	0.192864	0.261832	-0.047491	0.258798
-0.330	-0.000666	0.009389	-0.000688	0.000298	0.186913	0.261962	-0.052616	0.267693
-0.320	-0.000660	0.008655	-0.000669	0.000510	0.180965	0.262105	-0.052616	0.263044
-0.310	-0.000654	0.007900	-0.000651	0.000685	0.175015	0.262200	-0.052616	0.258431
-0.300	-0.000640	0.007176	-0.000636	0.000760	0.169076	0.262314	-0.054324	0.258317
-0.290	-0.000619	0.006565	-0.000625	0.000974	0.157199	0.257912	-0.056031	0.258199
-0.280	-0.000603	0.006938	-0.000609	0.001027	0.151265	0.258033	-0.057737	0.258079
-0.270	-0.000588	0.006233	-0.000593	0.001073	0.145335	0.258155	-0.059443	0.257957
-0.260	-0.000572	0.005543	-0.000576	0.001113	0.139408	0.258259	-0.061149	0.257853
-0.250	-0.000547	0.006057	-0.000562	0.001066	0.133484	0.258387	-0.064558	0.262245
-0.240	-0.000539	0.004214	-0.000544	0.001095	0.127564	0.258513	-0.066261	0.262114
-0.230	-0.000513	0.001785	-0.000526	0.001117	0.121647	0.258653	-0.067964	0.261980
-0.220	-0.000495	0.001171	-0.000508	0.001132	0.115734	0.258790	-0.069666	0.261843
-0.210	-0.000478	0.000571	-0.000489	0.001142	0.109824	0.258930	-0.071368	0.261704
-0.200	-0.000459	-0.000012	-0.000470	0.001145	0.103917	0.259074	-0.073069	0.261560
-0.190	-0.000450	0.000269	-0.000448	0.001071	0.103917	0.263755	-0.074768	0.261356
-0.180	-0.000441	0.000561	-0.000425	0.000969	0.103917	0.268433	-0.076468	0.261223
-0.170	-0.000431	0.000862	-0.000401	0.000843	0.103917	0.273107	-0.078166	0.261041
-0.160	-0.000422	0.001170	-0.000376	0.000696	0.103917	0.277776	-0.079863	0.260852
-0.150	-0.000342	0.005271	-0.000347	0.000477	0.074430	0.259992	-0.081559	0.260644
-0.140	-0.000321	0.005131	-0.000325	0.000425	0.068541	0.260161	-0.083255	0.260476
-0.130	-0.000392	0.002126	-0.000296	0.000169	0.103917	0.291721	-0.084949	0.260259
-0.120	-0.000278	0.004733	-0.000280	0.000326	0.056770	0.260496	-0.086643	0.260141
-0.110	-0.000256	0.004481	-0.000257	0.000280	0.050887	0.260667	-0.084324	0.259970
-0.100	-0.000234	0.004197	-0.000234	0.000236	0.045007	0.260838	-0.078430	0.259795
-0.090	-0.000212	0.003885	-0.000211	0.000195	0.039128	0.261010	-0.072539	0.259627
-0.080	-0.000190	0.003546	-0.000188	0.000157	0.033251	0.261189	-0.066651	0.259454
-0.070	-0.000168	0.003184	-0.000164	0.000123	0.027375	0.261357	-0.060765	0.259280
-0.060	-0.000146	0.002801	-0.000141	0.000092	0.021500	0.261531	-0.054881	0.259106
-0.050	-0.000124	0.002400	-0.000118	0.000066	0.015626	0.261706	-0.049000	0.258931
-0.040	-0.000101	0.001985	-0.000094	0.000043	0.009752	0.261881	-0.043120	0.258755
-0.030	-0.000079	0.001556	-0.000071	0.000024	0.003879	0.262057	-0.037241	0.258575
-0.020	-0.000056	0.001119	-0.000047	0.000010	-0.001994	0.262233	-0.031365	0.258403
-0.010	-0.000022	0.000466	-0.000023	0.000002	-0.013740	0.257889	-0.025489	0.258228
0.0	0.0	0.0	0.0	0.0	-0.019614	0.258058	-0.019614	0.258058
0.0	0.0	0.0	0.0	0.0	-0.019614	0.258058	-0.019614	0.258058
0.010	0.000022	0.000466	0.000023	0.000002	-0.025489	0.258228	-0.013740	0.257889
0.020	0.000056	0.001119	0.000047	0.000010	-0.031365	0.258403	-0.001994	0.262057
0.030	0.000079	0.001556	0.000071	0.000024	-0.037241	0.258575	0.003879	0.262057
0.040	0.000101	0.001985	0.000094	0.000043	-0.043120	0.258755	0.009752	0.261881

0.050	0.000124	0.002400	0.000118	0.000066	-0.049000	0.258931	0.015626	0.261706
0.060	0.000146	0.002801	0.000141	0.000092	-0.054881	0.259106	0.021500	0.261531
0.070	0.000168	0.003184	0.000164	0.000123	-0.060765	0.259280	0.027375	0.261357
0.080	0.000190	0.003546	0.000188	0.000157	-0.066651	0.259454	0.033251	0.261183
0.090	0.000212	0.003885	0.000211	0.000195	-0.072539	0.259627	0.039128	0.261010
0.100	0.000234	0.004197	0.000234	0.000236	-0.078430	0.259799	0.045007	0.260838
0.110	0.000256	0.004481	0.000257	0.000280	-0.084324	0.259970	0.050887	0.260667
0.120	0.000278	0.004733	0.000280	0.000326	-0.090223	0.260141	0.056770	0.260496
0.130	0.000392	-0.002126	0.000296	0.000169	-0.084949	0.260255	0.103917	0.251726
0.140	0.000421	0.005131	0.000325	0.000425	-0.083255	0.260476	0.068541	0.260161
0.150	0.000342	0.005271	0.000347	0.000477	-0.081559	0.260644	0.074430	0.259952
0.160	0.000422	-0.001170	0.000376	0.000696	-0.079863	0.260852	0.103917	0.277776
0.170	0.000431	-0.000862	0.000401	0.000843	-0.078166	0.261041	0.103917	0.273107
0.180	0.000441	-0.000561	0.000425	0.000969	-0.076468	0.261223	0.103917	0.268433
0.190	0.000453	-0.000269	0.000448	0.001071	-0.074768	0.261396	0.103917	0.263755
0.200	0.000459	0.000012	0.000470	0.001145	-0.073069	0.261560	0.103917	0.259074
0.210	0.000478	-0.000571	0.000485	0.001142	-0.071368	0.261704	0.109824	0.258930
0.220	0.000495	-0.001171	0.000508	0.001132	-0.069666	0.261843	0.115734	0.258790
0.230	0.000513	-0.001785	0.000526	0.001117	-0.067964	0.261980	0.121647	0.258653
0.240	0.000530	-0.002414	0.000544	0.001095	-0.066261	0.262114	0.127564	0.258515
0.250	0.000547	-0.003057	0.000562	0.001066	-0.064558	0.262245	0.133484	0.258387
0.260	0.000572	-0.003543	0.000576	0.001113	-0.061149	0.257853	0.139408	0.258259
0.270	0.000588	-0.004233	0.000593	0.001073	-0.059443	0.257957	0.145335	0.258155
0.280	0.000603	-0.004938	0.000609	0.001027	-0.057737	0.258079	0.151265	0.258033
0.290	0.000619	-0.005655	0.000625	0.000974	-0.056031	0.258199	0.157199	0.257912
0.300	0.000640	-0.007176	0.000636	0.000760	-0.054324	0.258317	0.169076	0.262314
0.310	0.000654	-0.007900	0.000651	0.000685	-0.052616	0.258431	0.175019	0.262260
0.320	0.000669	-0.008655	0.000669	0.000510	-0.052616	0.263044	0.180965	0.262105
0.330	0.000666	-0.009385	0.000688	0.000298	-0.052616	0.267693	0.186913	0.261962
0.340	0.000707	-0.011232	0.000706	0.000112	-0.047491	0.258798	0.192864	0.261832
0.350	0.000720	-0.011776	0.000720	0.000003	-0.045782	0.258907	0.198817	0.261723
0.360	0.000717	0.469675	0.001085	0.009189	-0.044072	0.261586	-0.891631	1.523020
0.370	0.000817	0.509069	0.001738	0.026948	-0.040652	0.261922	-0.430500	1.399673
0.380	0.000866	0.525204	0.002490	0.047658	-0.035519	0.258541	-0.222927	1.438833
0.390	0.000715	0.537290	0.003466	0.074356	-0.032095	0.261271	0.034461	1.352553
0.400	0.010794	0.535253	0.004485	0.102578	-0.026958	0.259890	0.303285	1.360344
0.410	0.011501	0.527679	0.005417	0.128157	-0.021819	0.257899	0.534541	1.443389
0.420	0.012474	0.507092	0.006225	0.150188	-0.018393	0.259437	1.076685	1.363016
0.430	0.012786	0.497947	0.006930	0.169431	-0.014965	0.260256	1.158302	1.530277
0.440	0.013353	0.475785	0.007520	0.185472	-0.011538	0.260164	1.293883	1.533830
0.450	0.013621	0.449443	0.008011	0.198792	-0.008110	0.259344	1.355685	1.655724
0.460	0.013864	0.437011	0.008417	0.209783	-0.004682	0.257936	1.411012	1.760668
0.470	0.014292	0.412189	0.008752	0.219636	-0.002968	0.260760	1.494055	1.710447
0.480	0.014503	0.400167	0.009129	0.228727	0.000461	0.258800	1.517616	1.757453
0.490	0.014697	0.388347	0.009441	0.236880	0.002175	0.261121	1.526570	1.876702
0.500	0.014889	0.376921	0.009726	0.244544	0.004293	0.258775	1.519186	1.550759
0.510	0.015307	0.364210	0.009997	0.250024	0.005469	0.111387	1.494044	2.020492
0.520	0.014559	0.400517	0.010280	0.259397	0.004397	0.258460	1.517616	2.538631
0.530	0.015486	0.352568	0.010455	0.263227	0.005538	0.113297	1.450118	2.278078
0.540	0.015135	0.366047	0.010851	0.274484	0.004500	0.258267	1.494044	2.539147
0.550	0.015513	0.351195	0.011097	0.279109	0.005642	0.113306	1.450118	2.566057
0.560	0.015836	0.339268	0.011334	0.285092	0.005711	0.111939	1.304138	2.529266
0.570	0.015746	0.326144	0.011550	0.292620	0.004639	0.259073	1.202458	2.554655
0.580	0.015754	0.326164	0.011762	0.298082	0.004673	0.266688	1.202458	2.606738
0.590	0.015900	0.317420	0.011966	0.303268	0.004708	0.262243	1.150525	2.605245
0.600	0.016049	0.309179	0.012153	0.308255	0.004777	0.259098	1.100599	2.607258
0.610	0.016440	0.293715	0.012352	0.310859	0.005515	0.113526	1.218427	2.600416
0.620	0.016586	0.288666	0.012537	0.315313	0.005598	0.111966	1.247907	2.589522
0.630	0.016718	0.278417	0.012716	0.319683	0.006022	0.112642	1.276933	2.574876
0.640	0.016608	0.282708	0.012884	0.325663	0.005123	0.237628	1.305396	2.556916
0.650	0.016723	0.276477	0.013045	0.329904	0.005123	0.243231	1.333183	2.536273
0.660	0.016835	0.270506	0.013202	0.334006	0.005123	0.248986	1.360179	2.512828
0.670	0.016949	0.262508	0.013338	0.338356	0.005089	0.259091	1.386268	2.489762
0.680	0.017180	0.251147	0.013494	0.342827	0.005123	0.260270	1.435261	2.550864
0.690	0.017167	0.250793	0.013654	0.346894	0.005156	0.261493	1.435261	2.426949
0.700	0.017201	0.250035	0.013793	0.350686	0.005227	0.258048	1.435261	2.240162
0.710	0.017308	0.241216	0.013931	0.354674	0.005262	0.259096	1.457937	2.196156
0.720	0.017316	0.240803	0.014066	0.357407	0.005296	0.260124	1.457937	1.939259
0.730	0.017419	0.231912	0.014198	0.360596	0.005331	0.261131	1.479249	1.884171
0.740	0.017519	0.222968	0.014325	0.363641	0.005368	0.262102	1.499093	1.829293
0.750	0.017535	0.222079	0.014441	0.366727	0.005435	0.258479	1.499093	1.511156
0.760	0.017632	0.213080	0.014563	0.369587	0.005469	0.259396	1.517366	1.450393
0.770	0.017725	0.204045	0.014680	0.372316	0.005504	0.260288	1.533973	1.390113
0.780	0.017733	0.203587	0.014795	0.375077	0.005538	0.261172	1.533973	1.023975
0.790	0.017823	0.194524	0.014907	0.377642	0.005573	0.262025	1.548805	0.960533
0.800	0.017641	0.193610	0.015012	0.380299	0.005642	0.258308	1.548805	0.824078
0.810	0.017850	0.193159	0.015119	0.382788	0.005677	0.259119	1.548805	0.836223
0.820	0.017937	0.184089	0.015224	0.385182	0.005711	0.259932	1.561789	0.838167
0.830	0.017947	0.183650	0.015330	0.387571	0.005746	0.260727	1.561785	0.852152
0.840	0.018030	0.174581	0.015432	0.389825	0.005780	0.261507	1.572869	0.852044
0.850	0.018040	0.174160	0.015534	0.392133	0.005815	0.262284	1.572869	0.863924
0.860	0.018060	0.173353	0.015625	0.354394	0.005884	0.258427	1.572869	0.875446
0.870	0.018070	0.172970	0.015729	0.396632	0.005919	0.259244	1.572869	0.887178
0.880	0.018151	0.163958	0.015827	0.398731	0.005953	0.259992	1.581985	0.888898
0.890	0.018162	0.163608	0.015925	0.400892	0.005988	0.260737	1.581985	0.900309
0.900	0.018027	0.180560	0.016035	0.403573	0.006022	0.261505	1.561789	0.930323
0.910	0.018193	0.162677	0.016142	0.405931	0.006092	0.257893	1.581985	0.923027
0.920	0.018272	0.153764	0.016235	0.407833	0.006126	0.258577	1.589081	0.924239
0.930	0.018282	0.153522	0.016324	0.409747	0.006095	0.259262	1.589087	0.935239
0.940	0.018357	0.144663	0.016414	0.411559	0.005747	0.259941	1.594137	0.936697
0.950	0.018368	0.144476	0.016458	0.413338	0.005459	0.260523	1.594137	0.946957
0.960	0.018440	0.135683	0.016583	0.415022	0.005171	0.261169	1.597110	0.948314
0.970	0.018796	0.160828	0.016655	0.413251	-0.008066	0.084659	1.597110	0.958289
0.980	0.018856	0.152563	0.016723	0.415084	-0.008374	0.084922	1.597991	0.959366
0.990	0.018861	0.153107	0.016790	0.416874	-0.008951	0.082919	1.597991	0.968966
1.000	0.018918	0.144691	0.016854	0.418599	-0.009236	0.083165	1.596777	0.969947

LINEARIZATION USING DESCRIBING FCNS

AMP	ALAM	DELM	WSRL
0.050	0.0723	1.4145	0.0673
0.100	0.0696	1.2840	0.0686
0.150	0.0710	0.9167	0.0683
0.200	0.0713	0.1880	0.0693
0.250	0.0676	-0.0873	0.0680
0.300	0.0655	-0.3601	0.0656
0.350	0.0633	-0.6509	0.0635
0.400	0.4313	22.6173	0.1605
0.450	0.6286	25.3948	0.3204
0.500	0.7153	23.3357	0.4167
0.550	0.7432	21.4271	0.4747
0.600	0.7506	19.9392	0.5107
0.650	0.7494	18.7951	0.5315
0.700	0.7385	14.8645	0.5420
0.750	0.7216	13.1634	0.5460
0.800	0.7026	11.5718	0.5453
0.850	0.6817	10.2456	0.5415
0.900	0.6594	9.2115	0.5359
0.950	0.6386	8.1930	0.5294
1.000	0.6221	7.4934	0.5214

PROFILE PRINCIPAL TRANSVERSE CURVATURES (1/IN)

XWR= LOCATION ON RIGHT WHEEL, POSITIVE OUT FROM TAPELINE (IN)
XRR= LOCATION ON RIGHT RAIL, POSITIVE OUT FROM CENTERLINE (IN)
XWL= LOCATION ON LEFT WHEEL, POSITIVE OUT FROM TAPELINE (IN)
XRL= LOCATION ON LEFT RAIL, POSITIVE OUT FROM CENTERLINE (IN)
CWR = PRINCIPAL TRANSVERSE CURVATURE OF RIGHT WHEEL PROFILE, POSITIVE FOR CURVATURE CENTER IN BODY (1/IN)
CYR = PRINCIPAL TRANSVERSE CURVATURE OF RIGHT RAIL PROFILE, POSITIVE FOR CURVATURE CENTER IN BODY (1/IN)
CWL = PRINCIPAL TRANSVERSE CURVATURE OF LEFT WHEEL PROFILE, POSITIVE FOR CURVATURE CENTER IN BODY (1/IN)
CYL = PRINCIPAL TRANSVERSE CURVATURE OF LEFT RAIL PROFILE, POSITIVE FOR CURVATURE CENTER IN BODY (1/IN)

XWR (IN)	CWR (1/IN)	XRR (IN)	CYR (1/IN)	XWL (IN)	CWL (1/IN)	XRL (IN)	CYL (1/IN)
-2.39861	1.086594	-1.43086	1.229009	-2.39861	1.086594	-1.43086	1.229009
-2.35000	1.239624	-1.40000	1.648176	-2.35000	1.239624	-1.40000	1.648176
-2.30000	1.381223	-1.35000	2.351565	-2.30000	1.381223	-1.35000	2.351565
-2.25000	1.495469	-1.30000	2.587111	-2.25000	1.495469	-1.30000	2.587111
-2.20000	1.570747	-1.25000	1.853100	-2.20000	1.570747	-1.25000	1.853100
-2.15000	1.597979	-1.20000	0.831286	-2.15000	1.597979	-1.20000	0.831286
-2.10000	1.573413	-1.15000	0.881850	-2.10000	1.573413	-1.15000	0.881850
-2.05000	1.500123	-1.10000	0.929957	-2.05000	1.500123	-1.10000	0.929957
-2.00000	1.387651	-1.05000	0.974213	-2.00000	1.387651	-1.05000	0.974213
-1.95000	1.249490	-1.00000	1.013176	-1.95000	1.249490	-1.00000	1.013176
-1.90000	1.299115	-0.95000	0.833619	-1.90000	1.299115	-0.95000	0.833619
-1.85000	1.526603	-0.90000	0.586083	-1.85000	1.526603	-0.90000	0.586083
-1.80000	1.358862	-0.85000	0.325156	-1.80000	1.358862	-0.85000	0.325156
-1.75000	0.868422	-0.80000	0.058185	-1.75000	0.868422	-0.80000	0.058185
-1.70000	0.212215	-0.75000	0.011608	-1.70000	0.212215	-0.75000	0.011608
-1.65000	-0.217905	-0.70000	0.050584	-1.65000	-0.217905	-0.70000	0.050584
-1.60000	-0.880708	-0.65000	0.089676	-1.60000	-0.880708	-0.65000	0.089676
-1.55000	-1.243132	-0.60000	0.128962	-1.55000	-1.243132	-0.60000	0.128962
-1.50000	-1.639226	-0.55000	0.168508	-1.50000	-1.639226	-0.55000	0.168508
-1.45000	-1.970916	-0.50000	0.208357	-1.45000	-1.970916	-0.50000	0.208357
-1.40000	-2.080045	-0.45000	0.248522	-1.40000	-2.080045	-0.45000	0.248522
-1.35000	-1.855027	-0.40000	0.288981	-1.35000	-1.855027	-0.40000	0.288981
-1.30000	-1.312252	-0.35000	0.290796	-1.30000	-1.312252	-0.35000	0.290796
-1.25000	-0.882938	-0.30000	0.268455	-1.25000	-0.882938	-0.30000	0.268455
-1.20000	-0.848465	-0.25000	0.245829	-1.20000	-0.848465	-0.25000	0.245829
-1.15000	-0.802314	-0.20000	0.222997	-1.15000	-0.802314	-0.20000	0.222997
-1.10000	-0.746202	-0.15000	0.200023	-1.10000	-0.746202	-0.15000	0.200023
-1.05000	-0.682002	-0.10000	0.176958	-1.05000	-0.682002	-0.10000	0.176958
-1.00000	-0.611559	-0.05000	0.153841	-1.00000	-0.611559	-0.05000	0.153841
-0.95000	-0.535782	0.00000	0.130701	-0.95000	-0.535782	0.00000	0.130701
-0.90000	-0.453786	0.05000	0.110712	-0.90000	-0.453786	0.05000	0.110712
-0.85000	-0.369733	0.10000	0.099400	-0.85000	-0.369733	0.10000	0.099400
-0.80000	-0.284482	0.15000	0.088092	-0.80000	-0.284482	0.15000	0.088092
-0.75000	-0.198605	0.20000	0.076790	-0.75000	-0.198605	0.20000	0.076790
-0.70000	-0.112446	0.25000	0.065497	-0.70000	-0.112446	0.25000	0.065497
-0.65000	-0.026184	0.30000	0.054213	-0.65000	-0.026184	0.30000	0.054213
-0.60000	0.060097	0.35000	0.042937	-0.60000	0.060097	0.35000	0.042937
-0.55000	0.146333	0.40000	0.031670	-0.55000	0.146333	0.40000	0.031670
-0.50000	0.222968	0.45000	0.021373	-0.50000	0.222968	0.45000	0.021373
-0.45000	0.193186	0.50000	0.123032	-0.45000	0.193186	0.50000	0.123032
-0.40000	0.163457	0.55000	0.224404	-0.40000	0.163457	0.55000	0.224404
-0.35000	0.133805	0.60000	0.325109	-0.35000	0.133805	0.60000	0.325109
-0.30000	0.104237	0.65000	0.424509	-0.30000	0.104237	0.65000	0.424509
-0.25000	0.074749	0.70000	0.521620	-0.25000	0.074749	0.70000	0.521620
-0.20000	0.045325	0.75000	0.615029	-0.20000	0.045325	0.75000	0.615029
-0.15000	0.015944	0.80000	0.702868	-0.15000	0.015944	0.80000	0.702868
-0.10000	-0.013422	0.85000	0.782850	-0.10000	-0.013422	0.85000	0.782850
-0.05000	-0.042801	0.90000	0.852391	-0.05000	-0.042801	0.90000	0.852391
0.00000	-0.072220	0.95000	0.908836	0.00000	-0.072220	0.95000	0.908836
0.05000	-0.083347	1.00000	0.949768	0.05000	-0.083347	1.00000	0.949768
0.10000	-0.074860	1.03920	0.969793	0.10000	-0.074860	1.03920	0.969793
0.15000	-0.066354	0.0	0.0	0.15000	-0.066354	0.0	0.0
0.20000	-0.057830	0.0	0.0	0.20000	-0.057830	0.0	0.0
0.25000	-0.049292	0.0	0.0	0.25000	-0.049292	0.0	0.0
0.30000	-0.040744	0.0	0.0	0.30000	-0.040744	0.0	0.0
0.35000	-0.032188	0.0	0.0	0.35000	-0.032188	0.0	0.0
0.40000	-0.023625	0.0	0.0	0.40000	-0.023625	0.0	0.0
0.45000	-0.015058	0.0	0.0	0.45000	-0.015058	0.0	0.0
0.50000	-0.006489	0.0	0.0	0.50000	-0.006489	0.0	0.0
0.55000	0.002082	0.0	0.0	0.55000	0.002082	0.0	0.0
0.60000	0.004395	0.0	0.0	0.60000	0.004395	0.0	0.0
0.65000	0.004568	0.0	0.0	0.65000	0.004568	0.0	0.0
0.70000	0.004741	0.0	0.0	0.70000	0.004741	0.0	0.0
0.75000	0.004914	0.0	0.0	0.75000	0.004914	0.0	0.0
0.80000	0.005087	0.0	0.0	0.80000	0.005087	0.0	0.0
0.85000	0.005260	0.0	0.0	0.85000	0.005260	0.0	0.0
0.90000	0.005433	0.0	0.0	0.90000	0.005433	0.0	0.0
0.95000	0.005606	0.0	0.0	0.95000	0.005606	0.0	0.0
1.00000	0.005778	0.0	0.0	1.00000	0.005778	0.0	0.0
1.05000	0.005951	0.0	0.0	1.05000	0.005951	0.0	0.0
1.10000	0.006124	0.0	0.0	1.10000	0.006124	0.0	0.0
1.15000	0.004898	0.0	0.0	1.15000	0.004898	0.0	0.0
1.20000	0.003457	0.0	0.0	1.20000	0.003457	0.0	0.0
1.25000	0.002016	0.0	0.0	1.25000	0.002016	0.0	0.0
1.30000	0.000576	0.0	0.0	1.30000	0.000576	0.0	0.0
1.35000	-0.000865	0.0	0.0	1.35000	-0.000865	0.0	0.0
1.40000	-0.002306	0.0	0.0	1.40000	-0.002306	0.0	0.0
1.45000	-0.003747	0.0	0.0	1.45000	-0.003747	0.0	0.0
1.50000	-0.005188	0.0	0.0	1.50000	-0.005188	0.0	0.0
1.55000	-0.006629	0.0	0.0	1.55000	-0.006629	0.0	0.0
1.60000	-0.008070	0.0	0.0	1.60000	-0.008070	0.0	0.0
1.65000	-0.009512	0.0	0.0	1.65000	-0.009512	0.0	0.0
1.70000	-0.010954	0.0	0.0	1.70000	-0.010954	0.0	0.0
1.75000	-0.012396	0.0	0.0	1.75000	-0.012396	0.0	0.0
1.80000	-0.013838	0.0	0.0	1.80000	-0.013838	0.0	0.0
1.85000	-0.015281	0.0	0.0	1.85000	-0.015281	0.0	0.0
1.90000	-0.016724	0.0	0.0	1.90000	-0.016724	0.0	0.0
1.95000	-0.018168	0.0	0.0	1.95000	-0.018168	0.0	0.0
2.00000	-0.019612	0.0	0.0	2.00000	-0.019612	0.0	0.0
2.00406	-0.019729	0.0	0.0	2.00406	-0.019729	0.0	0.0

CALCOMP PLOTTER OUTPUT - SYMMETRIC PROBLEM

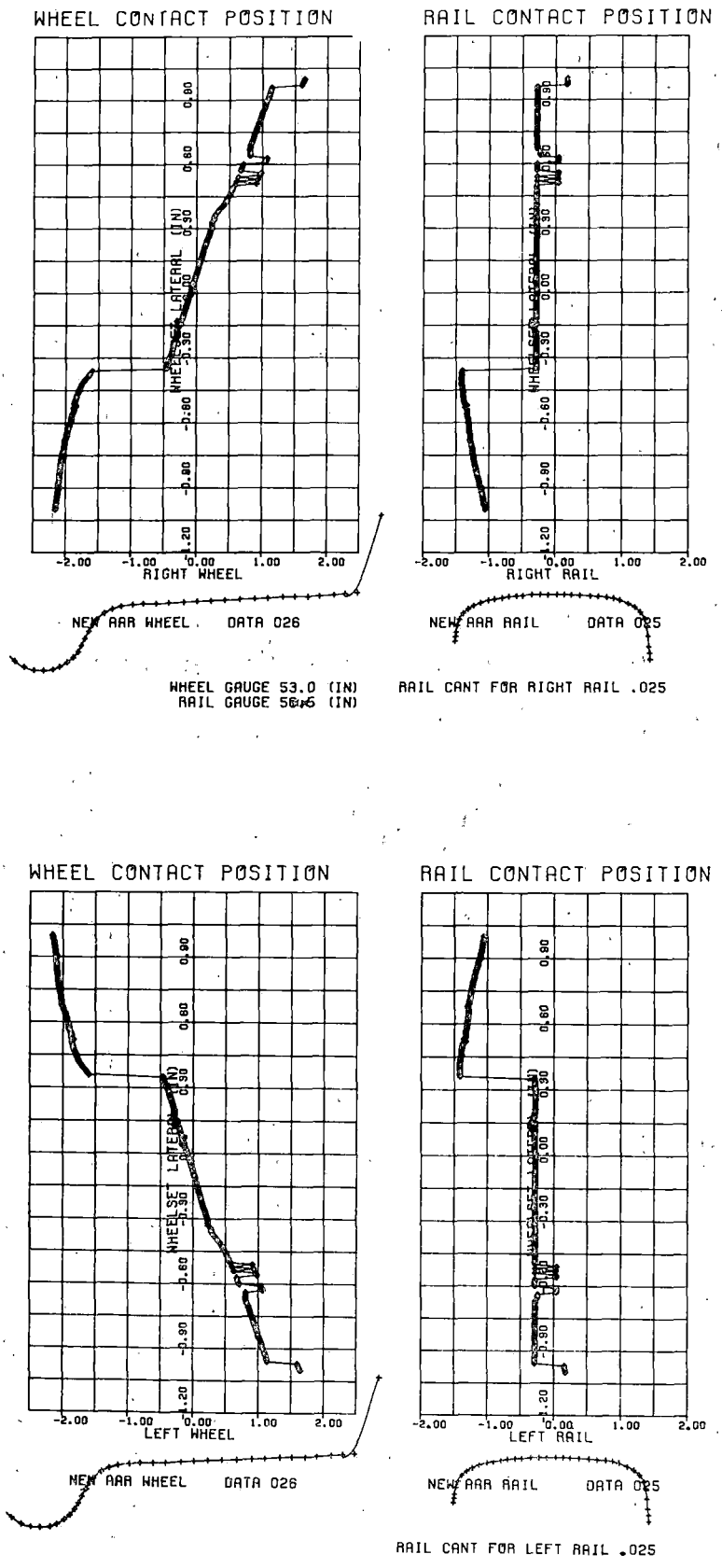
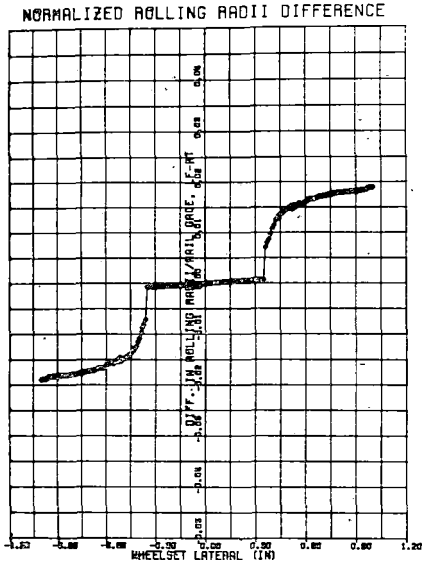
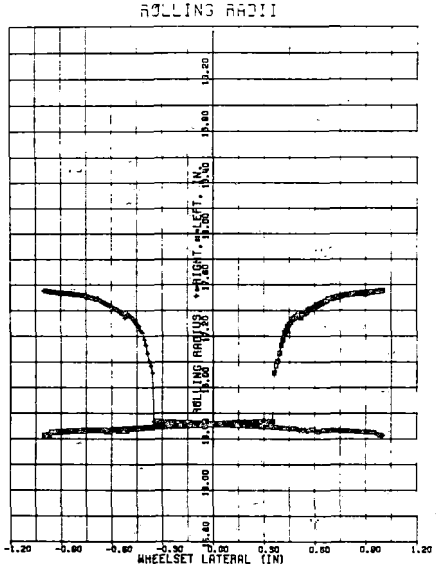


FIGURE 3A. CALCOMP PLOTTER OUTPUT - SYMMETRIC PROBLEM, WHEEL/RAIL PROFILES AND LOCATION OF CONTACT POINTS.



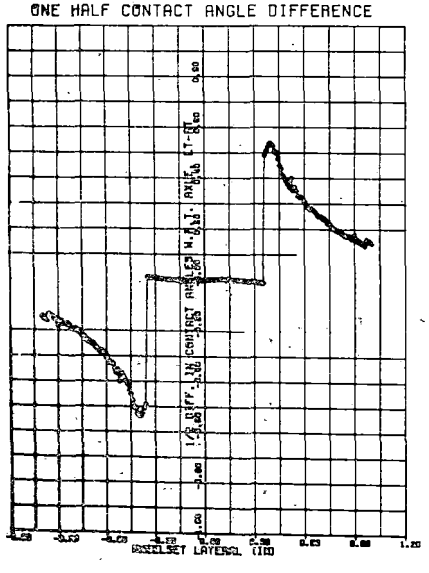


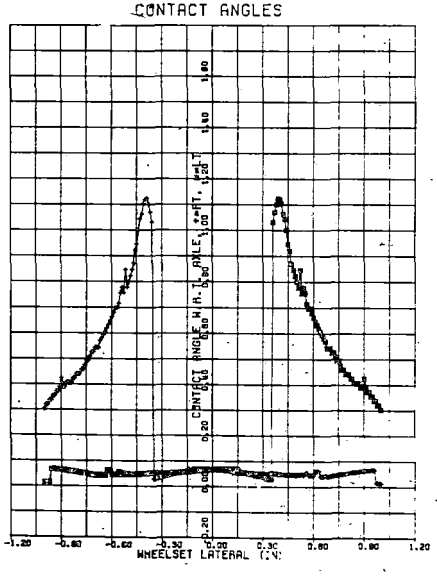
RIGHT SIDE

NEW AAR WHEEL DATA 026
NEW AAR RAIL DATA 025
RAIL CANT FOR RIGHT RAIL .025

LEFT SIDE

NEW AAR WHEEL DATA 026
NEW AAR RAIL DATA 025
RAIL CANT FOR LEFT RAIL .025





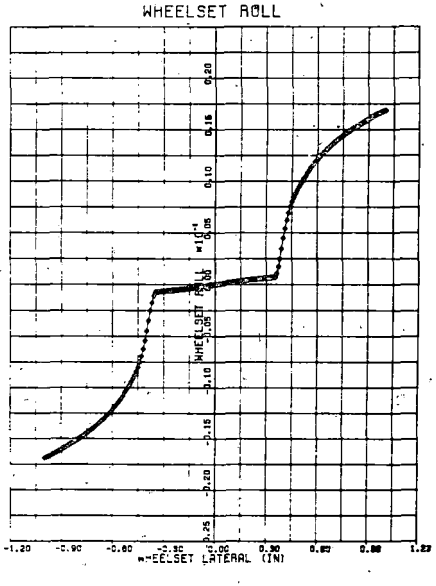


FIGURE 3B. CALCOMP PLOTTER OUTPUT - SYMMETRIC PROBLEM, GEOMETRIC CONSTRAINTS.

PARTIAL LISTING OF PUNCHED CARD OUTPUT - SYMMETRIC PROBLEM

```
 0.530000D+02 0.29563D+02 0.56500D+02 0.29750D+02 0.250000D-01 0.25000D-01

 COEFFICIENTS FOR PROFILE CURVE FITS

 NEW AAR WHEEL     DATA 026
 14
  1 0.4405190+03-0.7104370+03 0.4421820+03-0.1210410+03 0.1227390+02
 0.2000000+03 0.2298310+01
  2 0.1555370+02 0.1575400+01-0.1006580+01 0.2731350+00-0.2813760-01
 0.2298310+01 0.1819670+01
  3 0.1570280+02 0.2427170+01-0.2778270+01 0.1344880+01-0.2368990+00
 0.1819670+01 0.1334990+01
  4 0.1656630+02-0.3707880+00 0.6042870+00-0.4639510+00 0.1241230+00
 0.1334990+01 0.8050820+00
  5 0.1650960+02-0.6147290-01 0.1825800-01-0.3133290-02-0.3608650-02
 0.8050820+00 0.2388720+00
  6 0.1650960+02-0.5166240-01 0.3217590-01 0.1192490-01-0.1154260+00
 0.2388720+00-0.2980390+00
  7 0.1650820+02-0.8422190-01 0.1647020-01 0.2117730+00 0.1642800+00
-0.2980390+00-0.7976910+00
  8 0.1689990+02 0.1639960+01 0.2765980+01 0.2088070+01 0.6248470+00
-0.7976910+00-0.1204040+01
  9 0.2853000+02 0.3839280+02 0.4606830+02 0.2463610+02 0.5003670+01
-0.1204040+01-0.1512950+01
 10-0.2695490+02-0.1189490+03-0.1206460+03-0.5360570+02-0.8721790+01
-0.1512950+01-0.1647350+01
 11 0.5869440+03 0.1284520+04 0.1079240+04 0.4009410+03 0.5563560+02
-0.1647350+01-0.1799980+01
 12-0.1476490+03-0.3212700+03-0.2359790+03-0.7743020+02-0.9558570+01
-0.1799980+01-0.2012950+01
 13 0.4283870+01-0.1754740+02-0.8679330+01-0.1954130+01-0.1759460+00
-0.2012950+01-0.2325360+01
 14 0.5214570+02 0.5661550+02 0.3395990+02 0.8804470+01 0.8263800+00
-0.2325360+01-0.2829460+01

 NEW AAR RAIL      DATA 025
 14
  1-0.1239710+07 0.3493540+07-0.3691700+07 0.1733770+07-0.3053340+06
 0.2000000+03 0.1418880+01
  2-0.2234710+05 0.6678590+05-0.7481690+05 0.3724760+05-0.6953580+04
 0.1418880+01 0.1377260+01
  3-0.2187900+03 0.7699750+03-0.9822300+03 0.5558040+03-0.1178130+03
 0.1377260+01 0.1203180+01
  4-0.2830060-01 0.2871520+02-0.4312910+02 0.2858740+02-0.7144460+01
 0.1203180+01 0.9312770+00
  5 0.6709010+01 0.2383070+01-0.5439600+01 0.5314960+01-0.1964740+01
 0.9312770+00 0.6536630+00
  6 0.7115480+01-0.2075830+00 0.6369020+00-0.9094470+00 0.3865160+00
 0.6536630+00 0.3191580+00
  7 0.7094790+01 0.2694400-01-0.9564850-01-0.4791310+00 0.9752210+00
 0.3191580+00 0.3666800-01
```

```
  8 0.709452D+01 0.245721D-01 0.479225D-02-0.473900D+00-0.110899D+01
 0.366680D-01-0.276404D+00
  9 0.703868D+01-0.515251D+00-0.230577D+01-0.337448D+01-0.181905D+01
-0.276404D+00-0.572465D+00
 10 0.685740D+01-0.103994D+01-0.163633D+01-0.857042D+00-0.121276D+00
-0.572465D+00-0.929855D+00
 11 0.977150D+01 0.108459D+02 0.161084D+02 0.104963D+02 0.246690D+01
-0.929855D+00-0.110928D+01
 12-0.145265D+02-0.764514D+02-0.101152D+03-0.592945D+02-0.130635D+02
-0.110928D+01-0.133318D+01
 13-0.163258D+04-0.491188D+04-0.551570D+04-0.275182D+04-0.514757D+03
-0.133318D+01-0.145861D+01
 14 0.178741D+06 0.488819D+06 0.501228D+06 0.228378D+06 0.390132D+05
-0.145861D+01-0.150317D+01

 NEW AAR WHEEL     DATA 026
 14
  1 0.440519D+03-0.710437D+03 0.442182D+03-0.121041D+03 0.122739D+02
 0.200000D+03 0.229831D+01
  2 0.155537D+02 0.157540D+01-0.100658D+01 0.273135D+00-0.281376D-01
 0.229831D+01 0.181967D+01
  3 0.157028D+02 0.242717D+01-0.277827D+01 0.134488D+01-0.236899D+00
 0.181967D+01 0.133499D+01
  4 0.165683D+02-0.370788D+00 0.604287D+00-0.463951D+00 0.124123D+00
 0.133499D+01 0.805082D+00
  5 0.165096D+02-0.614729D-01 0.182580D-01-0.313329D-02-0.360865D-02
 0.805082D+00 0.238872D+00
  6 0.165096D+02-0.616624D-01 0.321759D-01 0.119249D-01-0.115426D+00
 0.238872D+00-0.298039D+00
  7 0.165082D+02-0.842219D-01 0.164702D-01 0.211773D+00 0.164280D+00
-0.298039D+00-0.797691D+00
  8 0.168990D+02 0.163996D+01 0.276598D+01 0.208807D+01 0.624847D+00
-0.797691D+00-0.120404D+01
  9 0.285300D+02 0.383928D+02 0.460683D+02 0.246361D+02 0.500367D+01
-0.120404D+01-0.151295D+01
 10-0.269549D+02-0.118949D+03-0.120646D+03-0.536057D+02-0.872179D+01
-0.151295D+01-0.164735D+01
 11 0.586944D+03 0.128452D+04 0.107924D+04 0.400941D+03 0.556356D+02
-0.164735D+01-0.179098D+01
 12-0.147649D+03-0.321270D+03-0.235979D+03-0.774302D+02-0.955857D+01
-0.179098D+01-0.201295D+01
 13 0.428387D+01-0.175474D+02-0.867933D+01-0.195413D+01-0.175946D+00
-0.201295D+01-0.232536D+01
 14 0.521457D+02 0.566155D+02 0.339599D+02 0.880447D+01 0.826380D+00
-0.232536D+01-0.282946D+01

 NEW AAR RAIL      DATA 025
 14
  1-0.123971D+07 0.349354D+07-0.369170D+07 0.173377D+07-0.305334D+06
 0.200000D+03 0.141888D+01
  2-0.223471D+05 0.667859D+05-0.748169D+05 0.372476D+05-0.695358D+04
 0.141888D+01 0.137726D+01
  3-0.218790D+03 0.769975D+03-0.982230D+03 0.555804D+03-0.117813D+03
  5 0.670901D+01 0.238307D+01-0.543960D+01 0.531496D+01-0.196474D+01
```

```
 -0.031277D+00 0.653663D+00
  6 0.711580D+01-0.207583D+00 0.636902D+00-0.909447D+00 0.386516D+00
 -0.653663D+00 0.319158D+00
  7 0.709470D+01 0.269440D-01-0.956485D-01-0.479131D+00 0.975221D+00
  9 0.703886D+01-0.615251D+00-0.230577D+01-0.337448D+01-0.181905D+01
-0.276404D+00-0.572465D+00
 10 0.686740D+01-0.103994D+01-0.163633D+01-0.857042D+00-0.121276D+00
-0.572465D+00-0.829855D+00
 11 0.977150D+01 0.108469D+02 0.161084D+02 0.104963D+02 0.246690D+01
-0.829855D+00-0.110928D+01
 12-0.145245D+02-0.764514D+02-0.101152D+03-0.592945D+02-0.130635D+02
-0.110928D+01-0.133318D+01
 13-0.163288D+04-0.491188D+04-0.551570D+04-0.275182D+04-0.514757D+03
-0.133318D+01-0.145861D+01
 14 0.178741D+06 0.488819D+06 0.501228D+06 0.228378D+06 0.390132D+05
-0.145861D+01-0.150317D+01

THE DATA IS ORDERED AS FOLLOWS:

 CONTACT POINTS, GEOMETRIC CONSTRAINTS, AND PROFILE CURVATURES
 AS A FUNCTION OF WHEELSET  LATERAL DISPLACEMENT

 YW = WHEELSET LATERAL, POSITIVE TO THE LEFT (IN)
 Y1 = CONTACT LOCATION ON RIGHT WHEEL, POSITIVE OUT FROM TAPELINE (IN)
 Y2 = CONTACT LOCATION ON RIGHT RAIL, POSITIVE OUT FROM CENTERLINE (IN)
 Y3 = CONTACT LOCATION ON LEFT WHEEL, POSITIVE OUT FROM TAPELINE  (IN)
 Y4 = CONTACT LOCATION ON LEFT RAIL, POSITIVE OUT FROM CENTERLINE (IN)
 PR = ROLLING RADII, RIGHT WHEEL (IN)
 YR = RAIL HEAD PROFILE HEIGHT, RIGHT RAIL (IN)
 PL = ROLLING RADII, LEFT WHEEL (IN)
 YL = RAIL HEAD PROFILE HEIGHT, LEFT RAIL (IN)
 MR = CONTACT ANGLE W.R.T. AXLE, RIGHT WHEEL (RAD)
 ML = CONTACT ANGLE W.R.T. AXLE, LEFT WHEEL (RAD)
(PL-PR)/2 = NORMALIZED DIFFERENCE IN ROLLING RADII (IN/IN)
 (ML-MR)/2 = NORMALIZED DIFFERENCE IN CONTACT ANGLES (RAD)
 WR        = WHEELSET ROLL ANGLE W.R.T. HORIZONTAL, POSITIVE UP ON LEFT (RAD)
 YCG       = VERTICAL DISPLACEMENT OF WHEELSET CENTROID FROM NOMINAL POS. (IN)
 RR CRV = PRINCIPAL ROLLING CURVATURE OF RIGHT WHEEL PROFILE (1/IN)
 RL CRV = PRINCIPAL ROLLING CURVATURE OF LEFT WHEEL PROFILE (1/IN)
 CWR       = PRINCIPAL TRANSVERSE CURVATURE OF RIGHT WHEEL PROFILE,
             POSITIVE FOR CURVATURE CENTER IN BODY (1/IN)
 CYR       = PRINCIPAL TRANSVERSE CURVATURE OF RIGHT RAIL PROFILE,
             POSITIVE FOR CURVATURE CENTER IN BODY (1/IN)
 CWL       = PRINCIPAL TRANSVERSE CURVATURE OF LEFT WHEEL PROFILE,
             POSITIVE FOR CURVATURE CENTER IN BODY (1/IN)
 CYL       = PRINCIPAL TRANSVERSE CURVATURE OF LEFT RAIL PROFILE,
             POSITIVE FOR CURVATURE CENTER IN BODY (1/IN)

202  5
-0.100000D+01-0.215946D+01-0.105506D+01 0.154054D+01 0.171793D+00 0.175550D+02
 0.698795D+01 0.164294D+02 0.709502D+01 0.303139D+00 0.137568D-01-0.189175D-01
-0.144691D+00-0.168540D-01 0.418599D+00
 0.543666D-01 0.508608D-01 0.159678D+01 0.969947D+00-0.923900D-02 0.831653D-01
```

```
-0.990000D+00-0.214946D+01-0.105622D+01  0.163054D+01  0.172884D+00  0.175518D+02
 0.698758D+01  0.164295D+02  0.709499D+01  0.320336D+00  0.141232D-01-0.188610D-01
-0.153107D+00-0.167899D-01  0.416874D+00
 0.540760D-01  0.608600D-01  0.159799D+01  0.968966D+00-0.895067D-02  0.829188D-01
-0.980000D+00-0.214946D+01-0.106737D+01  0.161054D+01  0.164020D+00  0.175518D+02
 0.698393D+01  0.164298D+02  0.709523D+01  0.320336D+00  0.152107D-01-0.188561D-01
-0.152553D+00-0.167232D-01  0.415084D+00
 0.540760D-01  0.608579D-01  0.159799D+01  0.959366D+00-0.837406D-02  0.849224D-01
-0.970000D+00-0.213946D+01-0.106860D+01  0.160054D+01  0.165185D+00  0.175483D+02
 0.698352D+01  0.164300D+02  0.709520D+01  0.337575D+00  0.159203D-01-0.187961D-01
-0.160528D+00-0.166547D-01  0.413251D+00
 0.537692D-01  0.608566D-01  0.159711D+01  0.958289D+00-0.808577D-02  0.846591D-01
-0.960000D+00-0.213946D+01-0.107988D+01  0.114054D+01-0.283841D+00  0.175483D+02
 0.697954D+01  0.164512D+02  0.709291D+01  0.337575D+00  0.662102D-01-0.184402D-01
-0.135683D+00-0.165833D-01  0.415022D+00
 0.537692D-01  0.608528D-01  0.159711D+01  0.948314D+00  0.517064D-02  0.261169D+00
-0.950000D+00-0.212946D+01-0.108139D+01  0.113054D+01-0.282410D+00  0.175447D+02
 0.697911D+01  0.164518D+02  0.709297D+01  0.354845D+00  0.658934D-01-0.183684D-01
-0.144476D+00-0.164984D-01  0.413338D+00
 0.534463D-01  0.606517D-01  0.159414D+01  0.946957D+00  0.545865D-02  0.260523D+00
-0.940000D+00-0.212946D+01-0.109270D+01  0.112054D+01-0.281123D+00  0.175447D+02
 0.697594D+01  0.164525D+02  0.709302D+01  0.354845D+00  0.655185D-01-0.183574D-01
-0.144663D+00-0.164135D-01  0.411559D+00
 0.534463D-01  0.606507D-01  0.159414D+01  0.936697D+00  0.574707D-02  0.259941D+00
-0.930000D+00-0.211946D+01-0.109428D+01  0.111054D+01-0.279620D+00  0.175409D+02
 0.697446D+01  0.164531D+02  0.709309D+01  0.372133D+00  0.650883D-01-0.182824D-01
-0.153522D+00-0.163244D-01  0.409747D+00
 0.531074D-01  0.606500D-01  0.158909D+01  0.935239D+00  0.603529D-02  0.259262D+00
-0.920000D+00-0.211946D+01-0.110582D+01  0.110054D+01-0.278106D+00  0.175409D+02
 0.697012D+01  0.164538D+02  0.709315D+01  0.372133D+00  0.646059D-01-0.182715D-01
-0.153764D+00-0.162346D-01  0.407833D+00
 0.531074D-01  0.606495D-01  0.158909D+01  0.924529D+00  0.612611D-02  0.258577D+00
-0.910000D+00-0.210946D+01-0.110742D+01  0.109054D+01-0.276594D+00  0.175369D+02
 0.696950D+01  0.164544D+02  0.709321D+01  0.389429D+00  0.640742D-01-0.181934D-01
-0.162677D+00-0.161417D-01  0.405901D+00
 0.527530D-01  0.606492D-01  0.158198D+01  0.923027D+00  0.609154D-02  0.257893D+00
-0.900000D+00-0.208946D+01-0.109961D+01  0.107054D+01-0.284584D+00  0.175283D+02
 0.697247D+01  0.164557D+02  0.709287D+01  0.423995D+00  0.626746D-01-0.180272D-01
-0.160560D+00-0.160354D-01  0.403573D+00
 0.519989D-01  0.606492D-01  0.156179D+01  0.930323D+00  0.602239D-02  0.261505D+00
-0.890000D+00-0.210946D+01-0.113119D+01  0.106054D+01-0.282884D+00  0.175369D+02
 0.695848D+01  0.164563D+02  0.709295D+01  0.389429D+00  0.622127D-01-0.181615D-01
-0.163608D+00-0.159247D-01  0.400892D+00
 0.527530D-01  0.606494D-01  0.158198D+01  0.900309D+00  0.598782D-02  0.260737D+00
-0.880000D+00-0.210946D+01-0.114286D+01  0.105054D+01-0.281234D+00  0.175369D+02
 0.695367D+01  0.164569D+02  0.709302D+01  0.389429D+00  0.615134D-01-0.181511D-01
-0.163958D+00-0.158269D-01  0.398731D+00
 0.527530D-01  0.606497D-01  0.158198D+01  0.888898D+00  0.595325D-02  0.259992D+00
-0.870000D+00-0.209946D+01-0.114461D+01  0.104054D+01-0.279580D+00  0.175327D+02
 0.695294D+01  0.164576D+02  0.709309D+01  0.406720D+00  0.607795D-01-0.180701D-01
-0.172970D+00-0.157288D-01  0.396632D+00
 0.523834D-01  0.606502D-01  0.157287D+01  0.887178D+00  0.591667D-02  0.259244D+00
-0.860000D+00-0.209946D+01-0.115644D+01  0.103054D+01-0.277774D+00  0.175327D+02
 0.694799D+01  0.164582D+02  0.709316D+01  0.406720D+00  0.600141D-01-0.180600D-01
```

```
-0.173353D+00-0.156285D-01 0.394394D+00
 0.523834D-01 0.606508D-01 0.157287D+01 0.875446D+00 0.588410D-02 0.258427D+00
-0.850000D+00-0.209946D+01-0.116794D+01 0.101054D+01-0.286310D+00 0.175327D+02
 0.694310D+01 0.164593D+02 0.709279D+01 0.406720D+00 0.584004D-01-0.180400D-01
-0.174160D+00-0.155344D-01 0.392133D+00
 0.523834D-01 0.606522D-01 0.157287D+01 0.863924D+00 0.581494D-02 0.262284D+00
-0.840000D+00-0.209946D+01-0.117968D+01 0.100054D+01-0.284589D+00 0.175327D+02
 0.693802D+01 0.164599D+02 0.709287D+01 0.406720D+00 0.575581D-01-0.180303D-01
-0.174581D+00-0.154324D-01 0.389625D+00
 0.523834D-01 0.606530D-01 0.157287D+01 0.852044D+00 0.578036D-02 0.261507D+00
-0.830000D+00-0.208946D+01-0.119150D+01 0.990541D+00-0.282862D+00 0.175283D+02
 0.693722D+01 0.164605D+02 0.709295D+01 0.423995D+00 0.566961D-01-0.179466D-01
-0.183650D+00-0.153300D-01 0.387571D+00
 0.519890D-01 0.606539D-01 0.156179D+01 0.850192D+00 0.574579D-02 0.260727D+00
-0.820000D+00-0.208946D+01-0.119329D+01 0.960541D+00-0.281103D+00 0.175283D+02
 0.693200D+01 0.164611D+02 0.709302D+01 0.423995D+00 0.558173D-01-0.179371D-01
-0.184089D+00-0.152258D-01 0.385182D+00
 0.519989D-01 0.606548D-01 0.156179D+01 0.838167D+00 0.571120D-02 0.259932D+00
-0.810000D+00-0.207946D+01-0.119519D+01 0.970541D+00-0.279304D+00 0.175237D+02
 0.693115D+01 0.164616D+02 0.709310D+01 0.441242D+00 0.549248D-01-0.178502D-01
-0.193159D+00-0.151191D-01 0.382786D+00
 0.515999D-01 0.606558D-01 0.154881D+01 0.836223D+00 0.567662D-02 0.259119D+00
-0.800000D+00-0.207946D+01-0.120701D+01 0.960541D+00-0.277510D+00 0.175237D+02
 0.692575D+01 0.164622D+02 0.709317D+01 0.441242D+00 0.540214D-01-0.178410D-01
-0.193610D+00-0.150120D-01 0.380299D+00
 0.515999D-01 0.606568D-01 0.154881D+01 0.824078D+00 0.564204D-02 0.258308D+00
-0.790000D+00-0.207946D+01-0.121882D+01 0.940541D+00-0.285735D+00 0.175237D+02
 0.692017D+01 0.164632D+02 0.709282D+01 0.441242D+00 0.521942D-01-0.178231D-01
-0.194524D+00-0.149073D-01 0.377642D+00
 0.515999D-01 0.606587D-01 0.154881D+01 0.960533D+00 0.557287D-02 0.262025D+00
-0.780000D+00-0.206946D+01-0.122081D+01 0.930541D+00-0.283847D+00 0.175189D+02
 0.691921D+01 0.164637D+02 0.709290D+01 0.458450D+00 0.512763D-01-0.177333D-01
-0.203587D+00-0.147955D-01 0.375077D+00
 0.511671D-01 0.606597D-01 0.153397D+01 0.102398D+01 0.553829D-02 0.261172D+00
-0.770000D+00-0.206946D+01-0.123279D+01 0.920541D+00-0.281891D+00 0.175189D+02
 0.691329D+01 0.164642D+02 0.709299D+01 0.458450D+00 0.503594D-01-0.177247D-01
-0.204045D+00-0.146796D-01 0.372316D+00
 0.511871D-01 0.606607D-01 0.153397D+01 0.139011D+01 0.550370D-02 0.260288D+00
-0.760000D+00-0.205946D+01-0.123467D+01 0.910541D+00-0.279916D+00 0.175138D+02
 0.691224D+01 0.164647D+02 0.709307D+01 0.475606D+00 0.494466D-01-0.176316D-01
-0.213080D+00-0.145627D-01 0.369587D+00
 0.507608D-01 0.606616D-01 0.151737D+01 0.145039D+01 0.546912D-02 0.259396D+00
-0.750000D+00-0.204946D+01-0.123701D+01 0.900541D+00-0.277888D+00 0.175086D+02
 0.691114D+01 0.164652D+02 0.709316D+01 0.492699D+00 0.485408D-01-0.175349D-01
-0.222679D+00-0.144414D-01 0.366727D+00
 0.503216D-01 0.606625D-01 0.149909D+01 0.151116D+01 0.543453D-02 0.258479D+00
```

ETC.

LISTING OF INPUT CARDS - ASYMMETRIC PROBLEM

```
.02
0000001
0010000
0010000
0610006
53.0 57.5 .025 .025
  MODERATELY WORN WHEEL  DATA 020
3.0625
0096
1 1
```

0.2426139E+01	-0.1636135E+02	0.2356796E+01	-0.1637052E+02
0.2310379E+01	-0.1637800E+02	0.2255187E+01	-0.1638466E+02
0.2194052E+01	-0.1639578E+02	0.2131219E+01	-0.1640157E+02
0.2069517E+01	-0.1641274E+02	0.2014892E+01	-0.1641339E+02
0.1961965E+01	-0.1641689E+02	0.1899697E+01	-0.1641766E+02
0.1837996E+01	-0.1642466E+02	0.1706386E+01	-0.1643241E+02
0.1652892E+01	-0.1643501E+02	0.1591191E+01	-0.1643305E+02
0.1522414E+01	-0.1643066E+02	0.1468921E+01	-0.1642669E+02
0.1407786E+01	-0.1642724E+02	0.1345518E+01	-0.1642546E+02
0.1292591E+01	-0.1642369E+02	0.1246740E+01	-0.1641792E+02
0.1185604E+01	-0.1641339E+02	0.1124469E+01	-0.1640886E+02
0.1040408E+01	-0.1640848E+02	0.9781411E+00	-0.1640560E+02
0.9099301E+00	-0.1640576E+02	0.8558706E+00	-0.1640162E+02
0.7947354E+00	-0.1639981E+02	0.6801070E+00	-0.1639132E+02
0.6113299E+00	-0.1638622E+02	0.5425529E+00	-0.1638342E+02
0.4579259E+00	-0.1638334E+02	0.3962247E+00	-0.1638538E+02
0.3268815E+00	-0.1638565E+02	0.2581045E+00	-0.1638540E+02
0.1734775E+00	-0.1638223E+02	0.1047004E+00	-0.1638213E+02
0.4299915E-01	-0.1638326E+02	-0.3418267E-02	-0.1638344E+02
-0.1027630E+00	-0.1638253E+02	-0.1644642E+00	-0.1638017E+02
-0.2179576E+00	-0.1638113E+02	-0.2720169E+00	-0.1637954E+02
-0.3331521E+00	-0.1638013E+02	-0.4024952E+00	-0.1637759E+02
-0.4789142E+00	-0.1637744E+02	-0.5406154E+00	-0.1638026E+02
-0.6028827E+00	-0.1638264E+02	-0.6869437E+00	-0.1638493E+02
-0.7639287E+00	-0.1638717E+02	-0.8338379E+00	-0.1639190E+02
-0.9031810E+00	-0.1639995E+02	-0.9654484E+00	-0.1640773E+02
-0.1027716E+01	-0.1641790E+02	-0.1097625E+01	-0.1642993E+02
-0.1152250E+01	-0.1644249E+02	-0.1207442E+01	-0.1645221E+02
-0.1284427E+01	-0.1646835E+02	-0.1331977E+01	-0.1648047E+02
-0.1379526E+01	-0.1649506E+02	-0.1449435E+01	-0.1651424E+02
-0.1504627E+01	-0.1652915E+02	-0.1559818E+01	-0.1655545E+02
-0.1616708E+01	-0.1658703E+02	-0.1664824E+01	-0.1662938E+02
-0.1699354E+01	-0.1665851E+02	-0.1739827E+01	-0.1670933E+02
-0.1766716E+01	-0.1674117E+02	-0.1791906E+01	-0.1678137E+02
-0.1818228E+01	-0.1682096E+02	-0.1844550E+01	-0.1687028E+02
-0.1863230E+01	-0.1690551E+02	-0.1880778E+01	-0.1694565E+02
-0.1900024E+01	-0.1699547E+02	-0.1910496E+01	-0.1702543E+02
-0.1929743E+01	-0.1710227E+02	-0.1933705E+01	-0.1711329E+02
-0.1951819E+01	-0.1718142E+02	-0.1962858E+01	-0.1721567E+02
-0.1973339E+01	-0.1725868E+02	-0.1984934E+01	-0.1730452E+02
-0.1995406E+01	-0.1736129E+02	-0.1998803E+01	-0.1737267E+02
-0.2016917E+01	-0.1743076E+02	-0.2035597E+01	-0.1747601E+02
-0.2045503E+01	-0.1750527E+02	-0.2055976E+01	-0.1753198E+02

```
-0.2082298E+01 -0.1757451E+02 -0.2130979E+01 -0.1761585E+02
-0.2186737E+01 -0.1764060E+02 -0.2249004E+01 -0.1765983E+02
-0.2311838E+01 -0.1766874E+02 -0.2404106E+01 -0.1767679E+02
-0.2488733E+01 -0.1767543E+02 -0.2572794E+01 -0.1765680E+02
-0.2631099E+01 -0.1763573E+02 -0.2683460E+01 -0.1769249E+02
 NEW AAR RAIL     DATA 025
1.5
0072
0 0
          0.1432941D 01  0.6106113D 01
          0.1429198D 01  0.6159716D 01
          0.1425683D 01  0.6202402D 01
          0.1422167D 01  0.6255852D 01
          0.1418878D 01  0.6299916D 01
          0.1411545D 01  0.6407996D 01
          0.1408483D 01  0.6459593D 01
          0.1405270D 01  0.6502649D 01
          0.1384819D 01  0.6620405D 01
          0.1377259D 01  0.6648965D 01
          0.1356582D 01  0.6720330D 01
          0.1327059D 01  0.6776739D 01
          0.1288766D 01  0.6827859D 01
          0.1246050D 01  0.6872249D 01
          0.1203183D 01  0.6906820D 01
          0.1155818D 01  0.6935483D 01
          0.1104030D 01  0.6958672D 01
          0.1039200D 01  0.6985167D 01
          0.9787940D 00  0.7009135D 01
          0.9312770D 00  0.7025605D 01
          0.8836100D 00  0.7038043D 01
          0.8359420D 00  0.7045928D 01
          0.7838520D 00  0.7052503D 01
          0.7187200D 00  0.7059757D 01
          0.6536630D 00  0.7068334D 01
          0.5929540D 00  0.7075092D 01
          0.5364410D 00  0.7079995D 01
          0.4495730D 00  0.7083493D 01
          0.3843660D 00  0.7085862D 01
          0.3191580D 00  0.7088399D 01
          0.2496790D 00  0.7091257D 01
          0.1931660D 00  0.7093536D 01
          0.1453470D 00  0.7095754D 01
          0.9325698D-01  0.7096725D 01
          0.3666800D-01  0.7096641D 01
         -0.3731000D-01  0.7092916D 01
         -0.9824601D-01  0.7091356D 01
         -0.1591060D 00  0.7090965D 01
         -0.2156190D 00  0.7093344D 01
         -0.2764040D 00  0.7093060D 01
         -0.3417630D 00  0.7090148D 01
         -0.3809630D 00  0.7087274D 01
         -0.4766760D 00  0.7078416D 01
         -0.5160275D 00  0.7077331D 01
         -0.5724651D 00  0.7072011D 01
```

```
            -0.62478230 00   0.70704020 01
            -0.68571830 00   0.70651516D 01
            -0.72941680 00   0.70554230 01
            -0.78608120 00   0.70413460 01
            -0.82985530 00   0.70346050 01
            -0.89948560 00   0.70233440 01
            -0.94745560 00   0.70174310 01
            -0.99107850 00   0.70067760 01
            -0.10479700 01   0.69881620 01
            -0.11092940 01   0.69678310 01
            -0.11660240 01   0.69449910 01
            -0.12143720 01   0.69243820 01
            -0.12582220 01   0.68990890 01
            -0.12978000 01   0.68719200 01
            -0.13331820 01   0.68444620 01
            -0.13728350 01   0.68047690 01
            -0.14040220 01   0.67669180 01
            -0.14308610 01   0.67112460 01
            -0.14403870 01   0.66980750 01
            -0.14586070 01   0.66212080 01
            -0.14681330 01   0.65845440 01
            -0.14775830 01   0.65141430 01
            -0.14785660 01   0.65070630 01
            -0.14835940 01   0.64519760 01
            -0.14929690 01   0.63853160 01
            -0.14937250 01   0.63817730 01
            -0.15031750 01   0.63237230 01
  SLIGHTLY WORN WHEEL  DATA 019
3.0625
0096
1 1
            0.2531451E+01 -0.1637387E+02  0.2440929E+01 -0.1640701E+02
            0.2357767E+01 -0.1642572E+02  0.2260439E+01 -0.1644249E+02
            0.2171022E+01 -0.1644784E+02  0.2090069E+01 -0.1645463E+02
            0.1977469E+01 -0.1646223E+02  0.1895964E+01 -0.1646889E+02
            0.1814458E+01 -0.1647018E+02  0.1732953E+01 -0.1647195E+02
            0.1656169E+01 -0.1647414E+02  0.1606739E+01 -0.1647408E+02
            0.1533145E+01 -0.1647979E+02  0.1479973E+01 -0.1648346E+02
            0.1413186E+01 -0.1649162E+02  0.1339040E+01 -0.1649154E+02
            0.1280165E+01 -0.1648930E+02  0.1177133E+01 -0.1648745E+02
            0.1109794E+01 -0.1649132E+02  0.1042456E+01 -0.1649824E+02
            0.9683096E+00 -0.1650267E+02  0.8868042E+00 -0.1650468E+02
            0.8200176E+00 -0.1650658E+02  0.7532308E+00 -0.1650618E+02
            0.6649183E+00 -0.1650491E+02  0.5834128E+00 -0.1650142E+02
            0.5171784E+00 -0.1649866E+02  0.4288657E+00 -0.1649519E+02
            0.3841572E+00 -0.1649435E+02  0.2879330E+00 -0.1649401E+02
            0.2059798E+00 -0.1649018E+02  0.1333858E+00 -0.1648738E+02
            0.7395858E-01 -0.1648706E+02 -0.1875162E-03 -0.1648727E+02
           -0.5906260E-01 -0.1648502E+02 -0.1179377E+00 -0.1648581E+02
           -0.1705577E+00 -0.1648746E+02 -0.2520632E+00 -0.1649298E+02
           -0.3262092E+00 -0.1649458E+02 -0.4003553E+00 -0.1649642E+02
           -0.4745014E+00 -0.1650150E+02 -0.5344809E+00 -0.1650799E+02
           -0.6018198E+00 -0.1651110E+02 -0.6601426E+00 -0.1651662E+02
           -0.7133149E+00 -0.1651746E+02 -0.7648306E+00 -0.1652543E+02
```

-0.8248100E+00	-0.1652832E+02	-0.8915967E+00	-0.1653842E+02
-0.9594877E+00	-0.1654641E+02	-0.1018915E+01	-0.1655605E+02
-0.1078894E+01	-0.1656198E+02	-0.1130962E+01	-0.1657462E+02
-0.1184687E+01	-0.1658725E+02	-0.1244666E+01	-0.1660393E+02
-0.1297286E+01	-0.1661488E+02	-0.1342547E+01	-0.1662623E+02
-0.1403079E+01	-0.1664417E+02	-0.1456251E+01	-0.1666380E+02
-0.1509975E+01	-0.1669279E+02	-0.1549533E+01	-0.1672355E+02
-0.1581732E+01	-0.1675108E+02	-0.1628649E+01	-0.1679364E+02
-0.1660847E+01	-0.1682117E+02	-0.1700405E+01	-0.1687081E+02
-0.1710525E+01	-0.1688895E+02	-0.1728557E+01	-0.1694678E+02
-0.1739782E+01	-0.1697382E+02	-0.1765173E+01	-0.1704951E+02
-0.1768486E+01	-0.1707465E+02	-0.1771799E+01	-0.1710065E+02
-0.1789279E+01	-0.1715367E+02	-0.1815222E+01	-0.1722298E+02
-0.1818536E+01	-0.1723089E+02	-0.1836567E+01	-0.1729899E+02
-0.1847240E+01	-0.1732774E+02	-0.1865272E+01	-0.1737617E+02
-0.1892751E+01	-0.1740830E+02	-0.1915502E+01	-0.1745711E+02
-0.1940341E+01	-0.1748588E+02	-0.1971987E+01	-0.1751823E+02
-0.2011545E+01	-0.1755478E+02	-0.2043744E+01	-0.1757856E+02
-0.2089557E+01	-0.1760946E+02	-0.2128562E+01	-0.1762619E+02
-0.2189094E+01	-0.1765136E+02	-0.2257537E+01	-0.1766224E+02
-0.2323219E+01	-0.1767350E+02	-0.2406381E+01	-0.1767132E+02
-0.2471511E+01	-0.1766782E+02	-0.2529834E+01	-0.1765149E+02
-0.2587605E+01	-0.1763233E+02	-0.2644824E+01	-0.1760462E+02
-0.2694131E+01	-0.1757347E+02	-0.2736078E+01	-0.1754230E+02
-0.2778026E+01	-0.1750694E+02	-0.2819421E+01	-0.1754966E+02

WORN LEFT RAIL DATA 013

1.5
0068
0 0

0.1506077E+01	0.6557813E+01
0.1500020E+01	0.6578593E+01
0.1490935E+01	0.6634485E+01
0.1488762E+01	0.6656404E+01
0.1486447E+01	0.6678204E+01
0.1473478E+01	0.6731257E+01
0.1464108E+01	0.6761106E+01
0.1454452E+01	0.6797377E+01
0.1448396E+01	0.6820712E+01
0.1442196E+01	0.6836851E+01
0.1406923E+01	0.6861816E+01
0.1367481E+01	0.6870808E+01
0.1313501E+01	0.6879155E+01
0.1260092E+01	0.6887437E+01
0.1209854E+01	0.6896540E+01
0.1163215E+01	0.6901584E+01
0.1102181E+01	0.6907925E+01
0.1041147E+01	0.6914180E+01
0.9909090E+00	0.6921088E+01
0.9193640E+00	0.6930240E+01
0.8669840E+00	0.6936432E+01
0.8223440E+00	0.6939390E+01
0.7719640E+00	0.6943836E+01
0.7217250E+00	0.6946827E+01
0.6497530E+00	0.6952409E+01

```
 0.5923180E+00  0.6954556E+01
 0.5309990E+00  0.6958132E+01
 0.4951550E+00  0.6958427E+01
 0.4446320E+00  0.6961606E+01
 0.3907950E+00  0.6963700E+01
 0.3332170E+00  0.6966094E+01
 0.2583000E+00  0.6968592E+01
 0.2000680E+00  0.6970100E+01
 0.1423480E+00  0.6971020E+01
 0.9182501E-01  0.6971973E+01
 0.3079098E-01  0.6975749E+01
-0.2304599E-01  0.6978940E+01
-0.8795400E-01  0.6982699E+01
-0.1418000E+00  0.6984702E+01
-0.2101740E+00  0.6987414E+01
-0.2642960E+00  0.6987439E+01
-0.3256150E+00  0.6984694E+01
-0.3798790E+00  0.6983723E+01
-0.4482530E+00  0.6980797E+01
-0.4881230E+00  0.6980071E+01
-0.5494421E+00  0.6976810E+01
-0.6035639E+00  0.6974906E+01
-0.6794200E+00  0.6970653E+01
-0.7372830E+00  0.6965367E+01
-0.7988872E+00  0.6959202E+01
-0.8603488E+00  0.6951859E+01
-0.9183544E+00  0.6943260E+01
-0.9729039E+00  0.6932135E+01
-0.1023855E+01  0.6920392E+01
-0.1078404E+01  0.6906254E+01
-0.1129498E+01  0.6889937E+01
-0.1184475E+01  0.6867587E+01
-0.1254274E+01  0.6834633E+01
-0.1305795E+01  0.6804682E+01
-0.1339323E+01  0.6778874E+01
-0.1376878E+01  0.6735724E+01
-0.1411546E+01  0.6676659E+01
-0.1427937E+01  0.6630489E+01
-0.1441014E+01  0.6557952E+01
-0.1467418E+01  0.6360455E+01
-0.1477181E+01  0.6268246E+01
-0.1478965E+01  0.6076671E+01
-0.1481389E+01  0.6046499E+01
RAIL CANT FOR RIGHT RAIL .025
RAIL CANT FOR LEFT RAIL .025
RAIL GAGE 57.5 (IN)
WHEEL GAUGE 53.0 (IN)
```

PRINTER OUTPUT - ASYMMETRIC PROBLEM

```
THE ASYMMETRIC WHRAIL/RAIL CONTACT CHARACTERIZATION PROGRAM
RUN OPTIONS SELECTED
        XWINC=  0.0200
        ISYM=  0        IPUNCH= 1
        IPLOT= 1        ICURV= 0
        IFLANG = 1
        NUMB= 61        IAC= 6
WHEEL GAUGE (IN), RAIL GAUGE (IN), RIGHT RAIL CANT (RAD), LEFT RAIL CANT (RAD)
  53.00000   57.50000    0.02500    0.02500

RIGHT WHEEL PROFILE INPUT DATA **********************************************************************
  MODERATELY WORN WHEEL  DATA C20
   3.06250
 96
          1              1
  1      0.2426139D+01   0.1636135D+02
  2      0.2350796D+01   0.1637052D+02
  3      0.2310379D+01   0.1637800D+02
  4      0.2255187D+01   0.1638466D+02
  5      0.2194052D+01   0.1639578D+02
  6      0.2131249D+01   0.1640157D+02
  7      0.2069517D+01   0.1641274D+02
  8      0.2014892D+01   0.1641335D+02
  9      0.1961965D+01   0.1641689D+02
 10      0.1899697D+01   0.1641766D+02
 11      0.1837996D+01   0.1642466D+02
 12      0.1780386D+01   0.1643241D+02
 13      0.1652092D+01   0.1643501D+02
 14      0.1591191D+01   0.1643305D+02
 15      0.1522414D+01   0.1643066D+02
 16      0.1468921D+01   0.1642669D+02
 17      0.1407786D+01   0.1642724D+02
 18      0.1345518D+01   0.1642546D+02
 19      0.1292591D+01   0.1642369D+02
 20      0.1240745D+01   0.1641792D+02
 21      0.1185604D+01   0.1641339D+02
 22      0.1124469D+01   0.1640886D+02
 23      0.1040408D+01   0.1640848D+02
 24      0.9781411D+00   0.1640560D+02
 25      0.9099301D+00   0.1640576D+02
 26      0.8558706D+00   0.1640162D+02
 27      0.7947354D+00   0.1639981D+02
 28      0.6801070D+00   0.1639132D+02
 29      0.6113299D+00   0.1638622D+02
 30      0.5425529D+00   0.1638342D+02
 31      0.4579259D+00   0.1638334D+02
 32      0.3902247D+00   0.1638536D+02
 33      0.3268815D+00   0.1638565D+02
 34      0.2581045D+00   0.1638540D+02
 35      0.1734775D+00   0.1638223D+02
 36      0.1047004D+00   0.1638213D+02
 37      0.4299915D-01   0.1638326D+02
 38     -0.3418267D-02   0.1638344D+02
 39     -0.1027630D+00   0.1638253D+02
 40     -0.1644642D+00   0.1638017D+02
 41     -0.2179576D+00   0.1638113D+02
 42     -0.2720169D+00   0.1637954D+02
 43     -0.3315521D+00   0.1638013D+02
 44     -0.4026952D+00   0.1637759D+02
 45     -0.4789142D+00   0.1637744D+02
 46     -0.5430154D+00   0.1638026D+02
 47     -0.6026827D+00   0.1638264D+02
 48     -0.6869437D+00   0.1638493D+02
 49     -0.7619287D+00   0.1638717D+02
 50     -0.8338379D+00   0.1639190D+02
 51     -0.9031401D+00   0.1639995D+02
 52     -0.9654484D+00   0.1640773D+02
 53     -0.1027746D+01   0.1641790D+02
 54     -0.1097625D+01   0.1642593D+02
 55     -0.1152255D+01   0.1644249D+02
 56     -0.1207442D+01   0.1645221D+02
 57     -0.1264427D+01   0.1646835D+02
 58     -0.1331977D+01   0.1648C47D+02
 59     -0.1379526D+01   0.1649506D+02
 60     -0.1449435D+01   0.1651424D+02
 61     -0.1504627D+01   0.1652515D+02
 62     -0.1559818D+01   0.1655545D+02
 63     -0.1618708D+01   0.1658703D+02
 64     -0.1664824D+01   0.1662538D+02
 65     -0.1699354D+01   0.1665651D+02
 66     -0.1739827D+01   0.1670933D+02
 67     -0.1766716D+01   0.1674117D+02
 68     -0.1791906D+01   0.1678137D+02
 69     -0.1818228D+01   0.1682C96D+02
 70     -0.1844550D+01   0.1687C28D+02
 71     -0.1868230D+01   0.1690551D+02
 72     -0.1887778D+01   0.1694565D+02
 73     -0.1911224D+01   0.1699547D+02
 74     -0.1916496D+01   0.17025+3D+02
 75     -0.1929743D+01   0.1710227D+02
 76     -0.1933705D+01   0.1711329D+02
 77     -0.1951619D+01   0.1718142D+02
 78     -0.1962858D+01   0.1721567D+02
 79     -0.1973330D+01   0.1725E68D+02
 80     -0.1984934D+01   0.1730452D+02
 81     -0.1995406D+01   0.1736129D+02
 82     -0.1998805D+01   0.1737267D+02
 83     -0.2016917D+01   0.1743C76D+02
 84     -0.2035597D+01   0.1747601D+02
 85     -0.2042503D+01   0.175C527D+02
 86     -0.2055976D+01   0.1753198D+02
 87     -0.2082298D+01   0.1757451D+02
 88     -0.2130979D+01   0.1761585D+02
 89     -0.2166737D+01   0.1764060D+02
 90     -0.2249004D+01   0.1765583D+02
 91     -0.2311883D+01   0.1766874D+02
 92     -0.2404106D+01   0.1767679D+02
 93     -0.2488733D+01   0.1767543D+02
 94     -0.2572794D+01   0.1765680D+02
 95     -0.2631099D+01   0.1763573D+02
 96     -0.2683460D+01   0.1769249D+02
```

RIGHT RAIL PROFILE INPUT DATA **********

NEW AAR RAIL DATA 025

1.50000

72

	0	0
1	0.1432941D+01	0.6106113D+01
2	0.1429158D+01	0.6159716D+01
3	0.1425683D+01	0.6202402D+01
4	0.1422167D+01	0.6255852D+01
5	0.1418878D+01	0.6299916D+01
6	0.1411545D+01	0.6407996D+01
7	0.1408483D+01	0.6459593D+01
8	0.1405270D+01	0.6502649D+01
9	0.1384819D+01	0.6620405D+01
10	0.1377259D+01	0.6648965D+01
11	0.1356582D+01	0.6720330D+01
12	0.1327059D+01	0.6776739D+01
13	0.1288766D+01	0.6827859D+01
14	0.1246305D+01	0.6872249D+01
15	0.1203183D+01	0.6906820D+01
16	0.1155818D+01	0.6935483D+01
17	0.1104030D+01	0.6958672D+01
18	0.1039200D+01	0.6985167D+01
19	0.9787940D+00	0.7009135D+01
20	0.9312770D+00	0.7025605D+01
21	0.8836100D+00	0.7038043D+01
22	0.8359420D+00	0.7045528D+01
23	0.7838520D+00	0.7052503D+01
24	0.7187200D+00	0.7059757D+01
25	0.6536630D+00	0.7068334D+01
26	0.5929540D+00	0.7075092D+01
27	0.5364410D+00	0.7079995D+01
28	0.4495730D+00	0.7083493D+01
29	0.3843660D+00	0.7085862D+01
30	0.3191580D+00	0.7088399D+01
31	0.2496790D+00	0.7091257D+01
32	0.1931660D+00	0.7093536D+01
33	0.1453470D+00	0.7095754D+01
34	0.9325698D-01	0.7096725D+01
35	0.3668000D-01	0.7096641D+01
36	-0.3731000D-01	0.7092516D+01
37	-0.9824601D-01	0.7091356D+01
38	-0.1591060D+00	0.7090965D+01
39	-0.2156190D+00	0.7093344D+01
40	-0.2764040D+00	0.7093060D+01
41	-0.3417630D+00	0.7090148D+01
42	-0.3809630D+00	0.7087274D+01
43	-0.4766760D+00	0.7078416D+01
44	-0.5160275D+00	0.7077331D+01
45	-0.5724651D+00	0.7072011D+01
46	-0.6247823D+00	0.7070402D+01
47	-0.6857183D+00	0.7061516D+01
48	-0.7294168D+00	0.7055423D+01
49	-0.7860812D+00	0.7041346D+01
50	-0.8298553D+00	0.7034605D+01
51	-0.8994856D+00	0.7023344D+01
52	-0.9474556D+00	0.7017431D+01
53	-0.9910785D+00	0.7006776D+01
54	-0.1047970D+01	0.6988162D+01
55	-0.1109284D+01	0.6967831D+01
56	-0.1166024D+01	0.6944591D+01
57	-0.1214372D+01	0.6924382D+01
58	-0.1258222D+01	0.6899089D+01
59	-0.1297800D+01	0.6871520D+01
60	-0.1333182D+01	0.6844462D+01
61	-0.1372835D+01	0.6804769D+01
62	-0.1404022D+01	0.6766918D+01
63	-0.1430861D+01	0.6711246D+01
64	-0.1440387D+01	0.6688075D+01
65	-0.1458670D+01	0.6621208D+01
66	-0.1468133D+01	0.6584544D+01
67	-0.1477583D+01	0.6514143D+01
68	-0.1478566D+01	0.6507063D+01
69	-0.1483594D+01	0.6451976D+01
70	-0.1492969D+01	0.6385316D+01
71	-0.1493725D+01	0.6381773D+01
72	-0.1503175D+01	0.6323723D+01

```
LEFT WHEEL PROFILE INPUT DATA ************************************************************************************************

  SLIGHTLY WORN WHEEL  DATA C19
    3.CC250
 96
          1                    1
TO EQUATE TOP OF WHEEL FLANGES ON LEFT AND RIGHT, LEFT WHEEL ROLLING RADII DATA HAVE BEEN ADJUSTED BY   0.018590 INCH
   1        0.2531451D+01   0.1639286D+C2
   2        0.2440929D+01   0.1642600D+C2
   3        0.2357767D+01   0.1644471D+C2
   4        0.2260439D+01   0.1646148D+C2
   5        0.2171022D+01   0.1646683D+02
   6        0.2090069D+01   0.1647362D+C2
   7        0.1977469D+01   0.1648122D+02
   8        0.1895964D+01   0.1648788D+C2
   9        0.1814458D+01   0.1648917D+C2
  10        0.1732953D+01   0.1649094D+C2
  11        0.1666166D+01   0.1649313D+C2
  12        0.1606739D+01   0.1649307D+C2
  13        0.1533145D+01   0.1649678D+C2
  14        0.1479973D+01   0.1650245D+02
  15        0.1413186D+01   0.1651061D+C2
  16        0.1339043D+01   0.1651053D+C2
  17        0.1280165D+01   0.1650829D+C2
  18        0.1177133D+01   0.1650644D+02
  19        0.1109794D+01   0.1651C31D+C2
  20        0.1042456D+01   0.1651723D+02
  21        0.9683096D+00   0.1652166D+02
  22        0.8868042D+00   0.1652367D+C2
  23        0.8200176D+00   0.1652557D+C2
  24        0.7523308D+00   0.1652517D+C2
  25        0.6649183D+00   0.1652390D+02
  26        0.5834128D+00   0.1652C41D+C2
  27        0.5171784D+00   0.1651765D+02
  28        0.4288657D+00   0.1651418D+C2
  29        0.3841572D+00   0.1651334D+C2
  30        0.2879330D+00   0.1651300D+C2
  31        0.2069798D+00   0.1650917D+C2
  32        0.1333858D+00   0.1650637D+C2
  33        0.7395858D-01   0.1650C65D+C2
  34       -0.1875162D-03   0.1650626D+C2
  35       -0.5900626D-01   0.165C4C1D+02
  36       -0.1179377D+00   0.1650480D+02
  37       -0.1765577D+00   0.1650645D+C2
  38       -0.2520632D+00   0.1651157D+C2
  39       -0.3262092D+00   0.1651357D+C2
  40       -0.4003553D+00   0.1651541D+02
  41       -0.4745014D+00   0.1652049D+C2
  42       -0.5344809D+00   0.1652698D+C2
  43       -0.6018198D+00   0.1653009D+C2
  44       -0.6601426D+00   0.1653561D+C2
  45       -0.7133149D+00   0.1653645D+C2
  46       -0.7648306D+00   0.1654442D+C2
  47       -0.8248130D+00   0.1654131D+C2
  48       -0.8915967D+00   0.1655741D+C2
  49       -0.9594877D+00   0.1656540D+02
  50       -0.1018915D+01   0.1657504D+C2
  51       -0.1078894D+01   0.1658097D+02
  52       -0.1130962D+01   0.1655361D+C2
  53       -0.1184687D+01   0.1660E24D+02
  54       -0.1244666D+01   0.1662292D+02
  55       -0.1297286D+01   0.1663387D+C2
  56       -0.1342547D+01   0.1664522D+02
  57       -0.1403079D+01   0.1666316D+C2
  58       -0.1456251D+01   0.1668279D+C2
  59       -0.1509975D+01   0.1671178D+C2
  60       -0.1549533D+01   0.1674254D+C2
  61       -0.1581732D+01   0.1677CC7D+C2
  62       -0.1628649D+01   0.1681263D+02
  63       -0.1660847D+01   0.1684C16D+C2
  64       -0.1700405D+01   0.1688588D+C2
  65       -0.1710525D+01   0.1690794D+02
  66       -0.1728557D+01   0.1696577D+C2
  67       -0.1739782D+01   0.1699281D+C2
  68       -0.1765173D+01   0.17CEE50D+C2
  69       -0.1768486D+01   0.1709364D+02
  70       -0.1771799D+01   0.1711964D+C2
  71       -0.1789279D+01   0.1717266D+02
  72       -0.1815222D+01   0.1724197D+C2
  73       -0.1816536D+01   0.1724588D+02
  74       -0.1836567D+01   0.1731798D+C2
  75       -0.1847240D+01   0.1734E73D+C2
  76       -0.1865272D+01   0.1739516D+C2
  77       -0.1882751D+01   0.1742729D+C2
  78       -0.1915502D+01   0.1747E10D+02
  79       -0.1940341D+01   0.175C487D+C2
  80       -0.1971987D+01   0.1753722D+02
  81       -0.2011545D+01   0.1757277D+C2
  82       -0.2043744D+01   0.1759755D+02
  83       -0.2084957D+01   0.1762E45D+02
  84       -0.2122562D+01   0.1764518D+02
  85       -0.2189094D+01   0.1767C35D+C2
  86       -0.2257537D+01   0.1768123D+C2
  87       -0.2322219D+01   0.1769249D+02
  88       -0.2406381D+01   0.1765C31D+C2
  89       -0.2471511D+01   0.1768E81D+02
  90       -0.2529834D+01   0.1767C48D+C2
  91       -0.2587650D+01   0.1765132D+02
  92       -0.2644824D+01   0.1762361D+C2
  93       -0.2694131D+01   0.1759246D+02
  94       -0.2736078D+01   0.1756129D+C2
  95       -0.2778026D+01   0.1752593D+C2
  96       -0.2819421D+01   0.1756865D+C2
```

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LEFT RAIL   PROFILE INPUT DATA ************

 WORN LEFT   RAIL DATA 013
   1.50000
 68
                0            0
  1        0.1506077D+01   0.6557813D+01
  2        0.1500020D+01   0.6578593D+01
  3        0.1490935D+01   0.6634485D+01
  4        0.1488762D+01   0.6656404D+01
  5        0.1486447D+01   0.6678204D+01
  6        0.1473478D+01   0.6731257D+01
  7        0.1464108D+01   0.6761106D+01
  8        0.1454452D+01   0.6797377D+01
  9        0.1448396D+01   0.6820712D+01
 10        0.1442196D+01   0.6836851D+01
 11        0.1406923D+01   0.6861816D+01
 12        0.1367481D+01   0.6870808D+01
 13        0.1313501D+01   0.6879155D+01
 14        0.1260092D+01   0.6887437D+01
 15        0.1209854D+01   0.6896540D+01
 16        0.1163215D+01   0.6901584D+01
 17        0.1102181D+01   0.6907925D+01
 18        0.1041147D+01   0.6914180D+01
 19        0.9909090D+00   0.6921088D+01
 20        0.9193640D+00   0.6930240D+01
 21        0.8689840D+00   0.6936432D+01
 22        0.8223440D+00   0.6939390D+01
 23        0.7719640D+00   0.6943836D+01
 24        0.7217250D+00   0.6946827D+01
 25        0.6497530D+00   0.6952409D+01
 26        0.5923180D+00   0.6954556D+01
 27        0.5309990D+00   0.6958132D+01
 28        0.4951550D+00   0.6958427D+01
 29        0.4446320D+00   0.6961606D+01
 30        0.3907950D+00   0.6963700D+01
 31        0.3332170D+00   0.6966094D+01
 32        0.2683000D+00   0.6968592D+01
 33        0.2000680D+00   0.6970100D+01
 34        0.1423480D+00   0.6971020D+01
 35        0.9182501D-01   0.6971973D+01
 36        0.3079098D-01   0.6975749D+01
 37       -0.2304599D-01   0.6978940D+01
 38       -0.8796400D-01   0.6982699D+01
 39       -0.1418000D+00   0.6984702D+01
 40       -0.2101740D+00   0.6987414D+01
 41       -0.2642960D+00   0.6987439D+01
 42       -0.3256150D+00   0.6984694D+01
 43       -0.3798790D+00   0.6983723D+01
 44       -0.4482530D+00   0.6980797D+01
 45       -0.4881230D+00   0.6980071D+01
 46       -0.5494421D+00   0.6976810D+01
 47       -0.6035639D+00   0.6974906D+01
 48       -0.6794200D+00   0.6970653D+01
 49       -0.7372830D+00   0.6965367D+01
 50       -0.7968872D+00   0.6959202D+01
 51       -0.8603488D+00   0.6951859D+01
 52       -0.9183544D+00   0.6943260D+01
 53       -0.9729039D+00   0.6932135D+01
 54       -0.1023855D+01   0.6920392D+01
 55       -0.1078404D+01   0.6906254D+01
 56       -0.1129498D+01   0.6889937D+01
 57       -0.1184475D+01   0.6867587D+01
 58       -0.1254274D+01   0.6834633D+01
 59       -0.1305795D+01   0.6804682D+01
 60       -0.1339323D+01   0.6778874D+01
 61       -0.1376878D+01   0.6735724D+01
 62       -0.1411546D+01   0.6676659D+01
 63       -0.1427937D+01   0.6630489D+01
 64       -0.1441014D+01   0.6557952D+01
 65       -0.1467418D+01   0.6360455D+01
 66       -0.1477181D+01   0.6268246D+01
 67       -0.1478965D+01   0.6076671D+01
 68       -0.1481389D+01   0.6046499D+01
 RAIL CANT FOR LEFT RAIL .025
 RAIL CANT FOR RIGHT RAIL .025
 RAIL GAGE 57.5 (IN)
 WHEEL GAUGE 53.0 (IN)
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LEFT SIDE

WHEEL/RAIL CONTACT CHARACTERIZATION

SLIGHTLY WORN WHEEL DATA 019

WHEEL GAGE=53.000
1/2 DIST BETWEEN TAPE LINES=29.563

CURVE FITS 6 PTS/CURVE FIT ZONE

	0TH	1ST	2ND	3RD	4TH				
1	0.128266D+01	0.297367D+02	-0.217413D+02	0.705471D+01	-0.859258D+00	FROM	200.0000	TO	2.0901
2	0.224066D+02	-0.128168D+02	0.102576D+02	-0.362104D+01	0.474031D+00	FROM	2.0901	TO	1.6067
3	0.231192D+02	-0.105257D+02	0.117152D+02	-0.573018D+01	0.103558D+01	FROM	1.6067	TO	1.1771
4	0.166938D+02	-0.106922D+01	0.226614D+01	-0.196264D+01	0.590000D+00	FROM	1.1771	TO	0.7532
5	0.165013D+02	0.707760D-01	-0.228450D+00	0.434430D+00	-0.264626D+00	FROM	0.7532	TO	0.2879
6	0.165047D+02	0.523937D-02	0.113306D+00	-0.617850D-01	-0.267257D+00	FROM	0.2879	TO	-0.1179
7	0.165054D+02	0.134114D-01	0.132551D+00	0.545437D-01	-0.236652D-01	FROM	-0.1179	TO	-0.5345
8	0.163438D+02	-0.949982D+00	-0.192276D+01	-0.177162D+01	-0.571225D+00	FROM	-0.5345	TO	-0.8516
9	0.160470D+02	-0.194034D+01	-0.292216D+01	-0.196159D+01	-0.458314D+00	FROM	-0.8916	TO	-1.2447
10	0.206284D+01	-0.402814D+02	-0.413435D+02	-0.185038D+02	-0.300322D+01	FROM	-1.2447	TO	-1.5495
11	0.686777D+03	0.171190D+04	0.163843D+04	0.696507D+03	0.111016D+03	FROM	-1.5495	TO	-1.7286
12	0.114358D+05	0.256190D+05	0.215434D+05	0.804836D+04	0.112723D+04	FROM	-1.7286	TO	-1.8152
13	0.436321D+04	0.926466D+04	0.739156D+04	0.261622D+04	0.346694D+03	FROM	-1.8152	TO	-1.9155
14	-0.814421D+02	-0.171680D+03	-0.112573D+03	-0.331004D+02	-0.367895D+01	FROM	-1.9155	TO	-2.1286
15	-0.419957D+02	-0.975061D+02	-0.663910D+02	-0.168212D+02	-0.177863D+01	FROM	-2.1286	TO	-2.5298
16	0.231189D+04	0.356965D+04	0.208054D+04	0.538212D+03	0.521373D+02	FROM	-2.5298	TO	-2.8194

WORN LEFT RAIL DATA 013

RAIL GAGE=57.500
1/2 DIST BETWEEN RAIL CENTERS=30.250
RAIL CANT= 0.025

CURVE FITS 6 PTS/CURVE FIT ZONE

	0TH	1ST	2ND	3RD	4TH				
1	0.400507D+06	-0.108454D+07	0.111124D+07	-0.496933D+06	0.840817D+05	FROM	200.0000	TO	1.4735
2	-0.911664D+03	0.281061D+04	-0.322080D+04	0.163836D+04	-0.312162D+03	FROM	1.4735	TO	1.3675
3	0.291367D+01	0.153721D+02	-0.216335D+02	0.133201D+02	-0.305166D+01	FROM	1.3675	TO	1.0411
4	0.721894D+01	-0.133609D+01	0.257877D+01	-0.221847D+01	0.676887D+00	FROM	1.0411	TO	0.7217
5	0.696657D+01	0.701733D-01	-0.346055D+00	0.479410D+00	-0.257014D+00	FROM	0.7217	TO	0.3508
6	0.697734D+01	-0.517195D-01	0.466340D-01	-0.146771D+00	0.388735D+00	FROM	0.3508	TO	0.0308
7	0.657737D+01	-0.658921D-01	0.212585D-01	0.764281D+00	-0.956031D+00	FROM	0.0308	TO	-0.3256
8	0.698517D+01	-0.513711D-01	-0.254394D+00	-0.370836D+00	0.229208D+00	FROM	-0.3256	TO	-0.6794
9	0.685212D+01	-0.679246D+00	-0.130965D+01	-0.110554D+01	-0.400664D+00	FROM	-0.6794	TO	-1.0239
10	-0.163688D+02	-0.851313D+02	-0.115767D+03	-0.696150D+02	-0.156815D+02	FROM	-1.0239	TO	-1.3393
11	-0.724255D+04	-0.215836D+05	-0.240810D+05	-0.119334D+05	-0.221632D+04	FROM	-1.3393	TO	-1.4814

*** WARNING *** WHEELSET RCLL ANGLE CONVERGED ONLY WITHIN WR(NEW)-WR(OLD)= -0.00019 AT Xw=-1.100
*** WARNING *** WHEELSET RCLL ANGLE CONVERGED ONLY WITHIN WR(NEW)-WR(OLD)= -0.00001 AT Xw=-1.120

********** RESULTS **********

RIGHT SIDE

WHEEL/RAIL CONTACT CHARACTERIZATION

MODERATELY WORN WHEEL DATA 020

WHEEL GAGE=53.000
1/2 DIST BETWEEN TAPE LINES=29.563

CURVE FITS 6 PTS/CURVE FIT ZONE

	0TH	1ST	2ND	3RD	4TH				
1	-0.156715D+01	0.304671D+C2	-C.191486D+02	C.53CC64D+01	-C.5476C5D+C0	FROM	200.0000	TO	2.1312
2	0.461405D+01	0.253235D+C2	-C.2C24C6D+C2	C.716336D+01	-0.949466D+00	FROM	2.1312	TO	1.7064
3	0.132918D+02	0.841071D+C1	-C.8434C9D+01	C.378832D+01	-C.6393C1D+CC	FROM	1.7064	TO	1.3455
4	C.147203D+02	0.631583D+C1	-C.6E1744D+C1	C.540219D+01	-0.121867D+01	FROM	1.3455	TO	C.9781
5	0.164533D+02	-0.376679D+C0	C.6402E1D+00	-C.356571D+0C	C.479CC3D-01	FROM	0.9781	TO	0.5426
6	0.163820D+02	0.5211540-C2	C.1C4573D+00	-C.435421D+0C	C.439686D+00	FROM	0.5426	TO	0.1047
7	0.163826D+02	0.1255620-C3	-C.16112ED-01	C.1362370+0C	C.26055CD+00	FROM	0.1047	TO	-0.2720
8	0.163838D+02	0.202176D-C1	C.143899C-01	0.662731C-03	0.338C35D-C1	FROM	-0.272C	TO	-0.6869
9	0.161467D+02	-0.121765D+01	-0.232756D+01	-C.190585D+01	-0.529247D+00	FROM	-0.6869	TO	-1.0576
10	C.189816D+02	0.893211D+C1	-C.1130C6D+02	C.623124D+01	C.125354D+C1	FROM	-1.0576	TO	-1.4494
11	-0.774151D+01	-0.590998D+C2	-C.5316E2D+C2	-C.207C12D+02	-0.288736D+01	FROM	-1.4494	TO	-1.7398
12	C.135810D+04	0.302583D+C4	C.2562340+04	C.964417C+C3	C.136151D+C3	FROM	-1.7398	TO	-1.8808
13	0.842673D+04	0.17416CD+C5	C.1352510+05	C.466906C+04	0.604663D+03	FROM	-1.8808	TO	-1.9629
14	0.230J53D+J5	0.4557840+05	C.3386470+05	C.111758D+05	C.138227D+C4	FROM	-1.9629	TO	-2.0356
15	-0.833937D+03	-0.1475080+C4	-C.557925D+03	-C.276391C+03	-0.298926D+02	FROM	-2.0356	TO	-2.2490
16	0.465938D+03	0.7679960+03	C.4916130+03	C.139362D+03	C.147635D+C2	FROM	-2.2490	TO	-2.6835

NEW AAR RAIL DATA 025

RAIL GAGE=57.500
1/2 DIST BETWEEN RAIL CENTERS=30.250
RAIL CANT= 0.025

CURVE FITS 6 PTS/CURVE FIT ZONE

	0TH	1ST	2ND	3RD	4TH				
1	-0.717974D+06	0.202315D+C7	-C.2137740+07	C.100387D+07	-0.176774D+06	FROM	200.0000	TO	1.4115
2	-C.471327D+04	0.146701D+C5	-C.1708560+05	C.883825D+C4	-C.171355D+C4	FROM	1.4115	TO	1.3271
3	-0.172785D+02	0.530384D+C2	-C.1324270+03	C.832903D+02	-0.196223D+02	FROM	1.3271	TO	1.0392
4	0.783270D+01	-0.368328D+C1	C.6619600+01	-C.515199D+01	C.138470+C1	FROM	1.0392	TO	0.7187
5	0.711787D+01	-0.237335D+CC	C.7556440+00	-C.111208D+01	0.501801D+00	FROM	0.7187	TO	C.3192
6	0.709466D+J1	0.287286D-C1	-C.8C3595D-01	C.595744D+0C	C.114622D+C1	FROM	0.3192	TO	-0.0373
7	0.709319D+01	0.215640-C1	C.235734D+00	C.808897C+0C	0.608104D+00	FROM	-0.0373	TO	-0.3810
8	0.718524D+J1	0.674892D+C0	C.176116D+01	C.2J7601D+01	C.809856D+C0	FROM	-0.3810	TO	-0.7294
9	C.757947D+01	0.186646D+C1	C.2486420+01	C.142573C+01	C.23CE63D+CC	FROM	-0.7294	TO	-1.0480
10	-0.925247D+J1	-0.590273D+C2	-C.756755D+02	-C.475542D+02	-0.106845D+02	FROM	-1.0480	TO	-1.3332
11	-C.217416D+04	0.650945D+C4	-0.7281C6D+04	-0.361792D+04	-C.673533D+C3	FROM	-1.3332	TO	-1.4681
12	0.312714D+06	0.852386D+C6	C.6711E7D+06	C.395682D+C6	0.673831D+05	FROM	-1.4681	TO	-1.5032

********** DATA POINTS **********

CONTACT POINTS, GEOMETRIC CONSTRAINTS, AND PROFILE CURVATURES
AS A FUNCTION OF WHEELSET LATERAL DISPLACEMENT

Xh = WHEELSET LATERAL, POSITIVE TO THE LEFT (IN)
X1 = CONTACT LOCATION ON RIGHT WHEEL, POSITIVE OUT FROM TAPELINE (IN)
X2 = CONTACT LOCATION ON RIGHT RAIL, POSITIVE OUT FROM CENTERLINE (IN)
X3 = CONTACT LOCATION ON LEFT WHEEL, POSITIVE OUT FROM TAPELINE (IN)
X4 = CONTACT LOCATION ON LEFT RAIL, POSITIVE OUT FROM CENTERLINE (IN)
RR = ROLLING RADII, RIGHT WHEEL (IN)
YR = RAIL HEAD PROFILE HEIGHT, RIGHT RAIL (IN)
RL = ROLLING RADII, LEFT WHEEL (IN)
YL = RAIL HEAD PROFILE HEIGHT, LEFT RAIL (IN)
MR = CONTACT ANGLE W.R.T. AXLE, RIGHT WHEEL (RAD)
ML = CONTACT ANGLE W.R.T. AXLE, LEFT WHEEL (RAD)
RR CRV = PRINCIPAL ROLLING CURVATURE OF RIGHT WHEEL PROFILE (1/IN)
RL CRV = PRINCIPAL ROLLING CURVATURE OF LEFT WHEEL PROFILE (1/IN)

Xh (IN)	X1 (IN)	X2 (IN)	X3 (IN)	X4 (IN)	RR (IN)	YR (IN)	RL (IN)	YL (IN)	MR (RAD)	ML (RAD)	RR CRV (1/IN)	RL CRV (1/IN)
-1.200	-2.1239	-1.3239	1.9065	-0.2558	17.61416	6.85282	16.48592	6.98691	0.669362	0.C45C59	C.044522	C.060585
-1.180	-2.0935	-1.3248	1.8865	-0.2471	17.58444	6.85345	16.46686	6.98658	0.880751	0.C44496	0.036201	0.060594
-1.160	-2.1135	-1.3745	1.8665	-0.2372	17.60563	6.80017	16.48771	6.98702	0.742056	0.C4CC36	0.041866	0.0606C3
-1.140	-2.1035	-1.3934	1.8465	-0.2285	17.55577	6.78086	16.48646	6.98702	0.812972	0.035771	0.039063	0.060610
-1.120	-1.9935	-1.3764	1.7865	-0.2017	17.34629	6.80025	16.49027	6.98663	1.323186	0.C25C57	0.014129	0.060623
-1.100	-1.9135	-1.4432	1.4665	-0.3773	17.C4225	6.68286	16.5C422	6.98362	1.275425	0.059269	0.017C81	0.060484
-1.080	-1.8235	-1.4104	1.4665	-0.3212	16.83074	6.75860	16.5C422	6.98557	1.027827	0.C55269	C.03C699	0.060484
-1.060	-1.7635	-1.4074	1.4465	-0.3C45	16.76875	6.76305	16.5C535	6.98664	0.973803	0.053791	0.033524	0.060499
-1.040	-0.1535	0.1980	1.4265	-0.2999	16.38182	7.09428	16.5C637	6.98616	-0.010929	0.047682	C.061C40	0.060514
-1.020	-0.1435	0.1878	1.4165	-0.2897	16.38192	7.09464	16.50683	6.98639	-0.010083	0.044454	C.061C40	0.060521
-1.000	-0.1235	0.1876	1.4065	-0.2755	16.38211	7.09465	16.5C726	6.98659	-0.008372	0.041142	0.061040	0.060528
-0.580	-0.1135	0.1774	1.3965	-0.2693	16.38218	7.09498	16.50765	6.98675	-0.007521	0.037771	C.061040	0.060535
-0.560	-0.0935	0.1771	1.3865	-0.2590	16.38232	7.09495	16.5CE01	6.98688	-0.005856	0.034367	C.061040	0.060541
-0.540	-0.0735	0.1769	1.3765	-0.2488	16.38252	7.09495	16.50834	6.98697	-0.004285	0.030954	C.061040	0.060546
-0.520	-0.0635	0.1668	1.3665	-0.2387	16.38246	7.09528	16.5C863	6.98702	-0.003550	0.027557	C.061041	0.060551
-0.500	-0.0435	0.1667	1.3565	-0.2286	16.38252	7.09528	16.5C889	6.98762	-0.002202	0.024201	C.061041	0.060556
-0.880	-0.0235	0.1666	1.3465	-0.2185	16.38255	7.09528	16.50912	6.98659	-0.001093	0.020911	0.061041	0.060559
-0.860	-0.0035	0.1665	1.3365	-0.2084	16.38256	7.09528	16.50931	6.98651	-0.000242	0.017712	C.061041	0.060562
-0.840	0.0165	0.1665	1.3165	-0.2C84	16.38256	7.09529	16.5C96C	6.98691	0.000291	0.011687	0.061041	0.060567
-0.820	0.0365	0.1665	1.3065	-0.1984	16.38255	7.09529	16.5C971	6.98619	0.000455	0.008911	C.061041	0.060568
-0.800	0.1065	0.2165	1.2965	-0.1884	16.38331	7.09352	16.50978	6.98663	-0.014793	0.006325	C.061C31	0.060569
-0.780	0.1165	0.2166	1.2865	-0.1785	16.38346	7.09394	16.5C983	6.98643	-0.014627	0.003955	C.061C31	0.060569
-0.760	0.1365	0.2067	1.2665	-0.1786	16.38375	7.09394	16.50987	6.98643	-0.013892	-0.000039	0.061030	0.060570
-0.740	0.1465	0.1968	1.2565	-0.1687	16.38388	7.09432	16.5C986	6.98619	-0.013343	-0.001613	0.061030	0.060570
-0.720	0.1565	0.1966	1.2365	-0.1685	16.38414	7.09433	16.5C981	6.98619	-0.011936	-0.003790	C.061030	0.060570
-0.700	0.1865	0.1966	0.9765	-0.4085	16.38436	7.09433	16.52015	6.98260	-0.010107	0.059155	C.061031	0.060426
-0.680	0.1965	0.1863	0.9665	-0.3982	16.38446	7.09439	16.52073	6.98354	-0.009211	0.056516	C.061031	0.060432
-0.660	0.2165	0.1861	0.9665	-0.3780	16.38462	7.0947C	16.52073	6.98359	-0.007107	0.056919	0.061031	0.060432
-0.640	0.2265	0.1758	0.9565	-0.3677	16.38469	7.09502	16.52129	6.98351	-0.006001	0.054491	C.061C32	0.060438
-0.620	0.2465	0.1755	0.9565	-0.3474	16.38478	7.09503	16.52129	6.98453	-0.003732	0.054491	0.061032	0.060438
-0.600	0.2565	0.1652	0.9665	-0.3171	16.38481	7.09532	16.52C73	6.98570	-0.002551	0.C56519	C.061C32	0.060432
-0.580	0.2765	0.1649	0.9465	-0.3168	16.38484	7.09533	16.52182	6.98571	-0.000348	0.051886	C.C61C32	0.060445
-0.560	0.7165	0.5844	0.9365	-0.3063	16.39344	7.07518	16.52233	6.98660	-0.061556	0.C49119	C.06C884	0.060451
-0.540	0.7365	0.5845	0.9265	-0.2964	16.39468	7.07517	16.52280	6.98624	-0.062119	0.C46202	C.06C878	0.060458
-0.520	0.7565	0.5846	0.9165	-0.2865	16.39553	7.07516	16.52325	6.98646	-0.062167	0.043150	0.060873	0.060464
-0.500	0.7765	0.5847	0.9065	-0.2766	16.39717	7.07515	16.52367	6.98664	-0.061768	0.039978	C.06C870	C.060471
-0.480	0.7865	0.5749	0.8965	-0.2667	16.39778	7.07631	16.52405	6.98679	-0.061291	0.036699	C.06C869	0.060477
-0.460	0.8065	0.5750	0.8865	-0.2569	16.40019	7.07600	16.52440	6.98650	-0.060489	0.033327	C.C6C869	0.060483
-0.440	0.8265	0.5752	0.8765	-0.2471	16.40019	7.07598	16.52550	6.98658	-0.058404	0.029876	C.06C871	0.060488
-0.420	0.8365	0.5652	0.8665	-0.2371	16.40077	7.07682	16.52500	6.98702	-0.057382	0.026362	C.06C872	0.060493
-0.400	0.8565	0.5653	0.8565	-0.2272	16.40189	7.07680	16.52524	6.98702	-0.054987	0.022797	0.060876	0.060498
-0.380	0.8665	0.5555	0.8465	-0.2174	16.40244	7.07759	16.52545	6.98658	-0.053616	0.C19197	C.06C879	0.060502
-0.360	0.8765	0.5457	0.8365	-0.2076	16.40296	7.07835	16.52563	6.98690	-0.052131	0.C15575	C.06C882	0.060505
-0.340	0.8965	0.5459	0.8265	-0.1978	16.40398	7.07834	16.52576	6.98678	-0.048821	0.011945	C.06C888	0.060507
-0.320	0.9065	0.5361	0.8165	-0.188C	16.40446	7.07906	16.52587	6.98662	-0.046999	0.008323	C.06C892	C.060509
-0.300	0.9165	0.5263	0.8065	-0.1782	16.40492	7.07975	16.52593	6.98642	-0.045067	0.004722	C.06C895	0.060510
-0.280	0.9265	0.5165	0.7565	-0.1684	16.40536	7.08042	16.52596	6.98619	-0.043027	0.001156	C.06C899	0.060511
-0.260	0.9465	0.5168	0.7565	-0.1587	16.40617	7.08040	16.52595	6.98644	-0.038624	-0.002361	C.06C907	0.060511
-0.240	0.9565	0.5070	0.7765	-0.1489	16.40655	7.08103	16.52591	6.98560	-0.036263	-0.005813	C.06C911	0.060510
-0.220	0.9665	0.4972	0.7565	-0.1492	16.40690	7.08163	16.52573	6.98560	-0.033759	-0.012465	C.06C915	0.060507
-0.200	0.9765	0.4875	0.7565	-0.1294	16.40723	7.08220	16.52573	6.98466	-0.031231	-0.012465	C.06C919	0.060507
-0.180	0.9765	0.4677	0.7565	-0.1097	16.40723	7.08327	16.52573	6.98358	-0.031230	-0.012469	0.060919	0.060507
-0.160	0.9765	0.4480	0.7565	-0.0899	16.40723	7.08423	16.52573	6.98257	-0.031230	-0.012465	C.06C919	0.060507
-0.140	0.9765	0.4282	0.7165	-0.1101	16.40723	7.08508	16.52474	6.98400	-0.031230	-0.023116	C.06C919	0.060499
-0.120	0.9765	0.4085	0.7065	-0.1004	16.40723	7.08585	16.52450	6.98352	-0.031230	-0.025215	C.06C919	0.060497
-0.100	1.1965	0.6084	0.6965	-0.0904	16.41464	7.07297	16.52424	6.98299	-0.071141	-0.027125	C.06C767	C.C6C455
-0.080	1.2365	0.6290	0.6765	-0.0909	16.41763	7.07093	16.52366	6.98362	-0.077182	-0.030407	C.06C729	0.060491
-0.060	1.2565	0.6296	0.6665	-0.0815	16.41919	7.07087	16.52335	6.98250	-0.078079	-0.031791	0.06C719	C.C6C450
-0.040	1.2765	0.6301	0.6565	-0.0721	16.42074	7.07081	16.52302	6.98156	-0.077251	-0.033012	C.06C717	0.060489
-0.020	1.2865	0.6207	0.6465	-0.0628	16.42151	7.07177	16.52269	6.98140	-0.076117	-0.034C78	C.06C719	0.060488
0.0	1.3065	0.6214	0.6265	-0.0633	16.42300	7.07170	16.52159	6.98144	-0.072263	-0.035765	C.06C731	0.060487
C.C	1.3065	0.6214	0.6265	-0.0633	16.42300	7.C7170	16.52199	6.98144	-0.072263	-0.035765	C.06C731	0.060487
C.020	1.3165	0.6119	0.7565	0.C862	16.42371	7.07264	16.52573	6.97332	-0.069486	-0.012470	0.060741	0.060507
C.040	1.3265	0.6023	0.7565	0.1058	16.42439	7.C7355	16.52573	6.97254	-0.066098	-0.012470	C.06C752	0.060507
0.060	1.3265	0.5827	0.7665	0.1354	16.42439	7.C7533	16.52584	6.97147	-0.066098	-0.009187	C.06C752	0.060505
C.080	1.3365	0.5731	0.7765	0.1650	16.42504	7.07616	16.52591	6.97081	-0.062073	-0.C05813	C.06C765	0.060510
C.100	1.3365	0.5534	0.7865	0.1947	16.42504	7.07776	16.52595	6.96965	-0.062073	-0.002361	C.06C765	C.C6C511
C.120	1.3365	0.5336	0.7965	0.2244	16.42504	7.C7924	16.52596	6.96887	-0.062073	0.001155	C.06C765	0.060511
C.140	1.3365	0.5139	0.7565	0.2442	16.42504	7.08059	16.52596	6.96838	-0.062073	0.001155	C.06C765	0.060511
C.160	1.3365	0.4941	0.7965	0.2640	16.42504	7.08182	16.52596	6.96791	-0.062073	0.001156	C.06C765	0.060511
C.180	1.3365	0.4741	0.7965	0.2840	16.42504	7.08294	16.52596	6.96743	-0.062073	0.001156	C.06C765	0.060511
C.200	1.3365	0.5042	0.7965	0.3038	16.42642	7.08121	16.52596	6.96659	-0.037299	0.001155	0.06C835	0.060511
C.220	1.3965	0.4945	0.7865	0.3135	16.42679	7.08179	16.52595	6.96670	-0.036167	-0.002361	C.06C836	0.060511
C.240	1.4165	0.4947	0.7865	0.3333	16.42749	7.08178	16.52595	6.96617	-0.034091	-0.005813	C.06C838	0.060511
C.260	1.4265	0.4849	0.7765	0.3431	16.42783	7.08235	16.52591	6.96550	-0.033238	-0.C05813	0.06C839	0.060510
0.280	1.4465	0.4851	0.7765	0.3629	16.42848	7.08234	16.52591	6.96529	-0.031762	-0.005813	0.06C839	0.060510
0.300	1.4465	0.4853	0.7665	0.3727	16.42910	7.08233	16.52584	6.96456	-0.030492	-0.009188	0.06C839	0.060509
C.320	1.4765	0.4755	0.7565	0.3825	16.42940	7.08286	16.52573	6.96461	-0.029896	-0.012465	C.06C839	0.060507
C.340	1.4965	0.4758	0.7365	0.3822	16.42999	7.08285	16.52516	6.96462	-0.028706	-0.018329	0.06C839	0.060504
C.360	1.5165	0.4761	0.7165	0.3819	16.43055	7.08283	16.52474	6.96463	-0.027416	-0.023116	C.06C835	C.C6C499
C.380	1.5265	0.4664	0.6965	0.3817	16.43082	7.08334	16.52424	6.96464	-0.026695	-0.027125	C.06C838	0.060495
C.400	1.5465	0.4666	0.7565	0.4613	16.43154	7.08333	16.52573	6.96071	-0.025024	-0.012470	C.06C840	C.060507
C.420	1.5565	0.4569	0.7565	0.4812	16.43158	7.08381	16.52573	6.95954	-0.024043	-0.012470	C.06C841	0.060507
C.440	1.5665	0.4471	0.7565	0.5010	16.43182	7.0847	16.52573	6.95856	-0.022946	-0.012470	C.06C842	0.060507
C.460	1.5865	0.4473	0.7565	0.5207	16.43225	7.08426	16.52573	6.95806	-0.020338	-0.012470	C.06C843	0.060507
C.480	1.5965	0.4375	0.7565	0.5405	16.43245	7.08469	16.52573	6.95716	-0.018797	-0.012465	C.06C844	0.060507
0.500	1.6065	0.4277	0.7565	0.5603	16.43263	7.08511	16.52573	6.95624	-0.017078	-0.012469	0.060846	0.060507
0.520	1.6165	0.4179	0.7565	0.5801	16.43279	7.08549	16.52573	6.95529	-0.015165	-0.012465	C.06C847	0.060507
C.540	1.6265	0.4081	0.7265	0.5659	16.43293	7.08586	16.52496	6.95578	-0.013042	-0.020823	0.060848	0.060501
C.560	1.6365	0.3983	0.7565	0.6197	16.43305	7.08621	16.52573	6.95333	-0.010695	-0.012469	0.060849	0.060507
C.580	1.6465	0.3885	0.7165	0.5995	16.43314	7.08654	16.52474	6.95435	-0.008168	-0.023116	0.060851	C.C6C499
C.600	1.6565	0.3786	0.7065	0.6094	16.43321	7.08686	16.52456	6.95386	-0.005265	-0.025215	C.06C852	0.060497
C.620	1.6665	0.3588	0.7065	0.6292	16.43321	7.08746	16.52456	6.95285	-0.005265	-0.025215	C.06C852	0.060497
C.640	1.6565	0.2391	0.6965	0.6389	16.43158	7.0924E	16.52424	6.95233	-0.024043	-0.027125	C.06C841	C.C6C457
C.660	1.5665	0.2293	0.6865	0.6487	16.43102	7.09295	16.52396	6.95161	-0.022946	-0.C28854	C.06C842	0.060495
C.680	1.5765	0.2196	0.6765	0.6584	16.43204	7.09339	16.52366	6.95128	-0.021716	-0.030407	0.06C842	0.060493
C.700	1.5965	0.2199	0.6665	0.6681	16.43265	7.09338	16.52335	6.95013	-0.018257	-0.031791	0.06C844	0.060490
C.720	1.6065	0.2099	-0.5435	-0.5219	16.43263	7.09380	16.52669	6.97840	-0.017078	0.062993	0.060846	0.060388

0.740	1.6765	0.1996	-0.5435	-0.5016	16.43279	7.09421	16.52669	6.97523	-0.015165	0.062993	0.060847	0.060388
0.760	1.6765	0.1893	-0.5435	-0.4813	16.43293	7.09459	16.52669	6.98001	-0.013042	0.062593	0.060848	0.060388
0.780	1.6765	0.1891	-0.7635	-0.6811	16.43314	7.09460	16.54261	6.97030	-0.008168	0.094884	0.060851	0.060178
0.800	1.6765	0.1785	-0.8235	-0.7205	16.43321	7.09494	16.54882	6.96718	-0.005265	0.110977	0.060852	0.060056
0.820	1.6765	0.1679	-0.8835	-0.7599	16.43325	7.09525	16.55554	6.96354	-0.002152	0.124676	0.060852	0.059932
0.840	1.6765	0.1572	-0.8835	-0.7392	16.43325	7.09551	16.55554	6.96552	0.001247	0.124676	0.060852	0.059932
0.860	1.6765	0.1465	-0.8835	-0.7185	16.43322	7.09574	16.55554	6.96735	0.004947	0.124676	0.060852	0.059932
0.880	1.6765	0.1357	-1.1235	-0.9377	16.43315	7.09592	16.59259	6.93525	0.008964	0.240481	0.060850	0.059017
0.900	1.6765	0.1144	-1.1835	-0.9764	16.43315	7.09614	16.60577	6.93172	0.008964	0.227917	0.060850	0.058663
0.920	1.6765	0.0922	-1.2535	-1.0241	16.43315	7.09618	16.62431	6.92187	0.008964	0.193715	0.060850	0.059028
0.940	1.6765	0.0707	-1.2535	-1.0027	16.43315	7.09605	16.62431	6.92559	0.008964	0.193715	0.060850	0.059028
0.960	1.6765	0.0447	-1.2835	-1.3065	16.43315	7.09567	16.77126	6.80724	0.008964	0.675385	0.060850	0.046386
0.980	1.6765	0.0184	-1.6135	-1.3101	16.43315	7.09510	16.79569	6.80448	0.008964	0.694370	0.060850	0.045753
1.000	1.6765	-0.0099	-1.6635	-1.3315	16.43315	7.09431	16.84331	6.78562	0.008964	0.854983	0.060850	0.038961
1.020	1.6765	-0.1468	-1.8335	-1.3600	16.43315	7.09283	17.30333	6.73729	0.008964	1.245294	0.060850	0.018454
1.040	1.6765	-0.2177	-1.9435	-1.3556	16.43315	7.09268	17.50824	6.70513	0.008964	0.858931	0.060850	0.037311
1.060	1.6765	-0.2517	-1.9135	-1.3319	16.43315	7.09224	17.47900	6.70526	0.008964	0.918055	0.060850	0.034748
1.080	1.7265	-0.2456	-2.0035	-1.3568	16.43093	7.09234	17.56606	6.70878	0.054594	0.704144	0.060770	0.043384
1.100	1.7465	-0.2603	-1.9735	-1.3321	16.42979	7.09207	17.54047	6.76512	0.058637	0.762118	0.060760	0.040449
1.120	1.7665	-0.2684	-1.9935	-1.3235	16.42859	7.09190	17.55534	6.79310	0.061410	0.730082	0.060755	0.042434
1.140	1.7865	-0.2756	-2.0135	-1.3158	16.42734	7.09172	17.57633	6.79939	0.063056	0.678325	0.060753	0.044299
1.160	1.8165	-0.2723	-2.0235	-1.2990	16.42543	7.09181	17.58418	6.81280	0.063986	0.652709	0.060757	0.045179
1.180	1.8465	-0.2682	-2.0435	-1.2928	16.42351	7.09190	17.59669	6.81715	0.063454	0.602325	0.060766	0.046823
1.200	1.8765	-0.2634	-2.0635	-1.2872	16.42162	7.09201	17.61173	6.82084	0.062112	0.553471	0.060778	0.048303

(RL-RR)/2A = NORMALIZED DIFFERENCE IN ROLLING RADII (IN/IN)
(ML-MR)/2 = NORMALIZED DIFFERENCE IN CONTACT ANGLES (RAD)
WR = WHEELSET ROLL ANGLE W.R.T. HORIZONTAL, POSITIVE UP ON LEFT (RAD)
YCG = VERTICAL DISPLACEMENT OF WHEELSET CENTROID FROM NOMINAL PCS. (IN)
CWR = PRINCIPAL TRANSVERSE CURVATURE OF RIGHT WHEEL PROFILE,
POSITIVE FOR CURVATURE CENTER IN BODY (1/IN)
CYR = PRINCIPAL TRANSVERSE CURVATURE OF RIGHT RAIL PROFILE,
POSITIVE FOR CURVATURE CENTER IN BODY (1/IN)
CWL = PRINCIPAL TRANSVERSE CURVATURE OF LEFT WHEEL PROFILE,
POSITIVE FOR CURVATURE CENTER IN BODY (1/IN)
CYL = PRINCIPAL TRANSVERSE CURVATURE OF LEFT RAIL PROFILE,
POSITIVE FOR CURVATURE CENTER IN BODY (1/IN)

YW (IN)	(RL-RR)/2A (IN/IN)	(ML-MR)/2 (RAD)	WR (RAD)	YCG (IN)	CWR (1/IN)	CYR (1/IN)	CWL (1/IN)	CYL (1/IN)
-1.200	-0.018648	-0.31C151	-0.016420	0.441802	7.669333	3.9C8910	0.095868	0.147359
-1.180	-0.018142	-0.318128	-0.015904	0.428021	3.575986	3.9C6563	C.C92457	0.142524
-1.160	-0.018476	-0.351C1C	-0.015329	0.412069	6.089517	2.816145	C.089042	0.137054
-1.140	-0.018303	-0.388631	-0.014812	0.397875	4.704428	2.713300	0.085622	0.132214
-1.120	-0.016149	-0.645065	-0.013864	0.285079	0.080805	2.819222	0.075341	0.117324
-1.100	-0.008893	-0.6CE078	-0.CC3596	0.077570	-0.434157	C.565435	0.020180	0.214783
-1.080	-0.005397	-0.484279	-0.001231	0.011870	-0.938502	1.668832	0.020180	0.183667
-1.060	-0.004354	-0.4600C6	-0.CCC218	-0.C15839	-1.259093	1.75C292	0.016723	0.176398
-1.040	0.002059	0.029306	0.000066	-0.023007	C.032306	C.C51545	0.013266	0.171844
-1.020	0.002065	0.027268	C.CCCC7E	-C.022425	0.037371	C.0904495	0.011537	0.166175
-1.000	0.002069	0.024757	0.000090	-0.021891	C.047501	C.09C465	0.012393	0.160518
-0.980	0.002074	0.022646	C.CCC101	-0.021408	0.052566	0.089017	0.014554	0.154862
-0.960	0.002078	0.020112	0.000111	-0.020967	C.054903	C.088972	0.016715	0.149128
-0.940	0.002081	0.017619	0.000120	-0.020582	0.048280	0.088952	0.018877	0.143493
-0.920	0.002086	0.015553	0.000126	-0.020249	0.044968	0.087508	0.021038	0.137867
-0.900	0.002089	0.013267	0.000136	-0.019962	0.038343	C.087492	0.023200	0.132249
-0.880	0.002092	0.011062	0.000143	-0.019715	0.031715	0.087479	0.025361	0.126640
-0.860	0.002095	0.008977	0.000149	-0.019534	0.025095	0.087467	0.027523	0.121040
-0.840	0.002100	0.006568	0.000154	-0.019388	0.018470	0.087458	0.031847	0.121004
-0.820	0.002102	0.004228	0.000158	-0.019275	0.011846	0.087462	0.034010	0.115463
-0.800	0.002090	0.001C559	0.000156	-0.019067	-0.011340	0.094597	0.036172	0.109942
-0.780	0.002089	0.000291	0.000153	-0.018860	-0.014653	C.093182	0.038335	0.104427
-0.760	0.002085	0.000526	0.000149	-0.018699	-0.021277	0.093193	0.042662	0.104468
-0.740	0.002082	0.005865	0.000144	-0.018563	-0.024590	C.091780	0.044826	0.098963
-0.720	0.002077	0.004073	0.000139	-0.018463	-0.031214	C.091758	0.049154	0.098877
-0.700	0.002244	0.004671	0.000148	-0.017974	-0.037838	C.091757	0.105507	0.219919

-0.680	0.002252	0.033065	0.000164	-0.017283	-0.041151	0.090294	0.107676	0.218555
-0.660	0.002250	0.032013	0.000181	-0.016622	-0.047774	0.090256	0.107676	0.215171
-0.640	0.002258	0.030246	0.000197	-0.015987	-0.051086	0.088791	0.109844	0.209481
-0.620	0.002256	0.029112	0.000214	-0.015378	-0.057710	0.088751	0.109844	0.198240
-0.600	0.002247	0.029755	0.000236	-0.014662	-0.061021	0.087275	0.107676	0.181393
-0.580	0.002264	0.026117	0.000254	-0.014094	-0.067643	0.087232	0.112013	0.181228
-0.560	0.002130	0.025338	0.000287	-0.014097	-0.059464	0.345680	0.114181	0.175415
-0.540	0.002118	0.024161	0.000282	-0.012995	-0.056489	0.345757	0.116350	0.169911
-0.520	0.002105	0.022658	0.000277	-0.011920	-0.053516	0.345848	0.118517	0.164414
-0.500	0.002091	0.020843	0.000271	-0.010880	-0.050543	0.345952	0.120685	0.158926
-0.480	0.002087	0.018995	0.000263	-0.009878	-0.049058	0.337406	0.122852	0.153445
-0.460	0.002073	0.016708	0.000255	-0.008919	-0.046087	0.337533	0.124905	0.147970
-0.440	0.002058	0.014140	0.000246	-0.008011	-0.043117	0.337672	0.122784	0.142503
-0.420	0.002053	0.011872	0.000236	-0.007143	-0.041633	0.328975	0.120663	0.136946
-0.400	0.002039	0.008892	0.000226	-0.006339	-0.038665	0.329122	0.118541	0.131485
-0.380	0.002033	0.006406	0.000215	-0.005587	-0.037182	0.320554	0.116419	0.126030
-0.360	0.002027	0.003853	0.000203	-0.004897	-0.035698	0.311964	0.114296	0.120581
-0.340	0.002013	0.000383	0.000191	-0.004264	-0.032732	0.312138	0.112173	0.115138
-0.320	0.002007	0.027661	0.000179	-0.003691	-0.031250	0.303539	0.110050	0.109701
-0.300	0.002000	0.024854	0.000166	-0.003181	-0.027763	0.294921	0.107926	0.104268
-0.280	0.001993	0.022091	0.000152	-0.002733	-0.023248	0.286286	0.105802	0.098840
-0.260	0.001980	0.018131	0.000138	-0.002348	-0.021422	0.286488	0.103678	0.093416
-0.240	0.001973	0.015225	0.000124	-0.002022	-0.005707	0.277844	0.101554	0.087997
-0.220	0.001964	0.010665	0.000109	-0.001760	-0.005194	0.269185	0.097305	0.088131
-0.200	0.001959	0.009381	0.000094	-0.001558	-0.000681	0.260511	0.097305	0.077169
-0.180	0.001959	0.009381	0.000079	-0.001466	-0.000681	0.242914	0.097305	0.066220
-0.160	0.001959	0.009381	0.000062	-0.001491	-0.000681	0.225263	0.097305	0.055276
-0.140	0.001942	0.004057	0.000045	-0.001542	-0.000681	0.207529	0.088807	0.066452
-0.120	0.001938	0.003008	0.000037	-0.001647	-0.000681	0.189756	0.086683	0.061671
-0.100	0.001812	0.022008	0.000035	-0.002151	0.098763	0.366352	0.084558	0.055518
-0.080	0.001753	0.023388	0.000002	-0.001698	0.116908	0.383826	0.080310	0.055821
-0.060	0.001722	0.023144	-0.000032	-0.001238	0.125989	0.384305	0.078186	0.050593
-0.040	0.001691	0.022119	-0.000068	-0.000795	0.135076	0.384792	0.076062	0.045371
-0.020	0.001672	0.021020	-0.000103	-0.000382	0.139621	0.376807	0.073939	0.040150
0.0	0.001636	0.018249	-0.000137	0.0	0.148714	0.377364	0.069692	0.040516
0.0	0.001636	0.018249	-0.000137	0.0	0.148714	0.377364	0.069692	0.040516
0.020	0.001686	0.028507	-0.000171	0.000381	0.153262	0.369266	0.097305	-0.003949
0.040	0.001675	0.026814	-0.000197	0.000914	0.157811	0.361082	0.097305	-0.001241
0.060	0.001677	0.028455	-0.000222	0.001447	0.157811	0.344200	0.099429	0.002856
0.080	0.001667	0.028130	-0.000244	0.001991	0.162360	0.335846	0.101554	0.006958
0.100	0.001668	0.029856	-0.000264	0.002507	0.162360	0.318688	0.103678	0.011066
0.120	0.001668	0.031614	-0.000280	0.002984	0.162360	0.301375	0.105802	0.015181
0.140	0.001668	0.031614	-0.000294	0.003417	0.162360	0.283926	0.105802	0.017917
0.160	0.001668	0.031614	-0.000306	0.003795	0.162360	0.266359	0.105802	0.020659
0.180	0.001668	0.031614	-0.000316	0.004116	0.162360	0.248550	0.105802	0.023426
0.200	0.001645	0.019227	-0.000322	0.004323	0.185110	0.275378	0.105802	0.026171
0.220	0.001639	0.016873	-0.000334	0.004675	0.189659	0.266764	0.103678	0.027513
0.240	0.001628	0.015865	-0.000345	0.005006	0.191518	0.266936	0.103678	0.030252
0.260	0.001621	0.013712	-0.000357	0.005298	0.187792	0.258216	0.101554	0.031607
0.280	0.001611	0.012974	-0.000369	0.005563	0.180337	0.258395	0.101554	0.034345
0.300	0.001599	0.010652	-0.000382	0.005791	0.172873	0.258579	0.099429	0.035698
0.320	0.001592	0.008713	-0.000395	0.005982	0.169138	0.249861	0.097305	0.037050
0.340	0.001573	0.005188	-0.000414	0.006185	0.161665	0.250136	0.093056	0.037008
0.360	0.001557	0.002150	-0.000430	0.006056	0.154186	0.250367	0.088807	0.036972
0.380	0.001544	-0.000215	-0.000447	0.006073	0.150446	0.241691	0.084558	0.036933
0.400	0.001560	0.006277	-0.000462	0.006108	0.142963	0.241910	0.097305	0.053016
0.420	0.001556	0.005787	-0.000476	0.006161	0.135221	0.233177	0.097305	0.061712
0.440	0.001552	0.005238	-0.000489	0.006191	0.135479	0.224425	0.097305	0.070408
0.460	0.001545	0.003934	-0.000502	0.006206	0.127994	0.224621	0.097305	0.079101
0.480	0.001542	0.003164	-0.000515	0.006193	0.124252	0.215847	0.097305	0.087795
0.500	0.001539	0.002304	-0.000528	0.006153	0.120510	0.207058	0.097305	0.096476
0.520	0.001536	0.001348	-0.000540	0.006082	0.116768	0.198253	0.097305	0.105156
0.540	0.001521	-0.000891	-0.000553	0.005945	0.113026	0.189457	0.090931	0.100677
0.560	0.001532	-0.000887	-0.000563	0.005840	0.109284	0.180605	0.097305	0.122490
0.580	0.001514	-0.000504	-0.000574	0.005690	0.105543	0.171765	0.088807	0.113664
0.600	0.001509	-0.000975	-0.000585	0.005516	0.101803	0.162902	0.086683	0.117966
0.620	0.001509	-0.000975	-0.000595	0.005308	0.101803	0.145008	0.086683	0.126634
0.640	0.001531	-0.001541	-0.000611	0.005243	0.139221	0.097807	0.084558	0.130881
0.660	0.001523	-0.002954	-0.000627	0.005193	0.135479	0.096422	0.082434	0.135124
0.680	0.001514	-0.004345	-0.000644	0.005111	0.131737	0.095036	0.080310	0.139364
0.700	0.001502	-0.006457	-0.000660	0.005004	0.124252	0.095075	0.078186	0.143600
0.720	0.001555	0.040036	-0.000658	0.005817	0.120510	0.093649	0.061481	0.234216
0.740	0.001552	0.039079	-0.000641	0.006639	0.116768	0.092181	0.061481	0.231657
0.760	0.001550	0.038018	-0.000624	0.007416	0.113026	0.090715	0.061481	0.229161
0.780	0.001809	0.051496	-0.000609	0.008132	0.105543	0.090681	-0.220322	0.253164
0.800	0.001911	0.058121	-0.000578	0.009253	0.101803	0.089182	-0.338962	0.257606
0.820	0.002028	0.063414	-0.000538	0.010544	0.098062	0.087663	-0.455342	0.261912
0.840	0.002028	0.061714	-0.000496	0.011794	0.094323	0.086139	-0.455342	0.259663
0.860	0.002028	0.059864	-0.000455	0.012930	0.090584	0.084617	-0.455342	0.257382
0.880	0.002635	0.097558	-0.000403	0.014387	0.086845	0.083071	-0.497536	0.791937
0.900	0.002853	0.109477	-0.000320	0.016575	0.086845	0.080026	-0.125215	0.900473
0.920	0.003160	0.092376	-0.000186	0.020063	0.086845	0.076853	0.301582	0.767665
0.940	0.003160	0.092376	-0.000096	0.022056	0.086845	0.073792	0.301582	0.826457
0.960	0.005589	0.335210	0.000268	0.031849	0.086845	0.070071	-4.043732	3.088272
0.980	0.005992	0.342703	0.000654	0.042016	0.086845	0.066309	-3.122414	3.066941
1.000	0.006779	0.423009	0.001157	0.055370	0.086845	0.062264	-1.707040	2.835462
1.020	0.014383	0.618415	0.002210	0.257854	0.086845	0.084979	0.301160	2.357429
1.040	0.017770	0.424983	0.001254	0.344620	0.086845	0.136556	3.960206	1.701913
1.060	0.017287	0.454545	0.002083	0.367751	0.086845	0.161188	2.643874	2.830219
1.080	0.018796	0.324775	0.002315	0.372196	0.075633	0.156802	3.146302	1.685660
1.100	0.018358	0.361651	0.003190	0.396306	0.068162	0.167478	4.492783	2.828254
1.120	0.018690	0.334336	0.003676	0.408531	0.060693	0.173349	3.816951	2.940083
1.140	0.018992	0.307617	0.004109	0.419963	0.053226	0.178651	2.297468	3.021074
1.160	0.019153	0.294362	0.004495	0.429641	0.042031	0.176134	1.320850	3.114886
1.180	0.019425	0.269436	0.004844	0.438200	0.030839	0.173153	-0.790926	3.116532
1.200	0.019671	0.245680	0.005156	0.445723	0.019651	0.169715	-0.458558	3.101384

PROFILE PRINCIPAL TRANSVERSE CURVATURES (1/IN)

XWR= LOCATION ON RIGHT WHEEL, POSITIVE OUT FROM TAPELINE (IN)
XRR= LOCATION ON RIGHT RAIL, POSITIVE OUT FROM CENTERLINE (IN)
XWL= LOCATION ON LEFT WHEEL, POSITIVE OUT FROM TAPELINE (IN)
XRL= LOCATION ON LEFT RAIL, POSITIVE OUT FROM CENTERLINE (IN)
CWR = PRINCIPAL TRANSVERSE CURVATURE OF RIGHT WHEEL PROFILE, POSITIVE FOR CURVATURE CENTER IN BODY (1/IN)
CYR = PRINCIPAL TRANSVERSE CURVATURE OF RIGHT RAIL PROFILE, POSITIVE FOR CURVATURE CENTER IN BODY (1/IN)
CWL = PRINCIPAL TRANSVERSE CURVATURE OF LEFT WHEEL PROFILE, POSITIVE FOR CURVATURE CENTER IN BODY (1/IN)
CYL = PRINCIPAL TRANSVERSE CURVATURE OF LEFT RAIL PROFILE, POSITIVE FOR CURVATURE CENTER IN BODY (1/IN)

XWR (IN)	CWR (1/IN)	XRR (IN)	CYR (1/IN)	XWL (IN)	CWL (1/IN)	XRL (IN)	CYL (1/IN)
-2.68346	-4.916701	-1.45861	0.743191	-2.32322	5.666380	-1.41155	1.444368
-2.65000	-6.002773	-1.45000	0.855714	-2.30000	5.278864	-1.40000	1.630697
-2.60000	-5.373230	-1.40000	1.966061	-2.25000	3.776591	-1.35000	2.537836
-2.55000	-2.948425	-1.35000	3.592058	-2.20000	2.265416	-1.30000	3.112927
-2.50000	-0.452110	-1.30000	3.326706	-2.15000	1.101800	-1.25000	2.585058
-2.45000	1.581500	-1.25000	0.548558	-2.10000	0.178332	-1.20000	0.983776
-2.40000	4.309479	-1.20000	0.664051	-2.05000	-0.703297	-1.15000	0.452925
-2.35000	1.102941	-1.15000	0.792467	-2.00000	3.400762	-1.10000	0.571573
-2.30000	-1.757321	-1.10000	0.924058	-1.95000	4.192184	-1.05000	0.698556
-2.25000	-4.761198	-1.05000	1.089575	-1.90000	2.097722	-1.00000	0.833884
-2.20000	5.136013	-1.00000	0.917455	-1.85000	0.515306	-0.95000	0.834370
-2.15000	11.069228	-0.95000	0.701745	-1.80000	0.036678	-0.90000	0.656146
-2.10000	4.285239	-0.90000	0.467059	-1.75000	-0.359781	-0.85000	0.466473
-2.05000	0.767846	-0.85000	0.221990	-1.70000	-1.043544	-0.80000	0.270460
-2.00000	0.124022	-0.80000	0.136220	-1.65000	-2.033803	-0.75000	0.260842
-1.95000	-0.203125	-0.75000	0.165548	-1.60000	-3.554763	-0.70000	0.255310
-1.90000	-0.489008	-0.70000	0.193954	-1.55000	-4.596130	-0.65000	0.249592
-1.85000	-0.754823	-0.65000	0.222228	-1.50000	-3.660505	-0.60000	0.243767
-1.80000	-1.122113	-0.60000	0.256751	-1.45000	-1.249604	-0.55000	0.237671
-1.75000	-1.530650	-0.55000	0.295587	-1.40000	1.291702	-0.50000	0.231501
-1.70000	-1.787291	-0.50000	0.308574	-1.35000	0.932218	-0.45000	0.225214
-1.65000	-1.789000	-0.45000	0.303465	-1.30000	0.596050	-0.40000	0.218825
-1.60000	-1.674478	-0.40000	0.268055	-1.25000	0.280208	-0.35000	0.199673
-1.55000	-1.754612	-0.35000	0.232257	-1.20000	-0.024724	-0.30000	0.171920
-1.50000	-1.431808	-0.30000	0.196199	-1.15000	-0.330652	-0.25000	0.144140
-1.45000	-0.957592	-0.25000	0.159578	-1.10000	-0.649277	-0.20000	0.116362
-1.40000	-0.397052	-0.20000	0.123664	-1.05000	-0.747545	-0.15000	0.088601
-1.35000	-0.180808	-0.15000	0.087301	-1.00000	-0.667054	-0.10000	0.060863
-1.30000	-0.223831	-0.10000	0.050516	-0.95000	-0.579438	-0.05000	0.033145
-1.25000	-0.267867	-0.05000	0.056537	-0.90000	-0.486795	0.00000	0.005440
-1.20000	-0.313014	0.00000	0.063684	-0.85000	-0.390814	0.05000	-0.008961
-1.15000	-0.359318	0.05000	0.070830	-0.80000	-0.292765	0.10000	-0.002040
-1.10000	-0.406753	0.10000	0.077972	-0.75000	-0.193525	0.15000	0.004882
-1.05000	-0.391460	0.15000	0.085110	-0.70000	-0.093682	0.20000	0.011804
-1.00000	-0.371964	0.20000	0.092241	-0.65000	0.006416	0.25000	0.018724
-0.95000	-0.351550	0.25000	0.099361	-0.60000	0.101555	0.30000	0.025642
-0.90000	-0.330367	0.30000	0.106466	-0.55000	0.066112	0.35000	0.032557
-0.85000	-0.308549	0.35000	0.113555	-0.50000	0.030725	0.40000	0.039466
-0.80000	-0.286219	0.40000	0.120143	-0.45000	-0.004629	0.45000	0.046996
-0.75000	-0.263487	0.45000	0.127043	-0.40000	-0.039583	0.55000	0.069990
-0.70000	-0.240444	0.50000	0.133163	-0.35000	-0.075375	0.55000	0.091952
-0.65000	-0.217171	0.55000	0.139732	-0.30000	-0.110841	0.65000	0.113865
-0.60000	-0.193639	0.60000	0.145116	-0.25000	-0.146387	0.65000	0.135707
-0.55000	-0.168448	0.65300	0.401488	-0.20000	-0.182015	0.70000	0.157452
-0.50000	-0.143184	0.70000	0.442484	-0.15000	-0.217717	0.75000	0.179065
-0.45000	-0.117861	0.75000	0.481663	-0.10000	-0.231431	0.80000	0.200504
-0.40000	-0.092559	0.80000	0.518666	-0.05000	-0.205720	0.85000	0.221716
-0.35000	-0.067232	0.85000	0.553727	0.00000	-0.179926	0.90000	0.242642
-0.30000	-0.041907	0.90000	0.583447	0.05000	-0.154094	0.95000	0.263211
-0.25000	-0.016584	0.95000	0.612264	0.10000	-0.128254	1.00000	0.283341
-0.20000	0.008737	1.00000	0.632627	0.15000	-0.102425	1.04115	0.299513
-0.15000	0.034059	1.03920	0.646735	0.20000	-0.076616	0.0	0.0
-0.10000	0.059369	0.0	0.0	0.25000	-0.050825	0.0	0.0
-0.05000	0.040510	0.0	0.0	0.30000	-0.025055	0.0	0.0
0.00000	0.023949	0.0	0.0	0.35000	0.000701	0.0	0.0
0.05000	0.007387	0.0	0.0	0.40000	0.021658	0.0	0.0
0.10000	-0.009174	0.0	0.0	0.45000	0.032248	0.0	0.0
0.15000	-0.025736	0.0	0.0	0.50000	0.042846	0.0	0.0
0.20000	-0.042296	0.0	0.0	0.55000	0.053449	0.0	0.0
0.25000	-0.058855	0.0	0.0	0.60000	0.064058	0.0	0.0
0.30000	-0.075409	0.0	0.0	0.65000	0.074674	0.0	0.0
0.35000	-0.091955	0.0	0.0	0.70000	0.085293	0.0	0.0
0.40000	-0.108673	0.0	0.0	0.75000	0.095915	0.0	0.0
0.45000	-0.099237	0.0	0.0	0.80000	0.106537	0.0	0.0
0.50000	-0.089741	0.0	0.0	0.85000	0.117153	0.0	0.0
0.55000	-0.080279	0.0	0.0	0.90000	0.122102	0.0	0.0
0.60000	-0.070821	0.0	0.0	0.95000	0.111263	0.0	0.0
0.65000	-0.061370	0.0	0.0	1.00000	0.100418	0.0	0.0
0.70000	-0.051925	0.0	0.0	1.05000	0.089573	0.0	0.0
0.75000	-0.042488	0.0	0.0	1.10000	0.078731	0.0	0.0
0.80000	-0.033058	0.0	0.0	1.15000	0.067894	0.0	0.0
0.85000	-0.023636	0.0	0.0	1.20000	0.057064	0.0	0.0
0.90000	-0.014222	0.0	0.0	1.25000	0.046241	0.0	0.0
0.95000	-0.004819	0.0	0.0	1.30000	0.035424	0.0	0.0
1.00000	0.004576	0.0	0.0	1.35000	0.024613	0.0	0.0
1.05000	0.013977	0.0	0.0	1.40000	0.013807	0.0	0.0
1.10000	0.023365	0.0	0.0	1.45000	0.017321	0.0	0.0
1.15000	0.032741	0.0	0.0	1.50000	0.025962	0.0	0.0
1.20000	0.042106	0.0	0.0	1.55000	0.034595	0.0	0.0
1.25000	0.051459	0.0	0.0	1.60000	0.043230	0.0	0.0
1.30000	0.060800	0.0	0.0	1.65000	0.051853	0.0	0.0
1.35000	0.070130	0.0	0.0	1.70000	0.060466	0.0	0.0
1.40000	0.079448	0.0	0.0	1.75000	0.069066	0.0	0.0
1.45000	0.088754	0.0	0.0	1.80000	0.077650	0.0	0.0
1.50000	0.098049	0.0	0.0	1.85000	0.086214	0.0	0.0
1.55000	0.107332	0.0	0.0	1.90000	0.094753	0.0	0.0
1.60000	0.116604	0.0	0.0	1.95000	0.103262	0.0	0.0
1.65000	0.125864	0.0	0.0	2.00000	0.111736	0.0	0.0
1.70000	0.135113	0.0	0.0	2.05000	0.120167	0.0	0.0
1.75000	0.144350	0.0	0.0	2.09067	0.126888	0.0	0.0
1.80000	0.153576	0.0	0.0	0.0	0.0	0.0	0.0
1.85000	0.162790	0.0	0.0	0.0	0.0	0.0	0.0
1.90000	0.171993	0.0	0.0	0.0	0.0	0.0	0.0
1.95000	-0.007739	0.0	0.0	0.0	0.0	0.0	0.0
2.00000	-0.026383	0.0	0.0	0.0	0.0	0.0	0.0
2.01489	-0.031937	0.0	0.0	0.0	0.0	0.0	0.0

CALCOMP PLOTTER OUTPUT - ASYMMETRIC PROBLEM

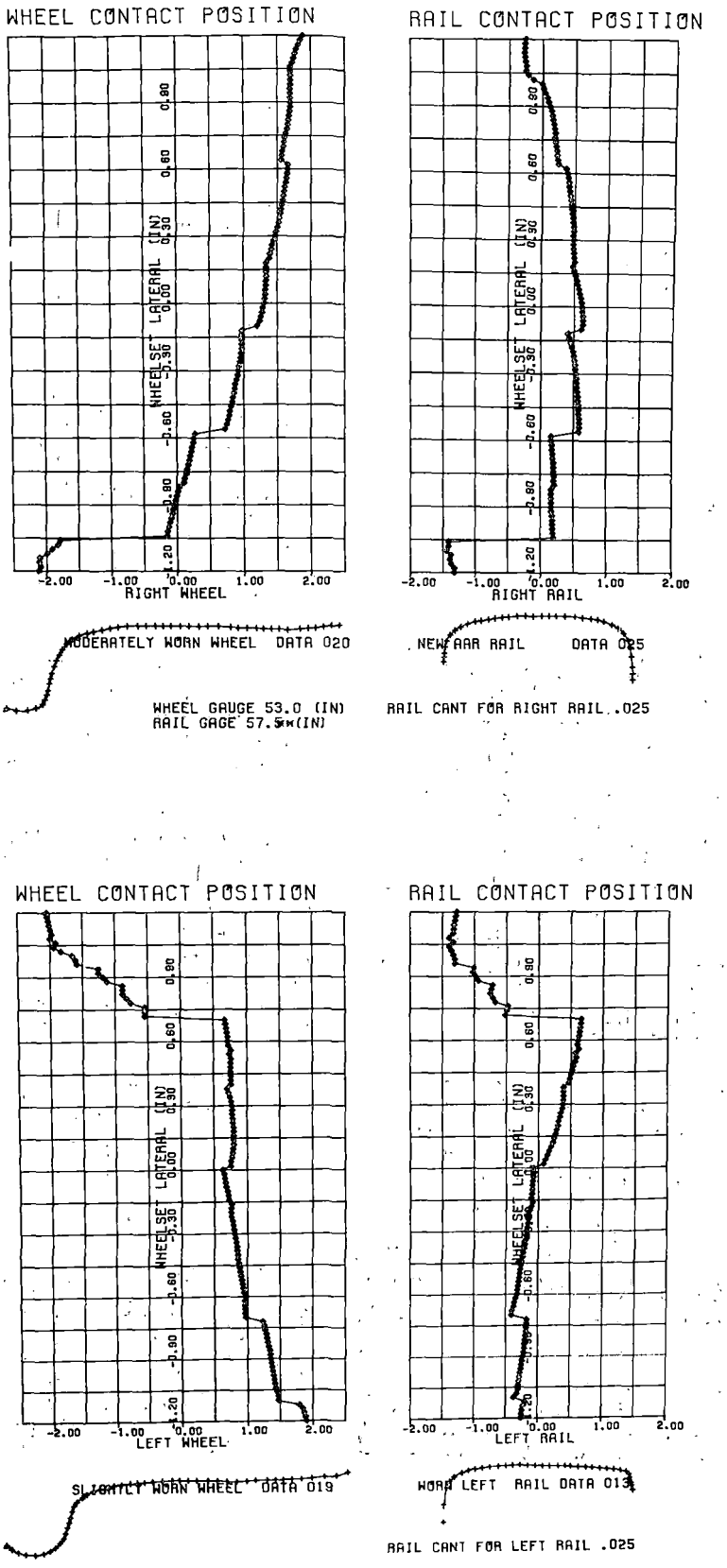

FIGURE 4A. CALCOMP PLOTTER OUTPUT - ASYMMETRIC PROBLEM, WHEEL/RAIL PROFILES AND LOCATION OF CONTACT POINTS.

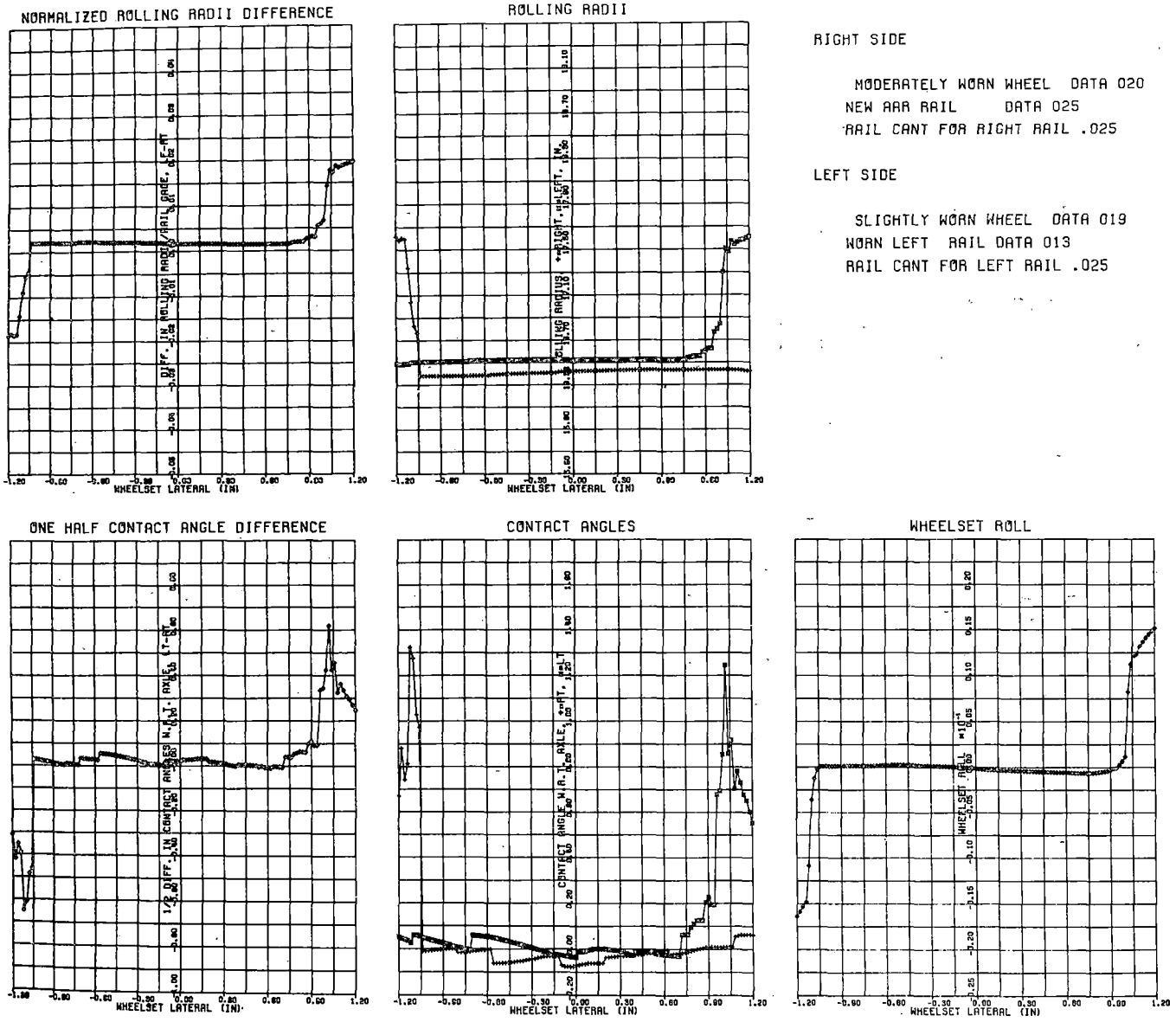

FIGURE 4B. CALCOMP PLOTTER OUTPUT - ASYMMETRIC PROBLEM, GEOMETRIC CONSTRAINTS..

PARTIAL LISTING OF PUNCHED CARD OUTPUT - ASYMMETRIC PROBLEM

```
0.530000D+02 0.29563D+02 0.57500D+02 0.30250D+02 0.25000D-01 0.25000D-01
COFFFICIENTS FOR PROFILE CURVE FITS
 MODERATELY WORN WHEEL  DATA 020
16
 1-0.156715D+01 0.304671D+02-0.191486D+02 0.530064D+01-0.547639D+00
0.200000D+03 0.213122D+01
 2 0.461405D+01 0.253235D+02-0.202406D+02 0.716336D+01-0.949460D+00
0.213122D+01 0.170639D+01
 3 0.132518D+02 0.841071D+01-0.843409D+01 0.378532D+01-0.639321D+00
0.170639D+01 0.134552D+01
 4 0.147203D+02 0.631983D+01-0.881744D+01 0.540219D+01-0.121867D+01
0.134552D+01 0.978141D+00
 5 0.164533D+02-0.376679D+00 0.640281D+00-0.356971D+00 0.479603D-01
0.978141D+00 0.542553D+00
 6 0.163820D+02 0.521154D-02 0.104573D+00-0.435421D+00 0.439686D+00
0.542553D+00 0.104700D+00
 7 0.163826D+02 0.125562D-03-0.161128D-01 0.136237D+00 0.260559D+00
0.104700D+00-0.272017D+00
 8 0.163838D+02 0.202176D-01 0.143899D-01 0.662731D-03 0.338039D-01
-0.272017D+00-0.686944D+00
 9 0.161467D+02-0.121765D+01-0.232796D+01-0.190585D+01-0.529247D+00
-0.686944D+00-0.109763D+01
 10 0.189816D+02 0.893211D+01 0.113006D+02 0.623124D+01 0.129394D+01
-0.109763D+01-0.144944D+01
 11-0.774151D+01-0.590998D+02-0.531682D+02-0.207012D+02-0.288736D+01
-0.144944D+01-0.173983D+01
 12 0.135610D+04 0.302583D+04 0.256234D+04 0.964417D+03 0.136191D+03
-0.173983D+01-0.188078D+01
 13 0.842673D+04 0.174160D+05 0.135251D+05 0.466906D+04 0.604663D+03
-0.188078D+01-0.196286D+01
 14 0.230053D+05 0.455784D+05 0.338647D+05 0.111758D+05 0.138227D+04
-0.196286D+01-0.203560D+01
 15-0.833937D+03-0.147508D+04-0.957925D+03-0.276391D+03-0.298926D+02
-0.203560D+01-0.224900D+01
 16 0.465908D+03 0.767996D+03 0.491613D+03 0.139362D+03 0.147635D+02
-0.224900D+01-0.268346D+01

 NEW AAR RAIL      DATA 025
12
 1-0.717974D+06 0.202315D+07-0.213774D+07 0.100387D+07-0.176774D+06
0.200000D+03 0.141155D+01
 2-0.471327D+04 0.146701D+05-0.170856D+05 0.883825D+04-0.171355D+04
0.141155D+01 0.132706D+01
 3-0.172785D+02 0.930384D+02-0.132427D+03 0.832903D+02-0.196223D+02
0.132706D+01 0.103920D+01
 4 0.783270D+01-0.368328D+01 0.661960D+01-0.515199D+01 0.138470D+01
0.103920D+01 0.718720D+00
 5 0.711787D+01-0.237339D+00 0.759644D+00-0.111208D+01 0.501801D+00
0.718720D+00 0.319158D+00
```

```
  6 0.709460D+01 0.287286D-01-0.803595D-01-0.595744D+00 0.114622D+01
 0.319158D+00-0.373100D-01
  7 0.709319D+01 0.215640D-01 0.235734D+00 0.808897D+00 0.608104D+00
-0.373100D-01-0.380963D+00
  8 0.718524D+01 0.674892D+00 0.176116D+01 0.207601D+01 0.809856D+00
-0.380963D+00-0.729417D+00
  9 0.757947D+01 0.186464D+01 0.248642D+01 0.142973D+01 0.230883D+00
-0.729417D+00-0.104797D+01
 10-0.925237D+01-0.590273D+02-0.796795D+02-0.475942D+02-0.106845D+02
-0.104797D+01-0.133318D+01
 11-0.217416D+04-0.650945D+04-0.728106D+04-0.361792D+04-0.673933D+03
-0.133318D+01-0.146813D+01
 12 0.312714D+06 0.852386D+06 0.871187D+06 0.395682D+06 0.673831D+05
-0.146813D+01-0.150317D+01

 SLIGHTLY WORN WHEEL  DATA 019
 16
  1 0.128266D+01 0.297367D+02-0.217413D+02 0.705471D+01-0.859258D+00
 0.200000D+03 0.209007D+01
  2 0.224666D+02-0.128168D+02 0.102578D+02-0.362104D+01 0.474031D+00
 0.209007D+01 0.160674D+01
  3 0.200192D+02-0.105257D+02 0.117192D+02-0.573018D+01 0.103558D+01
 0.160674D+01 0.117713D+01
  4 0.166938D+02-0.106922D+01 0.226674D+01-0.196264D+01 0.590000D+00
 0.117713D+01 0.753231D+00
  5 0.165013D+02 0.707760D-01-0.228450D+00 0.434430D+00-0.264626D+00
 0.753231D+00 0.287933D+00
  6 0.165047D+02 0.523937D-02 0.113306D+00-0.617850D-01-0.267297D+00
 0.287933D+00-0.117938D+00
  7 0.165054D+02 0.134114D-01 0.132511D+00 0.545437D-01-0.236652D-01
-0.117938D+00-0.534481D+00
  8 0.163438D+02-0.949982D+00-0.192276D+01-0.177162D+01-0.571225D+00
-0.534481D+00-0.891597D+00
  9 0.160470D+02-0.194034D+01-0.292016D+01-0.196159D+01-0.458314D+00
-0.891597D+00-0.124467D+01
 10 0.206284D+01-0.402814D+02-0.413435D+02-0.185038D+02-0.300320D+01
-0.124467D+01-0.154953D+01
 11 0.686777D+03 0.171190D+04 0.163843D+04 0.696507D+03 0.111018D+03
-0.154953D+01-0.172856D+01
 12 0.114358D+05 0.256190D+05 0.215434D+05 0.804836D+04 0.112723D+04
-0.172856D+01-0.181522D+01
 13 0.436321D+04 0.926468D+04 0.739158D+04 0.261622D+04 0.346694D+03
-0.181522D+01-0.191550D+01
 14-0.814421D+02-0.171680D+03-0.112573D+03-0.331004D+02-0.367898D+01
-0.191550D+01-0.212856D+01
 15-0.419957D+02-0.975061D+02-0.603910D+02-0.168212D+02-0.177863D+01
-0.212856D+01-0.252983D+01
 16 0.231189D+04 0.356985D+04 0.208054D+04 0.538212D+03 0.521373D+02
-0.252983D+01-0.281942D+01

 WORN LEFT  RAIL DATA 013
 11
  1 0.400597D+06-0.108454D+07 0.110124D+07-0.496933D+06 0.840817D+05
 0.200000D+03 0.147348D+01
```

```
  2-0.911684D+03 0.281061D+04-0.322080D+04 0.163836D+04-0.312162D+03
 0.147348D+01 0.136748D+01
  3 0.291367D+01 0.153721D+02-0.216339D+02 0.133201D+02-0.305166D+01
 0.136748D+01 0.104115D+01
  4 0.721894D+01-0.133609D+01 0.257877D+01-0.221847D+01 0.676887D+00
 0.104115D+01 0.721725D+00
  5 0.696657D+01 0.701733D-01-0.346095D+00 0.479410D+00-0.257014D+00
 0.721725D+00 0.390795D+00
  6 0.697734D+01-0.517195D-01 0.489304D-01 0.146771D+00-0.388735D+00
 0.390795D+00 0.307910D-01
  7 0.697737D+01-0.658921D-01 0.212585D-01 0.764281D+00 0.956031D+00
 0.307910D-01-0.325615D+00
  8 0.698517D+01-0.513711D-01-0.254394D+00-0.370836D+00-0.229208D+00
-0.325615D+00-0.679420D+00
  9 0.685212D+01-0.679246D+00-0.130965D+01-0.110554D+01-0.400664D+00
-0.679420D+00-0.102385D+01
 10-0.163686D+02-0.851313D+02-0.115767D+03-0.696150D+02-0.156815D+02
-0.102385D+01-0.133932D+01
 11-0.724255D+04-0.215836D+05-0.240810D+05-0.119334D+05-0.221632D+04
-0.133932D+01-0.148139D+01

THE DATA IS ORDERED AS FOLLOWS:

 CONTACT POINTS, GEOMETRIC CONSTRAINTS, AND PROFILE CURVATURES
 AS A FUNCTION OF WHEELSET  LATERAL DISPLACEMENT

 XW = WHEELSET LATERAL, POSITIVE TO THE LEFT (IN)
 X1 = CONTACT LOCATION ON RIGHT WHEEL, POSITIVE OUT FROM TAPELINE (IN)
 X2 = CONTACT LOCATION ON RIGHT RAIL, POSITIVE OUT FROM CENTERLINE (IN)
 X3 = CONTACT LOCATION ON LEFT WHEEL, POSITIVE OUT FROM TAPELINE  (IN)
 X4 = CONTACT LOCATION ON LEFT RAIL, POSITIVE OUT FROM CENTERLINE (IN)
 RR = ROLLING RADII, RIGHT WHEEL (IN)
 YR = RAIL HEAD PROFILE HEIGHT, RIGHT RAIL (IN)
 RL = ROLLING RADII, LEFT WHEEL (IN)
 YL = RAIL HEAD PROFILE HEIGHT, LEFT RAIL (IN)
 MR = CONTACT ANGLE W.R.T. AXLE, RIGHT WHEEL (RAD)
 ML = CONTACT ANGLE W.R.T. AXLE, LEFT WHEEL (RAD)
1(RL-RR)/24 = NORMALIZED DIFFERENCE IN ROLLING RADII (IN/IN)
 (ML-MR)/2 = NORMALIZED DIFFERENCE IN CONTACT ANGLES (RAD)
 WR        = WHEELSET ROLL ANGLE W.R.T. HORIZONTAL, POSITIVE UP ON LEFT (RAD)
 YCG       = VERTICAL DISPLACEMENT OF WHEELSET CENTROID FROM NOMINAL POS. (IN)
 RR CRV = PRINCIPAL ROLLING CURVATURE OF RIGHT WHEEL PROFILE (1/IN)
 RL CRV = PRINCIPAL ROLLING CURVATURE OF LEFT WHEEL PROFILE (1/IN)
 CWR         = PRINCIPAL TRANSVERSE CURVATURE OF RIGHT WHEEL PROFILE,
               POSITIVE FOR CURVATURE CENTER IN BODY (1/IN)
 CYR         = PRINCIPAL TRANSVERSE CURVATURE OF RIGHT RAIL PROFILE,
               POSITIVE FOR CURVATURE CENTER IN BODY (1/IN)
 CWL         = PRINCIPAL TRANSVERSE CURVATURE OF LEFT WHEEL PROFILE,
               POSITIVE FOR CURVATURE CENTER IN BODY (1/IN)
 CYL         = PRINCIPAL TRANSVERSE CURVATURE OF LEFT RAIL PROFILE,
               POSITIVE FOR CURVATURE CENTER IN BODY (1/IN)
```

```
122  6
-0.120000D+01-0.212346D+01-0.132554D+01 0.190654D+01-0.255794D+00 0.176142D+02
 0.685282D+01 0.164859D+02 0.698691D+01 0.669362D+00 0.490588D-01-0.186485D-01
-0.310151D+00-0.164204D-01 0.441802D+00
 0.445220D-01 0.605848D-01 0.766933D+01 0.390891D+01 0.958678D-01 0.147359D+00
-0.118000D+01-0.209346D+01-0.132482D+01 0.188654D+01-0.247092D+00 0.175844D+02
 0.685345D+01 0.164869D+02 0.698698D+01 0.880751D+00 0.444959D-01-0.181419D-01
-0.418128D+00-0.159037D-01 0.428021D+00
 0.362009D-01 0.605943D-01 0.357999D+01 0.390656D+01 0.924570D-01 0.142524D+00
-0.116000D+01-0.211346D+01-0.137446D+01 0.186654D+01-0.237246D+00 0.176056D+02
 0.6800170+01 0.164877D+02 0.698702D+01 0.742056D+00 0.400363D-01-0.184781D-01
-0.351010D+00-0.153291D-01 0.412069D+00
 0.418662D-01 0.606027D-01 0.608952D+01 0.281614D+01 0.890416D-01 0.137054D+00
-0.114000D+01-0.210346D+01-0.139344D+01 0.184654D+01-0.228535D+00 0.175958D+02
 0.678086D+01 0.164885D+02 0.698702D+01 0.812972D+00 0.357713D-01-0.183026D-01
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ETC.

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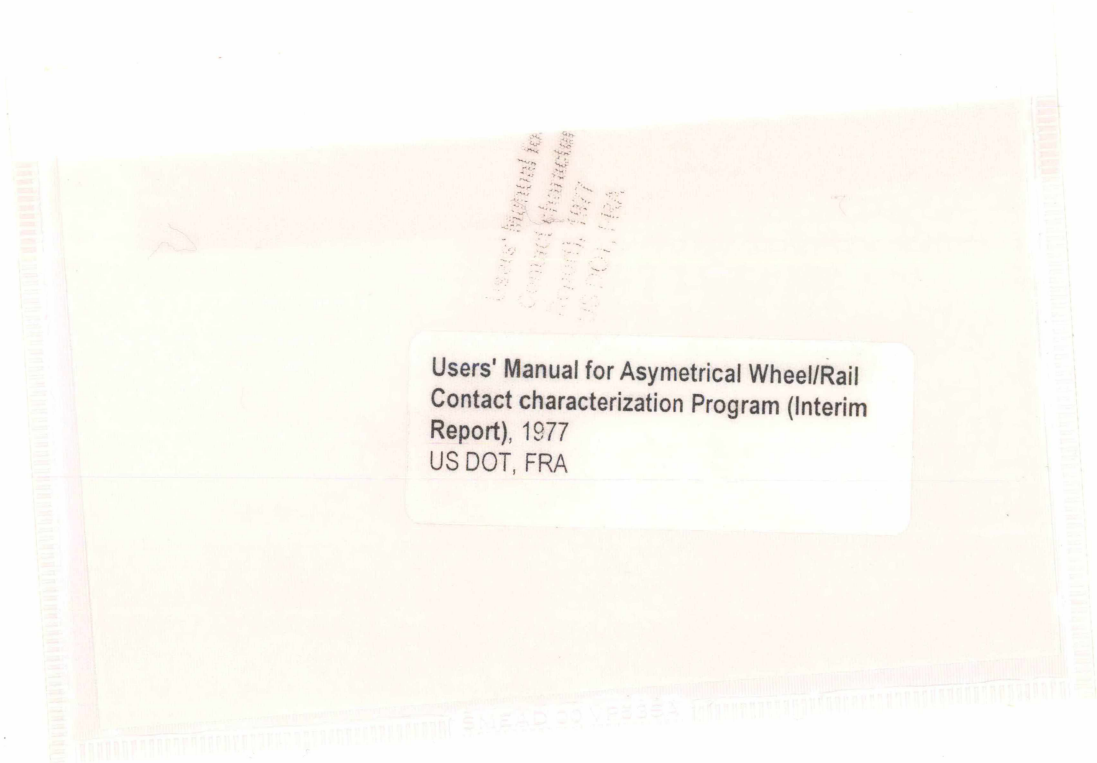

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