

MVMA TWO DIMENSIONAL CRASH
VICTIM SIMULATION
VERSION 4
VOLUME II

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MVMA TWO-DIMENSIONAL CRASH VICTIM SIMULATION, VERSION 4
VOLUME 2

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PART 3 USERS' GUIDE

This part of the report contains a detailed description of the data required to operate the MVMA 2-D model and program output generated using sample data sets. The first section contains a tabular listing of all data required, the format of the cards, and the units of physical quantities. The second section supplements this table with text to provide the user with information concerning particular data quantities which may not be easily chosen (e.g., sign conventions on joint angles, integration control parameters, etc.). The third section describes normal output.

Section 3.4 discusses two example simulations, including preparation of the data sets. It is highly recommended that all MVMA 2-D users read this section completely and carefully.

3.1 DESCRIPTION OF THE INPUT DATA CARDS

Two data decks are required for computer simulations made with the MVMA 2-D model. (See Figure 64.) Each data deck consists of a series of eighty-character lines which will be called "cards" in this discussion. The first data deck is read by the input pre-processor "INP," and the cards are identified by numbers 100 through 1000 in columns 78-80 or 77-80.* Primarily, these cards contain data which describe the crash event, the occupant, the vehicle interior, and the restraint systems. The second data deck is read by the output pre-processor "OUTP."** Each card is identified by a number 1001 through 1600 in columns 77-80. These cards contain data which control printout and various post-processing functions. In general, data cards can be in any order within a data deck. Cards which control model options not used for a particular simulation need not be present. Also, various quantities can be defaulted to constants stored within the program by omitting their cards from the data deck(s).

*There are a few cases of tabular input where no identification numbers are included (vehicle accelerations, energy-absorbing steering column parameters, airbag parameters).

**"INP" and "OUTP" are two of the five major parts of the computer model, discussed in Volume 3.

DATA DECKS

Card Number

100	Cards read by INP.
101	
102	100, 200,..., 900 content used for automatic titling of pages
1000	1000 (blank) marks end of data deck

1001	
1002	Cards read by OUTP.
1003	
1600	1600 (blank) marks end of data deck

FIGURE 64 Data Decks

Each card consists of ten fields. (See Figure 65.) The tenth field is reserved for the previously mentioned card identification number. The first nine fields, consisting of eight columns each, are data fields. Thus, up to nine numbers may be required per card although most cards make use of a smaller number of fields. Numerical data must be specified in either F, E, or D format, examples of which are given with Figure 65. Blanks in numeric fields are treated as zeros by most computer systems, so E- and D-format numbers must be right-adjusted within data fields. Alphanumeric data are required on some cards; blanks within an alphanumeric field will not be ignored since a blank is a legitimate alphanumeric character.

A summary of the cards required to exercise the MVMA 2-D model is included here as Table 6. This table contains a card identification number in the first column, a general description of data contents in the second, and the number of cards which may contain a particular identification number in the third. A detailed description of all data cards and their content, card by card and field by field, is given in Table 7. This table, which includes over 100 card layouts, is the primary reference for preparation of data sets. In addition to collecting in one place a description of all required input data, the table includes information regarding default values for fields of cards omitted from the data deck(s) and also information regarding required units for data, field by field. The units required for running the model with metric-system or English-system data are indicated separately.

Following Table 7, Section 3.2 contains input data descriptions that are more detailed than those included on the card layouts in Table 7. Section 3.2 also includes many figures and tables which should be useful in the preparation of input data sets. This section will answer many of the questions that are likely to arise during input data set development. However, the

1	2	3	4	5	6	7	8	9	ID NO.
1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9
0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0
1 1 1 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1 1 1
2 2 2 2 2 2 2 2 2 2	2 2 2 2 2 2 2 2 2 2	2 2 2 2 2 2 2 2 2 2	2 2 2 2 2 2 2 2 2 2	2 2 2 2 2 2 2 2 2 2	HIGHWAY SAFETY	2 2 2 2 2 2 2 2 2 2	2 2 2 2 2 2 2 2 2 2	2 2 2 2 2 2 2 2 2 2	2 2 2 2 2 2 2 2 2 2
3 3 3 3 3 3 3 3 3 3	3 3 3 3 3 3 3 3 3 3	3 3 3 3 3 3 3 3 3 3	3 3 3 3 3 3 3 3 3 3	3 3 3 3 3 3 3 3 3 3	RESEARCH INSTITUTE	3 3 3 3 3 3 3 3 3 3	3 3 3 3 3 3 3 3 3 3	3 3 3 3 3 3 3 3 3 3	3 3 3 3 3 3 3 3 3 3
4 4 4 4 4 4 4 4 4 4	4 4 4 4 4 4 4 4 4 4	4 4 4 4 4 4 4 4 4 4	4 4 4 4 4 4 4 4 4 4	4 4 4 4 4 4 4 4 4 4	HSRI	4 4 4 4 4 4 4 4 4 4	4 4 4 4 4 4 4 4 4 4	4 4 4 4 4 4 4 4 4 4	4 4 4 4 4 4 4 4 4 4
5 5 5 5 5 5 5 5 5 5	5 5 5 5 5 5 5 5 5 5	5 5 5 5 5 5 5 5 5 5	5 5 5 5 5 5 5 5 5 5	5 5 5 5 5 5 5 5 5 5	The University of Michigan Ann Arbor	5 5 5 5 5 5 5 5 5 5	5 5 5 5 5 5 5 5 5 5	5 5 5 5 5 5 5 5 5 5	5 5 5 5 5 5 5 5 5 5
6 6 6 6 6 6 6 6 6 6	6 6 6 6 6 6 6 6 6 6	6 6 6 6 6 6 6 6 6 6	6 6 6 6 6 6 6 6 6 6	6 6 6 6 6 6 6 6 6 6		6 6 6 6 6 6 6 6 6 6	6 6 6 6 6 6 6 6 6 6	6 6 6 6 6 6 6 6 6 6	6 6 6 6 6 6 6 6 6 6
7 7 7 7 7 7 7 7 7 7	7 7 7 7 7 7 7 7 7 7	7 7 7 7 7 7 7 7 7 7	7 7 7 7 7 7 7 7 7 7	7 7 7 7 7 7 7 7 7 7		7 7 7 7 7 7 7 7 7 7	7 7 7 7 7 7 7 7 7 7	7 7 7 7 7 7 7 7 7 7	7 7 7 7 7 7 7 7 7 7
8 8 8 8 8 8 8 8 8 8	8 8 8 8 8 8 8 8 8 8	8 8 8 8 8 8 8 8 8 8	8 8 8 8 8 8 8 8 8 8	8 8 8 8 8 8 8 8 8 8		8 8 8 8 8 8 8 8 8 8	8 8 8 8 8 8 8 8 8 8	8 8 8 8 8 8 8 8 8 8	8 8 8 8 8 8 8 8 8 8
9 9 9 9 9 9 9 9 9 9	9 9 9 9 9 9 9 9 9 9	9 9 9 9 9 9 9 9 9 9	9 9 9 9 9 9 9 9 9 9	9 9 9 9 9 9 9 9 9 9		9 9 9 9 9 9 9 9 9 9	9 9 9 9 9 9 9 9 9 9	9 9 9 9 9 9 9 9 9 9	9 9 9 9 9 9 9 9 9 9
1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10		1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10

Acceptable data formats

F

E

D

123.4

1.234E2

1.234D2

FIGURE 65 A Data Card

user may sometimes find it necessary to refer to Volume 1 or to the Tutorial System Self-Study Guide [8], which contains the most complete description available of input quantities needed by the MVMA 2-D model.

TABLE 6. SUMMARY OF REQUIRED INPUT DATA CARDS

I.D.	Card Contents	Number of Cards
<u>Control Block</u>		
100	Computer run title	1
101	Simulation Controls (Card 1)	1
102	Simulation Controls (Card 2)	1
103	Integration control	1
104	Debugging controls	1
105	Debugging controls	1
106	Contact interaction controls	up to 100
107	Stored output specifications (Card 1)	1
108	Stored output specifications (Card 2)	1
109	Stored output specifications (Card 3)	1
110	Stored output specifications (Card 4)	1
111	Stored output specifications (Card 5)	1
<u>Occupant Parameter Input Block</u>		
200	Occupant parameter subtitle	1
201	Occupant body segment lengths	1
202	End of link to center-of-mass lengths	1
203	Mass of body segments	1
204	Moments of inertia	1
205	Head-Neck joint parameters (forward)	1
206	Neck-Upper Torso joint parameters (forward)	1
207	Upper spine joint parameters	1
208	Lower spine joint parameters	1
209	Hip joint parameters	1
210	Knee joint parameters	1
211	Upper Arm-Upper Torso joint parameters	1
212	Elbow joint parameters	1
213	Neck element parameters (for elongation)	1
214	Shoulder element parameters (for elongation)	1
215	Head-Neck joint parameters (rearward)	1
216	Neck-Upper Torso joint parameters (rearward)	1

TABLE 6. SUMMARY OF REQUIRED INPUT DATA CARDS

I.D.	Card Contents	Number of Cards
217	"Natural" link displacements	1
218	Occupant accelerometer and belt attachment parameters	1
219	Contact ellipse specifications (Card 1)	1 for each ellipse
220	Contact ellipse specifications (Card 2)	1 for each ellipse
221- 226	Contact ellipse material cards (Same as 403-408)	1 set for each ellipse material
227	Head-Neck joint muscle tension coefficients	1
228	Neck-Upper Torso joint muscle tension coefficients	1
229	Upper Spine joint muscle tension coefficients	1
230	Lower Spine joint muscle tension coefficients	1
231	Hip joint muscle tension coefficients	1
232	Knee joint muscle tension coefficients	1
233	Upper Torso-Upper Arm muscle tension coefficients	1
234	Elbow joint muscle tension coefficients	1
235	Shoulder-Upper Torso joint muscle tension coefficients	1
236	Neck element elongation muscle tension coefficients	1
237	Shoulder element elongation muscle tension coefficients	1
238	Muscle tension versus time	1 for each point in each muscle tension table
239	Radial shoulder joint stiffness (elastic)	1 for each point in table
240	Radial shoulder joint stiffness (quadratic)	1 for each point in table
241	Radial shoulder joint stiffness (cubic)	1 for each point in table
242	Neck element parameters (for compression)	1
<u>Occupant Description Input Block</u>		
300	Occupant description subtitle	1
301	Initial body link angles relative to vehicle	1
302	Initial body link angular velocities relative to vehicle	1
303	Initial conditions for upper torso and neck	1
304	Initial shoulder location and velocity relative to upper torso attachment	1

TABLE 6. SUMMARY OF REQUIRED INPUT DATA CARDS

I.D.	Card Contents	Number of Cards
<u>Vehicle Interior Input Block</u>		
400	Vehicle Interior Characteristics subtitle	1
401-	Description of real line contact regions	2 cards for each region
402		
403-	Material property specification	1 set for each material
408		
409-	Line parameters within a region	1 set for each line within region
410		
411	Line segment location	1 set for each line segment in a region, ordered on time.
412	Friction coefficients	1 card for each friction combination
<u>Vehicle Interior Belt Anchors Input Block</u>		
500	Vehicle interior configuration subtitle	1
501	MODROS belt anchor points relative to vehicle origin	1
<u>Impact Specification Input Block</u>		
600	Vehicle impact subtitle	1
601	Vehicle initial conditions and accelerometer location	1
602	Vehicle horizontal acceleration versus time	1
-	Acceleration versus time	Several cards, 4 time points per card
603	Vehicle vertical acceleration versus time	1
-	Acceleration versus time	Several cards, 4 time points per card
604	Vehicle angular acceleration versus time	1
-	Acceleration versus time	Several cards, 4 time points per card
605	Head applied force specifications	1
606	Head applied force component versus time	1 for each point in head force table
<u>Belt Restraint System Input Block</u>		
700	Belt restraint system subtitle	1
701-	MODROS belt system parameters	3
703		

TABLE 6. SUMMARY OF REQUIRED INPUT DATA CARDS

I.D.	Card Contents	Number of Cards
704- 709	Belt material cards for MODROS and advanced belt systems	1 set for each material name used for belts
710- 719	Advanced belt system parameters	10
720	Advanced belt system and ring parameters	1
721- 723	Advanced belt system inertia reel parameters	3
<u>Energy Absorbing Steering Assembly Input Block</u>		
800	Energy absorbing steering assembly system subtitle	1
801- 803	EA steering assembly parameters	3
804	Gearbox position versus time	1
-	Position versus time	Several cards, 4 time points per card
805	Head/steering system properties	1
806	Upper torso/steering system properties	1
807	Middle torso/steering system properties	1
808	Lower torso/steering system properties	1
809	Front line intersection points	1
810	Steering wheel material card	1
811	Reaction material names	1
812- 817	Steering assembly system and body material properties	1 set for each material name used on Cards 805-811
<u>Airbag Restraint System Input Block</u>		
900	Airbag system subtitle	1
901- 903	Airbag system parameters	3
904	Airbag mass influx rate versus time	1
-	Rate versus time	Several cards, 4 time points per card
905	Supply gas temperature versus time	1
-	Temperature versus time	Several cards, 4 time points per card
906	Bag porosity versus pressure differential	1
-	Porosity versus temperature	Several cards, 4 time points per card

TABLE 6. SUMMARY OF REQUIRED INPUT DATA CARDS

I.D.	Card Contents	Number of Cards
907- 909	Airbag occupant contact reference points	3
<u>Execution and Output Block</u>		
1000	"Go" Card for model execution	1
1001- 1002	Category selection and ordering specification	2
1003	Printout controls	1
1004	Filter and HIC controls	1
1100- 1107	Joint relative angle test values	8
1200- 1201	Standard list test values	2
1202	Face and chest ellipse designation	1
1300	Type A comparisons	1
1400- 1401	Type B comparisons	2
1500- 1501	Stick figure control parameters	2
1502	Stick figure time point specifications	1
1600	"Go" Card for output processor	1

TABLE 7 INPUT DATA

COMPUTER RUN TITLE

(9 Fields of 8)

Field	Name of Quantity	Units	Definition
1	HTITLE(1 - 18)		Run Title Centered in columns 1 to 72

MVMA 2-D Model
Card 100

TABLE 7 INPUT DATA

SIMULATION CONTROLS (CARD 1)
(9 Fields of 8)

Field	Name of Quantity	Units	Definition	Defaults
1	MKSSWT		Switch = 0. Metric units # 0. English units	0.
2	INTOP		Integration Option Indicator (Set 1 at present) = 0. Variable Adams-Moulton = 1. Fixed Runge-Kutta = 2. Fixed Adams-Moulton	1.
3	G, g	ft/sec ² (m/sec ²)	Gravity	32.174 9.80665
4	EDEPS	in/sec ² or rad/sec ² (m/sec ²)	Acceleration Minimum magnitude (Editing constant).	.0001
5	TB	msec	Beginning Time	0.
6	TF	msec	Final Time	200.
7	DT, Δt	msec	Numerical Integration Step Size	1.
8	PTINC	msec	Output Print Increment (must be an integral multiple of Field 7)	5.
9	PLINC	msec	Output Plot Increment (must be an integral multiple of Field 8). If zero, no plot recording.	0.

NOTE: TB must be less than TF. DT and PTINC must be non-zero.

TABLE 7 INPUT DATA

SIMULATION CONTROLS (CARD 2)

Field	Name of Quantity	Units	Description	Defaults
1	NBELT		Switch = 0. no belts = 1. standard (MODROS) lap belt, no shoulder harness (BELT) = 2. standard (MODROS) lap belt plus shoulder harness (BELT) = 3. advanced belt system (BELT2)	0.
2	NBAG		Switch = 0. airbag interaction not desired ≠ 0. airbag interaction desired	0.
3	NSTCOL		Switch = 0. steering column interaction not desired ≠ 0. steering column interaction desired	0.
4	LHIB		Switch = 0, Ellipse-ellipse contacts on 106 cards are allowable 1, Ellipse-ellipse contacts on 106 cards are inhibited	0.
5	KHIB		Switch = 0, Ellipse-region contacts on 106 cards are allowable 1, Ellipse-region contacts on 106 cards are inhibited	1.
6	ILL		Switch = 0, Ellipse-ellipse contacts can occur 1, Global control to override LHIB.No ellipse-ellipse contacts are allowed despite LHIB and 106 cards.	1.
7	FNU	in/sec (m/sec)	Length of scaling ramp to insure friction force continuity	10. .254
8	EPSINV		Relative error tolerance for singularity in matrix inversion step	.0000(
9	MX	min.	Execution CPU Time Limit	5.

MVMA 2-D Model
Card 102

TABLE 7 INPUT DATA

INTEGRATION CONTROL
(9 Fields of 8)

Field	Name of Quantity	Units	Definition	Defaults
1	DSTEPX	in(cm)	Maximum step to search for balance in shared deflection.	.2
2	DSTEPN	in(cm)	Minimum step to search for balance in shared deflection.	.5
3	FORLIM	lbs(N)	Maximum force for rigid-rigid contact.	.02
4	HARDCN	lb/in(N/cm)	Linear elastic coefficient for rigid-rigid contact.	100,000. 450,000. 15000. 26000.
5	LIMCNT		Maximum number of iterations for finding force balance.	20:
6	TPC		Fraction of current ramp length for velocity change in moving contact lines.	.05
7	EPSFAC		Number of integration steps for maximum ramp length for velocity change in moving contact lines.	10.
8	BETELP, β		Minimum ratio of shorter to longer semi axis for ellipse to be treated as circle.	.75
9	GAMELP, γ		Fractional position of circle center along semi-major axis relative to position for circle-ellipse tangency at end of axis.	.9

Notes: See Section 2.6.4 for Fields 8, 9. If Field 9 is zero, all ellipses must be circles, or "circle-like," in the sense of Field 8.

TABLE 7 INPUT DATA
DEBUGGING CONTROLS (CARD 1)
(9 Fields of 8)

Field	Name of Quantity	Units	Definition	Defaults
1	THEX (1)	msec	Time to set debug switches	0.
2	HEX (1)		Debug switch settings in hexadecimal format	00000000
3	THEX (2)	msec	Same as field 1	2000.
4	HEX (2)		Same as field 2	00000000
5	THEX (3)	msec	Same as field 1	
6	HEX (3)		Same as field 2	
7	THEX (4)	msec	Same as field 1	
8	HEX (4)		Same as field 2	
9	KONSID		0. Debug controls to operate for all integration evaluations at each time *Switch = 1. Debug controls to operate only at final 0. evaluation at each time	

NOTE: Cards 104 and 105 allow specification of the hexadecimal debug switch at eight time points. The first time (0 ms) will be THEX (1), etc.

*NOTE: A value of 1, should normally be used for field 9. Debug printout for intermediate evaluations is seldom useful and can be voluminous.

NOTE: See the note on Card 105 for information about a debug switch which controls printout from INP and OUTP.

TABLE 7 INPUT DATA

DEBUGGING CONTROLS (CARD 2)
(9 Fields of 8)

Field	Name of Quantity	Units	Definition	Defaults
1	THEX (5)	msec	Time to set debug switches	
2	HEX (5)		Debug switch settings in hexadecimal format	
3	THEX (6)	msec	Same as field 1	
4	HEX (6)		Same as field 2	
5	THEX (7)	msec	Same as field 1	
6	HEX (7)		Same as field 2	
7	THEX (8)	msec	Same as field 1	
8	HEX (8)		Same as field 2	
9	KDICTP		1. Do not print Switch = 0. Print packing debug dictionary and binary file index summary	

NOTE: There is an additional debug switch which controls debug printout from INP and OUTP. This switch is specified by inclusion in the INP and/or OUTP data decks of any number of cards with negative numbers in their card ID fields. This switch is automatically initialized in INP for no debug printout and may be set anywhere in the data deck before Card 1000 by a card with -2, -3, or -4 in the ID field. These values correspond to debug levels 1, 2, and 3 as discussed in Section 4.2.4 of Volume 3. Debug level can be re-set to 0, 1, 2, or 3 by additional cards with values -1, -2, -3, or -4 in the ID field. If the debug level is not 0 when the 1000-Card is processed, then its current value will be used in OUTP until it is changed in the OUTP data deck.

MVMA 2-D Model
 Card 105

TABLE 7 INPUT DATA

CONTACT INTERACTION CONTROLS
(9 Fields of 8)

Field	Name of Quantity	Units	Description
1-2			Ellipse Name
3-4			Ellipse Name or Region Name

NOTE: Each card specifies a combination which will be interpreted according to the settings of KHIB, LHIB, and ILL on Card 102.

TABLE 7 INPUT DATA

STORED OUTPUT SPECIFICATIONS (CARD 1)
(9 Fields of 8)

Field	Name of Quantity	Units	Definition	Defaults
1	Category 1		Switch = {0, 1, Inhibit Store vehicle response	0.
2	Category 2		Switch = {0, 1, Inhibit Store region parameters	0.
3	Category 3		Switch = {0, 1, Inhibit Store region segment movement	0.
4	Category 4		Switch = {0, 1, Inhibit Store occupant-vehicle contacts, including belts	0.
5	Category 5		Switch = {0, 1, Inhibit Store neck reaction forces	0.
6	Category 6		Switch = {0, 1, Inhibit Store unfiltered body accelerations	0.
7	Category 7		Switch = {0, 1, Inhibit Store filtered body accelerations	0.
8	Category 8		Switch = {0, 1, Inhibit Store unfiltered severity indices	0.
9.	Category 9		Switch = {0, 1, Inhibit Store filtered severity indices	0.

NOTE: Use Cards 1001 and 1002 to specify desired printed output

TABLE 7 INPUT DATA

STORED OUTPUT SPECIFICATIONS (CARD 2)
 (9 Fields of 8)

Field	Name of Quantity	Units	Description	Defaults
1	Category 10		Switch = 0,, Store body link angles 1, Inhibit	0.
2	Category 11		Switch = 0,, Store body link angular velocities 1, Inhibit	0.
3	Category 12		Switch = 0,, Store body link angular accelerations 1, Inhibit	0.
4	Category 13		Switch = 0,, Store body joint coordinates 1, Inhibit	0.
5	Category 14		Switch = 0,, Store body joint velocities 1, Inhibit	0.
6	Category 15		Switch = 0,, Store body joint torques 1, Inhibit	0.
7	Category 16		Switch = 0,, Store body joint absorbed energies 1, Inhibit	0.
8	Category 17		Switch = 0,, Store body kinetic energies 1, Inhibit	0.
9	Category 18		Switch = 0,, Store airbag variables 1, Inhibit	0.

NOTE: Use Cards 1001 and 1002 to specify desired printed output

TABLE 7 INPUT DATA

STORED OUTPUT SPECIFICATIONS (CARD 3)
(9 Fields of 8)

Field	Name of Quantity	Units	Description	Defaults
1	Category 19		Switch = 0., Store airbag contact forces 1., Inhibit	0.
2	Category 20		Switch = 0., Store airbag center of mass forces and moments 1., Inhibit	0.
3	Category 21		Switch = 0., Store neck joint coordinates 1., Inhibit	0.
4	Category 22		Switch = 0., Store shoulder joint coordinates 1., Inhibit	0.
5	Category 23		Switch = 0., Store joint torque linear components 1., Inhibit	0.
6	Category 24		Switch = 0., Store joint torque nonlinear components 1., Inhibit	0.
7	Category 25		Switch = 0., Store joint torque friction components 1., Inhibit	0.
8	Category 26		Switch = 0., Store joint torque viscosity components 1., Inhibit	0.
9	Category 27		Switch = 0., Store joint absorbed energy, joint stop components ₀ . 1., Inhibit	

NOTE: Use Cards 1001 and 1002 to specify desired printed output

MVMA 2-D Model
Card 109

TABLE 7 INPUT DATA

STORED OUTPUT SPECIFICATIONS (CARD 4)
(9 Fields of 8)

Field	Name of Quantity	Units	Description	Defaults
1	Category 28		Switch = 0., Store joint absorbed energy, friction components 1., Inhibit 0.	
2	Category 29		Switch = 0., Store joint absorbed energy, viscosity components 1., Inhibit 0.	
3	Category 30		Switch = 0., Store center of mass x-component forces 1., Inhibit (includes head applied forces) 0.	
4	Category 31		Switch = 0., Store center of mass z-component forces 1., Inhibit (includes head applied forces) 0.	
5	Category 32		Switch = 0., Store center of mass resultant moments 1., Inhibit 0.	
6	Category 33		Switch = 0., Store steering column coordinates 1., Inhibit 0.	
7	Category 34		Switch = 0., Store steering column generalized coordinates 1., Inhibit 0.	
8	Category 35		Switch = 0., Store steering column forces and moments 1., Inhibit 0.	
9	Category 36		Switch = 0., Store forces and moments on body due to steering column 1., Inhibit 0.	

NOTE: Use Cards 1001 and 1002 to specify desired printed output.

MVMA 2-D Model
Card 110

TABLE 2. INPUT DATA

STORED OUTPUT SPECIFICATIONS (CARD 5)
 (9 Fields of 8)

Field	Name of Quantity	Units	Description	Defaults
1	Category 37		Switch = 0., Store neck and shoulder forces 1., Inhibit	0.
2	Category 38		Switch = 0., Store muscle tension forces 1., Inhibit	0.
3	Category 39		Switch = 0., Store muscle tension energy absorption 1., Inhibit	0.
4	Category 40		Switch = 0., Store femur and tibia accelerations and loads 1., Inhibit	0.
5	Category 46		Switch = 0., Store head c.g. motion 1., Inhibit	0.
6	Category 47		Switch = 0., Store chest c.g. motion 1., Inhibit	0.
7	Category 48		Switch = 0., Store hip motion 1., Inhibit	0.
8	Category 49		Switch = 0., Store joint relative angles 1., Inhibit	0.
9	Category 50		Switch = 0., Store joint relative angle velocities 1., Inhibit	0.

Note: Use Cards 1001 and 1002 to specify desired printed output.

Note: Categories 41-45 are for quantities determined by the output processor. See Table 11 and Cards 1001 and 1002.

TABLE 7 INPUT DATA

<u>OCCUPANT PARAMETER SUBTITLE</u>			
(3 Fields of 8)			
<u>Field</u>	<u>Name of Quantity</u>	<u>Units</u>	<u>Definition</u>
1-3	STITLE (1 ~ 5)		Run subtitle for Occupant Parameters Input Block centered in columns 1-19.

TABLE 7 INPUT DATA

OCCUPANT BODY-SEGMENT LENGTHS
(9 Fields of 8)

Field	Name of Quantity	Units	Definition	Defaults
1	CONDYL,C	inches (cm)	A-P offset of upper neck joint from head c.g. (positive rearward)	1.68 4.27
2	L ₂₃ , L ₂₃	FLJI(3)	inches (cm) Upper Torso Length	7.09 18.01
3	L ₃₄ , L ₃₄	FLJI(4)	inches (cm) Middle Torso Length	5.95 15.11
4	L ₄₅ , L ₄₅	FLJI(5)	inches (cm) Lower Torso Length	7.28 18.49
5	L ₅₆ , L ₅₆	FLJI(6)	inches (cm) Hip-Knee Length	17.1 43.43
6	L ₂₇ , L ₂₇	FLJI(7)	inches (cm) (not used)	
7	L ₇₈ , L ₇₈	FLJI(8)	inches (cm) Shoulder-Elbow Length	11.91 30.25
8	ASH, a	inches (cm)	Rest point x of shoulder joint relative to upper torso C.G., pos. along centerline toward joint 2 from c.g.	
9	BSH, b	inches (cm)	Rest point z of shoulder joint relative to upper torso C.G., pos. toward front of body.	1.84, 4.67 0.

NOTE: See Section 2.1, Figures 2 and 6 or Figures 66 and 67.

FLJI(I-1) = length of Ith segment

TABLE 7 INPUT DATA

END OF LINK TO CENTER-OF-MASS LENGTHS
(9 Fields of 8)

Field	Name of Quantity	Units	Definition	Defaults
1	L1, ℓ_1	inches (cm)	Head / neck joint -head C-M length (component along inferior-superior axis)	6.14 15.6
2	L2, ℓ_2	inches (cm)	Neck-Chest C-M Length	4.02 10.21
3	L3, ℓ_3	inches (cm)	Upper Torso Joint - Middle Torso C-M Length	2.45 6.22
4	L4, ℓ_4	inches (cm)	Lower Torso Joint - Lower Torso C-M Length	3.03 7.70
5	L5, ℓ_5	inches (cm)	Hip-Upper Leg C-M Length	7.41 18.82
6	L6, ℓ_6	inches (cm)	Knee-Lower Leg C-M Length	7.08 18.0
7	L7, ℓ_7	inches (cm)	Shoulder-Upper Arm C-M Length	5.2 13.21
8	L8, ℓ_8	inches (cm)	Elbow-Lower Arm C-M Length	4.56 11.58
9	ALF, α		Proportion of neck mass at upper joint	0.5

NOTES: 1. See Figure 66 and Sections 2.1 and 2.2 for definitions.

2. $(1-\alpha)m_\eta$ will be at the lower neck joint.

TABLE 7 INPUT DATA

MASS OF BODY SEGMENTS
(9 Fields of 8)

Field	Name of Quantity	Units	Definition	Defaults
1	M1, M1	lb sec ² /in (kg)	Head Mass	0.0242
2	M2, M2	lb sec ² /in (kg)	Chest Mass	4.238
3	M3, M3	lb sec ² /in (kg)	Middle Torso Mass	0.0641
4	M4, M4	lb sec ² /in (kg)	Lower Torso Mass	11.226
5	M5, M5	lb sec ² /in (kg)	Upper Leg Mass (Both Legs)	0.0613
6	M6, M6	lb sec ² /in (kg)	Lower Leg Mass (Both Legs)	10.735
7	M7, M7	lb sec ² /in (kg)	Upper Arm Mass (Both Arms)	0.0734
8	M8, M8	lb sec ² /in (kg)	Lower Arm Mass (Both Arms)	12.854
9	EM9, M _n	lb sec ² /in (kg)	Total Neck Mass	0.0839
				14.693
				0.0532
				9.317
				0.029
				5.079
				0.0214
				3.748
				0.009
				1.576

NOTE: See Sections 2.1 and 2.2 and Figure 66 for definitions.

TABLE 7 INPUT DATA

MOMENTS OF INERTIA
 (9 Fields of 8)

Field	Name of Quantity	Units	Definition	Defaults
1	I ₁ , I ₁	lbs-sec ² -in(kg-m ²)	Head	0.325 0.0367
2	I ₂ , I ₂	lbs-sec ² -in(kg-m ²)	Chest	3.04 0.344
3	I ₃ , I ₃	lbs-sec ² -in(kg-m ²)	Middle Torso	2.39 0.27
4	I ₄ , I ₄	lbs-sec ² -in(kg-m ²)	Lower Torso	4.6 0.52
5	I ₅ , I ₅	lbs-sec ² -in(kg-m ²)	Upper Leg	2.341 0.2645
6	I ₆ , I ₆	lbs-sec ² -in(kg-m ²)	Lower Leg	1.259 0.1422
7	I ₇ , I ₇	lbs-sec ² -in(kg-m ²)	Upper Arm	0.383 0.04327
8	I ₈ , I ₈	lbs-sec ² -in(kg-m ²)	Lower Arm	0.223 0.0252

TABLE 7 INPUT DATA

OCCUPANT JOINT PARAMETERS
(9 Fields of 8)

Field	Name of Quantity	Units	Definition
1	KJI (I,1), $K_{i,1}$	in-lb/deg (N-m/deg)	Linear Angular Deflection Coefficient (elastic or joint stop)
2	KJI (I,2), $K_{i,2}$	in-lb/deg ² (N-m/deg ²)	Quadratic Angular Deflection Coefficient (joint stop)
3	KJI (I,3), $K_{i,3}$	in-lb/deg ³ (N-m/deg ³)	Cubic Angular Deflection Coefficient (joint stop)
4	CJI (I), C_i^J	in-lb-sec/deg (N-m-sec/deg)	Viscous Friction Coefficient
5	FJI, F_i^J	in-lb (N-m)	Constant Friction
6	WJI, V_i^J	deg/sec	Velocity Threshold for Constant Friction
7	THSI (I,1), $\theta_{i,1}^S$	deg	Positive-Most Joint Stop (not used for 205 and 206)
8	THSI (I,2), $\theta_{i,2}^S$	deg	Negative-Most Joint Stop
9	RJI (I), R_i^J		Conserved-Absorbed energy ratio

NOTES:

- 1. Card 205 I = 1 = 1 Head-Neck Forward
- 206 I = 1 = 2 Neck-Upper Torso Forward
- 207 I = 1 = 3 Upper Spine
- 208 I = 1 = 4 Lower Spine
- 209 I = 1 = 5 Hip
- 210 I = 1 = 6 Knee
- 211 I = 1 = 7 Upper Arm-Upper Torso (relative angle $\theta_R = \theta_7 - \theta_2$)
- 212 I = 1 = 8 Elbow

2. See Figure 2, Section 2.1, and Section 2.3 for definitions

- 3. Field 1: $K_{i,1} > 0$ means elastic coefficient is $|K_{i,1}|$, and linear joint stop torque coefficient is 0; $K_{i,1} < 0$ means elastic coefficient is 0 and linear joint stop torque coefficient is $|K_{i,1}|$.
- 4. These cards may be supplemented by Cards 243 to 246.

MVWA 2-D Model
Cards 205-212

TABLE 7 INPUT DATA

OCCUPANT JOINT PARAMETERS
(9 Fields of 8)

Field	Name of Quantity	Units	Definition
1	KJI (I,1), K _{I,1}	lb/in (N/cm)	Linear Deflection Coefficient
2	KJI (I,2), K _{I,2}	lb/in ² (N/cm ²)	Quadratic Deflection Coefficient
3	KJI (I,3), K _{I,3}	lb/in ³ (N/cm ³)	Cubic Deflection Coefficient
4	CJI (I), C _I ^J	lb sec/in (N sec/cm)	Viscous Friction Coefficient
5			(not used)
6			(not used)
7	RSH	in (cm)	Shoulder Stop Circle Radius (not used for Card 213)
8			(not used)
9	RJI (I), R _I ^J		Conserved-Absorbed energy ratio (not used for Card 213)

NOTES: 1. Card 213 I = i = 9 Neck (stretching of element; also see Card 242)
 214 I = i = 10 Shoulder (extensible element)

2. See Figure 2, Section 2.1 and Section 2.3 for definitions.
3. Field 1, Card 214: See Note 3, Cards 205-212.
4. These cards may be supplemented by Card 247.

NMMA 2-D Model
 Cards 213-214

TABLE 7 INPUT DATA
 OCCUPANT JOINT PARAMETERS
 (9 Fields of 8)

Field	Name of Quantity	Units	Definition
1	KJI (I,1), K _{i,1}	in-lb/deg (N-m/deg)	Linear Angular Deflection Coefficient
2	KJI (I,2), K _{i,2}	in-lb/deg ² (N-m/deg ²)	Quadratic Angular Deflection Coefficient
3	KJI (I,3), K _{i,3}	in-lb/deg ³ (N-m/deg ³)	Cubic Angular Deflection Coefficient
4	CJI (I), C _i ^J	in-lb-sec/deg (N-m-sec /deg)	Viscous Friction Coefficient
5	FJI, F _i ^J	in-lb (N-m)	Constant Friction
6	VJI, V _i ^J	deg/sec	Velocity Threshold for Constant Friction
7	THSI (I,1), θ _{i,1} ^S	deg	Positive-Most Joint Stop
8			
9	RJI (I), R _i ^J		Conserved-Absorbed energy ratio

NOTES: 1. Card 215 I = 1 = 11 Head-Neck Rear
 216 I = i = 12 Neck-Upper Torso Rear

2. See Figure 2, Section 2.1, and Section 2.3 for definitions
3. Field 1: See Note 3, Cards 205-212.
4. These cards may be supplemented by Card 243.

TABLE 7 INPUT DATA

"NATURAL" LINK DISPLACEMENTS (ZETAS)
(9 Fields of 8)

Field	Name of Quantity	Units	Definition
1	THROI(1), θ_1^R	Degrees	Upper neck joint angle for zero torque.
2	THROI(2), θ_2^R	Degrees	Lower neck joint angle for zero torque.
3	THROI(3), θ_3^R	Degrees	Upper spine angle for zero torque.
4	THROI(4), θ_4^R	Degrees	Lower spine angle for zero torque.
5	THROI(5), θ_5^R	Degrees	Hip angle for zero torque.
6	THROI(6), θ_6^R	Degrees	Knee angle for zero torque.
7	THROI(7), θ_7^R	Degrees	Shoulder angle for zero torque.
8	THROI(8), θ_8^R	Degrees	Elbow angle for zero torque.

NOTE: See Figures 8, 73, and/or 74 and Section 2.3 for definitions.

TABLE 7 INPUT DATA

OCCUPANT ACCELEROMETER AND BELT ATTACHMENT PARAMETERS
(9 Fields of 8)

Field	Name of Quantity	Units	Definition
1	AH	inches (cm)	Distance component along head centerline to head accelerometer, measured from upper neck joint.
2	AC	inches (cm)	Directed distance along upper torso centerline to chest accelerometer measured from lower neck joint.
3	AHH	inches (cm)	Posterior offset of head accelerometer from head centerline.
4	CSIB1, ξ_1^B	inches (cm)	Distance along centerline of lower torso from joint 4 for Lap belt reference point.
5	ZETAB1, ξ_1	inches (cm)	Distance perpendicular to centerline of lower torso for Lap belt reference point.
6	CSIB2, ξ_2^B	inches (cm)	Distance along centerline of upper torso from joint 2 for upper torso belt reference point.
7	ZETAB2, ξ_2	inches (cm)	Distance perpendicular to centerline of upper torso for upper torso belt reference point.
8	CSIB3, ξ_3^B	inches (cm)	Distance along centerline of torso from upper joint of torso element for lower torso belt reference point.*
9	ZETAB3, ξ_3	inches (cm)	Distance perpendicular to centerline of torso for lower torso belt reference point.

NOTE: See Figure 75 and Section 2.5.1 for definitions.

NOTE: Fields 4 to 9 are not needed if the advanced belt system BELT2 has been selected. See Cards 710-723.

*The lower torso belt may be attached to the upper, middle or lower torso link ($+\xi$ downward along body, $+\xi$ toward back of body). See Field 7 of Card 702. Figure 75 illustrates attachment to the middle link.

MVMA 2-D Model
Card 218

TABLE 7 INPUT DATA

CONTACT ELLIPSE SPECIFICATIONS (CARD 1)
(9 Fields of 8)

Field	Name of Quantity	Units	Description
1-2			Name of Ellipse (Up to 16 characters)
3-4			Material of Ellipse (Up to 16 characters) Blank if rigid.
5			Number of body segment to which ellipse is attached. 1. = Head, 2. = Upper Torso, 3. = Middle Torso, 4. = Lower Torso, 5. = Upper legs 6. = Lower legs 7. = Upper arms 8. = Lower arms
6			Friction Class (1-5)

NOTE: There should be two contact ellipse specification cards for each body ellipse selected.

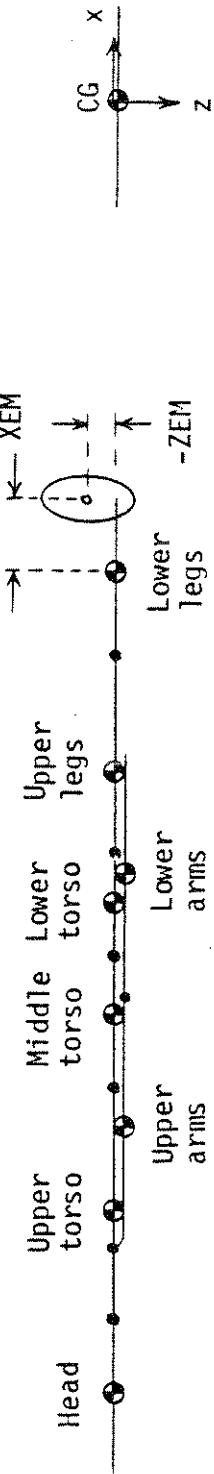
NOTE: If femur and tibia loads are of interest, a knee ellipse should be attached to the upper legs and a foot ellipse should be attached to the lower legs. A hip ellipse, if used, should be assigned to the lower torso element. See Section 4.6.2.5.

TABLE 7 INPUT DATA

CONTACT ELLIPSE SPECIFICATIONS (Card 2)
 (9 Fields of 8)

Field	Name of Quantity	Units	Description
1-2			
3	XEM, x_{em}	inches (cm)	x-coordinate of ellipse center in body segment coordinates.
4	ZEM, z_{em}	inches (cm)	z-coordinate of ellipse center in body segment coordinates.
5	a	inches (cm)	Semi-axis length along x-coordinate.
6	c	inches (cm)	Semi-axis length along z-coordinate.

NOTE: See Section 2.6.1 and figure below for definitions.



Example for a "foot" ellipse

TABLE 7 INPUT DATA

CONTACT ELLIPSE MATERIAL CARDS
(9 Fields of 8)

NOTE: Contact ellipse material properties are specified in the same manner as contact region material properties. See Cards 403-408 for format.

MVMA 2-D Model
Cards 221-226
(403-408)

TABLE 7 INPUT DATA
 MUSCLE TENSION COEFFICIENTS
 (9 Fields of 8)

Field	Name of Quantity	Units	Definition	Defaults
1	AMUS (I,1), a_1	I = 1-9 I = 10, 11 1b/in (N/cm)	Stiffness coefficient ($k = a_1 + a_2 M $)	0.
2	AMUS (I,2), a_2	I = 1-9 I = 10,11 deg^{-1} in^{-1} (cm^{-1})	Stiffness coefficient ($k = a_1 + a_2 M $)	0.
3	AMUS (I,3), a_3	I = 1-9 I = 10,11 sec/deg sec/in (sec/cm)	Damping coefficient ($c = a_3 M $)	0.
4	TMUS (I)	I = 1-9 I = 10,11 1b (N)	Initial value of muscle force or moment resultant (normally zero)	0.
5	MUSNAM (1-2,I)		Name assigned to muscle tension table M vs. time. (up to 8 characters)	
NOTES:	Card 227	I = 1	Head-Neck Joint (θ_1^R)	
	228	I = 2	Neck-Upper Torso Joint (θ_2^R)	
	229	I = 3	Upper Spine Joint (θ_3^R)	
	230	I = 4	Lower Spine Joint (θ_4^R)	
	231	I = 5	Hip (θ_5^R)	
	232	I = 6	Knee (θ_6^R)	
	233	I = 7	Upper Torso - Upper Arm Joint (θ_7^R)	
	234	I = 8	Elbow (θ_8^R)	
	235	I = 9	Shoulder-Upper Torso Joint (θ_S)	
	236	I = 10	Neck (extensible element) (L_n)	
	237	I = 11	Shoulder (extensible element) (L_s)	

TABLE 7 INPUT DATA

MUSCLE TENSION VERSUS TIME
(9 Fields of 8)

Field	Name of Quantity	Units	Definition
1			NAME assigned to muscle tension table $ M $ vs. time.
2	t	msec	Time associated with a specified muscle tension value.
3	TENSE (I), $ M $, $ T $, 1b or 1b in (N.m)	(N)	Muscle contraction force or moment (should be ≥ 0 .)

TABLE 7 INPUT DATA
 RADIAL SHOULDER JOINT STIFFNESS TABLES
 (9 Fields of 8)

Field	Name of Quantity	Units	Definition
1	θ_S	deg	Relative shoulder angle associated with specified linear stiffness.
2	KJI (10,1), $K_{10,1}$	$\frac{lb}{in}$ ($\frac{N}{cm}$)	Linear radial shoulder joint stiffness coefficient.

NOTE: If $K_{10,1}$ is desired to be constant, then the value in field 1 of the 214 Card will suffice. Only if $K_{10,1}$ is to be tabular must 239 Cards be present, one card per point. $K_{10,1}$ is assumed periodic, with period of 360° . Points at $\theta_S = 0^\circ$ and 360° and desired intermediate abscissa values are entered.

TABLE 7 INPUT DATA

RADIAL SHOULDER JOINT STIFFNESS TABLES
(9 Fields of 8)

Field	Name of Quantity	Units	Definition
1	θ_s	deg	Relative shoulder angle associated with specified quadratic stiffness.
2	KJI (10,2), $K_{10,2}$	$\frac{lb}{in}$ ($\frac{N}{cm}$)	Quadratic radial shoulder joint stiffness coefficient.

NOTE: A table for $K_{10,2}$ is optional. See note for Card 239.

TABLE 7 INPUT DATA

RADIAL SHOULDER JOINT STIFFNESS TABLES
(9 Fields of 8)

Field	Name of Quantity	Units	Definition
1	θ_s	deg	Relative shoulder angle associated with specified cubic stiffness.
2	KJI (10,3), $K_{10,3}$	$\frac{\text{lb}}{\text{in}}$ ($\frac{\text{N}}{\text{cm}}$)	Cubic radial shoulder joint stiffness coefficient.

NOTE: A table for $K_{10,3}$ is optional. See note for Card 239.

TABLE 7 INPUT DATA

OCCUPANT NECK COMPRESSION PARAMETERS
(4 Fields of 8)

Field	Name of Quantity	Units	Definition
1	KJI(13,1), $K_{13,1}$	lb/in(N/cm)	Linear Compression Coefficient
2	KJI(13,2), $K_{13,2}$	lb/in ² (N/cm ²)	Quadratic Compression Coefficient
3	KJI(13,3) $K_{13,3}$	lb/in ³ (N/cm ³)	Cubic Compression Coefficient
4	CJI(13), C_{13}^J	lb sec/in (N sec/cm)	Viscous friction coefficient

- NOTES: 1. This card contains neck compression parameters; see Card 213 for neck elongation parameters.
 2. This card may be supplemented by Card 247.

MVMA 2-D Model
 Card 242

TABLE 7 INPUT DATA

OCCUPANT JOINT-STOP MATERIAL NAMES
 (8 Fields of 8)

Field	Card Reference	Definition
1-2	205	Material name for upper neck joint flexion.
3-4	215	Material name for upper neck joint extension.
5-6	206	Material name for lower neck joint flexion.
7-8	216	Material name for lower neck joint extension.

NOTES:

1. These materials are used only for joint stops.
2. Neck flexion is forward bending; extension is rearward.
3. Fields 1 (if negative), 2, 3, and 9 of the indicated joint parameter cards are not used if a material name is specified. Leave the material name fields blank if polynomial coefficients on the reference card are to be used.
4. Material specifications are made on Cards 403-408.

TABLE 7 INPUT DATA

OCCUPANT JOINT-STOP MATERIAL NAMES
(8 Fields of 8)

Field	Card Reference	Definition
1-2	207	Material name for upper torso joint flexion.
3-4	207	Material name for upper torso joint extension.
5-6	208	Material name for lower torso joint flexion.
7-8	208	Material name for lower torso joint extension.

NOTES: 1. Torso flexion is forward bending; extension is rearward.
 2. See Notes for Card 243.

TABLE 7 INPUT DATA

OCCUPANT JOINT-STOP MATERIAL NAMES
(8 Fields of 8)

Field	Card Reference	Definition
1-2	209	Material name for hip joint forward bending.
3-4	209	Material name for hip joint rearward bending.
5-6	210	Material name for knee joint flexion (bending).
7-8	210	Material name for knee joint extension (straightening).

- NOTES:
1. The order of material names for the knee are reversed, in a sense, from the other joints since for this joint, flexion corresponds to rearward bending (into "upper" stop) and extension corresponds to forward bending (into "lower" stop).
 2. See Notes for Card 243.

TABLE 7 INPUT DATA

OCCUPANT JOINT-STOP MATERIAL NAMES
(8 Fields of 8)

Field	Card Reference	Definition
1-2	211	Material name for shoulder joint, forward arm rotation.
3-4	211	Material name for shoulder joint, rearward arm rotation.
5-6	212	Material name for elbow flexion (bending).
7-8	212	Material name for elbow extension (straightening).

NOTE : See Notes for Card 243.

TABLE 7 INPUT DATA

OCCUPANT JOINT-STOP MATERIAL NAMES
(6 Fields of 8)

Field	Card Reference	Definition
1-2	213	Material name for neck link elongation.
3-4	242	Material name for neck link compression.
5-6	214	Material name for shoulder link elongation.
7-8	-	(Unused material name)

- NOTES:
1. The "stop" locations for neck link elongation and compression are not specified by the user. They are determined as the initial neck link length.
 2. The shoulder link "stop" locations are specified by the shoulder stop circle radius in field 7 of Card 214.
 3. See Notes for Card 243.

TABLE 7 INPUT DATA

UNLOADING CURVES
(3 Fields of 8)

NOTE: Contact ellipse material unloading curves are specified in the same manner as curves for contact region materials. See Card 413 for format.

TABLE 7 INPUT DATA

OCCUPANT DESCRIPTION SUBTITLE
(3 Fields of 8)

Field	Name of Quantity	Units	Definition
1-3	STITLE (6-10)		Run subtitle for Occupant Orientation Input Block centered in columns 1 to 19

MVMA 2-D Model
Card 300

TABLE 7 INPUT DATA

INITIAL BODY LINK ANGLES (RELATIVE TO VEHICLE)
(9 Fields of 8)

Field	Name of Quantity	Units	Definition
1	TH1, θ_1	deg.	Head Angle
2	TH2, θ_2	deg.	Upper Torso Angle
3	TH3, θ_3	deg.	Middle Torso Angle
4	TH4, θ_4	deg.	Lower Torso Angle
5	TH5, θ_5	deg.	Upper Leg Angle
6	TH6, θ_6	deg.	Lower Leg Angle
7	TH7, θ_7	deg.	Upper Arm Angle
8	TH8, θ_8	deg.	Lower Arm Angle
9	TH9, θ_9 , θ_n	deg.	Neck angle

NOTE: See Figure 78 for definition.

TABLE 7 INPUT DATA

INITIAL BODY LINK ANGULAR VELOCITIES (RELATIVE TO VEHICLE)
(9 Fields of 8)

Field	Name of Quantity	Units	Definition	Defaults
1	TH1D, $\dot{\theta}_1$	deg/sec	Head Angular Velocity	0.
2	TH2D, $\dot{\theta}_2$	deg/sec	Upper torso Angular Velocity	0.
3	TH3D, $\dot{\theta}_3$	deg/sec	Middle torso Angular Velocity	0.
4	TH4D, $\dot{\theta}_4$	deg/sec	Lower torso Angular Velocity	0.
5	TH5D, $\dot{\theta}_5$	deg/sec	Upper leg Angular Velocity	0.
6	TH6D, $\dot{\theta}_6$	deg/sec	Lower leg Angular Velocity	0.
7	TH7D, $\dot{\theta}_7$	deg/sec	Upper Arm Angular Velocity	0.
8	TH8D, $\dot{\theta}_8$	deg/sec	Lower Arm Angular Velocity	0.
9	TH9D, $\dot{\theta}_9$, $\dot{\theta}_n$	deg/sec	Neck Angular Velocity	0.

TABLE 7 INPUT DATA

INITIAL CONDITIONS FOR UPPER TORSO AND NECK
(9 Fields of 8)

Field	Name of Quantity	Units	Definition	Defaults
1	XH, \dot{x}_2	inches (cm)	Initial X coordinate of upper torso C-G relative to vehicle origin.	0.
2	XHD, \dot{x}_2	ft/sec (m/sec)	Initial X velocity of upper torso C-G relative to initial vehicle X velocity.	0.
3	ZH, \dot{z}_2	inches (cm)	Initial Z coordinate of upper torso C-G relative to vehicle origin.	0.
4	ZHD, \dot{z}_2	ft/sec (m/sec)	Initial Z velocity of upper torso C-G relative to initial vehicle Z velocity.	0.
5	ELN, L_n	inches (cm)	Initial length of neck.	4.
6	ELND, \dot{L}_n	in/sec (cm/sec)	Initial rate of extension of neck.	0.

NOTE: 1. See Figure 2 for definitions of (x_2, z_2) and L_n .

2. L_n cannot be 0. Further, a small value for L_n will necessitate a small integration time step. Δt must be no larger than about 0.5 msec if L_n is 0.1 inches.

3. Note that x_2 is in "inches" while \dot{x}_2 is in "ft/sec", etc.

TABLE 7 INPUT DATA

INITIAL SHOULDER LOCATION AND VELOCITY RELATIVE TO UPPER TORSO ATTACHMENT

Field	Name	Units	Definition	Defaults
1	x_S, x_s	in (cm)	Initial X coordinate of shoulder joint relative to upper torso attachment point.	0.
2	\dot{x}_S, \dot{x}_s	in/sec (cm/sec)	Initial X velocity in upper torso system.	0.
3	z_S, z_s	in (cm)	Initial Z coordinate of shoulder joint relative to upper torso attachment point.	0.
4	\dot{z}_S, \dot{z}_s	in/sec (cm/sec)	Initial Z velocity in upper torso system.	0.

NOTE: See Figure 67 for definition of (x_s, z_s) .

TABLE 7 INPUT DATA

VEHICLE INTERIOR CHARACTERISTICS SUBTITLE
(3 Fields of 8)

Field	Name of Quantity	Units	Definition
1-3	STITLE (11 - 15)		Run subtitle. Used to describe general character of interior panels used to simulate the interior. Centered in columns 1 to 19.

TABLE 7 INPUT DATA

DESCRIPTION OF REAL LINE CONTACT REGIONS (CARD 1)
(9 Fields of 8)

Field	Name of Quantity	Units	Description
1-2			Name of region.
3-4			Name of material (Blank if rigid).
5	IDEF		Switch = $\begin{cases} 0^*, & \text{Use standard model of permanent material deformation (See Sections 2.4.1, 2.6.1, 2.6.4).} \\ 1^*, & \text{Permanent material deformation coupled with structural response (See Section 2.6.8 for discussion of migration rule).} \end{cases}$
6	ISCALE		Switch = $\begin{cases} 0., & \text{Multiple forces acting on one line segment required to sum to maximum of all forces (See Section 2.6.10.6) (See Field 8).} \\ 1., & \text{Multiple forces acting on one line segment are independent (See Field 8).} \end{cases}$
7	IAPP		Switch = $\begin{cases} 0., & \text{When one ellipse contacts several segments, use special force apportionment (See Section 2.6.9).} \\ 1., & \text{When one ellipse contacts several segments, the forces are computed independently.} \end{cases}$
8	IMULTI		Switch = $\begin{cases} 0., & \text{Use cavity analysis (See Section 2.6.10). This global switch activates Field 6.} \\ 1., & \text{Do not use cavity analysis.} \end{cases}$

NOTE: This is the first of two descriptive cards which must be supplied for each contact region.

* The switch in Field 5 of Card 402 must be set to 0. for this switch to be effective.

TABLE 7 INPUT DATA

DESCRIPTION OF REAL LINE CONTACT REGIONS (CARD 2)
(9 Fields of 8)

Field	Name of Quantity	Units	Description
1-2			Name of Contact region.
3	NSR		Number of line segments in region.
4			Friction class (1. to 10).
5	IMIG		Switch = {0, Structural deformation allowed. This switch controls use of the migration rules Section 2.6.8. 1., Structural deformation not used.}
6			Switch = {0, Region description with respect to vehicle coordinates. 1., Region description with respect to inertial coordinates.}
7			Switch = {0, Output printed in vehicle coordinates. 1., Output printed in inertial coordinates.}

NOTE: Field 6 refers to segment position data on 411-cards.

TABLE 7 INPUT DATA

MATERIAL PROPERTIES (CARD 1)
(9 Fields of 8)

Field 1-2	Name of Quantity	Units	Description	Name of material.
3	DA, δ_A	inches (cm)	* Deflection at peak of inertial spike curve.	
4	DB, δ_B	inches (cm)	* Deflection at cutoff of inertial spike curve.	
5	DC, δ_C	inches (cm)	* Deflection at yield point.	
6	DE, δ_D	inches (cm)	* Deflection at beginning of breakdown.	
7	DF, δ_F	inches (cm)	* Deflection at breaking point.	
8	FM, F_{max}	pounds (N)	**Force saturation level (If this quantity is zero, force saturation is not used).	
9	DM, β	lbs/in (N/cm)	* Slope of unloading curve from saturation state. (or negative)	

NOTES: 1. See Section 2.4.1 and Figures 12 and 81 to 85 for definitions.

2. This is the first of six cards which must be entered for each material specification (vehicle region, ellipse, belt).

3. Required conditions: $0 \leq \delta_A \leq \delta_B \leq \delta_D < \delta_F$; $\delta_C \geq 0$

*4. Belts may have material properties defined optionally in terms of strain. (See Cards 702 and 717.) In this case all δ 's in Fields 3 to 7 will have strain units (in/in) and Field 9 will be in force per unit strain.

5. Field 9: If a negative value is in Field 9, then the unloading curve is determined from the G-ratio.

*6. All δ 's for joint stop materials are in degrees and unloading slope from saturation is in in-lb/deg or N-m/deg. Units for neck and shoulder link elongation and compression are inches or cm.

**7. "Force saturation level" for joint stop materials has units in-lb or N-m. Units for neck and shoulder link elongation and compression are lbs or N.

TABLE 7 INPUT DATA

MATERIAL PROPERTIES (CARD 2)

Field	Name of Quantity	Units	Description
1-2		Name of material.	
3	FOREPS, ϵ_D	pounds (N)	Epsilon for shared deflection force balancing (allowed error)
4	XLAM(1), λ_1		Cavity Coefficient No. 1.
5	XLAM(2), λ_2		Cavity Coefficient No. 2.
6	XLAM(3), λ_3		Cavity Coefficient No. 3.
7			Name assigned to static curve.
8			Name assigned to inertial spike.
9			Name assigned to G and R ratios.

- NOTES:
1. See Section 2.4.1 for fields 2, 7, 8, 9.
 2. See Section 2.6.10 for fields 4, 5, 6.
 3. Fields 4, 5, 6 apply only to contact regions.
 4. Field 3 applies to contact regions and ellipses and also to belts if body deformations are allowed.

TABLE 7 INPUT DATA

MATERIAL PROPERTIES (CARD 3)
(9 Fields of 8)

Field	Name of Quantity	Units	Description
1			Name assigned to G and R ratios (See Card 404, Field 9)
2	D, δ	Inches (cm)	*Deflection associated with a specified G-ratio. If a negative value is given, G is assumed constant.

3 GEF, G Ratio of permanent deformation to maximum deflection.

NOTES: 1. See Section 2.4.1 and Figure 12.

2. At least one 405 and one 406 card must be included for each name occurring in field 9 of 404 cards.

*3. Belts may have material properties defined optionally in terms of strain.(See cards 702 and 717.) In this case Field 2 will have strain units (in/in).

4. G should not be 1.

5. Deflection is in degrees for joint stop materials (inches or cm for neck and shoulder link elongation and compression).

TABLE 7 INPUT DATA

MATERIAL PROPERTIES (CARD 4)
(9 Fields of 8)

Field	Name of Quantity	Units	Description
1			Name assigned to G and R ratios (See Card 404, field 9).
2	D, δ	inches (cm)	*Deflection associated with a specified R-ratio. If a negative value is given, R is assumed constant.
3	ARE, R		Ratio of conserved energy to total energy.

NOTES: 1. See Section 2.4.1 and Figures 12 and 85.

2. At least one 405 and one 406 card must be included for each name occurring in field 9 of 404 cards.

*3. See Note 3 of Card 405.

4. R should not be 0.

5. Deflection is in degrees for joint stop materials (inches or cm for neck and shoulder link elongation and compression).

MVMA 2-D Model
Card 406 (224,707,815)

TABLE 7 INPUT DATA

MATERIAL PROPERTIES (CARD 5)
(9 Fields of 8)

Field	Name of Quantity	Units	Description
1			Name assigned to static curve (See Card 404, Field 7).
2	D_0 ,	inches (cm)	*Deflection at which a value of force is specified. If a negative value is given, polynomial coefficients are to be specified in Fields 4-9.
3	F or C_1	lbs or (N or lbs/in N/cm)	*Force or linear spring constant.
4	C_2	lbs/in ² (N/cm ²)	*Second order polynomial coefficient.
5	C_3	lbs/in ³ (N/cm ³)	*Third order polynomial coefficient.
6	C_4	lbs/in ⁴ (N/cm ⁴)	*Fourth order polynomial coefficient.
7	C_5	lbs/in ⁵ (N/cm ⁵)	*Fifth order polynomial coefficient.
8	C_6	lbs/in ⁶ (N/cm ⁶)	*Sixth order polynomial coefficient.

NOTES: 1. See Section 2.4.1 and Figures 12 and 81.

2. At least one 407 card must be included for each name in Field 7 of 404 cards.

3. If a polynomial is selected, force is computed by:

$$F = C_1\delta + C_2\delta^2 + C_3\delta^3 + C_4\delta^4 + C_5\delta^5 + C_6\delta^6$$

If tabular input is selected, more than one 407 card must be supplied.

*4. Belts may have material properties defined optionally in terms of strain. (See Cards 702 and 717.) In this case Field 2 must have strain units and spring coefficients in Fields 3-8 are defined accordingly.

5. Deflection is in degrees for joint stop materials, "force" units are in-lb or N-mm, and polynomial coefficients have units in-lb/deg or N-mm/deg, etc. Units for neck and shoulder link elongation and compression are as indicated in the eight-field layout above.

TABLE 7 INPUT DATA

MATERIAL PROPERTIES (CARD 6)
(9 Fields of 8)

Field	Name of Quantity	Units	Description
1			Name assigned to inertial spike (See Card 404, Field 8)
2	D,	inches (cm)	* Deflection at which a value of force is specified. If a negative value is given, polynomial coefficients are to be specified in Fields 4-9.
3	F or C ₁	lbs or N or lbs/in N/cm)	* Force or linear spring constant.
4	C ₂	lbs/in ² (N/cm ²)	* Second order polynomial coefficient.
5	C ₃	lbs/in ³ (N/cm ³)	* Third order polynomial coefficient.
6	C ₄	lbs/in ⁴ (N/cm ⁴)	* Fourth order polynomial coefficient.
7	C ₅	lbs/in ⁵ (N/cm ⁵)	* Fifth order polynomial coefficient.
8	C ₆	lbs/in ⁶ (N/cm ⁶)	* Sixth order polynomial coefficient.

NOTES: 1. See Section 2.4.1 and Figures 12 and 82.

2. At least one 408 card must be included for each name in Field 8 of 404 cards.
 3. If a polynomial is selected, force is computed by:

$$F = C_1\delta + C_2\delta^2 + C_3\delta^3 + C_4\delta^4 + C_5\delta^5 + C_6\delta^6$$

If tabular input is selected, more than one 408 card must be supplied.
 *4. See Note 4 of Card 407.

5. The inertial spike curve should be zero at δ_B . See Card 403.
 6. See Note 5 of Card 407 for joint stop materials.

TABLE 7 INPUT DATA

LINE PARAMETERS WITHIN A REGION (CARD 1)
(9 Fields of 8)

Field	Name of Quantity	Units	Description
1-2			Name assigned to line segment.
3-4			Name assigned to region.
5	inches (cm)		Penetration limit.
6			Edge constant.
7			Direction factor (defines front and rear of segment).
8			Line segment position within the region, from 1. to NSR where 1. = segment at one end of region and NSR = segment at other end of region (See Card 402, Field 3).

NOTES: 1. See Section 2.6.3 for Field 8. Also Figure 89.
 2. See Section 2.6.2 for Field 6. Also Figures 87 and 88.

3. See Section 2.6.3 for Field 5.

4. The first endpoint of the first segment in a region is numbered "1." The remaining segments are numbered consecutively.
 5. This is the first of three cards which must be included for each line segment.

TABLE 7 INPUT DATA

LINE PARAMETERS WITHIN A REGION (CARD 2)
(9 Fields of 8)

Field	Name of Quantity	Units	Description
1-2			Name assigned to line segment
3			Number of time points for which the location of this line segment is to be specified.
4	$XG(I+1)$, γ_{i+1}	$in/lb sec^2$ or $1/mass(1/kg)$	Mass compliance at second endpoint.
5	$XK(I+1)$, k_{i+1}	$in/lb deg(N-m/deg)$	Bending constant at second endpoint.
6	$XG(I)$, γ_i	$in/lb sec^2$ or $1/mass(1/kg)$	Mass compliance at first endpoint
7	$XK(I)$, k_i	$in/lb deg(N-m/kg)$	Bending constant at first endpoint.

NOTES:

1. The last two fields are used only when Card 409, field 8 = 1.
2. $I = 1, \dots, NSR$ (See Card 402, Field 3).
3. See Section 2.6.8 for Fields 4-7.
4. This is the second of three cards which must be included for each line segment.

TABLE 7 INPUT DATA

LINE SEGMENT LOCATION
(9 Fields of 8)

Field	Name of Quantity	Units	Description
1-2			Name assigned to line segment.
3	T, t	msec	Time at which line segment location is specified. If a negative number is entered, line segment location is time-independent and only one 411 card need be entered.
4	XHAT(1), x _i	inches (cm)	x-coordinate of first endpoint.
5	XHAT(2), z _i	inches (cm)	z-coordinate of first endpoint.
6	XHAT(3), x _{i+1}	inches (cm)	x-coordinate of second endpoint.
7	XHAT(4), z _{i+1}	inches (cm)	z-coordinate of second endpoint.
8	II		Enter 1., 2., 3., 4., 5., or 6. on t=0 cards to indicate that first endpoint is a point of the frontal interior outline for airbag contact.

- Notes:
1. All coordinates should be given with respect to the coordinate system specified on Card 402, Field 6 for the corresponding region (Inertial or vehicle).
 2. All values must be filled in through field 7.
 3. These cards must be ordered with respect to time for each line segment.
 4. Field 8: Two to six points must be indicated if airbag is present. 1. should be for bottom of toeboard. Numbers must be used sequentially and the largest number should be for a point near the top of the windshield. Number of points minus one equals number of lines.
 5. No line segment should pass exactly through the inertial origin at t=0.
 6. See Section 2.6.8 and Figure 27 for definitions.
 7. The coordinates of the first endpoint of the second segment in a region must be identical to the coordinates of the second endpoint of the first segment, etc.

TABLE 7 INPUT DATA

FRICITION COEFFICIENTS
(9 Fields of 8)

Fields	Name of Quantity	Units	Description	Defaults
1			Ellipse friction class (1. to 5.)	
2			Region friction class (1. to 10.)	
3	CMU (.,.,1), μ_k^0		Constant friction coefficient.	0.
4	CMU (.,.,2), μ_k^1	1/in (1/cm)	Linear friction coefficient.	0.
5	CMU (.,.,3), μ_k^2	1/in ² (1/cm ²)	Second order friction coefficient	0.

NOTES: 1. A non-linear friction coefficient is computed to simulate "plowing."

$$\mu = \mu_k^0 + \mu_k^1 \delta + \mu_k^2 \delta^2$$

2. There must be one 412 card for each combination of ellipse and region friction class indicated on Cards 215 and Cards 402.
3. See Section 2.6.6.

TABLE 7 INPUT DATA

*** VERSION 3 ***		UNLOADING CURVES (3 Fields of 8)		*** VERSION 3 ***
Fields	Name of Quantity	Units	Description	
1-2			Name of Material	
3	NBI		Number of unloading curves to be specified for this material	

NOTES: 1. NBI cards with unloading curve specifications must immediately follow this card.

2. G- and R- ratios are ignored for a material for which unloading curves are specified.
3. Cards 413 (and 248, 724, 818) may be used only with Version 3.

TABLE 7 INPUT DATA

*** VERSION 3 *** UNLOADING CURVES
 (5 Fields of 8) *** VERSION 3 ***

Fields	Name of Quantity	Units	Description
1	δ_1	in (cm)	Deflection for complete unloading, δ_1
2	δ_2	in (cm)	Deflection at break in bilinear curve, δ_2
3	δ_3	in (cm)	Deflection at beginning of unloading, δ_3
4	S_1	lb/in (N/cm)	Slope of lower segment of bilinear unloading curve, S_1
5	S_2	lb/in (N/cm)	Slope of upper segment of bilinear unloading curve, S_2

NOTES: 1. For each material, prescribed unloading curves must be in order of increasing deflection at beginning of unloading (δ_3).
 2. See field 3 and notes for Card 413.

TABLE 7 INPUT DATA

VEHICLE INTERIOR CONFIGURATION SUBTITLE
(3 Fields of 8)

Field	Name of Quantity	Units	Definition
1-3	STITLE(16-20)		Run subtitle for Vehicle Interior Configuration Input Block. Centered in Columns 1 to 19.

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TABLE 7 INPUT DATA

BELT ANCHOR POINTS (RELATIVE TO VEHICLE ORIGIN)
 (9 Fields of 8)

Field	Name of Quantity	Units	Definition
1	XVAI (1), X_1^{VA}	inches (cm)	Lap belt inboard anchor point. (x-coordinate)
2	ZVAI (1), Z_1^{VA}	inches (cm)	Lap belt inboard anchor point. (z-coordinate)
3	XVAI (2), X_2^{VA}	inches (cm)	Lap belt outboard anchor point. (x-coordinate)
4	ZVAI (2), Z_2^{VA}	inches (cm)	Lap belt outboard anchor point. (z-coordinate)
5	XVAI (3), X_3^{VA}	inches (cm)	Torso belt upper anchor point. (x-coordinate)
6	ZVAI (3), Z_3^{VA}	inches (cm)	Torso belt upper anchor point. (z-coordinate)
7	XVAI (4), X_4^{VA}	inches (cm)	Torso belt lower anchor point. (x-coordinate)
8	ZVAI (4), Z_4^{VA}	inches (cm)	Torso belt lower anchor point. (z-coordinate)

NOTE: See Section 2.5.1 and Figure 16 for definitions.

NOTE: This card is not needed if the advanced belt system BELT2 has been selected. See Cards 710-723.

TABLE 7 INPUT DATA

VEHICLE IMPACT SUBTITLE
 (3 Fields of 8)

Field	Name of Quantity	Units	Definition
1-3	STITLE (21 - 25)		Run subtitle for Vehicle Impact Specification Input Block. Centered in columns 1 to 19.

MVMA 2-D Model
Card 600

TABLE 7 INPUT DATA

VEHICLE INITIAL CONDITIONS AND ACCELEROMETER LOCATION
(9 Fields of 8)

Field	Name of Quantity	Units	Definition	Defaults
1	XV, \dot{X}_v	inches (cm)	X coordinate of vehicle origin	0.
2	XVD, \dot{X}_v	ft/sec (m/sec)	X component of initial vehicle velocity	0.
3	ZV, \dot{Z}_v	inches (cm)	Z coordinate of vehicle origin	0.
4	ZVD, \dot{Z}_v	ft/sec (m/sec)	Z component of initial vehicle velocity	0.
5	THV, θ_v	degrees	Initial vehicle pitch angle	0.
6	THWD, $\dot{\theta}_v$	deg/sec	Initial vehicle pitch angular velocity	0.
7	AA, a	inches (cm)	X coordinate of vehicle accelerometer in vehicle frame	0.
8	C, c	inches (cm)	Z coordinate of vehicle accelerometer in vehicle frame	0.
9	VM			

0. = vehicle motion data are specified as x- and z-accelerometer readings
 1. = inertial x and z accelerations are specified for the vehicle origin
 2. = inertial x and z positions are specified for the vehicle origin
 3. = inertial x acceleration and inertial z position are specified for the vehicle origin
 4. = inertial x position and inertial z acceleration are specified for the vehicle origin
 -1. = translational vehicle motion is defined by x-accelerometer reading data and the time-varying position of a pivot point

- NOTES:
1. See Section 2.9 for discussion of vehicle motion.
 2. For Version 3, Card 601 must precede Cards 602, 603, and 604 in the data deck unless Card 601 is defaulted.
 3. Field 9 is not used for Version 4.
 4. If position points are to be specified (field 9 = 2, 3, 4, , or -1), or field 2 of Card 604 = 2, or 3.), the integration time step on Card 601 should be no greater than half the minimum difference between any two successive time coordinates in the time-position tables. Equivalently, for a given integration time step Δt , the minimum spacing in the position tables should be at least $2\Delta t$.
 5. See Note 9 on Card 603.

MVMA 2-D Model
Card 601

TABLE 7 INPUT DATA

*** VERSION 3 *** VEHICLE HORIZONTAL ACCELERATION VERSUS TIME
 (4 Fields of 8) *** VERSION 3 ***

Field	Name of Quantity	Units	Definition	Default*
1	NPX		Number of time-acceleration or time-position pairs.	24.
2	HEAD (1)		Acceleration or position indicator 0. = in/sec ² or in (m/sec ² or cm) 1. = g's	1.
3	DCONT(1)		For position input only. The fraction of current position ramp length over which full velocity change takes place. (See Note 7.)	0.

*4 DCONT(2) in/sec²(cm/sec²) For position input, estimated maximum magnitude for the inertial x-acceleration. (See Note 5.) 0.

NOTES: 1. The type of motion specified must be as indicated in field 9 of Card 601.
 2. Acceleration (or position) data follow on succeeding unnumbered cards, four time (MSEC) - acceleration (or position) pairs per card starting in field 1 and filling eight fields.
 3. Summed field 1 values for Cards 602, 603, and 604 cannot exceed 600.
 4. See Note 2 on Card 601.

*5. Note that the required metric system units for DCONT(2) are cm/sec², not in/sec² or g's.
 6. Position specification is not allowed for Version 4.

7. For each position ramp, of time length $t_2 - t_1$, velocity ramps to full values over $DCONT(1) * (t_2 - t_1)$ and then remains constant through t_2 . Acceleration is slope of velocity curve. (See Figure 32.) A good value for DCONT(1) may be selected in the following manner: a) let n be the number of integration time steps within the smallest difference between any two successive time coordinates in the time-position table. (n should be at least 2.); b) Take DCONT(1) as $\approx 8/3n$, or $\approx 3/n$.

*8. The "AMA Frontal Barrier Profile" is used for default. The twenty-four time-acceleration pairs for the 30 mph frontal collision are as follows:

$$\begin{aligned} & (0, 0)(5, -5)(10, -2)(15, -4)(20, -9.5)(25, -16.5)(30, -15.5) \\ & (35, -15)(40, -15)(45, -15.5)(50, -15)(60, -15)(65, -14.5)(70, -15.5) \\ & (75, -18.5)(80, -19)(85, -19)(90, -17)(95, -14.7)(100, -11.7) \\ & (105, -8.5)(110, -4.5)(115, 0)(200, 0) \end{aligned}$$

Default times are in milliseconds and accelerations are in g's.

*** VERSION 3 *** VEHICLE VERTICAL ACCELERATION VERSUS TIME *** VERSION 3 ***
 TABLE 7 INPUT DATA
 (7 Fields of 8)

Field	Name of Quantity	Units	Definition	Default*
1	NPZ		Number of time-acceleration or time-position pairs if field 9 Card 601 is non-negative. Otherwise, the number NPP of timepoints for which the inertial Z position of a "pivot point" is specified.	2.
2	HEAD(2)		Acceleration or position units indicator 0. = in/sec ² or in (m/sec ² or cm) 1. = g's	0.
3	NPP		Number of time-position pairs for instantaneous x position (in vehicle frame) of the "pivot point"	0.
4	NPQ		Number of time-position pairs for instantaneous z position (in vehicle frame) of the "pivot point"	0.
5	DCONT(3)		For position input only (including pivot coordinates). Time in- terval fraction for velocity ramping. See Note 7, Card 602.	0.
*6	DCONT(4)	in/sec ² (cm/sec ²)	For position input (including pivot), estimated maximum magnitude for the inertial acceleration. (See Note 5.)	0.
*7	DCONT(5)	in/sec ² (cm/sec ²)	For pivot input, estimated maximum magnitude for the rate of velocity change (x- or z-acceleration) within the vehicle frame for the changing location of the pivot point. (See Note 5.)	0.

- NOTES:
- The type of motion specified must be as indicated in field 9 of Card 601. Also see Section 2.9.
 - Acceleration (or position) data follow on succeeding unnumbered cards, four time (msec)-acceleration (or position) pairs per card starting in field 1 and filling eight fields. For pivot data there must be three sets of unnumbered cards, for NPZ, NPP, and NPQ points.
 - Fields 3 and 4 are not used if field 9 of Card 601 is non-negative.
 - If pivot point data are specified, this card is followed by three sets of unnumbered cards. The first set is for the NPP time-position pairs described for field 1. The second and third sets are for the NPP and NPQ time-position pairs described for fields 3 and 4.
 - Note that the required metric system units for DCONT(4) and DCONT(5) are cm/sec, not m/sec² or g's.
 - See Note 2 on Card 601.
 - See Note 3 on Card 602.
 - For input of pivot data, z-accelerometer printout calculated by the program will be "jumpy" (although not necessarily inaccurate) unless all of the following are smooth: a) X-accelerometer input; b) angular acceleration (from direct entry or numerical differentiation of tabular $\theta(t)$); c) inertial Z-acceleration of pivot point (second derivative of Z input). Even when Z-accelerometer calculations are unreliable, vehicle inertial velocities and displacements will be good, and only these terms enter the equations of motion.
 - Take care to prescribe compatible time zero values for the inertial and vehicle relative pivot point coordinates and the vehicle pitch angle and z coordinate of the vehicle origin on Card 601. These five values should satisfy equation (314.1) of Volume 1. If they do not, ZV (for Card 601) will be adjusted by the program and a warning will be printed.

** The default time-acceleration pairs are: (0.,0.) (2000.0.)

MVMA 2-D Model
Card 603

TABLE 7 INPUT DATA

*** VERSION 4 *** VEHICLE HORIZONTAL ACCELERATION VERSUS TIME
 (3 Fields of 8)

Field	Name of Quantity	Units	Definition	Defaults*
1			Number of time-acceleration pairs.	24.
2	HEAD (1)		Acceleration units indicator = 0. in/sec ² (m/sec ²) = 1.g's = 2. lbs (N)	1.
3	HEAD (3)		If 0., the accelerations given on the following cards are interpreted as accelerometer readings (MODROS convention). If ≠ 0., the accelerations are interpreted directly as vehicle origin inertial accelerations (HSRI convention).	1.

Note: Acceleration data follows on succeeding cards, four time (MSEC) acceleration pairs per card starting in Field 1 and filling eight fields.

NOTE: If field 3 on either Card 602 or 603 is non-zero, it is as if both were.

* The "AMA Frontal Barrier Profile" is used for default. The twenty-four time-acceleration pairs for the 30 mph frontal collision are as follows:

(0.,0.)(5.,-5.)(10.,-2.)(15.,-4.)(20.,-9.5)(25.,-16.5)(30.,-15.5)
(35.,-15.)(40.,-15.)(45.,-15.5)(50.,-15.)(60.,-15.)(65.,-14.5)(70.,-15.5)
(75.,-18.5)(80.,-19.)(85.,-19.)(90.,-17.)(95.,-14.7)(100.,-11.7)
(105.,-8.5)(110.,-4.5)(115.,0.)(2000.,0.)

Times are in milliseconds and accelerations are in g's.

TABLE 7 INPUT DATA

*** VERSION 4 ***
VEHICLE VERTICAL ACCELERATION VERSUS TIME
(3 Fields of 8)

Field	Name of Quantity	Units	Definition	Defaults*
1			Number of time-acceleration pairs.	2.
2	HEAD (2)		Acceleration units indicator $\approx 0. \text{in/sec}^2 (\text{m/sec}^2)$ $= 1.g \text{'s}$ $= 2.\text{lbs (N)}$	0.
3	HEAD (3)		If 0., the accelerations given on the following cards are interpreted as accelerometer readings (MODROS convention). If $\neq 0.$, the accelerations are interpreted directly as vehicle origin inertial accelerations (HSRI convention).	

Note: Acceleration data follows on succeeding cards, four time (MSEC) acceleration pairs per card starting in Field 1 and filling eight fields.

NOTE: If Field 3 on either Card 602 or 603 is non-zero, it is as if both were

- * The default time-acceleration pairs are: $(0, 0)$, $(2000, 0)$.

TABLE 7 INPUT DATA
 VEHICLE ANGULAR ACCELERATION VERSUS TIME
 (4 Fields of 8)

Field	Name of Quantity	Units	Definition	Defaults*
1	NPTH		Number of time - acceleration or time-angle pairs	2.
2	TRAD		0. = deg/sec ² 1. = rad/sec ²	2. = deg (angle input) 3. = rad (angle input)
3	DCONT(6)		For angle input only. Time interval fraction for velocity ramping. See Note 7, Card 602.	0.
4	DCONT(7)	(units--see Note 2)	For angle input, estimated maximum magnitude for the angular acceleration.	0.

NOTES: 1. Acceleration (or angle) data follow on succeeding unnumbered cards, four time (MSEC) - acceleration (or angle) pairs per card starting in Field 1.
 2. Units for DCONT(7) must be deg/sec² if field 2 is 2. and rad/sec² if field 2 is 3.
 3. See Note 3 on Card 602 and Note 2 of Card 601.
 4. Angle input is not allowed for Version 4.

* The default time-acceleration pairs are: (0.,0.) (2000.,0.).

TABLE 7 INPUT DATA
HEAD APPLIED FORCE SPECIFICATIONS

Field	Name of Quantity	Units	Definition
1	MUSNAM (1-2, 12)		Name assigned to applied force table F_x vs time (up to 8 characters); leave blank if no F_x table.
2	MUSNAM (1-2, 13)		Name assigned to applied force table F_z vs time (up to 8 characters); leave blank if no F_z table.
3	JFORCE		0. if applied force components are in the inertial frame; non-zero if in the head coordinate system
4	AF, α	in (cm)	X coordinate in head system of point of application of force vector (positive toward feet from head c.g.).
5	CF, c	in (cm)	Z coordinate in head system of point of application of force vector (positive rearward from head c.g.).

NOTE: Printout for head applied forces is obtained by requesting Categories 30 and 31 on Cards 110 and 1001/1002.

TABLE 7 INPUT DATA
HEAD APPLIED FORCE COMPONENT VERSUS TIME

Field	Name of Quantity	Units	Definition
1			NAME assigned to applied force table (F_x or F_z) vs. time.
2	t	msec	Time associated with a specified force value.
3	FORCEX, FORCEZ, F_x , F_z	lb (N)	Component of applied force vector.

NOTE: Printout for head applied forces is obtained by requesting Categories 30 and 31 on Cards 110 and 1001/1002.

TABLE 7 INPUT DATA
BELT RESTRAINT SYSTEM SUBTITLE
(3 Fields of 8)

Field	Name of Quantity	Units	Definition
1-3	STITLE	(26 - 30)	Run Subtitle for Belt Restraint System Input Block Centered in columns 1 to 9.

TABLE 7 INPUT DATA
 BELT SYSTEM PARAMETERS (CARD 1)
 (9 Fields of 8)

Field	Name of Quantity	Units	Definition
1	LBL0, Δt_B^{BL}	inches(cm)	Total lap belt length.
2	DELBL, Δt_B^{BL}	inches(cm)	Total lap belt slack.
3	LBTU0, Δt_B^{BU}	inches(cm)	Total upper torso belt length.
4	DELBTU, Δt_B^{BU}	inches(cm)	Total upper torso belt slack.
5	FBLMAX, $F_{\text{MAX}}^{\text{BL}}$	lbs(N)	Lap belt breaking force.
6	FBTMAX, $F_{\text{MAX}}^{\text{BT}}$	lbs(N)	Torso belt breaking force.
7	DELTB, Δt_B	msec	Time duration for belt failure.

NOTE: See Section 2.5.1 for analysis.

NOTE: This card is not needed if the advanced belt system BELT2 has been selected. See Cards 710-723.

TABLE 7 INPUT DATA
BELT SYSTEM PARAMETERS (CARD 2)
 (9 Fields of 8)

Field	Name of Quantity	Units	Description
1-2			Name assigned to lap belt material.
3-4			Name assigned to body material for shared deflection with belt (or blank if shared deflection with belt is not desired).
5	LBTLO, $\varrho_B T$	inches (cm)	Total lower torso belt length.
6	DELBTL, $\Delta_B T$	inches (cm)	Total lower torso belt slack.
7	LBTLA		Lower torso belt attachment indicator 2. = upper torso link 4. = lower torso link otherwise = middle torso link
8	LBSTAN		Switch = {0, Force-strain input data. {1, Force-deflection input data.

NOTE: See Section 2.5.1 for analysis.

NOTE: This card is not needed if the advanced belt system BELT2 has been selected. See Cards 710-723.

TABLE 7 INPUT DATA
BELT SYSTEM PARAMETERS (CARD 3)
(9 Fields of 8)

Field	Name of Quantity	Units	Description
1-2			Name assigned to upper torso belt material
3-4			Name assigned to body material for shared deflection with upper torso belt (or blank if shared deflection with belt is not desired).
5-6			Name assigned to lower torso belt material.
7-8			Name assigned to body material for shared deflection with lower torso belt (or blank if shared deflection with belt is not desired).

NOTE: See Section 2.5.1 for analysis.

NOTE: This card is not needed if the advanced belt system BELT2 has been selected. See Cards 710-723.

TABLE 7 INPUT DATA
BELT MATERIAL CARDS
(9 Fields of 8)

Field	Name of Quantity	Units	Description
NOTES:			
	1.	Belt material properties are specified in the same manner as contact region belt properties. See Cards 403-408 for format.	
	2.	(BELT option) If Card 702, Field 8 is set for force-strain, all deflections will be interpreted as strains.	
	3.	(BELT2 option) If Card 717, Field 8 is set for force-strain, all deflections will be interpreted as strains.	
	4.	See notes for Cards 704-709 in Section 3.2.	
	5.	With regard to assigning belt material names for the belt segments in the advanced belt system, see Note 2 of Card 720.	

TABLE 7 INPUT DATA

ADVANCED BELT SYSTEM PARAMETERS
(9 Fields of 8)

Field	Name of Quantity	Units	Definition
1	ATTANC(1,1,J)	in(cm)	X-coordinate on body segment of belt attachment point (along centerline from upper joint of torso segment of attachment)
2	ATTANC(1,2,J)	in(cm)	Z-coordinate on body segment of belt attachment point (measured perpendicular to torso segment toward front of body)
3	ATTANC(2,1,J)	in(cm)	X-coordinate in vehicle of belt anchor
4	ATTANC(2,2,J)	in(cm)	Z-coordinate in vehicle of belt anchor
5	SLAK(J) (J=1-4) BL(J) (J=5-7)	in(cm)	Initial belt slack (negative if initial tension) for belts 1-4 or total initial unstrained belt length for belts 5-7
6-7	-	-	Belt material name (see cards 704-709)
8-9	-	-	Material name for body segment (needed only if shared deflection between belt and body)

NOTES: 1. See Figures 90 and 91.

2. Anchor point for belt 1 is not needed if belt 6 is present.
3. Anchor points for belts 2 & 3 are not needed if belt 5 is present.
4. Fields 1, 2, 8, 9 not used for belts 5, 6, 7 (Cards 714-716)
5. Anchor points for belts 2 and 3 should be coincident if belt 5 is present. Attachment points for belts 3 and 4 should be coincident.
6. Card 710 = belt 1 = upper torso belt
 Card 711 = belt 2 = lower torso belt
 Card 712 = belt 3 = inboard lap belt
 Card 713 = belt 4 = outbound lap belt
 Card 714 = belt 5 = lower ring strap
 Card 715 = belt 6 = upper ring strand
 Card 716 = belt 7 = upper torso belt extension
7. With regard to material names, see Note 2 of Card 720.

MVMA 2-D Model
Card 710-716

TABLE 7 INPUT DATA
 ADVANCED BELT SYSTEM PARAMETERS
 (7 Fields of 8)

Field	Name of Quantity	Units	Description	Defaults
1	INFLNC	—	Switch for type of interbelt influence for torso belts: 0. = independent belts, 1. = friction, 2. = saturation based on force difference, 3. = percent influence	0.
2	MBELT	—	0. = Force-deflection material properties for all belts ≠ 0. = Force-strain material properties for all belts	0.
3	LBTIA	—	Lower torso belt attachment indicator 2. = upper torso segment 3. = middle torso segment 4. = lower torso segment	4.
4	YSEP(1)	in(cm)	Out-of-plane separation between torso belt attachment points	0.
5	YSEP(2)	in(cm)	Out-of-plane separation between lap belt attachment points	0.
6	II(1)		Switch = 0., no free slipping over body for torso belt ≠ 0., free slipping (force equalization)	0.
7	II(3)		Switch = 0., no free slipping over body for lap belt ≠ 0., free slipping (force equalization)	0.

NOTES: 1. For Fields 6 and 7, "free slipping" means force equalization in the two torso or lap belt segments by considering a single deflection for the combined length of these two and all other belt segments acting together.
 2. If Field 6 is non-zero, the force saturation option for Field 1 is inactive. Set INFLNC to 0. (or 3.).
 3. If Field 1 is 1., two different approaches to calculation of belt friction across the torso may be used
 1) If Field 6 is zero, the first estimate to torso belt tensions (unadjusted for friction) is based on the assumption of independent belts ($\mu = \infty$). 2) If Field 6 is nonzero, the first estimate is based on free slipping ($\mu = 0$). The second approach is preferred. See Note 2 on Card 719.
 4. Regarding fields 1, 6, and 7, see Note 2 of Card 720.

TABLE 7 INPUT DATA

ADVANCED BELT SYSTEM: RELAXATION CONTROLS PARAMETERS

Field	Name of Quantity	Units	Description	Defaults
1	Not Used			

2	IPRMT(3)	-	Maximum number of iterations allowed per evaluation for force balance at ring	20.
3	REPS	lbs(N)	Force epsilon for x- and z-force balance	20. 88,9644

NOTE: If belts 5 and 6 are both absent, this card is not needed.

TABLE 7 INPUT DATA

TORSO INTERBELT INFLUENCE
(7 Fields of 8)

Field	Name of Quantity	Units	Description
1	BMUK	-	Kinetic friction coefficient for torso belt with body
2	BMUS	-	Static friction coefficient for torso belt with body
3	ZINFL, ζ	-	Enter a value from 0. to 1. Zero or a value near zero is recommended. (See Section 2.5.2.3)
4	INF(1,2)	-	1. = tension in belt 1 (influencer) causes adjustment in tension for belt 2 (influencee) -1. = belt 2 is influencer, belt 1 is influencee
5	RFSAT, F_S	lbs(N)	Force difference saturation level for torso belts
6	AFSAT, F_B	lbs(N)	Maximum force influence for influencer or influencee
7	PERCNT, P_{ij}	-	Positive or negative percent influence (fractional) for modification of influence by influencer

NOTES: 1. Certain fields of this card are needed only for certain values of INFNC , Field 1 of Card 717.

INFNC
Fields of Card 719 Needed

- 0. none (leave out card)
- 1. 1,2,3,(4)
- 2. 5
- 3. 4,6,7

2. For the case INFNC=1, field 4 of this card is used only if field 6 of Card 717 is nonzero. In this case, the value for INF should normally be 1. since the upper torso belt tension may normally be expected to exceed the lower torso belt tension.
3. For field 4, the influencer should normally be selected as the belt expected to have the greater tension.

TABLE 7 INPUT DATA

ADVANCED BELT SYSTEM ANCHOR AND RING PARAMETERS
(8 Fields of 8)

Field	Name of Quantity	Units	Description	Default
1	ANCHOR(1)	-	Anchor 1 type: 0. = free (absent or broken) 1. = belt 4, 5, 6, or 7 fixed to anchor (ring is present) 2. = belt 5, 6, or 7 with inertia reel 3. = anchored ring (ring strap absent) or belt 1, 2, 3, or 4 fixed at anchor	3.
2	ANCHOR(2)		Anchor 2 type (See Field 1)	3.
3	ANCHOR(3)		Anchor 3 type (See Field 1)	3.
4	ANCHOR(4)		Anchor 4 type (See Field 1)	1.
5	RING(1)		Belt influence type for upper harness ring: 1. = fixed to (torso) belt or ring absent 2. = friction with belt 3. = free (belt slips freely, no friction)	1.
6	RING(2)		Belt influence type for lower harness ring	1.
7	RINGMU(1)		Coefficient of friction for belt slipping at upper harness ring (needed only if RING(1) = 2.)	0.
8	RINGMU(2)		Coefficient of friction for belt slipping at lower harness ring (needed only if RING(2) = 2.)	0.

NOTES : 1. See Figures 90, 92, and 93.

2. Specification of $RING()=1$. makes the parts of the belt system on either side of the ring independent. In general, parts of the belt system are independent if separated by no-slip specifications at ring or body. Any belt segments that should be treated as parts of a common strap should be assigned the same material. Whenever belts should be treated as a common strap but the materials for the separate segments are different, the program arbitrarily uses the material for one of the members. (Version 3 prints a warning message.) Specifically, the conditions that make contiguous parts of the system independent are: 1) $RING()=1$; 2) $II(3)=0$. for lap belts (field 7 of Card 717); 3) $INFLNC=0$. and $II(1)=0$. for torso belts (fields 1 and 6 of Card 717).

TABLE 7 INPUT DATA

ADVANCED BELT SYSTEM INERTIA REEL

(6 Fields of 8)

Field	Name of Quantity	Units	Description	Defaults
1	REEL(1)	-	1. = inertia reel at anchor 1 is vehicle sensitive 0. = inertia reel at anchor 1 is webbing sensitive	1.
2	TLOCK(1)	msec	Time at which reel 1 locks (vehicle sensitive)(or -1.)	-1.
3	ALOCK(1)	g's	Value for resultant acceleration at reel 1 which will cause it to lock (vehicle sensitive)	.4
4	PLOCK(1)	deg	Value of vehicle pitch angle which will cause reel 1 to lock (vehicle sensitive)	14.
5	VLOCK(1)	in/sec (cm/sec)	Velocity for belt feed-out which will cause reel 1 to lock (webbing sensitive) (or -1.)	-1.
6	ALOCK(1)	g's	Acceleration for belt feed-out which will cause reel 1 to lock (webbing sensitive) (or -1.)	.75

NOTE: Use only Field 2 or Fields 3 and 4 if Field 1 is 1. (enter -1. in field 2 if fields 3 & 4 are used)
 Use only Field 5 or Field 6 if Field 1 is 0. (enter -1. in Field 5 or 6, whichever is not used)

NOTE: This card is needed only if Field 1 of Card 720 is 2.

MVMA 2-D Model
 Card 721

TABLE 7 INPUT DATA
ADVANCED BELT SYSTEM INERTIA REEL
(6 Fields of 8)

Field	Name of Quantity	Units	Description
1	REEL(2)	-	
2	TLOCK(2)	msec	
3	ALOCK(2)	g's	same as Card 721 except for inertia reel at anchor 2
4	PLOCK(2)	deg	
5	VLOCK(2)	in/sec(cm/sec)	
6	ALOCK(2)	g's	

NOTE: Use only Field 2 or Fields 3 and 4 if Field 1 is 1. (enter -1. in field 2 if fields 3 & 4 are used)
Use only Field 5 or Field 6 if Field 1 is 0. (enter -1. in Field 5 or 6, whichever is not used)

NOTE: This card is needed only if Field 2 of Card 720 is 2.

MVMA 2-D Model
Card 722

TABLE 7 INPUT DATA

ADVANCED BELT SYSTEM INERTIA REEL
(6 Fields of 8)

Field	Name of Quantity	Units	Description
1	REEL(3)	-	
2	TLOCK(3)	msec	
3	ALOCK(3)	g's	
4	PLOCK(3)	deg	
5	VLOCK(3)	in/sec(cm/sec)	
6	ALOCK(3)	g's	

NOTE: Use only Field 2 or Fields 3 and 4 if Field 1 is 1. (enter -1 in Field 2 if Fields 3 & 4 are used)
 Use only Field 5 or Field 6 if Field 1 is 0. (enter -1 in Field 5 or 6, whichever is not used)

NOTE:

This card is needed only if Field 3 of Card 720 is 2.

TABLE 7 INPUT DATA

UNLOADING CURVES
(3 Fields of 8)

NOTE: Belt material unloading curves are specified in the same manner as curves for contact region materials. See Card 413 for format.

MVMA 2-D Model
Card 724
(413)

TABLE 7 INPUT DATA

*** VERSION 3 *** OUT-OF-PLANE BELT SYSTEM DIMENSIONS *** VERSION 3 ***
 (7 Fields of 8)

Field	Name of Quantity	Units	Description
1	YDEL(1)	in(cm)	y-separation between anchor (or ring) and attachment for belt 1
2	YDEL(2)	in(cm)	y-separation between anchor (or ring) and attachment for belt 2
3	YDEL(3)	in(cm)	y-separation between anchor (or ring) and attachment for belt 3
4	YDEL(4)	in(cm)	y-separation between anchor and attachment for belt 4
5	YDEL(5)	in(cm)	y-separation between ring and anchor for belt 5
6	YDEL(6)	in(cm)	y-separation between ring and anchor for belt 6
7	YDEL(7)	in(cm)	y-separation between ring and anchor for belt 7

- Notes : 1. Out-of-plane separations between torso belt attachments and lap belt attachments are entered in fields 4 and 5 of Card 717 (YSEP(1) and YSEP(2)).
2. Card 725 may be used only with Version 3.
3. YDEL(1-4) positive if anchor (ring) is further from the occupant's mid-plane than the belt attachment. YDEL(5-7) positive if belt anchor is further from the occupant's mid-plane than is the ring.

TABLE 7 INPUT DATA

*** VERSION 3 *** BELT LENGTHS
 (7 Fields of 8) *** VERSION 3 ***

Field	Name of Quantity	Units	Description
1	BELTL(1)	in(cm)	Unstrained length of belt 1 (upper torso belt)
2	BELTL(2)	in(cm)	Unstrained length of belt 2 (lower torso belt)
3	BELTL(3)	in(cm)	Unstrained length of belt 3 (inboard lap belt)
4	BELTL(4)	in(cm)	Unstrained length of belt 4 (outboard lap belt)
5	BELTL(5)	in(cm)	Unstrained length of belt 5 (lower ring strap)
6	BELTL(6)	in(cm)	Unstrained length of belt 6 (upper ring strap)
7	BELTL(7)	in(cm)	Unstrained length of belt 7 (upper torso belt extension)

NOTES: 1. This card is ignored unless the force-strain option is selected (Card 717, field 2).
 2. This card is optional for all simulations. Unstrained belt lengths are normally calculated by the model from endpoint coordinates and slack. However, those calculations will be omitted for any belt for which a nonzero length is entered on this card. The calculation is omitted also for one case of a zero entry: in the case that a belt pair participates in free slipping (see Note 4) and/or is not (for torso belts only) an "independent" belt pair (i.e., INFLNC is not zero--Card 717), then if one BELTL() is zero and the other is nonzero, the nonzero value is assumed to be the total length for the pair.

3. Unstrained lengths are the webbing lengths in three dimensions (including slack).
 4. If the force equalization option is selected for the lap belt (Card 717, field 7), then the individual lap belt segment lengths are not important, only their sum. This sum should include any out-of-plane separation between attachment points since YSEP(2) on Card 717 will be ignored if BELTL(3) and/or BELTL(4) are nonzero and force equalization has been selected. Similar considerations apply for the torso belts if force equalization is selected (Card 717, field 6). YSEP(1) will be ignored if BELTL(1) and/or BELTL(2) are nonzero.

5. Unstrained belt lengths, whether calculated or specified, are used for calculating belt strain: $\epsilon = \delta / L_0$, where δ is deflection and L_0 is unstrained webbing length.
 6. Card 726 may be used only with Version 3.

1/8/81

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TABLE 7 INPUT DATA

ENERGY ABSORBING STEERING ASSEMBLY SYSTEM SUBTITLE
(3 Fields of 8)

Field	Name of Quantity	Units	Definition
1-3	STITLE (31 - 35)		Run subtitle for Steering Column System Input Block Centered in Columns 1 to 17.

NOTE:

Energy Absorbing Steering Assembly System Subtitle and Airbag System Subtitle are mutually exclusive. If only one of them is present in the data deck, that one will appear. If both are present, the one occurring last will appear.

MVMA 2-D Model
Card 800

TABLE 7 INPUT DATA

ENERGY ABSORBING STEERING ASSEMBLY SYSTEM PARAMETERS
(9 Fields of 8)

Field	Name of Quantity	Units	Description
1	HL, ℓ	inches (cm)	Length of steering column from instrument panel to steering wheel attachment.
2	HL0, $\dot{\varphi}$	in/sec (cm/sec)	Time rate of HL (See Field 1).
3	HAL1, α_1	deg	Initial angle of steering column measured clockwise from horizontal.
4	HAL1D, $\dot{\alpha}_1$	deg/sec	Time rate of HAL1 (See Field 3).
5	HAL2, α_2	deg	Initial angle of steering wheel measured clockwise from horizontal to steering wheel axis.
6	HAL2D, $\dot{\alpha}_2$	deg/sec	Time rate of HAL2, (See Field 5).
7	HH, h	inches (cm)	Initial distance between the steering column attachment point on the instrument panel and the place of the steering wheel.
8	HH0, \dot{h}	in/sec (cm/sec)	Time rate of HH (See Field 7).

TABLE 7 INPUT DATA

ENERGY ABSORBING STEERING ASSEMBLY SYSTEM PARAMETERS

Field	Name of Quantity	Units	Description
1	HA, a	inches(cm)	Distance between upper hinge and steering column center of gravity.
2	HR _ω , r _ω	inches(cm)	Steering wheel radius.
3	HLOC, l _c	inches(cm)	Length of lower column from steering gear box to attachment point.
4	HLI, l ₀	inches(cm)	Initial value of l.
5	HH1, h ₁	inches(cm)	Distance between upper hinge and the steering column hub constant point.
6	HS1, s ₁	inches(cm)	Reference coordinates to orient the steering assembly with respect to the vehicle reference point (X_v, Z_v).
7	HS2, s ₂	inches(cm)	
8	HS5, s ₅	inches(cm)	

TABLE 7 INPUT DATA

ENERGY ABSORBING STEERING ASSEMBLY SYSTEM PARAMETERS
(9 Fields of 8)

Field	Name of Quantity	Units	Description
1	H11, I ₁	lb sec ² /in (kg in ²)	Moment of inertia of segment 1 of steering assembly.
2	H12, I ₂	lb sec ² /in (kg in ²)	Moment of inertia of segment 2 of steering assembly.
3	Hm1, m ₁	lb sec ² /in (kg)	Mass of segment 1 of steering assembly.
4	Hm2, m ₂	lb sec ² /in (kg)	Mass of segment 2 of steering assembly.

TABLE 7 INPUT DATA

GEARBOX POSITION VERSUS TIME
(1 Field of 8)

Field	Name of Quantity	Units	Definition
1	HTX11(n), HX111(n)		Number of time-position pairs

NOTES: 1. Data follows on succeeding cards, four time-position pairs per card starting on Field 1.
 2. Time in msec and position in inches (cm).

TABLE 7 INPUT DATA

HEAD/STEERING SYSTEM PROPERTIES
(9 Fields of 8)

Field	Name of Quantity	Units	Description
1-2			Name assigned to head material (blank if rigid)
3	RHO(1), ρ_1	inches (cm)	Radius of circle for head contact surface.
4	SCMU(1,1), μ_0		Constant friction coefficient.
5	SCMU(1,2), μ_1	1/in (1/cm)	Linear friction coefficient.
6	SCMU(1,3), μ_2	1/in ² (1/cm ²)	Second order friction coefficient.

³⁰ NOTE: A non-linear friction coefficient is computed to simulate "plowing" $\mu = \mu_0 + \mu_1 \delta + \mu_2 \delta^2$

TABLE 7 INPUT DATA

UPPER TORSO/STEERING SYSTEM PROPERTIES
(9 Fields of 8)

Field	Name of Quantity	Units	Description
1-2			Name assigned to upper torso material (blank if rigid)
3	SCENTX	inches (cm)	Distance from center of semicircle of upper torso to the center line (negative if the center is in front of center line).
4	SCENTZ	inches (cm)	Along center line distance (from joint 2) to the center of upper torso semicircle.
5	RHOI(2), ρ_2	inches (cm)	Radius of semicircle of the top of upper torso for contact surface.
6	SZETAI(1), ξ_{10}	inches (cm)	Distance from center line to contact surface of upper torso (negative value).
7	SCMU(2,1), μ_0		Constant friction coefficient.
8	SCMU(2,2), μ_1	1/in (1/cm)	Linear friction coefficient.
9	SCMU(2,3), μ_2	1/in ² (1/cm ²)	Second order friction coefficient.

- NOTE: 1. See Card 805 Note.
 2. See Figure 62 for definition of SCENTX, SCENTZ, ρ_2 , ξ_{10} .

TABLE 7 INPUT DATA

MIDDLE TORSO/STEERING SYSTEM PROPERTIES
(9 Fields of 8)

Field	Name of Quantity	Units	Description
1-2			Name assigned to middle torso material (blank if rigid)
3	SZETAI(2), ξ_{12}	inches (cm)	Distance from center line to contact surface of middle torso (negative value).
4	SCMU(3,1), μ_0		Constant friction coefficient.
5	SCMU(3,2), μ_1	1/in (1/cm)	Linear friction coefficient.
6	SCMU(3,3), μ_2	1/in ² (1/cm ²)	Second order friction coefficient.

NOTE: 1. See Card 805 Note.
 2. See Figure 62 for definition of ξ_{12} .

TABLE 7 INPUT DATA

LOWER TORSO/STEERING SYSTEM PROPERTIES
(9 Fields of 8)

Field	Name of Quantity	Units	Description
1-2			Name assigned to lower torso material (blank if rigid)
3	SZETAI(3), ξ_{14}	inches (cm)	Distance from center line to contact surface of lower torso (Negative).
4	SCMU(4,1), μ_0		Constant friction coefficient.
5	SCMU(4,2), μ_1	1/in (1/cm)	Linear friction coefficient.
6	SCMU(4,3), μ_2	1/in ² (1/cm ²)	Second order friction coefficient.

NOTE: 1. See Card 805 Note.
 2. See Figure 62 for definition of ξ_{14} .

TABLE 7 INPUT DATA

FRONT LINE INTERSECTION POINTS
 (9 Fields of 8)

Field	Name of Quantity	Units	Description
1	SCSI(1), x_1	inches (cm)	Distance from point 1 to the center line of the upper torso.
2	SZETA(1), ξ_1	inches (cm)	Distance from joint 2 along the center line of upper torso to point 1.
3	SCSI(2), x_2	inches (cm)	Distance from point 2 to the center line of the middle torso.
4	SZETA(2), ξ_2	inches (cm)	Distance from joint 3 along the center line of the middle torso to point 2.
5	SCSI(3), x_3	inches (cm)	Distance from point 3 to the center line of the lower torso.
6	SZETA(3), ξ_3	inches (cm)	Distance from joint 4 along the center line of the lower torso to point 3.
7	SCSI(4), x_4	inches (cm)	Distance from point 4 to the center line of lower torso.
8	SZETA(4), ξ_4	inches (cm)	Distance from joint 5 along the center line of the lower torso to point 4.

NOTE: Points 1, 2, 3 and 4 and the signs of x_j , ξ_j see Figure 62.

TABLE 7 INPUT DATA

STEERING WHEEL MATERIAL CARD
(9 Fields of 8)

Field	Name of Quantity	Units	Description
1-2			Name assigned to material of steering wheel edge.
3-4			Name assigned to material of steering wheel center.
5-6			Name assigned to material of hub

NOTE: Leave field blank for rigid material.

TABLE 7 INPUT DATA

REACTION MATERIAL NAMES

(9 Fields of 8)

Field	Name of Quantity	Units	Description
1-2			Name assigned to material for force resistance at F_{A1} .
3-4			Name assigned to material for moment resistance at M_{J1} .
5-6			Name assigned to material for force resistance at F_{A2} .
7-8			Name assigned to material for moment resistance at M_{J2} .

NOTE: Leave field blank for rigid material.

TABLE 7 INPUT DATA

STEERING ASSEMBLY SYSTEM AND BODY MATERIAL PROPERTIES

Field	Name of Quantity	Units	Description
NOTE: Reaction material properties are specified in the same manner as contact region material properties. See cards 405-408 for format.			

MVMA 2-D Model
Cards 812-817

TABLE 7 INPUT DATA

UNLOADING CURVES
(3 Fields of 8)

NOTE: Steering system material unloading curves are specified in the same manner as curves for contact region materials. See Card 413 for format.

TABLE 7 INPUT DATA

AIRBAG SYSTEM SUBTITLE
(3 Fields of 8)

Field	Name of Quantity	Units	Definition
1-3	STITLE (31 - 35)		Run subtitle for Airbag Restraint System Input Block Centered in columns 1-17

NOTE: See note on Card 800

TABLE 7 INPUT DATA

AIRBAG SYSTEM PARAMETERS
(9 Fields of 8)

Field	Name of Quantity	Units	Definition	Defaults
1	INIT		Switch to initialize values (Set = 0.0).	0.
2	RLTHET	Degrees	Angle of reference line, counterclockwise from +x	161.
3	WIDTH	inches (cm)	Bag width.	36. 91.44 1.
4	PRMTOL	inches (cm)	Perimeter iteration tolerance.	2.54 1.
5	ITRTOP		Maximum iteration count.	30.
6	BPERIM	inches (cm)	Bag perimeter when fully inflated.	75.4 191.5
7	BGPRSS	lbs/in ² (N/cm ²)	Pressure differential necessary to burst membrane.	2. 1.38
8	ORFICE	in ² (cm ²)	Area of one deflation orifice (Two orifices assumed).	12. 71.4
9	BGXCOR	inches (cm)	X coordinate of bag attachment point in vehicle system.	20. 50.8

TABLE 7 INPUT DATA

AIRBAG SYSTEM PARAMETERS CONTINUED
 (9 Fields of 8)

Field	Name of Quantity	Units	Definition	Default
1	BGZCOR	inches(cm)	Z coordinate of bag attachment point in vehicle system -3!	40.
2	GASTMP	Fahrenheit deg.(Celsius deg.)	Temperature of supply gas.	4.4
3	OCCWID(1)	inches(cm)	Occupant head width.	8.
4	OCCWID(2)	inches(cm)	Occupant shoulder width.	20.
5	OCCWID(3)	inches(cm)	Occupant torso width.	50.8
6	OCCWID(4)	inches(cm)	Occupant hip width.	20.
7	OCCWID(5)	inches(cm)	Occupant thigh width.	50.8
8	BFRIMP		Bag fire Impulse. (not used)	20.
9	TBGFR	msec	Bag fire time.	50.8

TABLE 7 INPUT DATA
 AIRBAG SYSTEM PARAMETERS CONTINUED
 (9 Fields of 8)

Field	Name of Quantity	Units	Definition	Defaults
1	RX	ft-lb/lbm°F(Joules/kg°C)	Gas Constant	55.15
2	PEX	lb/in ² (N/cm ²)	Exhaust Pressure (one atmosphere)	296.7
3	GAMMB		Ratio of Specific Heats (C_p/C_v)	14.7
4	TAU	sec	Decay Time (not used)	10.135
5	CP	BTU/lbm°F(Joules/gm°C)	Specific Heat at Constant Pressure	1.
6	SPSI	deg	Roof angle with respect to vehicle X-axis. 150.	0.25
7	RHEAD	in(cm)	Average head radius.	1.0465
				6.
				15.24

TABLE 7 INPUT DATA

AIRBAG MASS INFUX RATE VERSUS TIME
(1 Field of 8)

Field	Name of Quantity	Units	Definition
1		lb.	Number of time - rate pairs

NOTES: 1. Data follows on succeeding cards, four time - rate pairs per card starting in Field 1, BTIM and MDOT alternating in the first eight fields.

2. Mass rate units are 1b/sec(kg/sec) and time is msec.

TABLE 7 INPUT DATA

SUPPLY GAS TEMPERATURE VERSUS TIME
(1 Field of 8)

Field	Name of Quantity	Units	Definition
1			Number of time-temperature pairs.

NOTES: 1. Data follows on succeeding cards, four time-temperature pairs per card starting in Field 1, TTIM and TEMPS alternating in the first eight fields.

2. Temperature is °F(°C) versus time in msec.

TABLE 7 INPUT DATA

BAG POROSITY VERSUS PRESSURE DIFFERENTIAL
(1 Field of 8)

Field	Name of Quantity	Units	Definition
1			Number of pressure-porosity pairs.

- NOTES:
1. Data follows on succeeding cards, four pressure-porosity pairs per card starting in Field 1, DELTAP and PERM alternating in the first eight fields.
 2. Pressure units are lb/ft^2 (N/cm^2). Porosity units are $ft^3/ft^2/min$ ($m^3/m^2/min$).

MVMA 2-D Model
Card 906

TABLE 7 INPUT DATA

AIRBAG OCCUPANT CONTACT REFERENCE POINTS (CARD 1)
(8 Fields of 8)

Field	Name of Quantity	Units	Definition
1	CSI(1), ξ_1	inches(cm)	Distance along centerline from reference joint (see card 909) to contact reference point 1.
2	ZETAI(1), ξ_1	inches(cm)	Distance perpendicular to centerline from reference joint (see card 909) to contact reference point 1.
3	CSI(2), ξ_2	inches(cm)	See Field 1 (Reference Point 2)
4	ZETAI(2), ξ_2	inches(cm)	See Field 2 (Reference Point 2)
5	CSI(3), ξ_3	inches(cm)	(Not used.)
6	ZETAI(3), ξ_3	inches(cm)	(Not used.)
7	CSI(4), ξ_4	inches(cm)	See Field 1 (Reference Point 4)
8	ZETAI(4), ξ_4	inches(cm)	See Field 2 (Reference Point 4)

NOTE: See Figure 46 and figure on Card 909.

TABLE 7 INPUT DATA

AIRBAG OCCUPANT CONTACT REFERENCE POINTS (CARD 2)
(8 Fields of 8)

Field	Name of Quantity	Units	Definition
1	CSI(5), ξ_5	inches (cm)	(Not used)
2	ZETAI(5), ξ_5	inches (cm)	(Not used)
3	CSI(6), ξ_6	inches (cm)	
4	ZETAI(6), ξ_6	inches (cm)	See Card 907. Reference Points 6 to 8.
5	CSI(7), ξ_7	inches (cm)	
6	ZETAI(7), ξ_7	inches (cm)	
7	CSI(8), ξ_8	inches (cm)	
8	ZETAI(8), ξ_8	inches (cm)	

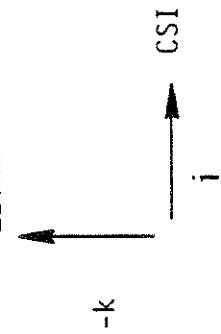
MVMA 2-D Model
Card 908

TABLE 7 INPUT DATA

AIRBAG OCCUPANT CONTACT REFERENCE POINTS (CARD 3)
(4 Fields of 8)

Field	Name of Quantity	Units	Definition
1	CSI(9), ξ_9	inches (cm)	
2	ZETAI(9), ξ_9	inches (cm)	
3	CSI(10), ξ_{10}	inches (cm)	See Card 907 Reference Points 9 and 10
4	ZETAI(10), ξ_{10}	inches (cm)	

Reference Point	Definition	Reference Joint
1	Top of Chest Line	Neck
2	Bottom of Chest Line	Neck
3	Top of Gut Line	Upper Torso
4	Bottom of Gut Line	Upper Torso
5	Top of Pelvis Line	Lower Torso
6	Bottom of Pelvis Line	Lower Torso
7	Top of Upper Leg Line	Hip
8	Bottom of Upper Leg Line	Hip
9	Top of Lower Leg Line	Knee
10	Bottom of Lower Leg Line	Knee



MVMA 2-D Model
Card 909

TABLE 7 INPUT DATA

CONSTANT VALUES
(2 Fields of 8)

Fields	Name of Quantity	Units	Description
1	n		Decimal number for n, $1 \leq n \leq 100$
2	CVALUE(n)		A constant which is to be used directly in the Input, Execution, or Output Processors

NOTES:

- 318.1
1. Cards 999 provide a means for the user to enter values in a standard manner via the Input Processor for use by user-modified program code in subroutines of the Input, Execution, or Output Processors. It is necessary only to add the common block COMMON/VALUES/CVALUE(100) to the affected routines. Comment statements in subroutines INMMMA, READIN, and OUTMM regarding definition of elements of the CVALUE array should be kept up to date as uses of the array are changed.
 2. Units for all CVALUE entries should be in Newtons, meters, and seconds for metric system simulations and in pounds, inches, and seconds for English system simulations.
 3. Card 999 may be used only with Version 3.

8/6/80

MVMA 2-D Model
Card 999

318.2

8/6/80

TABLE 7 INPUT DATA

"GO CARD" DESCRIPTION

This "Go-Card" has no fields. It serves to let the model know that a complete data set has been submitted and to start model execution. This card must be present in the deck.

TABLE 7 INPUT DATA

CATEGORY SELECTION AND ORDERING SPECIFICATION
 (Free Format, Columns 1-72)

Specifications are made by using a string of intermixed entries which are either individual listings ("a" below) or contiguous range listings ("b" below) ordered as desired.

- (a) "NN," where NN is a one or two digit number in the range 0 to 50 with or without leading zeroes. The comma appears literally for punctuation.
- (b) "NN-NN," where NN is as above and the hyphen appears for punctuation. The first number may be larger or smaller than the second.

NOTES

1. Blanks are ignored
2. If card 1001 and 1002 are both missing or blank, the default cards below are used.
3. If card 1001 has -lbb (b=blank) in first four columns, the default ordering is used minus printout of input data summary (category 0).
4. Cols. 1 to 72 of Card 1002 are treated as 73 to 144 of Card 1001.
5. The comma is not necessary in the last specification on the two cards.
6. See Card 1001, 1002 writeup in Section 3.2.

DEFAULTS

1001	0,1,46-48,10-14,21,22,37,5,38,49,50,15,23-26,2-4,18-20,33-36,30-32,16,
1002	27-29,39,17,40,6-9,45

MVMA 2-D Model
 Cards 1001, 1002

TABLE 7 INPUT DATA

PRINTOUT CONTROLS
(2 Fields of 8)

Field	Name of Quantity	Units	Definition	Defaults
1	IDB		Switch = 0. no detailed HIC printout 1. print details of HIC scan.	0.
2	K0		0. if separate printout of peak and 3 msec accel calculation is not desired. switch = #0. is logical device number that this information is to be put on.	0.
3	NIXP		Switch = 0. Do not repeat filtering or computation of special indices if previously done. 1. Repeat using new specifications.	0.
4	FENSOR	in (cm)	Distance from hip joint to sensor located on upper leg center- 13.5 line.	13.5 (34.29)
5	SKMASS	lb sec ² /in (kg)	Upper leg mass between sensor and knee.	.015 (2.627)

MVMA 2-D Model
Card 1003

TABLE 7 INPUT DATA

FILTER AND HIC CONTROLS
(8 Fields of 8)

Field	Name of Quantity	Units	Definition	Defaults
1	NPP		NPP is number of filter weights. Number of points used in filtering each point is $2 * NPP + 1$.	40.
2	FC	Hz	Filter Cut-Off Frequency	500.
3	FT	Hz	Filter Roll-Off Frequency	560.
4	MIRROR	-	Switch = 0. if extension for filtering at data endpoints is by polar 0. Switch ≠ 0. if extension is by mirror image	
5	FRAK	-	Fraction of max HIC below which scanning is stopped.	0.85
6	NUSE	-	No. of pts. to be used for HIC	201.
7	NFLT	-	No. of points the T1 of a HIC duration is indexed	5.
8	NSCN	-	No. of points the T2 of a HIC duration is indexed	5.

NOTE: The supplied values of NPP, FT, FC must satisfy the following relationships:

$$1. \quad FC \leq \frac{.5}{DT}$$

2. $NPP * DT * (FT - FC) \geq \begin{cases} 2 & \text{for } 1\% \\ 3 & \text{for } 1/2\% \end{cases}$ expected error
3. $NPP \leq 500$

where DT is the value specified in the original input deck on Card 101, field 7 converted to seconds.

MVMA 2-D Model
Card 1004

TABLE 7 INPUT DATA

JOINT RELATIVE ANGLE TEST VALUES
(2 Fields of 8)

Field	Name of Quantity	Units	Definition
1	RAH (I)	deg	High Test Value
2	RAL (I)	deg	Lower Test Value

NOTE: 1. Card 1100 I=1 Head-Neck (Upper Neck)
 1101 I=2 Neck-upper Torso (Lower Neck)
 1102 I=3 Upper Torso-Middle Torso (Upper Spine)
 1103 I=4 Middle Torso-Lower Torso (Lower Spine)
 1104 I=5 Upper Leg-Lower Torso (Hip)
 1105 I=6 Lower Leg-Upper Leg (Knee)
 1106 I=7 Upper Arm-Upper Torso (Shoulder)
 1107 I=8 Lower Arm-Upper Arm (Elbow)

2. No defaults

TABLE 7 INPUT DATA

STANDARD LIST TEST VALUES (CARD 1)
(9 Fields of 8)

Field	Name of Quantity	Units	Description
1	TESTV(1)	g's	Head frontal acceleration test value
2	TESTV(2)	g's	Head vertical acceleration test value
3	TESTV(3)	g's	Head resultant acceleration test value
4	TESTV(4)	deg/sec ²	Head angular acceleration test value
5	TESTV(5)	sec	HIC
6	TESTV(6)	lbs(N)	Face load
7	TESTV(7)	in(cm)	Chest deflection
8	TESTV(8)	lbs(N)	Chest load
9	TESTV(9)	g's	Chest frontal acceleration test value

NOTE: 1. If a test value is set zero or left blank, the corresponding comparison will not be made.

2. No defaults.

MVMA 2-D Model
Card 1200

TABLE 7 INPUT DATA
STANDARD LIST TEST VALUES (CARD 2)
(9 fields of 8)

Field	Name of Quantity	Units	Description
1	TESTV(10)	g's	Chest vertical acceleration test value
2	TESTV(11)	g's	Chest resultant acceleration test value (3 msec. average)
3	TESTV(12)	sec	Chest frontal Severity Index test value
4	TESTV(13)	sec	Chest vertical Severity Index test value
5	TESTV(14)	sec	Chest resultant Severity Index test value
6	TESTV(15)	g's	Pelvic Horizontal acceleration test value
7	TESTV(16)	g's	Pelvic vertical acceleration test value
8	TESTV(17)	g's	Pelvic resultant acceleration test value
9	TESTV(18)	lbs(N)	Femur load at sensor test value

NOTE: See note for card 1200.

MVMA 2-D Model
Card 1201

TABLE 7 INPUT DATA

STANDARD LIST ELLIPSE SPECIFICATIONS
 { 4 fields of 8 }

Field	Name of Quantity	Units	Description
1-2			Name of 'face' ellipse
3-4			Name of 'chest' ellipse

Note: No Defaults

TABLE 7 INPUT DATA

TYPE A COMPARISONS
(8 Fields of 8)

Field	Name of Quantity	Units	Description
1	-	-	Category number of quantity
2	-	-	Column number of quantity
3-4	-	-	Name of first identifier
5-6	-	-	Name of second identifier
7	Various	High test value	
8	Various	Low test value	

Note: No Defaults

MVMA 2-D Model
Card 1300

TABLE 7 INPUT DATA

TYPE B COMPARISON (CARD 1)
(7 Fields of 8)

Field	Name of Quantity	Units	Description
1	-		Category Number of First Quantity
2	-		Column Number of First Quantity
3-4	-		Name of first identifier of First Quantity
5-6	-		Name of second identifier of First Quantity
7	-		Number used to match with 1401 Card and order pair in printout. If left zero, assigned in order of physical position among no match 1400 cards

Note: No Defaults.

MVMA 2-D Model
Card 1400

TABLE 7 INPUT DATA

TYPE B COMPARISON (CARD 2)
(7 Fields of 8)

Field	Name of Quantity	Units	Description
1	-		Category Number of Second Quantity
2	-		Column Number of Second Quantity
3-4	-		Name of First Identifier of Second Quantity
5-6	-		Name of Second Identifier of Second Quantity
7	-		Number used to match with 1400 Card and order pair in printout. If left zero, assigned in order of physical position among no match 1400 cards

Note: No Defaults

MVMA 2-D Model
Card 1401

TABLE 7 INPUT DATA

STICK FIGURE CONTROL PARAMETERS (CARD 1)
 (9 Fields of 8)

Field	Name of Quantity	Units	Description	Defaults
1	IZERO	-	Switch = 0. if zero coordinate lines desired 1. if not desired	0.
2	IPP	-	Switch = 0. if printer plot desired based on input values 1. if not desired	0.
3	XMIN	in (cm)	Value of X at left margin of plots.	-33. (-83.8)
4	XMAX	in (cm)	Value of X at right margin of plots.	70. (177.8)
5	ZMIN	in (cm)	Value of Z at bottom margin of plots	20. (50.8)
6	ZMAX	in (cm)	Value of Z at top margin of plots	-50. (-127.)
7	NOP	in (cm)	Switch = 0. if no filler points to be plotted >0. = number of filler symbols to be plotted every 10 in. (10 cm) of scaled length.	5.
8	IBELT	-	Switch = 0. to plot belt anchors and attachments >0. for no plot of belt anchors and attachments.	0.

NOTE: $X_{MAX} > X_{MIN}$ and $Z_{MIN} < Z_{MAX}$ since the x-axis points right and the z-axis points down. If the respective condition is not met; X_{MAX} and/or Z_{MIN} is adjusted to provide the default plot range (103 in. (261.6 cm) for X and 70 in (177.8 cm) for Z).

MVMA 2D Model
Card 1500

TABLE 7 INPUT DATA

STICK FIGURE CONTROL PARAMETERS (Card 2)
(9 Fields of 8)

Field	Name of Quantity	Units	Description	Defaults
1	ISTEP	-	Number of plots to be printed. The maximum number is 27 (not including plots based on input).	11.
2	IELLIP	-	Switch = 0. if contact ellipse positions are desired 1. if not desired	0.
3	HEDRAD	in(cm)	Switch = 0. do not plot circle around head c.g. >0. radius of circle around head c.g.	6. (15.24)
4	IBAG	-	Switch = 0. plot airbag perimeter if present 1. do not plot airbag perimeter	0.
5	IMHEEL	-	Switch = 0. plot steering col outline if present 1. do not plot steering col outline	0.
6	ICNTCT	-	Switch = 0. plot line segments of contacts 1. do not plot contacts	0.
7	METH	-	Switch = 0. if time points to be specified on 1502 cards 1. if time points to be generated.	1.
8	FIRST	msec	Time at which first plot is desired.	0.
9	DELTA	msec	Time increment between plots. (if zero, all recorded plots will be made.)	0..

NOTE: Fields 8 & 9 ignored if field 7 = 0. If field 7 = 0, the time points specified on 1502 cards must be integral multiples of the output plot increment in field 9 of Card 101.

MVMA 2-D Model
Card 1501

TABLE 7 INPUT DATA

STICK FIGURE TIME POINT SPECIFICATION
(9 Fields of 8)

Field	Name of Quantity	Units	Description
I = 1,..,9	POINTS (9N+I-1)	SEC	Time at which plot desired

where I = field number
 N = total number of 1502
 cards occurring in the deck before this card.

NOTE: 1. Limit of 27 time points can be specified and they must be specified in order.

2. No defaults
3. Time points must be integral multiples of the output plot increment in field 9 of Card 101.

MVMA 2-D Model
Card 1502

TABLE 7 INPUT DATA

"GO CARD" DESCRIPTION

This "Go-Card" has no fields. It serves to let the output processor know that the input data is complete and start execution. This card must be present in the deck.

MVMA 2-D Model
Card 1600

3.2 DETAILED DESCRIPTION OF INPUT DATA QUANTITIES

This section of the report includes material to supplement Table 7 of Section 3.1. Answers to many questions that will arise during preparation of input data sets will be found here. This section is necessarily relatively brief, however. If a user's question is not adequately answered in this section, it is suggested that reference be made to the 397-page Tutorial System Self-Study Guide [8]. The focus of the Tutorial System is preparation of input data sets. It provides the user with detailed information about all aspects of the simulation model and also gives general guidance in proper use of the model for predicting occupant dynamics. Tables 8 and 9, which follow, are an index to use of the Tutorial System Self-Study Guide.

DATA CARDS REFERENCED BY MODULES

Module	Data Cards Referenced
2	201-217, 303, 227-238
3	201-203, 205-217, 227, 228, 233, 235-242, 303
4	102, 103, 106, 219-226, 402, 412, 903, 907-909
5	102, 103, 106, 219, 401-412
6-1	103, 219, 221-226, 401, 403-408, 702-716
6-2	102, 103, 219, 222, 401, 402, 404, 409, 410, 412, 605, 606, 705
7	205, 206, 215, 216, 301-304, 409, 1501, 1502
8	601-606
9	102, 218, 501, 701-723
10	102, 411, 901-909
11	-
12	101, 102, 104, 105, 107-111, 218, 1000-1004, 1100-1107, 1200-1202, 1300, 1400, 1401, 1500-1502, 1600

Table 8. Data Cards Referenced By Tutorial System Modules.

DATA CARD FIELDS
AND REFERENCING MODULES

Card	Field								
	1	2	3	4	5	6	7	8	9
101	12	12	12	12	12	12	12	12	12
102	9,12	10,12	12	4	4,5	4	6-2	12	12
103	6-2	6-2	6-1	6-1	6-2	5	5	4	4
104	12	12	12	12	12	12	12	12	12
105	12	12	12	12	12	12	12	12	12
106	4,5	4,5	4,5	4,5					
107	12	12	12	12	12	12	12	12	12
108	12	12	12	12	12	12	12	12	12
109	12	12	12	12	12	12	12	12	12
110	12	12	12	12	12	12	12	12	12
111	12	12	12	12					
201	2,3	2	2	2	2		2	3	3
202	2,3	2,3	2	2	2	2	2	2	3
203	2	2	2	2	2	2	2	2	2,3
204	2	2	2	2	2	2	2	2	
205	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3,7	2,3
206	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3,7	2,3
207	2	2	2	2	2	2	2	2	2
208	2	2	2	2	2	2	2	2	2
209	2	2	2	2	2	2	2	2	2
210	2	2	2	2	2	2	2	2	2
211	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3
212	2	2	2	2	2	2	2	2	2

Table 9. Data Card Fields Referencing Modules (Page 1 of 6)
(Tutorial System)

Card	Field								
	1	2	3	4	5	6	7	8	9
213	3	3	3	3					
214	3	3	3	3			3		3
215	2,3	2,3	2,3	2,3	2,3	2,3	2,3,7	2,3	2,3
216	2,3	2,3	2,3	2,3	2,3	2,3	2,3,7	2,3	2,3
217	2	2	2	2	2	2	2,3	2	
218	12	12	12	9	9	9	9	9	9
219	4	4	4,6-1	4,6-1	4	4,5,6-2			
220	4	4	4	4	4	4			
221	4,6-1	4,6-1	4,6-1	4,6-1	4,6-1	4,6-1	4,6-1	4,6-1	4,6-1
222	4,6-1	4,6-1	4,6-2				4,6-1	4,6-1	4,6-1
223	4,6-1	4,6-1	4,6-1						
224	4,6-1	4,6-1	4,6-1						
225	4,6-1	4,6-1	4,6-1	4,6-1	4,6-1	4,6-1	4,6-1	4,6-1	
226	4,6-1	4,6-1	4,6-1	4,6-1	4,6-1	4,6-1	4,6-1	4,6-1	
227	2,3	2,3	2,3	2,3	2,3				
228	2,3	2,3	2,3	2,3	2,3				
229	2	2	2	2	2				
230	2	2	2	2	2				
231	2	2	2	2	2				
232	2	2	2	2	2				
233	2,3	2,3	2,3	2,3	2,3				
234	2	2	2	2	2				
235	2,3	2,3	2,3	2,3	2,3				

Table 9. Data Card Fields Referencing Modules (page 2 of 6)

Card	Field								
	1	2	3	4	5	6	7	8	9
236	2,3	2,3	2,3	2,3	2,3				
237	2,3	2,3	2,3	2,3	2,3				
238	2,3	2,3	2,3						
239	3	3							
240	3	3							
241	3	3							
242	3	3	3	3					
301	7	7	7	7	7	7	7	7	7
302	7	7	7	7	7	7	7	7	7
303	7	7	7	7	2,3,7	3,7			
304	3,7	7	3,7	7					
401	5	5	5,6-1	5,6-1	5,6-2	5,6-2	5,6-2	5,6-2	
402	5	5	5	4,5,6-2	5,6-2	5	5		
403	5,6-1	5,6-1	5,6-1	5,6-1	5,6-1	5,6-1	5,6-1	5,6-1	5,6-1
404	5,6-1	5,6-1	5,6-2	6-2	6-2	6-2	5,6-1	5,6-1	5,6-1
405	6-1	6-1	6-1						
406	6-1	6-1	6-1						
407	6-1	6-1	6-1	6-1	6-1	6-1	6-1	6-1	
408	6-1	6-1	6-1	6-1	6-1	6-1	6-1	6-1	
409	5	5	5	5	5,6-2,7	6-2	5	5	
410	5	5	5	6-2	6-2	6-2	6-2		
411	5	5	5	5,10	5,10	5	5	10	
412	4,5,6-2	4,5,6-2	4,5,6-2	5,6-2	5,6-2				

Table 9. Data Card Fields Referencing Modules (page 3 of 6)

Card	Field								
	1	2	3	4	5	6	7	8	9
501	9	9	9	9	9	9	9	9	
601	8	8	8	8	8	8	8	8	
602	8	8	8						
603	8	8	8						
604	8	8							
605	6-2,8	6-2,8	6-2,8	6-2,8	6-2,8				
606	6-2,8	6-2,8	6-2,8						
701	9	9	9	9	9	9	9		
702	6-1,9	6-1,9	9	9	9	9	9	9	
703	6-1,9	6-1,9	9	9	6-1,9	6-1,9	9	9	
704	6-1,9	6-1,9	6-1,9	6-1,9	6-1,9	6-1,9	6-1,9	6-1,9	6-1,9
705	6-1,9	6-1,9	6-2,9				6-1,9	6-1,9	6-1,9
706	6-1,9	6-1,9	6-1,9						
707	6-1,9	6-1,9	6-1,9						
708	6-1,9	6-1,9	6-1,9	6-1,9	6-1,9	6-1,9	6-1,9	6-1,9	
709	6-1,9	6-1,9	6-1,9	6-1,9	6-1,9	6-1,9	6-1,9	6-1,9	
710	9	9	9	9	9	6-1,9	6-1,9	9	9
711	9	9	9	9	9	6-1,9	6-1,9	9	9
712	9	9	9	9	9	6-1,9	6-1,9	9	9
713	9	9	9	9	9	6-1,9	6-1,9	9	9
714	9	9	9	9	9	6-1,9	6-1,9	9	9
715	9	9	9	9	9	6-1,9	6-1,9	9	9
716	9	9	9	9	9	6-1,9	6-1,9	9	9

Table 9. Data Card Fields Referencing Modules (page 4 of 6)

Card	Field								
	1	2	3	4	5	6	7	8	9
717	9	9	9	9	9	9	9		
718		9	9						
719	9	9	9	9	9	9	9		
720	9	9	9	9	9	9	9	9	
721	9	9	9	9	9	9			
722	9	9	9	9	9	9			
723	9	9	9	9	9	9			
901	10	10	10	10	10	10	10	10	10
902	10	10	10	10	10	10	10		10
903	10	10	10		10	10	4,10		
904	10								
905	10								
906	10								
907	4,10	4,10	4,10	4,10			4,10	4,10	
908			4,10	4,10	4,10	4,10	4,10	4,10	
909	4,10	4,10	4,10	4,10					
1000	12								
1001	12								
1002	12								
1003	12	12	12	12	12				
1004	12	12	12	12	12	12	12	12	
1100	12	12							
1101	12	12							

Table 9. Data Card Fields Referencing Modules (page 5 of 6)

Table 9. Data Card Fields Referencing Modules (page 6 of 6)

INPUT DATA CARDS

Card 100

This card contains the run title. It is used by the program in the automatic preparation of headings for each page of printed output.

Card 101

The switch MKSSWT instructs the program to interpret input data from all following cards in metric units or English units. The required units for all input values, whether metric or English, are indicated in Table 7. Input units are mixed, e.g., "in" (or "cm") might be required for one value while "ft" (or "m") will be required for another. Internal units, however, are in-lb-sec for a run made in English system units and m-N-sec for a metric system run. See Table 10 for conversion constants.

The integration option indicator, INTOP, should be set equal to 1. at present. The integration subroutine which has been supplied with this program uses a fixed Runge-Kutta approach and is the same one supplied originally with MODROS. If another value is chosen, it will automatically be set to 1.

The quantity, EDEPS, in field 4 is an editing constant. After inversion of the matrix, the resulting accelerations are compared with this value. If they are smaller than EDEPS, they are set to zero. This procedure was developed in previous HSRI models to minimize the effects of truncation, roundoff, inversion, and other types of small errors. The value usually chosen is 0.

METRIC/ENGLISH SYSTEM CONVERSION CONSTANTS

PHYSICAL QUANTITY	CONVERSION RELATION
Length	1 in. = 2.54 cm*
Length	1 ft. = .3048 m*
Length	39.370075 in. = 1 m
Force	1 lb. = 4.4482216 N
Mass	1 lbm = .45359237 kg*
Mass	1 lb-sec ² /in. = 175.12684 kg
Mass	1 slug = 14.593903 kg.
Moment of Inertia	1 lb-sec ² -in = 0.11298483 kg-m ²
Torque	1 lb-in = 0.11298483 N-m
Energy	1 in-lb = 0.11298483 N-m
Linear Spring Coefficient	1 lb/in. = 1.7512684 N/cm
Second Order Coefficient	1 lb/in ² = 0.68947573 N/cm ²
Third Order Coefficient	1 lb/in ³ = 0.27144714 N/cm ³
Fourth Order Coefficient	1 lb/in ⁴ = 0.10686895 N/cm ⁴
Fifth Order Coefficient	1 lb/in ⁵ = 0.042074390 N/cm ⁵
Sixth Order Coefficient	1 lb/in ⁶ = 0.016564721 N/cm ⁶
Pressure	1 lb/in ² = 0.68947573 N/cm ²
Pressure	1 atm. = 14.696 lb/in ² = 1.0132535 x 10 ⁵ N/m ²
Gas Constant	1 ft-lb/(lbm °F) = 5.38032 Joules/(kg °C)
Specific Heat	1 BTU/lb-°F = 1 kg-cal/kg-°C = 4.1868 Joules/gm-°C*
Earth Standard Gravity	1 E.S.G. = 9.80665 m/sec ² * = 32.174049 ft/sec ² = 386.08858 in/sec ²

* Exact conversion

Table 10. Metric/English System Conversion Constants

Beginning time, TB, is usually chosen to be 0.0 msec unless the exercise is a restart. The final time, TF, usually ranges from 150-250 msec for vehicle occupant studies and up to 1 second for pedestrian studies.

The numerical integration step size, DT, is usually selected as 0.001 sec. Smaller sizes have been used in particularly violent dynamic events.

The print time increment, PTINC, in Field 8 is sometimes set to 0.001 sec. For applications where the increment is not so critical, PTINC = 0.005 sec. will produce a complete record of an output subject on one sheet of printed paper for a 200-msec simulation.

Card 102

The first three fields of Card 102 indicate whether belt, airbag, and energy-absorbing steering assembly submodels are to be used. If an option is not desired, it is necessary only to enter a 0 here; the associated submodel parameter cards need not be removed from the data deck.

The fourth, fifth, and sixth fields of Card 102 control inhibitions of contact between body segments and the various regions describing the vehicle. Field 6, ILL, should be selected first. If it is set to 1, contact between body ellipses is not sensed in the program. If it is set to 0, then the setting of LHIB in field 4 controls ellipse contact inhibitions. Some of the Cards 106 contain two ellipse names. If LHIB = 0, these potential contacts are allowed; if LHIB ≠ 0, these contacts are not considered. Field 5 controls the meaning of Cards 106 for region-ellipse contacts. It should be noted that only those contacts which are likely to be important should be included. The more contacts which must be tested, the more complex the algorithm and costly the computer run.

Field 7 contains FNU. This quantity attempts to soften the effect of a discontinuous frictional force. Assume that a normal force begins to move tangentially over a surface. Theory states that a friction force exists

the moment this tangential motion starts. FNU defines a velocity ramp. For zero velocity, tangential friction is zero. For the velocity, FNU, the friction force attains its full value. For tangential velocities between 0 and FNU, the tangential force behaves as a linear function of velocity. (See Section 2.6.6). Values from 1.0 to 10 in/sec are reasonable.

Field 8 contains EPSINV. This quantity is used to sense errors introduced during matrix inversion due to singularity conditions. The quantity is particularly tuned to matrix diagonal quantities which are very small compared with their neighbors. If the matrix tends to singularity, this check will register as a fatal error and execution will be terminated. This value which has been used successfully in HSRI crash victim simulators is 0.000001.

Field 9 contains MX, the execution CPU time limit. This quantity will depend on user experience with the particular simulation event which is being conducted. It is estimated that 2 min. should be sufficient for most purposes.

Card 103

The first, second, and fifth fields define DSTEPX, DSTEPM, and LIMCNT which are used when deflection is shared between a contact ellipse and a region (or other ellipse). The shared deflection problem can be stated as

$$\begin{aligned}F_1(\delta_1) &= F_2(\delta_2) \\ \delta_1 + \delta_2 &= \delta\end{aligned}$$

where

F_1 , F_2 are the forces on the contacting elements,

δ is the total deflection

δ_1 , δ_2 are the deflections of the individual elements.

Without including an elaborate formulation, the shared deflection algorithm can be described as follows. First, a non-zero δ is sensed. It is necessary to balance forces and solve the individual deflections, δ_1 and δ_2 . A function G is defined as follows:

$$G(\delta_1) = F_1(\delta_1) - F_2(\delta - \delta_1)$$

and the algorithm attempts to find δ_1 in the range 0 to δ for which

$$G(\delta_1) = 0.$$

For initial contact, two δ 's are estimated.

$$\delta_{11} = \frac{\delta}{2}, \quad \delta_{12} = \frac{\delta}{4}$$

The quantity G is computed for both. If both G's have the same sign, δ_1 does not lie between δ_{11} and δ_{12} and new δ_{1i} 's must be selected until δ_1 is trapped. When the two G's are of the same sign, then δ_1 is trapped and an interval halving procedure is used to isolate it.

For the case of continuing contact, the following information is available to the program: a new δ as well as δ_1 and δ_2 for the previous time step.

In this case new δ_{1i} 's must be estimated until δ_1 is trapped as described above.

The quantities, δ_{1i} , are estimated using a classical Newton's method.

DSTEPX and DSTEPN are the maximum and minimum allowed trial adjustments of the component deflection values at any iteration step. Values of .2 and .02 are virtually always suitable. The number of iterations allowed, LIMCNT, should be about 20. The zero of $G(\delta_1)$ is usually found in fewer than 10 iterations. LIMCNT is essentially the limit of the subscript i in δ_{1i} .

Fields 3 and 4 contain FORLIM and HARDCN which relate to the contact between two elements specified to be "rigid." In reality the model treats rigid members as extremely stiff elastic-plastic solids. The linear elastic constant, HARDCN, is usually chosen to be 15,000 lb/in while FORLIM often limits the value of the resulting contact force to 100,000 lb.

Fields 6 and 7 contain TPC and EPSFAC which are used when contact region line segments are specified to move as a function of time (See Figure 32). They are introduced to avoid abrupt changes in velocity at line segment corner points. The quantity EPSFAC is the number of integration time steps over which the maximum ramp length connecting the two velocity levels is specified. The quantity TPC defines the ramp length on the basis of a percentage of the time between t_1 and t_2 . The quantity, ϵ , shown in Figure 32 is defined as

$$\epsilon = \min \{ TPC \times (t_2 - t_1), EPSFAC \times \Delta t \}$$

The usual value for TPC is 0.05 (5% of the ramp) and 10 for EPSFAC which allows a change of velocity to become complete within 5 msec if the integration time step is selected to be 0.5 msec.

Fields 8 and 9 contain the geometric quantities BETELP and GAMELP which relate to ellipse contact. Because the true ellipse contact problem involves an extremely complex algorithm, HSRI has chosen to replace all ellipses by

special circles thus leading to an important reduction in computer exercise costs. If the ellipse is nearly a circle (if the ratio of the shorter to the longer semi-axis is nearly unity), the ellipse is simply replaced by a circle placed at the ellipse center. The ratio of axis lengths (the level of the desired approximation) is controlled by the input quantity BETELP. HSRI usually sets BETELP at least as large as 0.75, usually 1.0.

If the ratio of the semi-axes is less than BETELP, a circle with a radius equal to the shorter semi-axis is allowed to migrate along the major axis essentially sweeping out a rectangle capped with semi-circular ends. This geometric figure replaces the ellipse. In a way this is similar to the straight line techniques used in ROS but without the attendant analytical problems. The quantity GAMELP controls the extent of the excursion of the circle. When GAMELP = 1, the circle can travel to a point where it is tangent with the end of the ellipse. HSRI practice is to choose GAMELP = 0.9 or higher. See Section 2.6.7 for the analysis and Figure 35 for a schematic.

Cards 104-105

Auxiliary or debugging printout for this program is organized in terms of sixteen four-level switches. Each switch corresponds to a particular section of the program. The levels of a particular switch control the depth of detail of the debugging printout. Examples of hexadecimal debug words for use on the 104-105 cards as well as a complete description of the output available using this technique are included as Section 4.3.5 of this report. Because debug printout is specified as a function of time, it is possible to isolate very small time domains for detailed study. This is usually necessary because of the immense amount of printout which can be generated by the debug commands.

Debug printout can be obtained for all four evaluations of derivatives required by the Runge-Kutta integration or only at the final evaluation (at the full time step Δt). If debug printout for the intermediate evaluations is felt unlikely to be of value for a particular run, then the total amount of debug printout can be reduced to one fourth by setting Field 9 of Card 104 to 1. While it is generally true that intermediate evaluations are not important for uncovering a program bug, they can in some cases be of value. A value of 1. is recommended.

Field 9 of Card 105 contains KDIRTP. The packing debug dictionary contains internal references to storage of contact force information and connects these references to external alphabetic titles of contact ellipses and regions. Although this material is not useful in the case of routine exercises, it should be obtained when new simulation problems are initiated or when debug printout is required. A value of 0. is recommended.

Card 106

Each of these cards contains the name of an ellipse attached to the body of the crash victim and either another ellipse or one of the contact regions describing the vehicle. Depending on the settings of KHIB, LHIB, and ILL on Card 102, they may refer to contacts which are allowed or which are disallowed. The most customary practice is to select desired or anticipated contacts and include them on these cards. The general operational philosophy is to use as few contacts as possible thus minimizing run costs.

Cards 107-111

These cards contain switches controlling storage of potential program output quantities. The amount of storage should be kept at a minimum to reduce costs. The actual printout of these classes of variables is controlled by Card 1001 and 1002. Table 11 provides a listing of all output categories.

Category Number	Description
0	Formatted Printout of Input Quantities
1	Vehicle Response
2	Real Line Region Parameters
3	Real Line Region Individual Line Segment Movement
4	Contact Forces Including Occupant-Vehicle, Occupant-Belt, Occupant-Occupant
5	Neck Reaction Forces
6	Unfiltered Body Accelerations (Head, Chest, Pelvis)
7	Filtered Body Accelerations (Head, Chest, Pelvis)
8	Unfiltered Severity Indices
9	Filtered Severity Indices
10	Body Link Angles
11	Body Link Angular Velocities
12	Body Link Angular Accelerations
13	Body Joint Coordinates
14	Body Joint Velocities
15	Body Joint Torques
16	Body Joint Absorbed Energies
17	Body Kinetic Energies
18	Airbag Variables
19	Airbag Contact Forces
20	Airbag Center of Mass Forces and Moments
21	Neck Joint Coordinates
22	Shoulder Joint Coordinates
23	Joint Torque Elastic Components
24	Joint Torque Joint-Stop Components
25	Joint Torque Friction Components
26	Joint Torque Viscosity Components
27	Joint Absorbed Energy Joint Stop Components
28	Joint Absorbed Energy Friction Components
29	Joint Absorbed Energy Viscosity Components
30	Center of Mass X-Component Forces
31	Center of Mass Z-Component Forces

Table 11 List of Output Categories

Category Number	Description
32	Center of Mass Resultant Moments
33	Steering Column Coordinates
34	Steering Column Generalized Coordinates
35	Steering Column Forces and Moments
36	Forces and Moments on Body Due to Steering Column
37	Neck and Shoulder Forces
38	Muscle Tension Forces
39	Muscle Tension Energy Absorption
40	Femur and Tibia Accelerations and Loads
41	Joint Relative Angle Comparisons Against Upper and Lower Test Values
42	Standard List of Quantities to be Compared Against Test Values
43	Individual Type A Comparisons
44	Individual Type B Comparisons
45	Printer-Plots of Stick Figures
46	Head Center-of-Gravity Motion
47	Chest Center-of-Gravity Motion
48	Hip Motion
49	Joint Relative Angles
50	Joint Relative Angle Velocities

Table 11 List of Output Categories

Card 200

This card contains the run subtitle for the occupant parameter input block. It is used by the program in the automatic preparation of headings for each page of printed output.

Cards 201-204

Useful schematics are included as Figures 66 and 67.

Cards 205-216 (plus Card 242)

There are a variety of quantities on these cards which define the geometry and torsional strength properties of the various joint structures. Joint geometry will be discussed followed by a discussion of joint torque generation.

Figure 68 is a sketch of a human in a standing position. His body links have been sketched in to show that they are not necessarily in alignment. This factor becomes important in auxiliary programs which compute body link dimensions on the basis of external anthropometric data.

Figure 69 is a schematic representation of the standing man represented by his links and contact circles. In this diagram the misalignment of the links is shown and the misalignment on angular displacement between the upper torso link and the neck link is labeled ZETA.

Figure 70 is a sketch of a human in a seated position. His body links as required for input to the program have been superimposed on the body outline to show their positions. The same considerations apply to sitting position as were discussed for the standing position in Figure 68.

Figure 71 is similar to Figure 69 except that the occupant is seated. It is apparent that the natural angular displacement of the links at the knee and hip are different for the seated position and the standing position. Distinction between seated and standing positions becomes necessary when the simulation is used to characterize vehicle occupants and pedestrians.

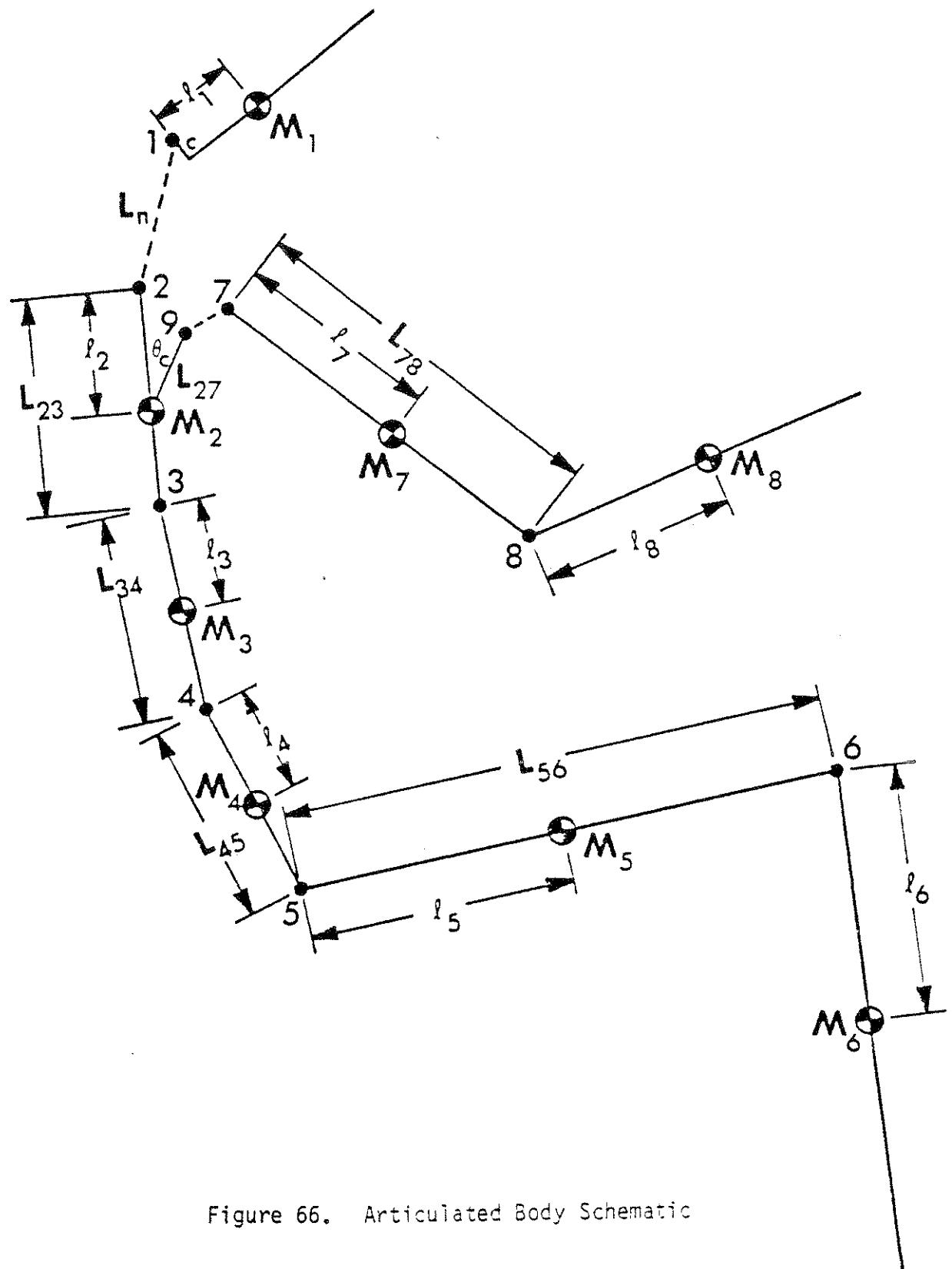
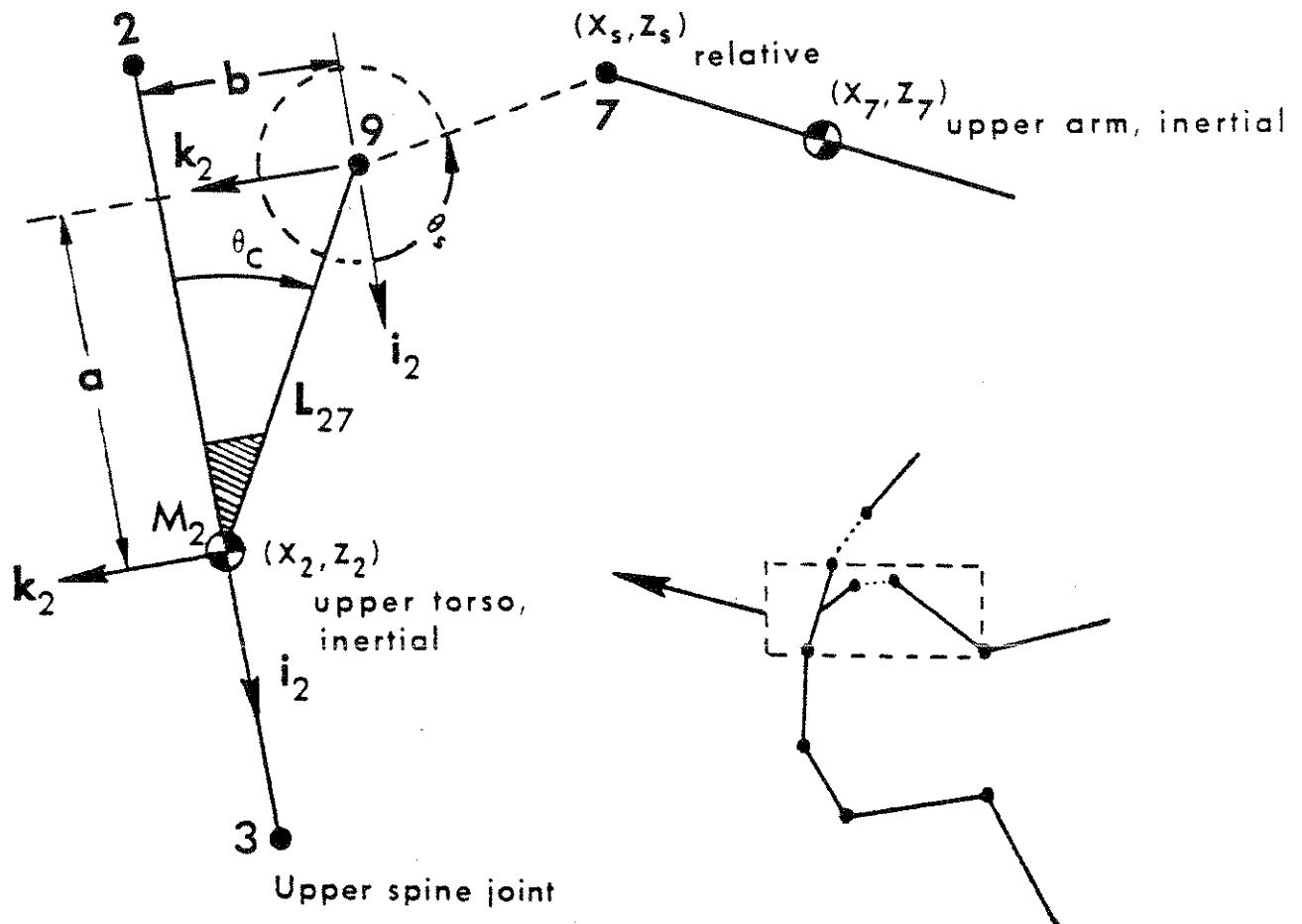


Figure 66. Articulated Body Schematic

Lower neck joint



$$\vec{x}_{9 \rightarrow 7} = x_s i_2 + z_s k_2$$

θ_c = constant

L_{27} = constant

Figure 67. Shoulder Joint

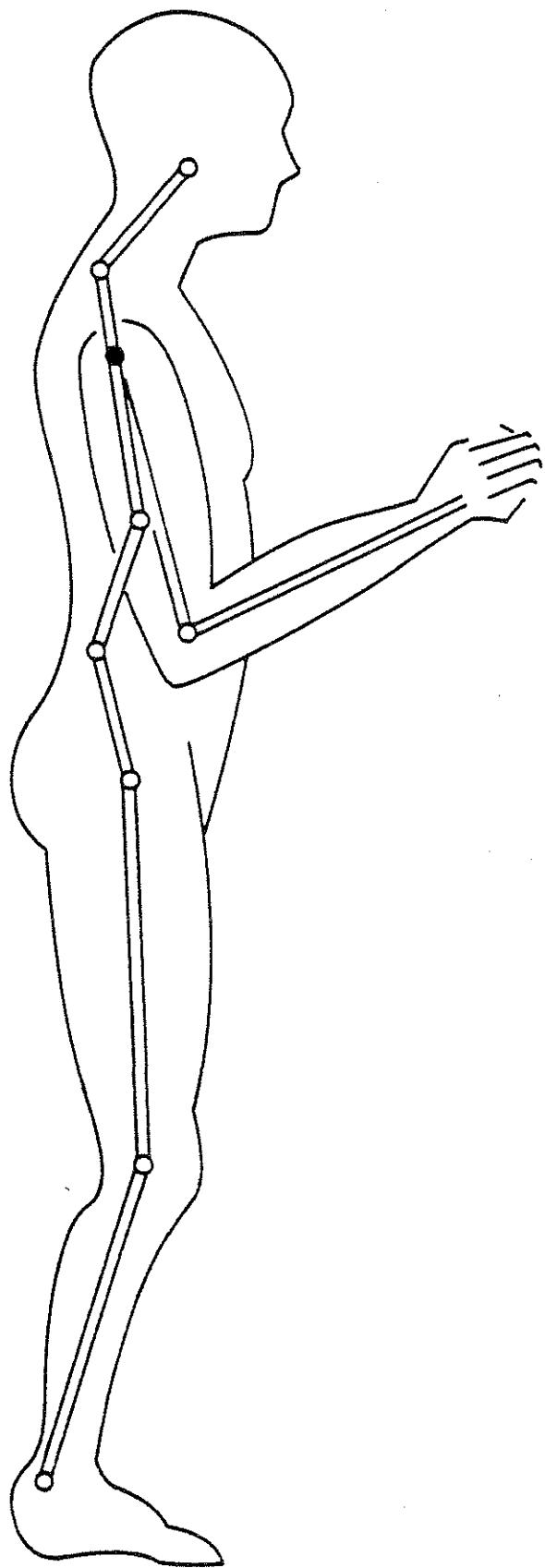


Figure 68. Standing Position

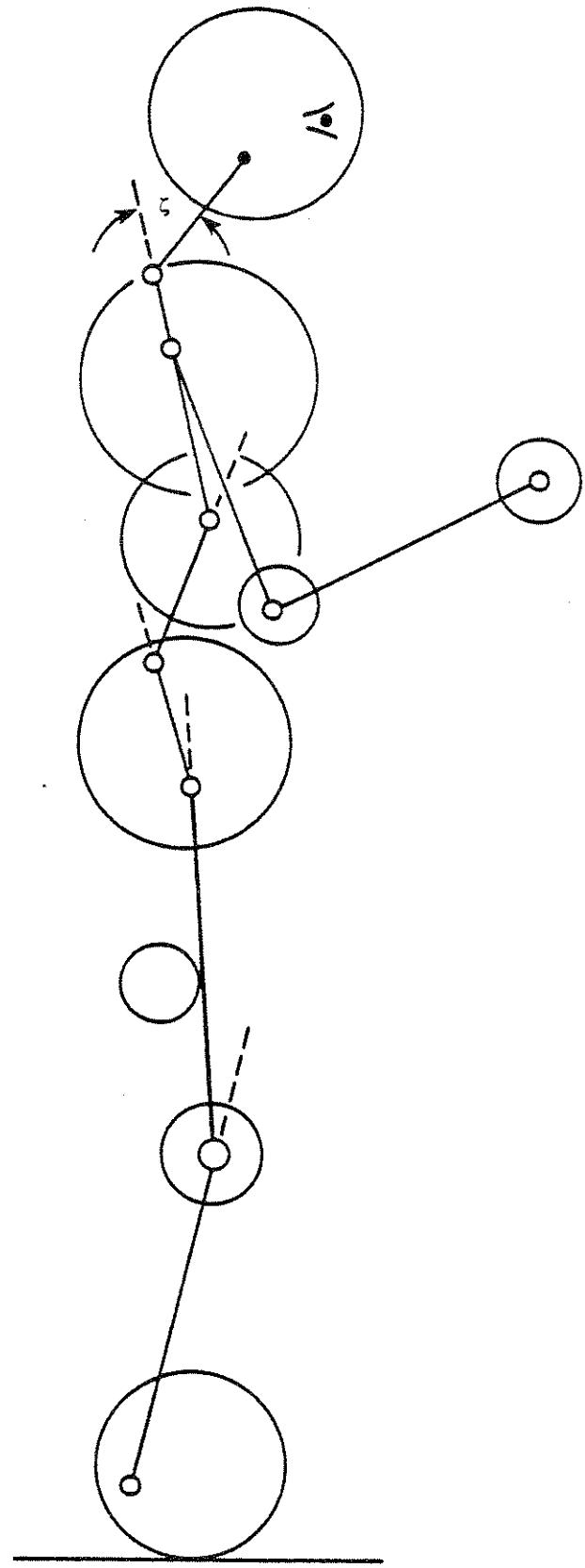


Figure 69. Schematic Representation of Man

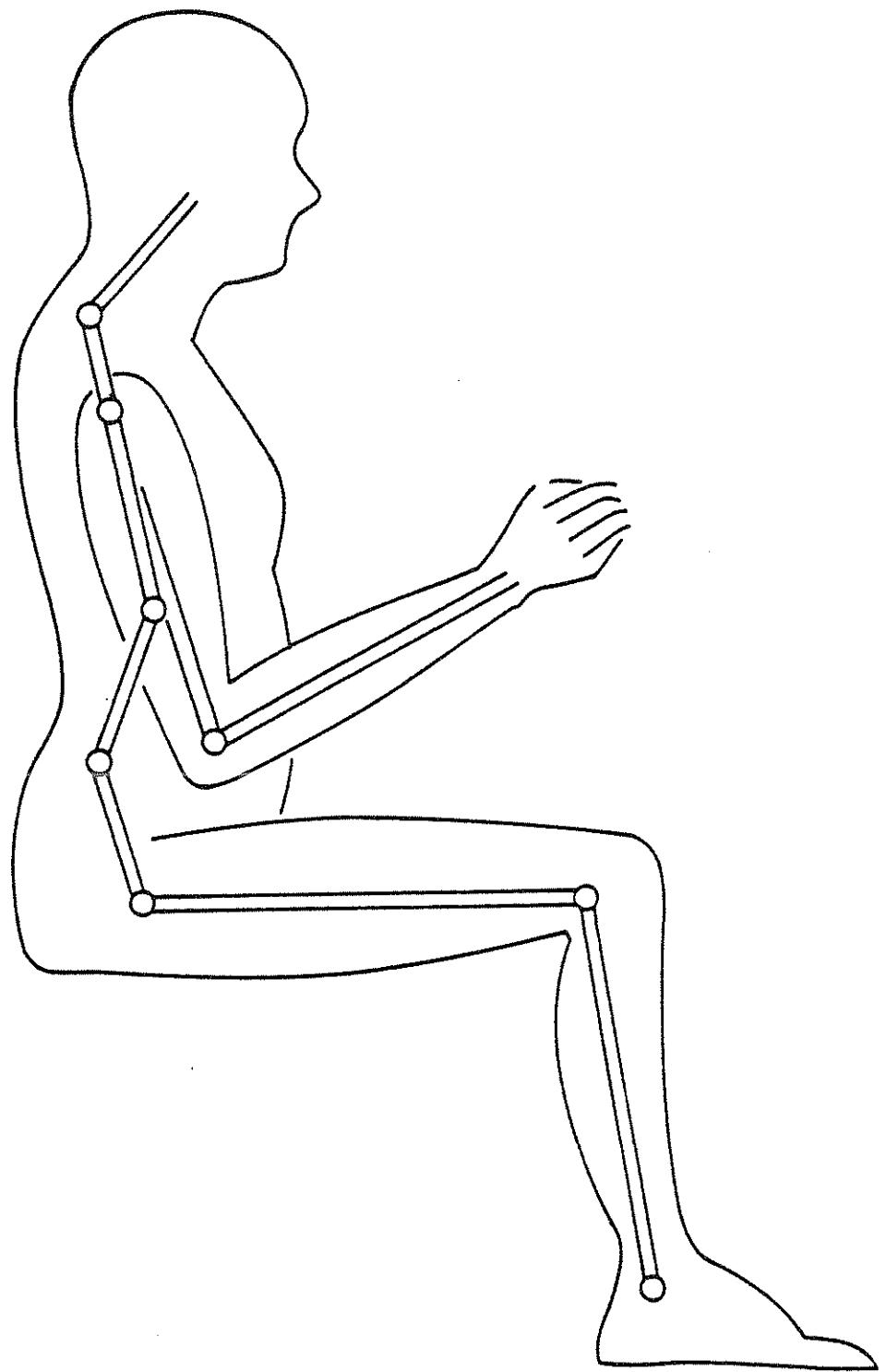


Figure 70. Sitting Position

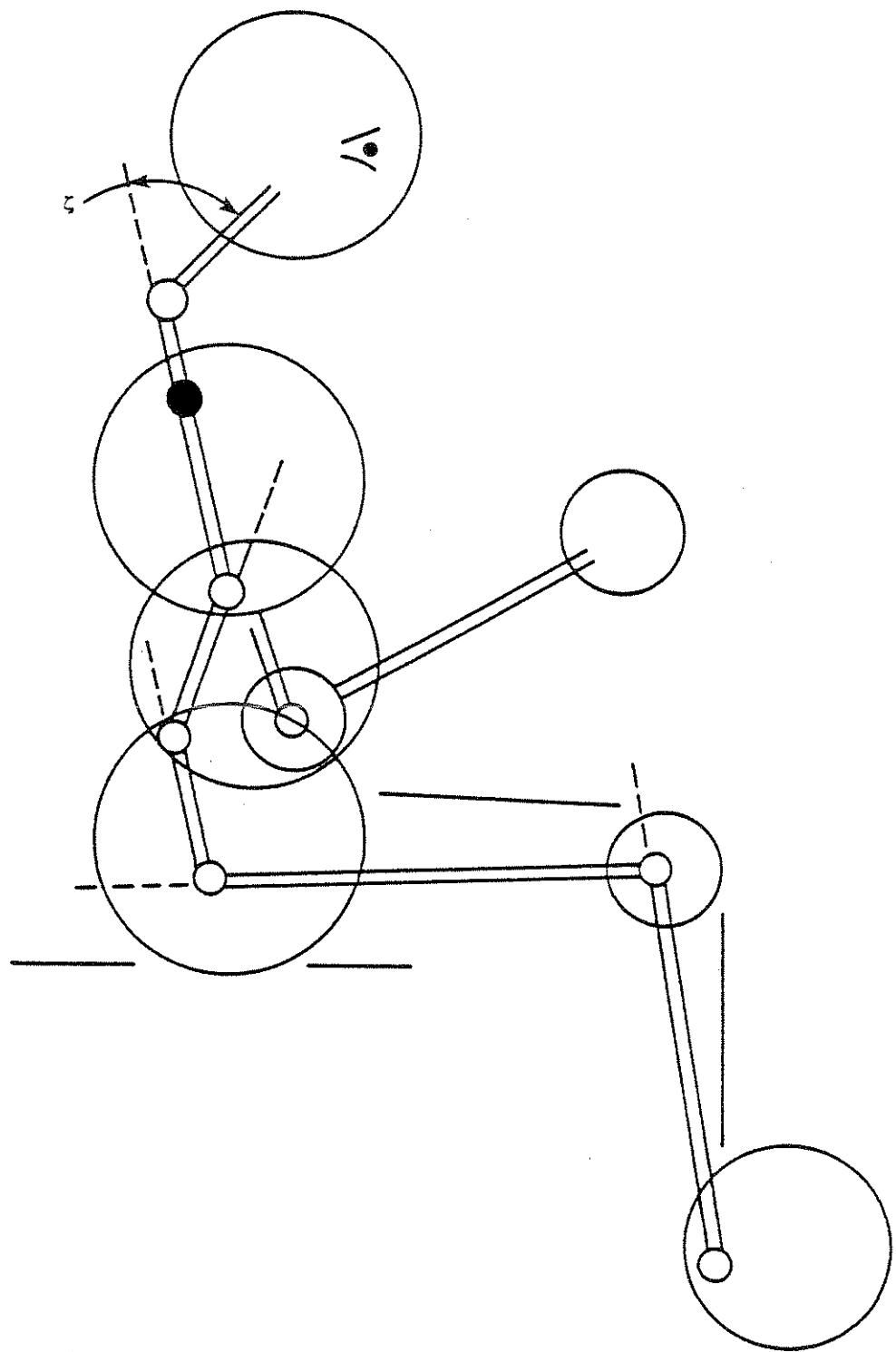


Figure 71. Schematic Sitting Position

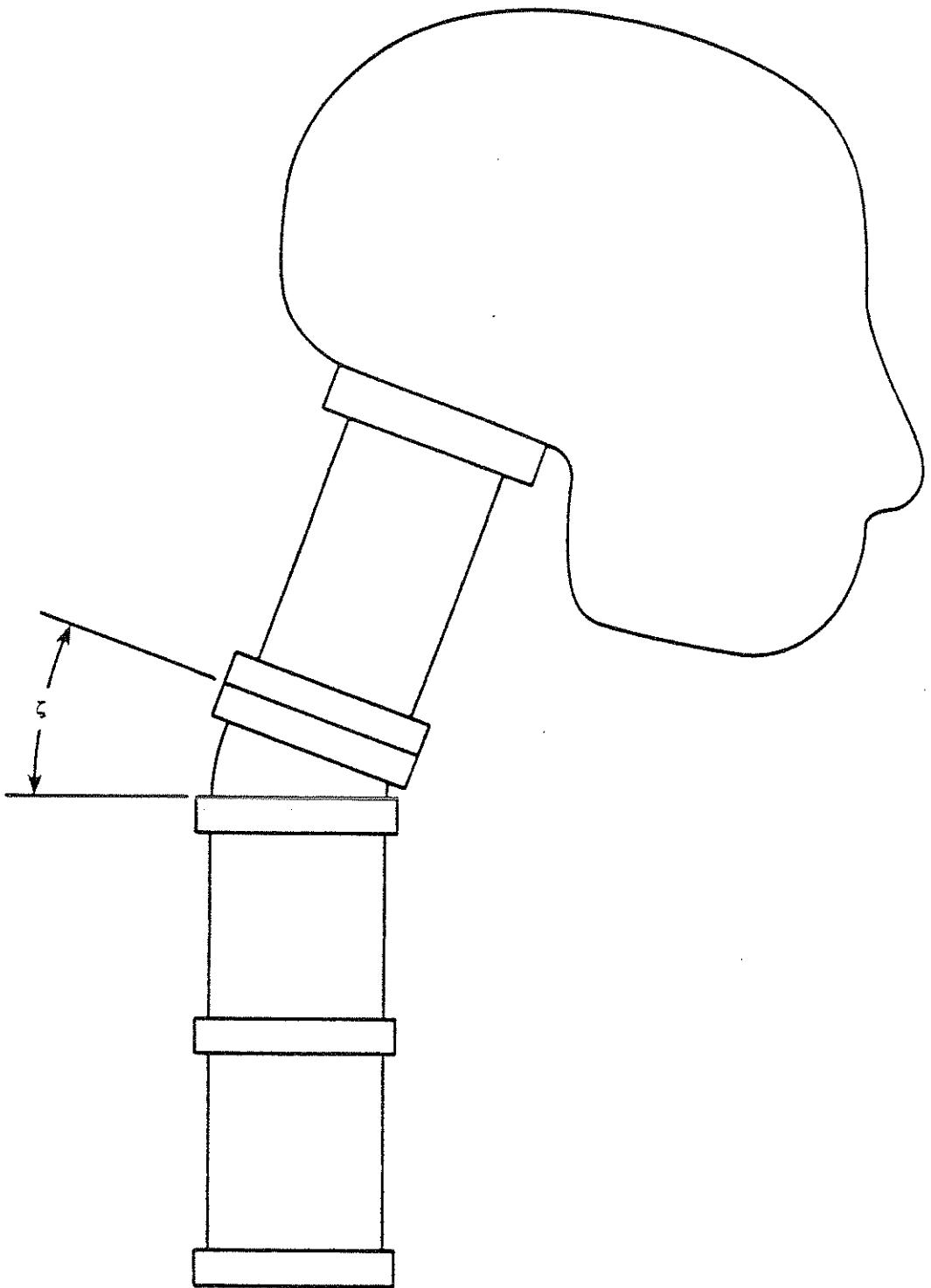


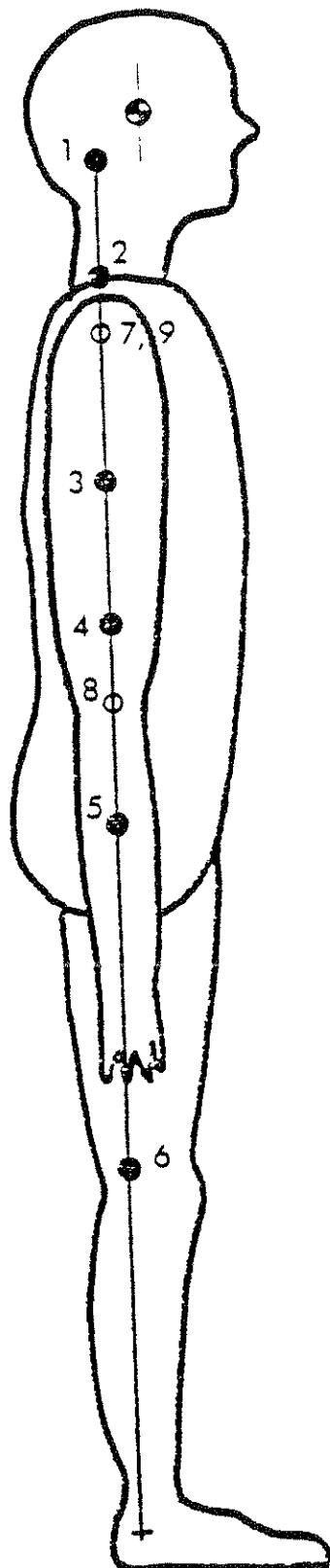
Figure 72. Provision for "Natural" Link Orientation

Figure 72 shows how natural link orientation might be obtained in the construction of a dummy which employs an assemblage of symmetrical jointed links. Namely, interconnecting flanges of appropriate angular sweep could be used between the links. This feature would allow the joint to be at rest in a natural position without exerting a torque. In actual dummy construction, the individual links might incorporate the angular characteristics required at each end. This figure is included only to point out that both dummies and the mathematical models of humans must accommodate the natural angular displacement of the links when the human is at rest.

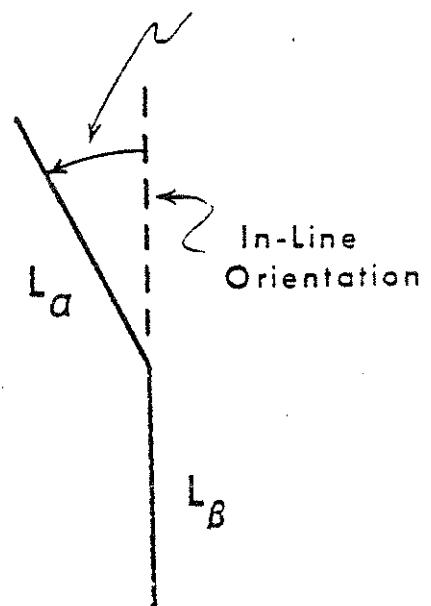
On Cards 205-216, joint-stop angles and a "natural link angle" must be prescribed for each joint. All are prescribed as "relative angles."

Figure 73 defines, for the purposes of this discussion, the relative angular displacements between two adjacent links. Figure 74 illustrates the definitions of joint-stop angles and the "natural link angle." Consider the joint between body links " L_α " and " L_β ." Here, " α " shall designate the link nearer to the head and " β " the link nearer to the feet. The upper and lower joint-stop angles and the "natural link angle" are defined by counterclockwise (positive) rotation of L_α with respect to L_β , as shown in the Figures. Positions of L_α requiring clockwise rotation are described by negative angles.

Field 1 of Cards 205-212 and 215-216 contains KJI(I,1). If positive, this is the linear coefficient of an elastic torque generated when two links move away from their "natural" link orientation defined above. If negative, the magnitude is taken as a linear joint-stop spring stiffness. Quadratic and cubic joint-stop stiffnesses are in fields 2 and 3.



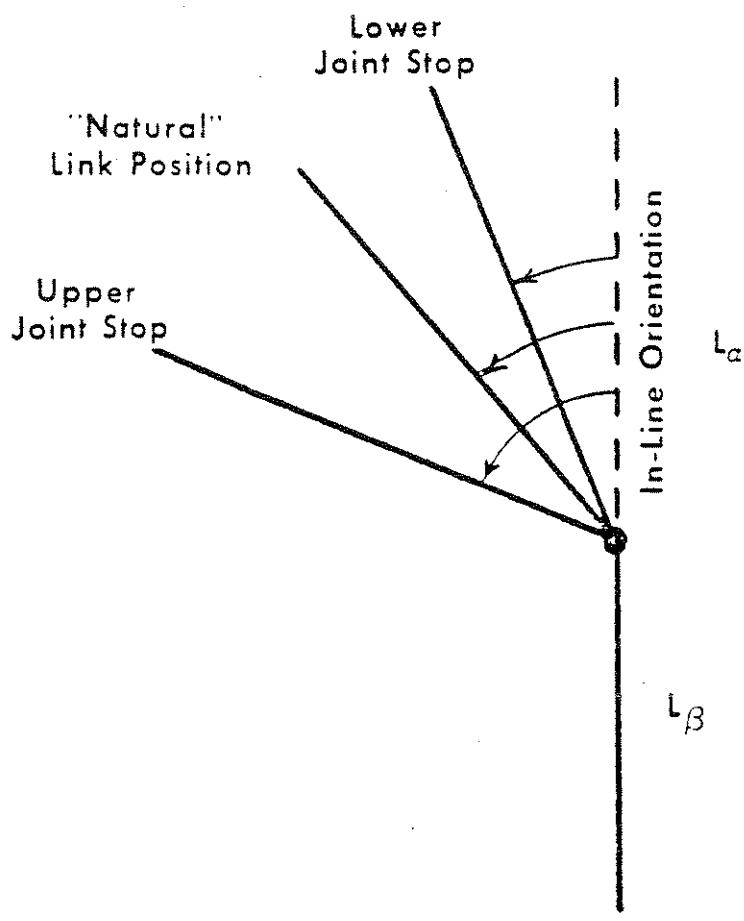
Positive Relative Angle



L_a = body link nearer to head

L_b = body link nearer to feet

Figure 73. In-line Orientation



(α, β) - joint

L_α = body link nearer
to head

L_β = body link nearer
to feet



+ rotation

Figure 74. Definition of joint stop angles and natural link position

Field 4 on these cards contains a viscous damping constant. The damping torque generated at a joint is

$$T_i^v = C_i^j \dot{\theta}_i^v ,$$

where T_i^v is the torque, C_i^j is the damping constant, and $\dot{\theta}_i^v$ is the relative angular velocity between the two adjacent body elements.

Fields 5 and 6 define the joint constant friction properties of the crash victim as shown in Figure 7. When the relative angular velocity between the two adjacent body segments exceeds the threshold velocity V_i^J , the frictional torque, F_i^J , is applied to resist the motion.

Fields 7 and 8 on cards 205-212 and 215-216 define the location of upper and lower joint stops. Field 9 defines the ratio of conserved to stored energy in the stops. It is used in the computation of an unloading curve.

Cards 213, 214, and 242 contain similar quantities for elongation and compression of the neck and shoulder elements. Analogies with the quantities on Cards 205-212 and 215-216 do not always hold strictly. First, there is no "stop" for the neck element. It might be considered that there is a stop at zero elongation since the quadratic and cubic deflection coefficients take effect immediately with deviation from the initial neck length (Field 5 of Card 303), but no conserved-absorbed energy ratio (Field 9) is used. Energy can be dissipated through viscous damping for both the neck and shoulder element, but there is no constant friction. The shoulder element does have a stop (RSR), i.e., an elongation at which a conserved-absorbed energy ratio takes effect along with a stiffening of the deflection curve (the quadratic and cubic deflection coefficients). The neck element behaves differently in elongation and compression if the coefficients on Cards 213 and 242 differ.

Card 217

Fields 1-7 on Card 217 define the "natural" link displacements for the joints. When relative joint angles equal these "rest angles," the joint torques due to linear spring forces are zero. It should be noted that this natural angle does not have to correspond to the initial position of the crash victim. The "natural" angle is described in Figure 74.

Card 218

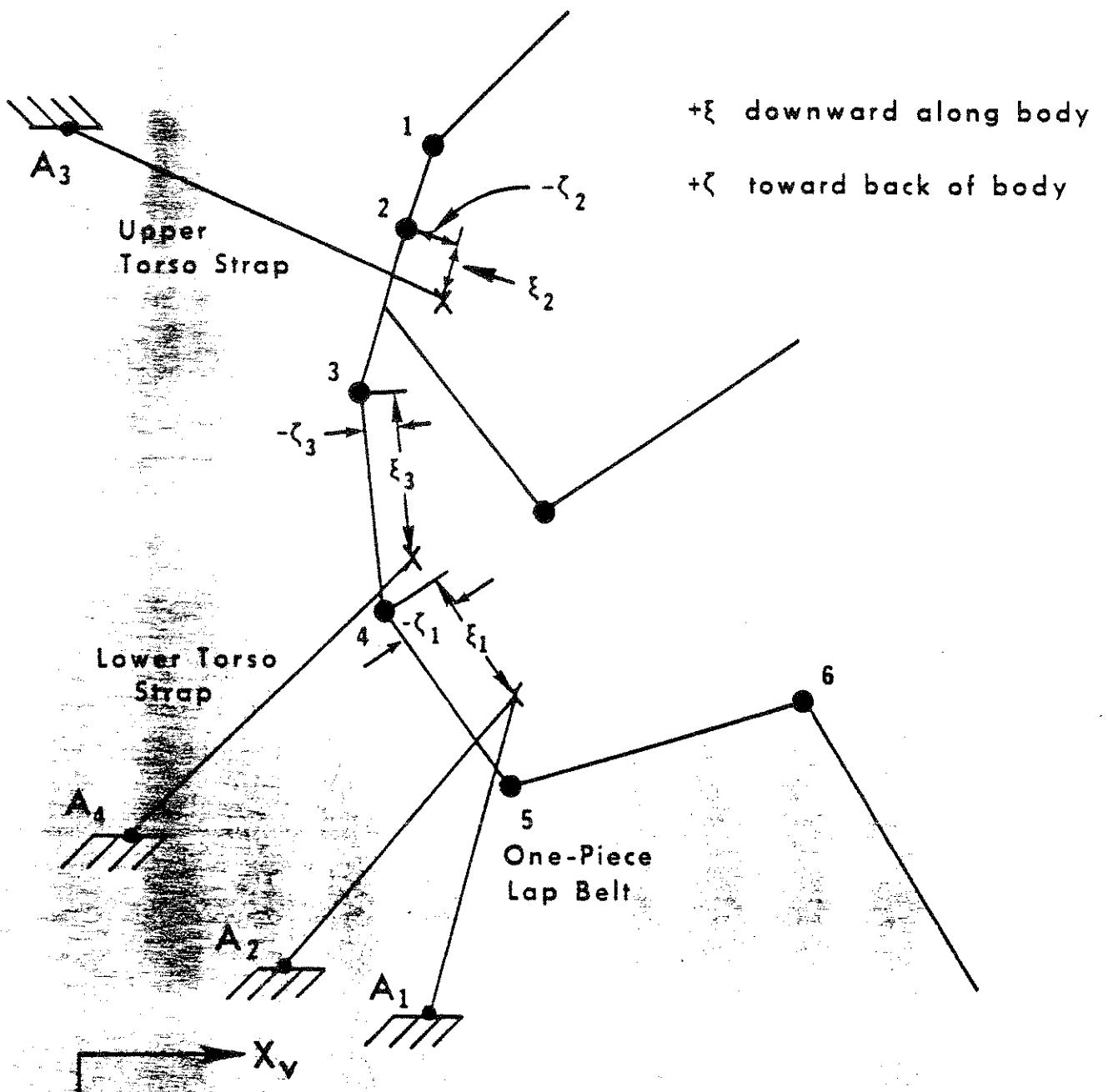
Self-contained. (See Figure 75.)

Card 219

This card and at least two following it should be included for each contact-sensing ellipse attached to the crash victim. This first contains an ellipse name used in output headings, the name of the material defining the force-deformation characteristics of the ellipse, the body element on which the ellipse is attached, and the friction class. A friction class number is assigned to each ellipse and each contact region. For each pair of friction class numbers, a friction constant is assigned (see Card 412).

Card 200

This card locates the ellipse with respect to the center of gravity of the particular body segment to which it is attached. Fields 3 and 4 locate the center of the ellipse while fields 4 and 6 determine the semi-axes of the ellipse which are located parallel to the moving coordinate system attached to each body element. Figure 76 illustrates the definition of these various parameters.



The attachment point (ξ_3, ζ_3) is illustrated for lower torso belt attachment to the middle torso element. In general this belt may be attached to any torso element and the coordinates (ξ_3, ζ_3) are specified with respect to the upper joint of the element to which it is attached.

Figure 75. Three-Belt System Geometry

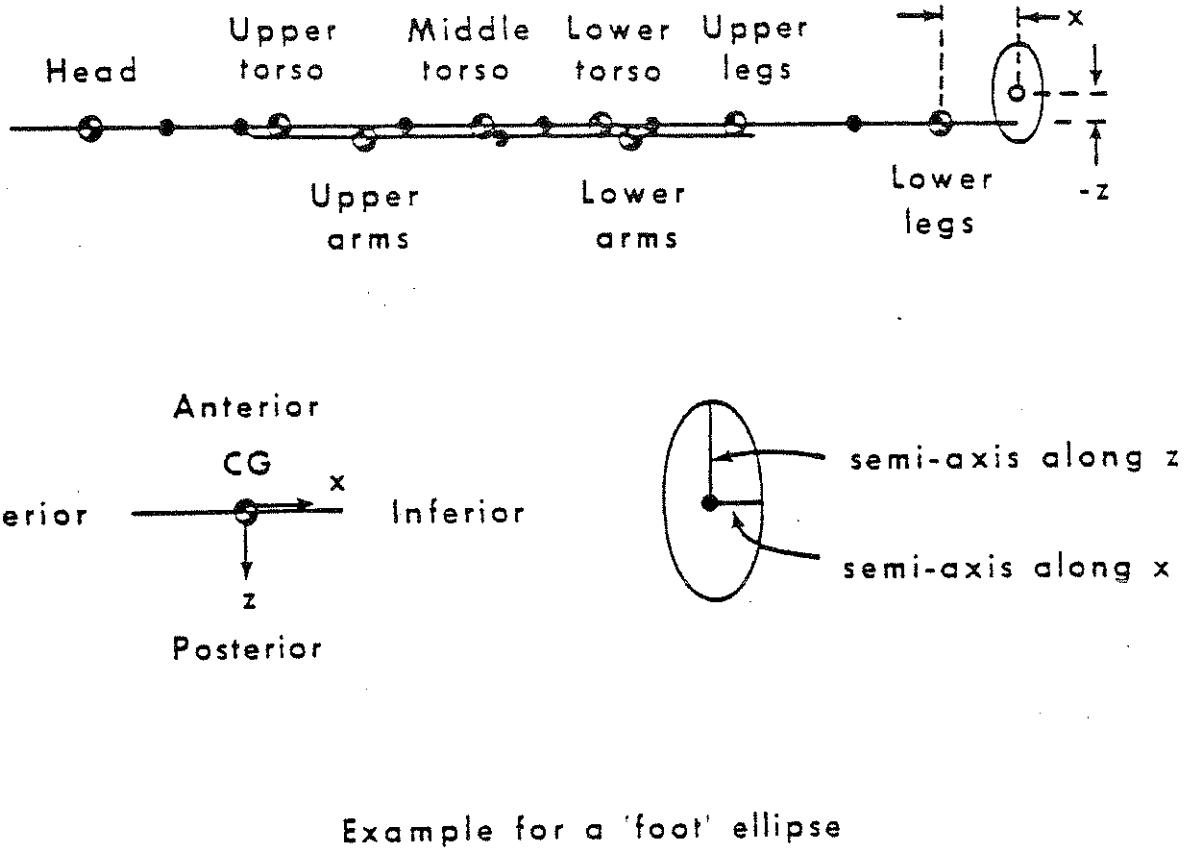


Figure 76. Definition of Location and Dimensions of Contact-Sensing Ellipses

Cards 221-226

See Cards 403-408.

Cards 227-238

Cards 227-237 contain the muscle element coefficients a_1 , a_2 , a_3 , which, together with the tabular time-dependent muscle tensions $|M|$ from 238-Cards, define the Maxwell coefficients of the composite musculature at a joint. This is discussed in Section 2.3.2.

The literature does not at present contain a great deal of experimental information relating to the values a_1 , a_2 , a_3 , and $M(t)$. HSRI has successfully used values determined by Bowman [10] from certain published data for the knee and by scaling on the basis of available anthropometric data. The available values which are pertinent to the MVMA 2-D simulation are given below. $|M|_{max}$ in each instance is the maximum degree of muscle contraction by an average man. Figure 77 pertains to scaling of these data.*

Upper neck joint and lower neck:

$$a_1 = 1.476 \text{ lb in/deg}$$

$$a_2 = 0.153 \text{ deg}^{-1}$$

$$a_3 = 0.0129 \text{ sec/deg}$$

$$|M|_{max} = 210 \text{ lb in}$$

Shoulder-upper torso joint:

$$a_1 = 0.15 \text{ lb in/deg}$$

$$a_2 = 0.153 \text{ deg}^{-1}$$

$$a_3 = 0.0129 \text{ sec/deg}$$

$$|M|_{max} = 5 \text{ lb in}$$

Neck element elongation:

$$a_1 = 42.3 \text{ lb/in}$$

$$a_2 = 4.4 \text{ in}^{-1}$$

*L is the effective moment arm at a joint for action of a muscle.

$a_3 = 0.37 \text{ sec/in}$

$|M|_{\max} = 210 \text{ lb}$

*Shoulder-upper torso joint:

$a_1 = 0.15 \text{ lb in/deg}$

$a_2 = 0.153 \text{ deg}^{-1}$

$a_3 = 0.0129 \text{ sec/deg}$

$|M|_{\max} = 5 \text{ lb in}$

*Shoulder element elongation:

$a_1 = 4.23 \text{ lb/in}$

$a_2 = 4.4 \text{ in}^{-1}$

$a_3 = 0.37 \text{ sec/in}$

$|M|_{\max} = 200 \text{ lb}$

Knee:

$a_1 = 10.44 \text{ lb in/deg}$

$a_2 = 0.105 \text{ deg}^{-1}$

$a_3 = 0.0088 \text{ sec/deg}$

$|M|_{\max} = 4320 \text{ lb in (two knees together)}$

Cards 239-241

Since shoulder flexibility may be more restricted in some directions than in others (See Section 2.3.1) allowance has been made for angular dependence of the stiffness coefficients for elongation of the shoulder element. Periodic tables may be entered by use of Cards 239-241.

Card 242

See the last paragraph of the section describing Cards 205-216.

Card 300

This card contains the run subtitle for the occupant orientation input block. It is used by the program in the automatic preparation of headings for each page of printed output.

* The shoulder muscle tension parameter values are little better than guesses.

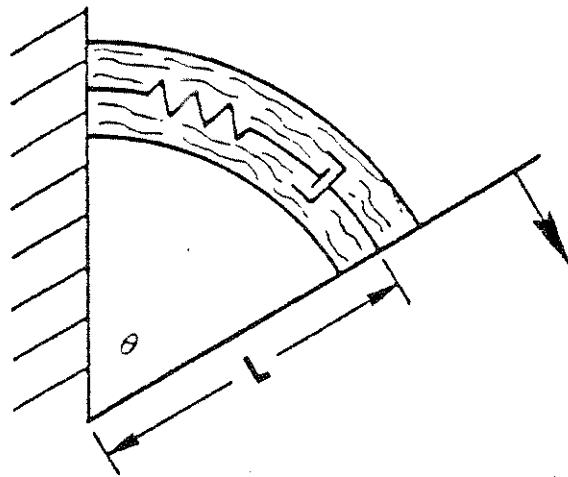


Figure 77. Muscle at a joint

SCALING LAWS RELATING MUSCLE PARAMETERS

FOR JOINTS I AND II:

$$a_{1,II} = \left(\frac{L_{II}}{L_I} \right)^2 a_{1,I} - \frac{|F_{max,II}|}{|F_{max,I}|}$$

$$a_{2,II} = \left(\frac{L_{II}}{L_I} \right) a_{2,I}$$

$$a_{3,II} = \left(\frac{L_{II}}{L_I} \right) a_{3,I}$$

$$\text{where } |F_{max,j}| = |M_{max,j}| / L_j.$$

NOTE: I and II indicate either two joints for the same individual or the same joint for two individuals. $M_{max,j}$ is the maximum static torque that can be voluntarily generated at joint j. $F_{max,j}$ is the maximum static tension that can be generated in the muscle element under the same conditions. For scaling from individual to individual for the same joint, $|F_{II}|/|F_I|$ can reasonably be taken as $(m_{II}/m_I)^{\frac{2}{3}}$, where m is total body mass.

Card 301

This card contains the initial body link angles. They are computed relative to the null position shown in Figures 78 and 79. Two examples are also shown in Figure 79, an upright occupant position with arms extended and a representative seated position. The angles included in the tabular output use this same convention.

In auxiliary debug output, the angles are computed using a different convention. The null position is shown in Figure 80 as well as the values corresponding to the seated example of Figure 79.

Card 302

Self-contained (See Card 301)

Cards 303-304

Self-contained. (See Figure 67 for X_s and Z_s .)

Card 400

This card contains the run subtitle for the input block used to describe the shape and physical properties of the vehicle interior. It is used by the program for the automatic preparation of headings for each page of printed output.

Cards 401-402

These two cards which must be supplied for each contact region contain the control switches which select the various contact force generation options available with the program.

Each contact region is given a region name and a name for the material properties as specified in Fields 1-4 of Card 401. The switch in Field 5 selects the force generation model to be used. The standard model (switch = 0) uses techniques similar to MODROS and older HSRI models. That is, line segments within a region deform independently for each impinging contact-sensing ellipse and continuity is not maintained between adjacent line segments within a region. The force-deformation curve may be tabular, polynomial or a combination. The standard force-deformation model does have the advantages of the real-line

$$\theta_1, \theta_2, \theta_3, \theta_4, \theta_5, \theta_6, \theta_7, \theta_8, \theta_n = 0 \quad (\text{input or output})$$

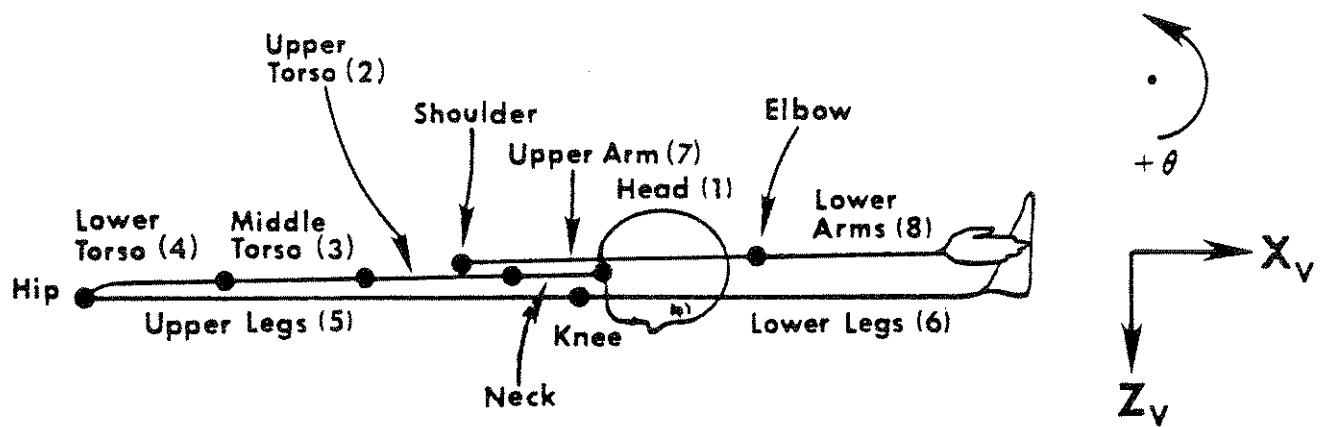
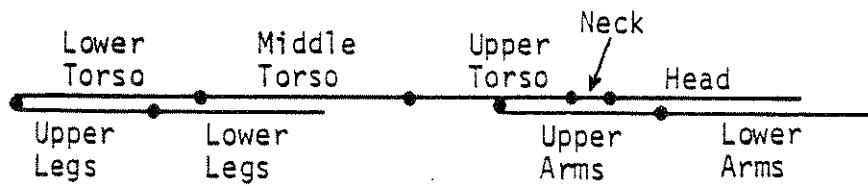
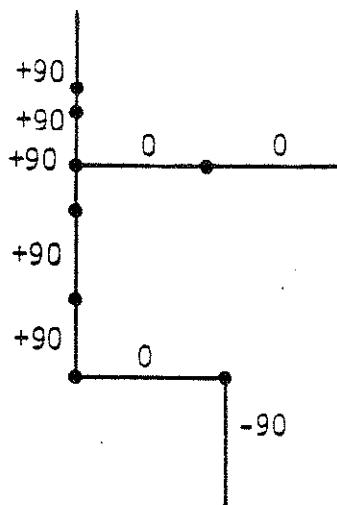


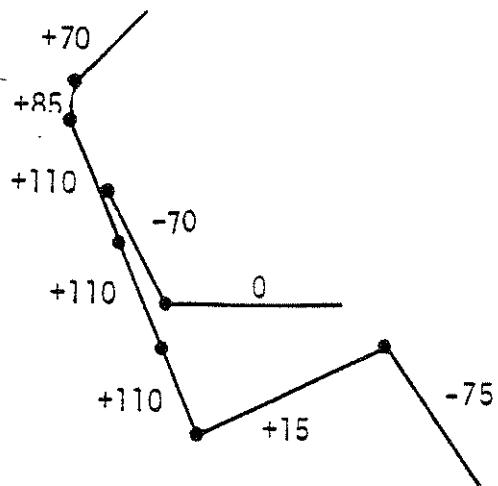
Figure 78. Occupant Model Configuration with all Body Link Angles Equal to Zero, for INPUT or OUTPUT



Null Position

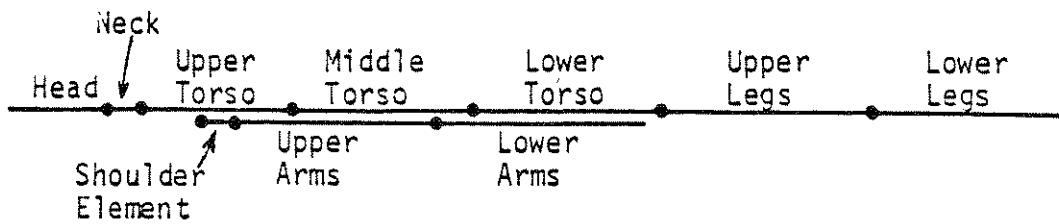


Upright Position

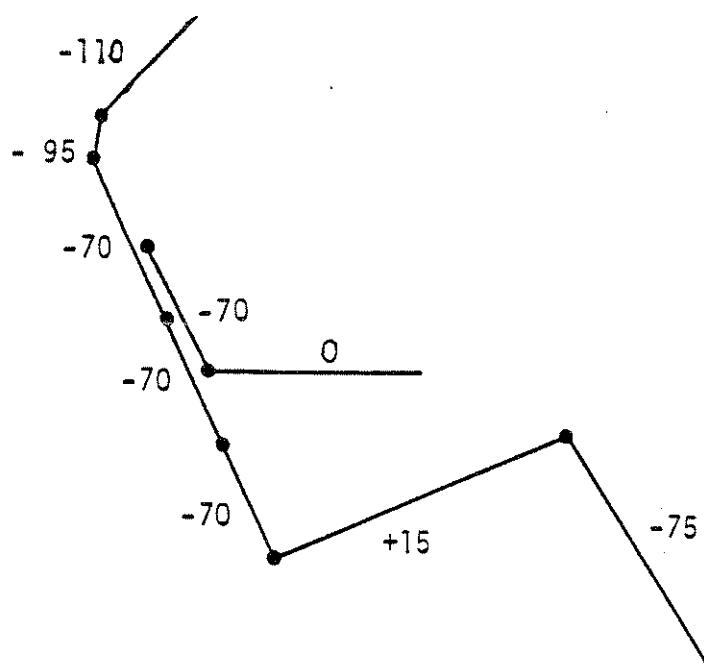


Seated Position

Figure 79. Body Link Angle Conventions for Input Data and Tabular Output



Null Position



Seated Position

Figure 80. Body Link Angle Conventions for Auxiliary Debug Output.

interior model in the sense that resultant forces are computed in a direction perpendicular to the particular line segments of the region which are contacted.

If the switch = 1 in Field 5, a model of material response coupled with structural deformation is used. The force-deformation properties for the region are applicable for all line segments. However, continuity of the line segments is maintained and permanent deformation of one segment will result in permanent deformation for all. This permanent deformation also affects the location of the region for contacts involving additional ellipses. In addition, the use of this structural model allows variable stiffness within a contact region. A use of this is to simulate exactly the force-deformation curve of a region in the place where test data is available and to provide stiffer response near support structure for the region.

Field 6 of Card 401 supplements the contact model.

If the switch = 0, multiple ellipses interacting with one line segment are not considered independently. Rather, the sum of their independent forces is required to equal the maximum of the forces generated if they are all considered independently. This effectively distributes the loading of several contact ellipses over the surface and improves the model of contact. If the switch = 1, the older technique is used where each contact-sensing ellipse interacts independently with the contact line segments. For this option to work the cavity analysis must be used as specified by the switch in Field 8 of Card 401.

The switch in Field 7 of card 401 considers the case where a large contact-sensing ellipse interacts with a curved area within a region including several line segments. When the switch = 0, the forces generated by all the involved line segments are combined to yield a resultant force acting in the appropriate direction. When the switch = 1, the forces act

independently on the ellipse as is the case with older HSRI models and MODROS.

The switch in Field 8 of Card 401 controls the use of a "cavity analysis" for line segments within a region. Individual contact ellipses yield a "dent" when they impinge on a surface. The shape of this dent is controlled by parameters on Card 404, the "cavity coefficients." The purpose of these dents is to control the phasing of contact ellipse interactions with a surface. If one ellipse interacts, a dent is formed with deformation of the surface existing away from the area of contact. If a second ellipse begins to impinge, it should see this dent rather than the original contact surface for proper phasing of contact forces. This refinement of the analysis is not included in MODROS or older HSRI models.

Field 3 of card 402 includes the number of individual line segments in the contact region. The location and properties of each of the line segments are included on 409-411 cards.

Field 4 of Card 402 identifies the friction class of the contact region. A friction class number is attached to each ellipse and each contact region. For each pair of friction class numbers, friction coefficients are assigned (see Card 412).

The switch in Field 5 of Card 402 controls use of the structural deformation model. If the switch is 0, structural deformation is allowed. If the switch is 1, it is not.

The switches in Fields 6 and 7 of Card 402 define the coordinate systems used in the input data and in the printed output. Vehicle coordinates will most often be selected for occupant protection studies while inertial coordinates will be mostly used in pedestrian studies.

Cards 403-408 (221-226) (704-709) (812-817)

These six cards are used to describe material properties for regions, contact ellipses, belts, and steering assembly components. A set must be included for each material property name included elsewhere in the input data.

Card 403 (221, 704, 812)

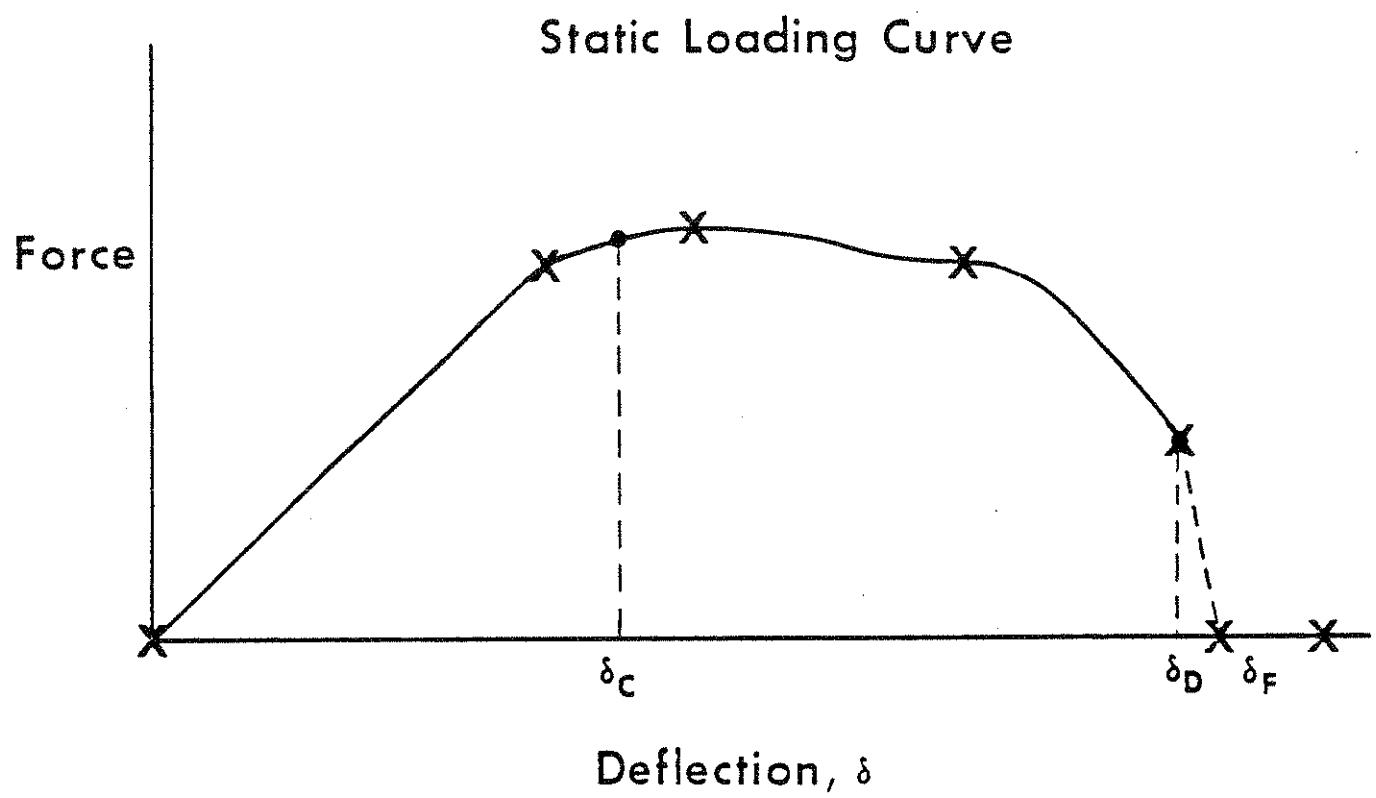
The quantities included in Fields 3-9 determine key points on the force-deformation curve shown as Figures 12, 81, 82, 83, 84, and 85.

Card 404 (222, 705, 813)

Field 3 contains the quantity FOREPS. When shared deflection is used, it is necessary to solve for a deflection in two elements such that the force is the same acting on both. Because exact solution is not possible, a range of error must be specified. This range of error is specified on the applied force. For most problems an error range of 5 lb. is felt to be adequate.

Fields 4, 5, and 6 contain cavity coefficients which are read if this option is selected. The quantity λ_1 controls the extent of the dent due to the deflection. The quantity λ_2 controls the extent of the dent due to the size of the impinging ellipse and λ_3 controls the shape of the dent under the contact ellipse. The action of these coefficients is shown in Figure 86. Their values should be selected based on the size of the dent observed when a ball impinges into the contact surface during an experimental impact. The smallest possible cavity is given by
 $\lambda_1 = \lambda_2 = \lambda_3 = 0$.

Fields 7, 8, and 9 specify names for various material properties specified in detail on other cards.

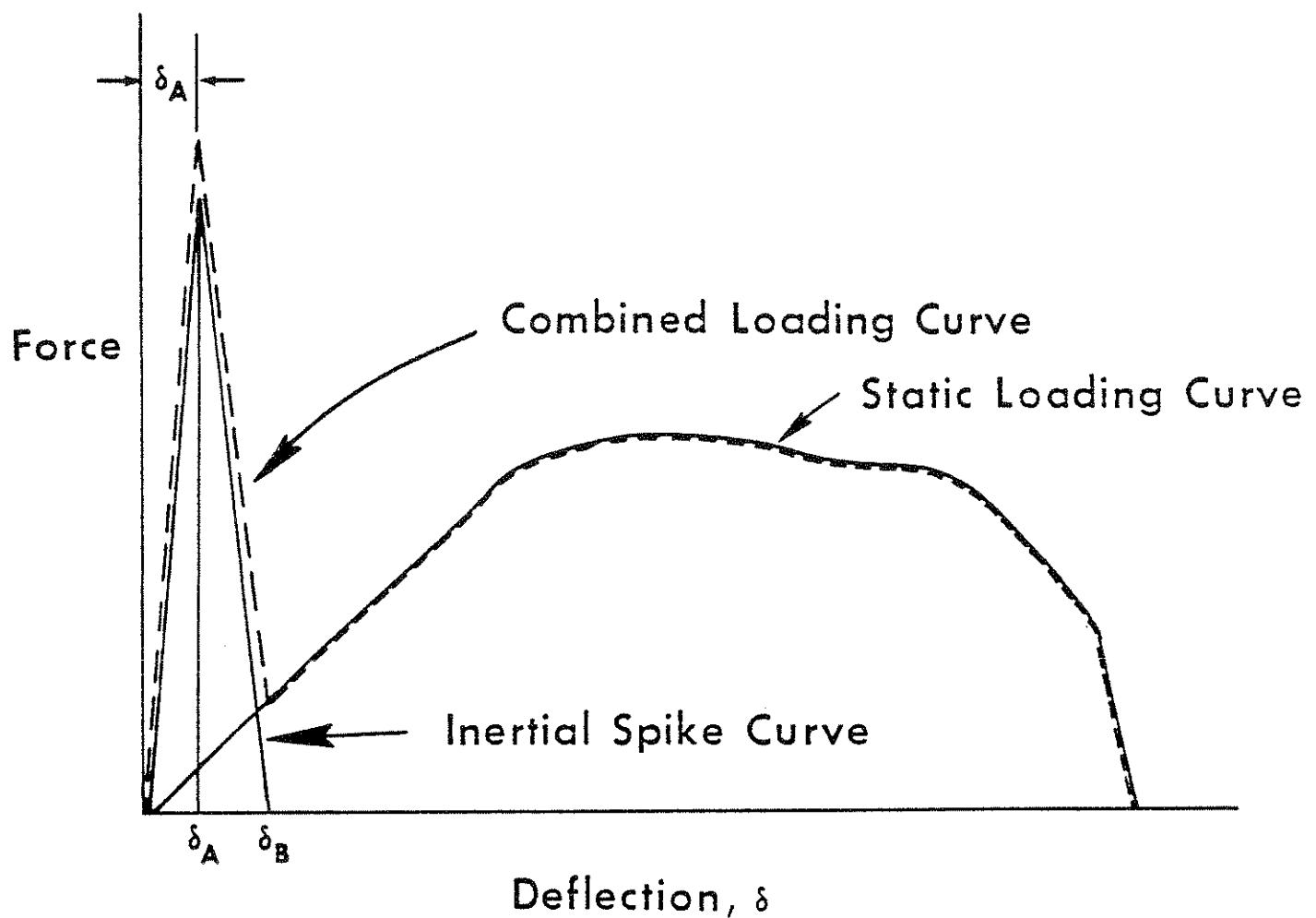


δ_C = yield point (elastic limit)

δ_D = breaking point

δ_F = end of breakdown curve

Figure 81. Static Loading Curve



δ_A = deflection at peak of inertial spike curve

δ_B = deflection at cutoff of inertial spike curve

Figure 82. Inertial Spike Curve

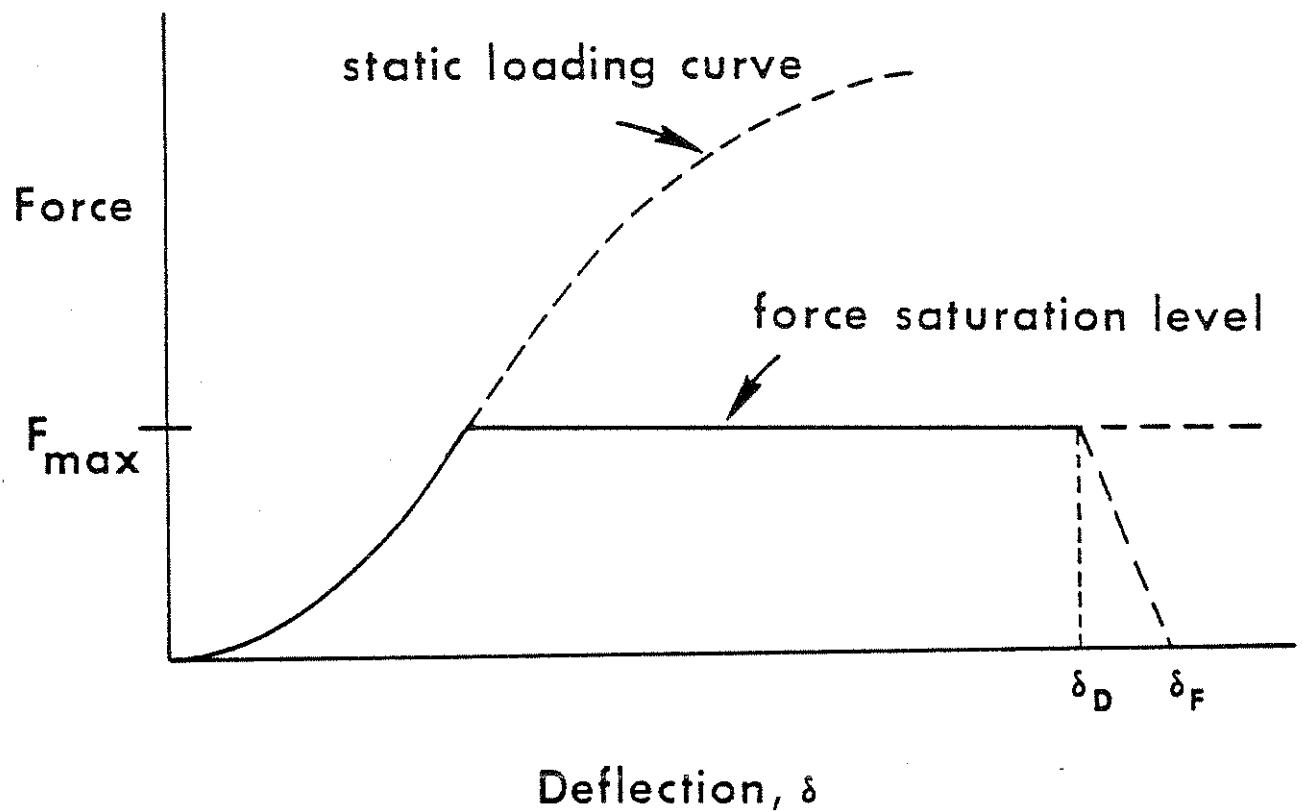
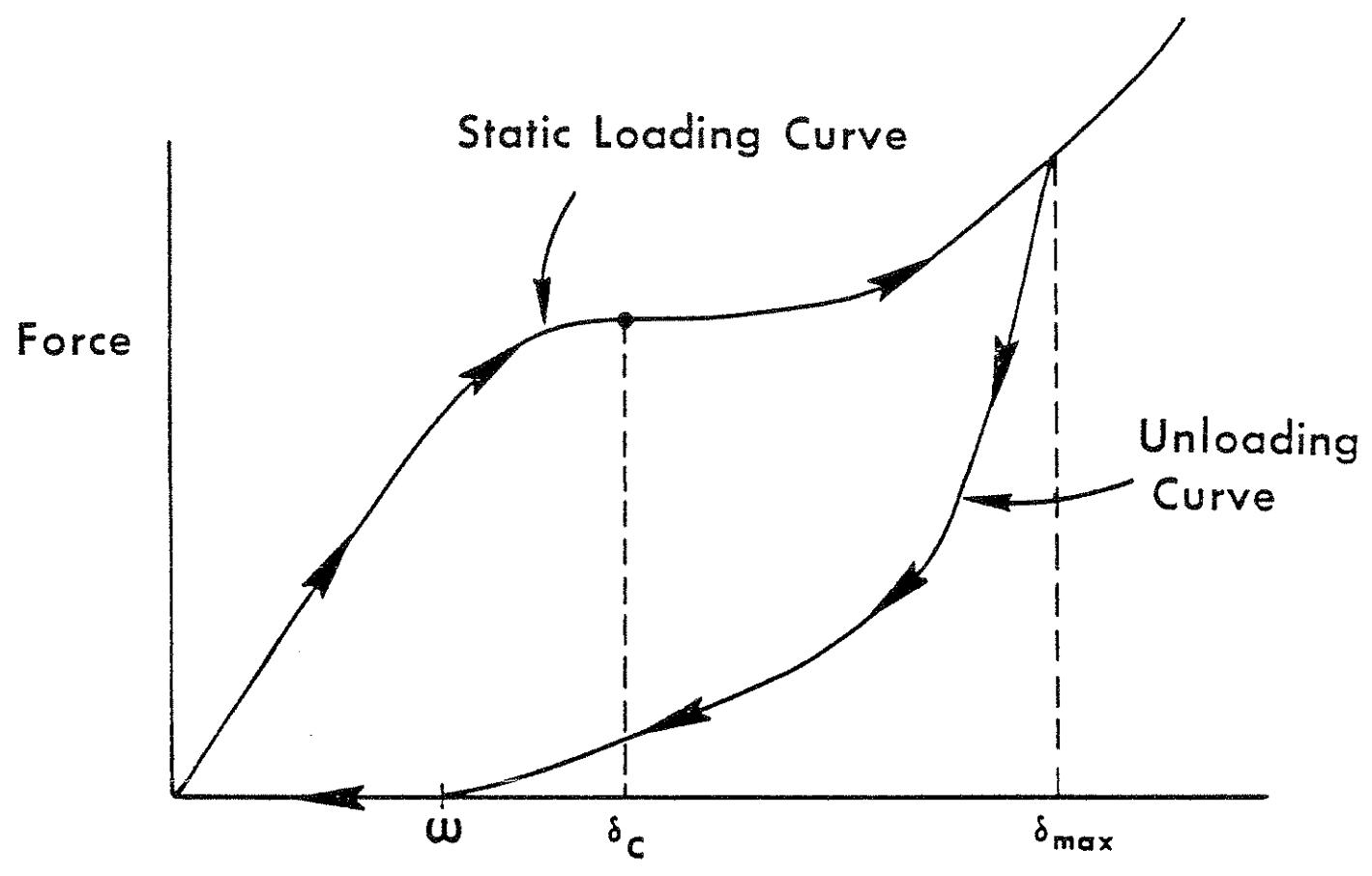


Figure 83. Static Loading Curve with Force Saturation



$$\delta_{\max} > \delta_c$$

Figure 84. Unloading With Permanent Deformation from Deflections Greater Than δ_c

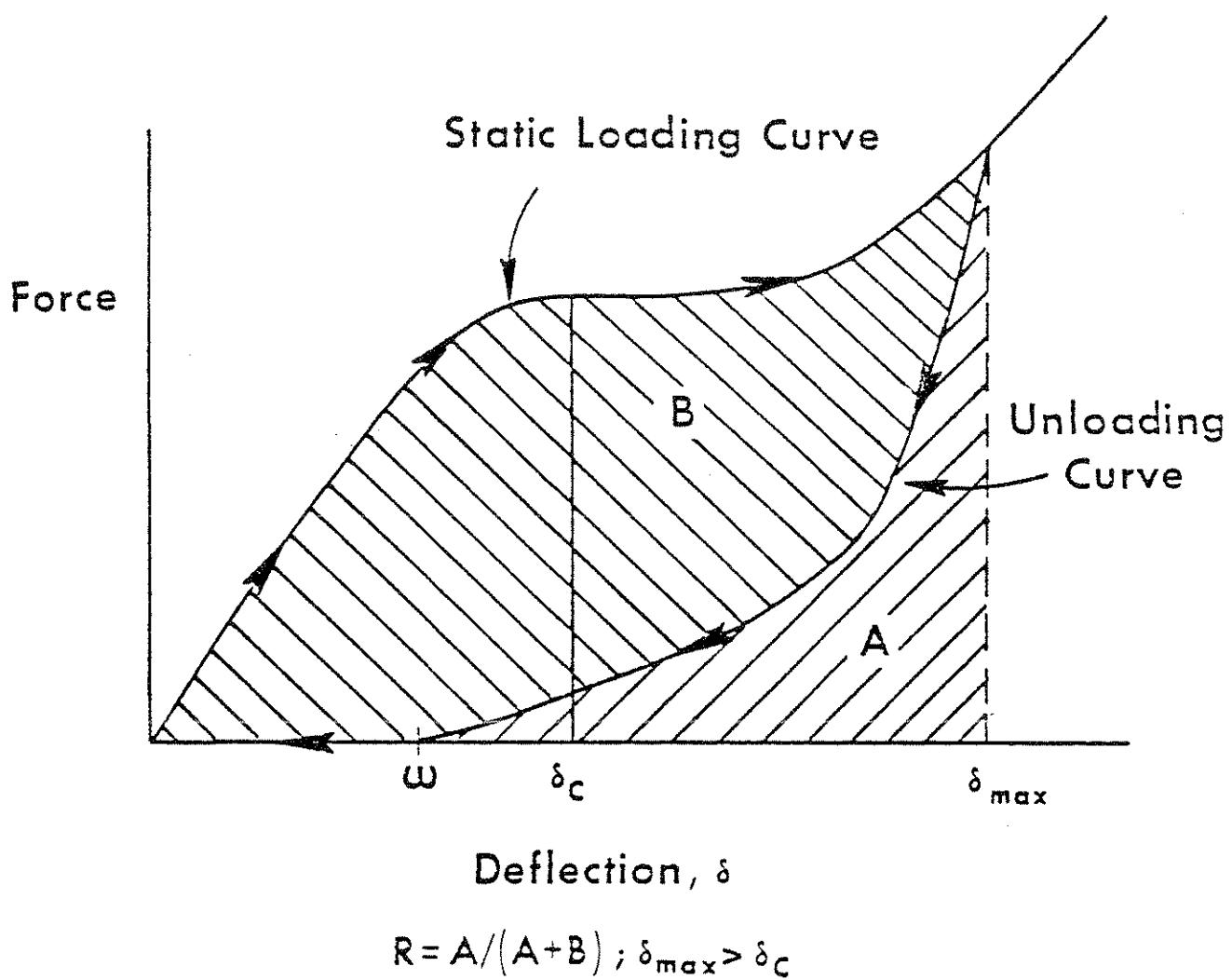
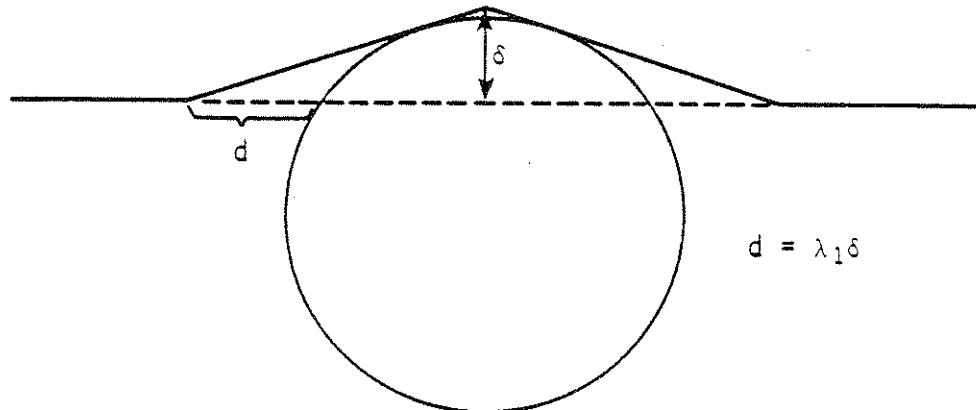
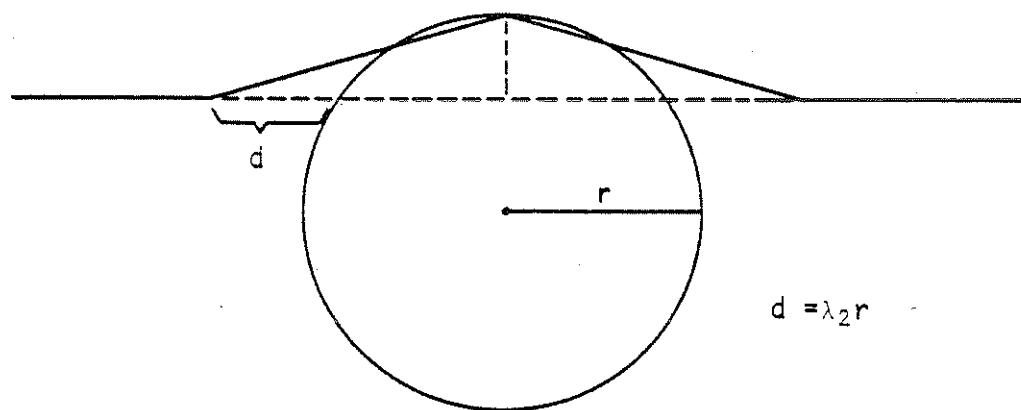


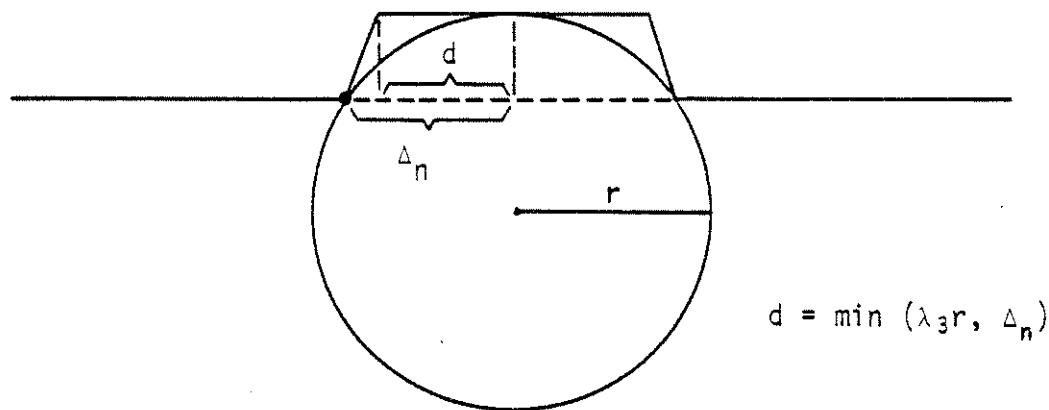
Figure 85. Unloading with Energy Loss from Deflections Greater Than δ_c



Cavity for $\lambda_1 \neq 0, \lambda_2 = 0, \lambda_3 = 0$



Cavity for $\lambda_1 = 0, \lambda_2 \neq 0, \lambda_3 = 0$



Cavity for $\lambda_1 = 0, \lambda_2 = 0, \lambda_3 \neq 0$

Figure 86. Cavity Coefficients

Card 405 (223, 706, 814)

This card or cards defines the ratio of permanent deflection to maximum deflection used in computing material unloading force-deflection curves. Field 2 contains a deflection or a negative number. If a negative number is given, there is only one 405 card for this material and G is assumed to be constant. See Figure 84.

Card 406 (224, 707, 815)

This card or cards defines the ratio of conserved energy to total energy used in computing material unloading force-deflection curves. Field 2 contains a deflection or a negative number. If a negative number is given, there is only one 406 card for this material and R is assumed to be constant. See Figure 85.

Card 407 (225, 708, 816) (See Figures 81 through 85.)

This card defines the static force-deflection curve for a material (Field 1) either as a polynomial or as a table of force versus deflection. If Field 2 contains a negative number, then force is given by

$$F = C_1\delta + C_2\delta^2 + C_3\delta^3 + C_4\delta^4 + C_5\delta^5 + C_6\delta^6$$

If Field 2 contains a deflection and Field 3 contains a force, then multiple 407 cards must be included to build a force-deflection table.

Card 408 (226, 709, 817)

The comments given for Card 407 apply except that the specified curve is the inertial spike shown in Figure 82 and discussed in Section 2.4.1.

Cards 409 and 410

These two cards must be included for each line segment and contain several required and optional quantities. Fields 5, 6, and 7 of Card 409 refer to the penetration limit, edge constant, and direction factors which are

defined as in previous HSRI models. The penetration limit is needed to avoid force generation when a contact ellipse is legitimately under a contact surface. For example, the knee is often placed under the plane of the upper instrument panel. The value for this number should be selected larger than the amount of deflection which is expected of the surface in one time integration step.

The edge constant has been defined to handle cases where a contact ellipse interacts at the edge of a region or at a corner where two line segments meet. Its effect is shown in Figures 87 and 88. The force calculated based on a deflection, δ , is reduced from its full value where the ellipse is in full contact with the surface, to zero when the ellipse has slid to the side off the edge of the surface. The value for this constant should be chosen

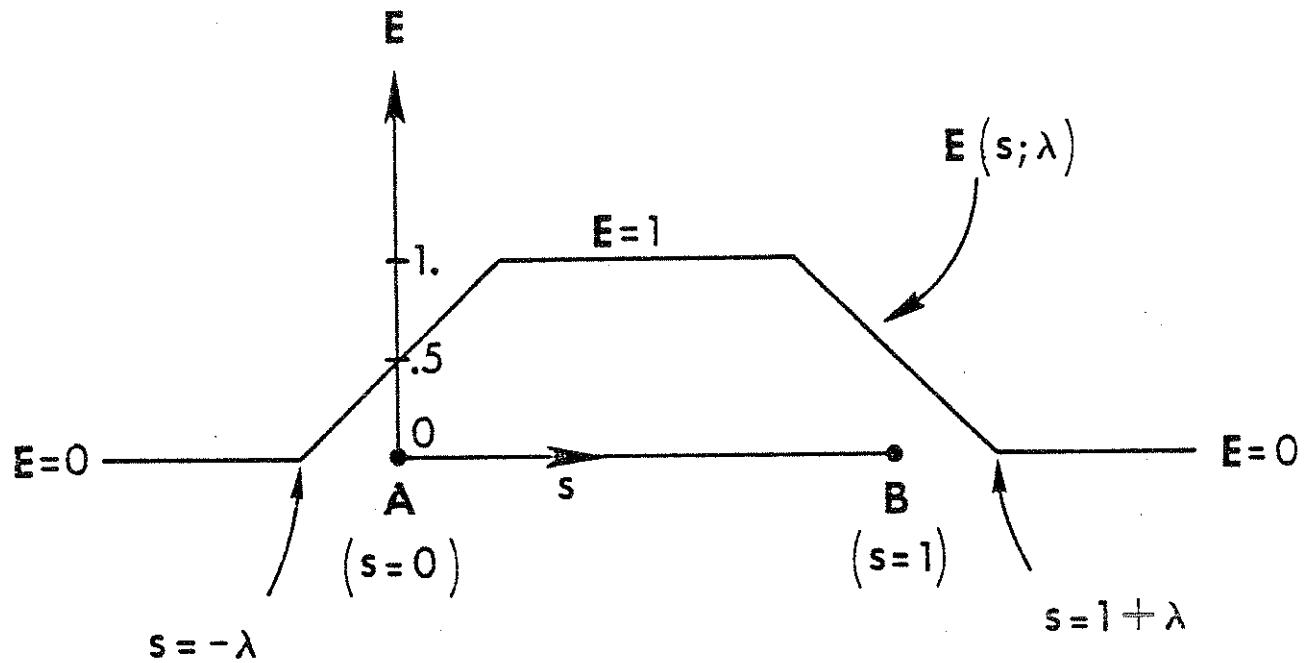
$$0 \leq \lambda \leq 0.5$$

An example of the selection of a particular value is included in Section 2.6.2.

The direction factor indicates which side of a surface should be contacted. It is selected based on a determination of whether the time-zero inertial origin lies behind or in front of the contact surface. If the inertial origin is on the same side of the surface which should be contacted, 1. should be entered. Otherwise -1. should be entered.* See Figure 89.

The third field of Card 410 determines whether the contact line segment is programmed to move as a predetermined function of time thus representing events such as vehicle collapse or motion of a deployable restraint system. If the region does not move, 1. should be entered.

*No line segment defined by 411-Cards is allowed to pass through the inertial origin at t=0.



$$F_{\text{eff}} = E F(\delta)$$

Figure 87. Effectiveness Factor E as a Function of s , the Position of Contact Point with Respect to Line Segment, With Edge Constant λ as a Parameter

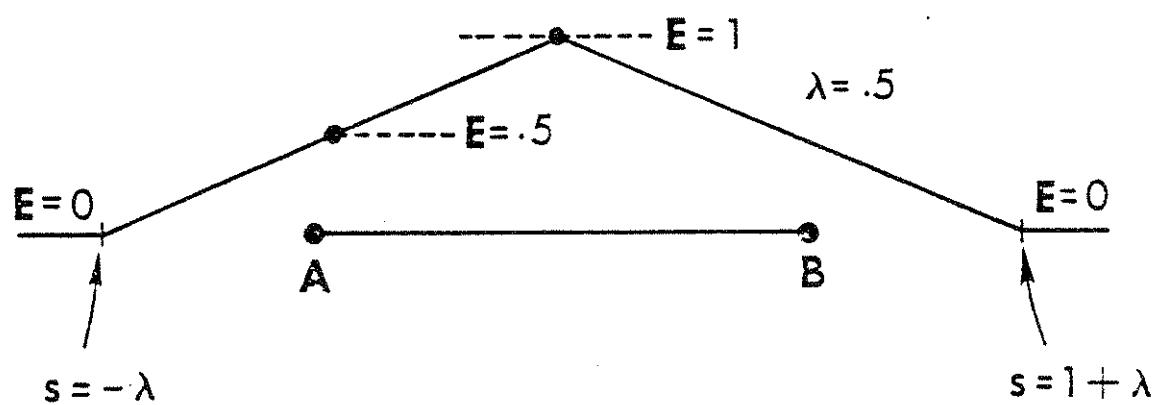
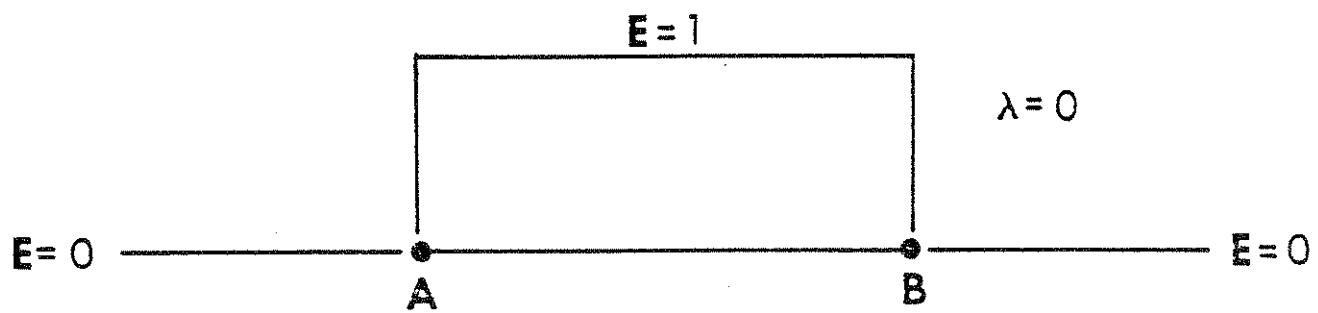


Figure 88. Effectiveness Factors for Edge Constant Values of 0. and .5

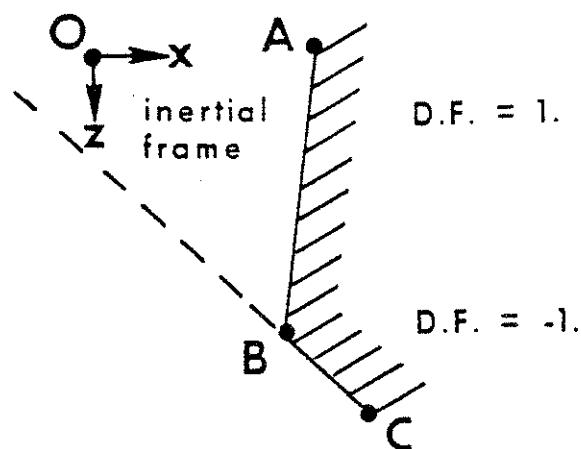
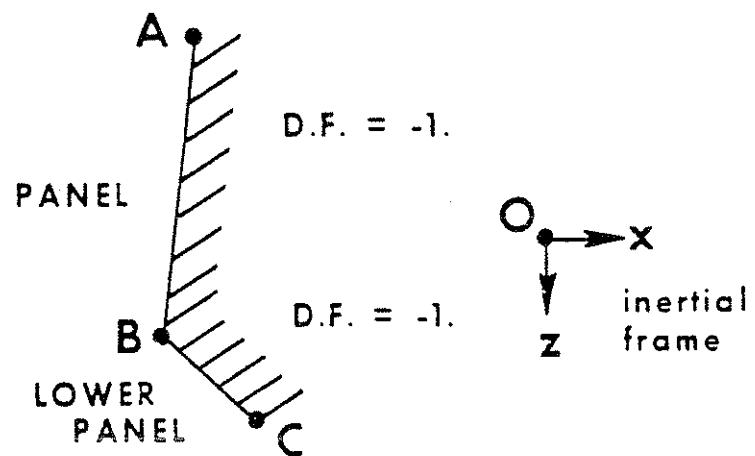
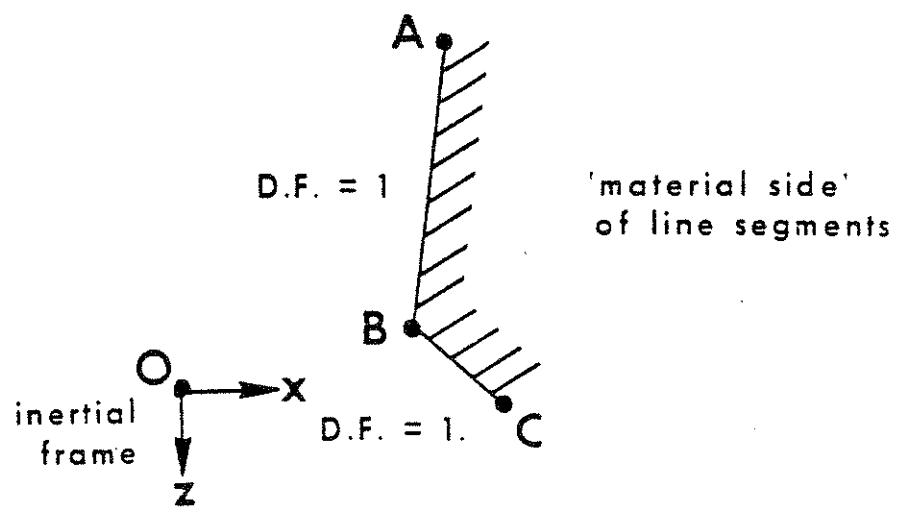


Figure 89. Line-Segment Direction Factors, Defined at $t = 0$

The fourth through seventh fields of Card 410 are used to simulate structural response of a contact region. The gamma (γ) quantities have the units of inverse mass and are therefore called "mass impedance." Their effect is to influence the amount a line segment can be pushed out of the way during the force action of a contact ellipse. When $\gamma = 0$, the end point of a line segment cannot be pushed out of the way. When γ is a very large number, the line segment can be pushed out of the way without generating a substantial force. Therefore, it is apparent that γ quantities must be selected while developing force-deformation curves and can probably be used to simulate the inertial spike.

The k's relate to the structural connection between the line segments within a region. When $k = 0$, the line segments within a region are connected, but only for the purpose of maintaining continuity. As k is increased, the coupling of line segments with respect to one another becomes more apparent. The effect of the k's is that of a torsional spring at the points where line segments meet. Hence, they are called "bending constants."

The main use of the k and γ quantities which is obvious at this early stage of their development is to allow variation of material properties within a region. Let us assume that a force-deformation curve is determined from a single test such as a pendulum test of an instrument panel. Most likely this test is conducted at a "soft" part of the instrument panel. Where the panel is more curved or where it is supported by substructure, it will be stiffer. The γ quantities should be chosen $\gamma > 0$ for the line segments where the "soft" test result is measured. For sharp corners and for substructure, values of $\gamma \approx 0$ should be chosen. The effect of γ is governed by

$$\Delta\delta = \gamma F (\Delta t)^2 + \Delta\delta_{\text{permanent}}$$

where $\Delta\delta$ is the total permanent motion of the line segment during a time integration step.

$\Delta\delta_{\text{permanent}}$ is the permanent motion of the line segment due to permanent deformation resulting from the force-deformation curve

F is the force at the beginning of the time integration step

Δt is the size of the time integration step.

Therefore, the value of γ may be estimated on the basis of the relationship desired between the measured force-deformation curve, the expected applied force and the time duration during which the force acts.

Card 411

At least one 411 card must be included for each line segment of each region. The identification name is given in the first field. The remaining fields locate the line segment as a function of time.* Although the line segments will move with the vehicle to simulate a non-deforming occupant compartment or vehicle exterior surface, it is also possible to specify their location as a function of time with respect to the vehicular or inertial coordinate systems in order to model such physical events as predetermined vehicle collapse or deployment of a restraint system. This motion is then superimposed upon any of the types of structural deformation which may occur during occupant-vehicle contact. The third field specifies the point in time at which position is specified while the 4th through 7th fields specify location of the endpoints. If the location of the line segment is time independent, a negative number should be entered in Field 3.

*It is not allowed for a line segment or its extension to pass exactly through the inertial origin at $t=0$.

Field 8 is used to define a point of a frontal interior outline for airbag contact. This usage is described completely in footnotes for Card 411.

Card 412

Card 412 contains friction coefficients for ellipse-region contact. It should be recalled that a friction class has been assigned to each region and to each ellipse. These cards match regions and ellipses for which non-zero friction is desired in the first two fields while the last three fields contain the linear and nonlinear friction coefficients.

Card 500

This card contains the run subtitle for the vehicle interior configuration input block. It is used by the program for automatic preparation of headings for each page of printed output.

Card 501

This card contains anchor points for the belt restraint systems as defined in Figure 16, all relative to the vehicle-fixed coordinate frame.

Card 600

This card contains the run subtitle for the vehicle impact specification input block. It is used by the program for the automatic preparation of headings for each page of printed output.

Card 601

Fields 1-6 give the vehicle x, y, and θ position and initial velocity with respect to the inertial coordinate system. Because it is possible to use accelerometer data from a test as input to this program, accelerometer location in vehicle coordinates is specified in Fields 7 and 8. If deceleration force is given instead of acceleration, vehicle or sled mass must be included in Field 9.

Cards 602, 603, 604, 605, 606

These sets of cards define vehicle horizontal, vertical, and angular accelerations as functions of time and also head-applied forces. Card content is self-explanatory.

Card 700

This card contains the run subtitle for the belt restraint system input block. It is used by the program for the automatic preparation of headings for each page of printed output.

Card 701 (See Figure 75 for Simple Belt System schematic.)

Card 701 contains physical parameters relating to the lap belt and the upper torso belt attached to the upper spine body segment. Belt length and slack quantities are self-explanatory. The breaking force features available with the HSRI force-deformation routines are duplicated in the belt routine using Fields 5, 6, and 7 of this card. The time duration, DELTB, insures that the belt force will gradually be reduced to zero rather than undergo a step-function dropoff, a potential source of solution instability. This technique differs from that available with the force-deformation routines where force dropoff occurs over a small change in deformation. The technique used in preparing input data may well depend on the availability of experimental data. If a force-deformation curve of the belt material is available, that technique would probably be easiest. Where a dynamic break test is available the 701 Card would probably be best.

Card 702

Fields 1-4 represent an attempt to uncouple compliance of a lap belt structure with compliance of the vehicle occupant whether it be dummy, cadaver, or human. In otherwords, physical properties may be determined separately for the belt structure and for the occupant. The material names for occupant and belt materials are included in these four fields.

Fields 5-7 refer to the lower torso belt element. Field 7 allows the belt to be attached on any of the three torso elements.

Field 8 allows the user to supply either force-strain or force-deflection input data for the three belt segments. The two types of data may not be mixed.

Card 703

The eight fields of this card contain the material names for the torso belts. Belt material properties are again uncoupled from occupant deformation properties.

Cards 704-709

See Cards 403-408. Note: Belts B_1 and B_7 (see Figure 90) should have the same material unless they are made independent by the conditions at the upper ring (viz. RING(1) = 1; see Card 720). This holds in addition for belts B_2 and B_3 at the lower ring. It also applies for pairs $B_1 - B_2$ and $B_3 - B_4$ if the force equalization options are selected (Card 717).

Whenever a belt pair must be treated as a common strap but the materials for the separate segments are different, the program arbitrarily uses the material for the first member of the pair.

Cards 710-716

Figures 90 and 91 illustrate the Advanced Belt System and the definition of attachment points on the occupant. (Note that while belt attachment points are measured from joints for input, the internal values are with respect to torso segment CG's.)

Card 717

Field 1 allows the user to specify one of three types of interbelt influence for the belt segments passing over the torso. If zero is entered, then the belt segments are considered independent (as in the MODROS belt option) and no adjustment of torso belt forces is made. Interbelt influence is discussed in Section 2.5.2.3.

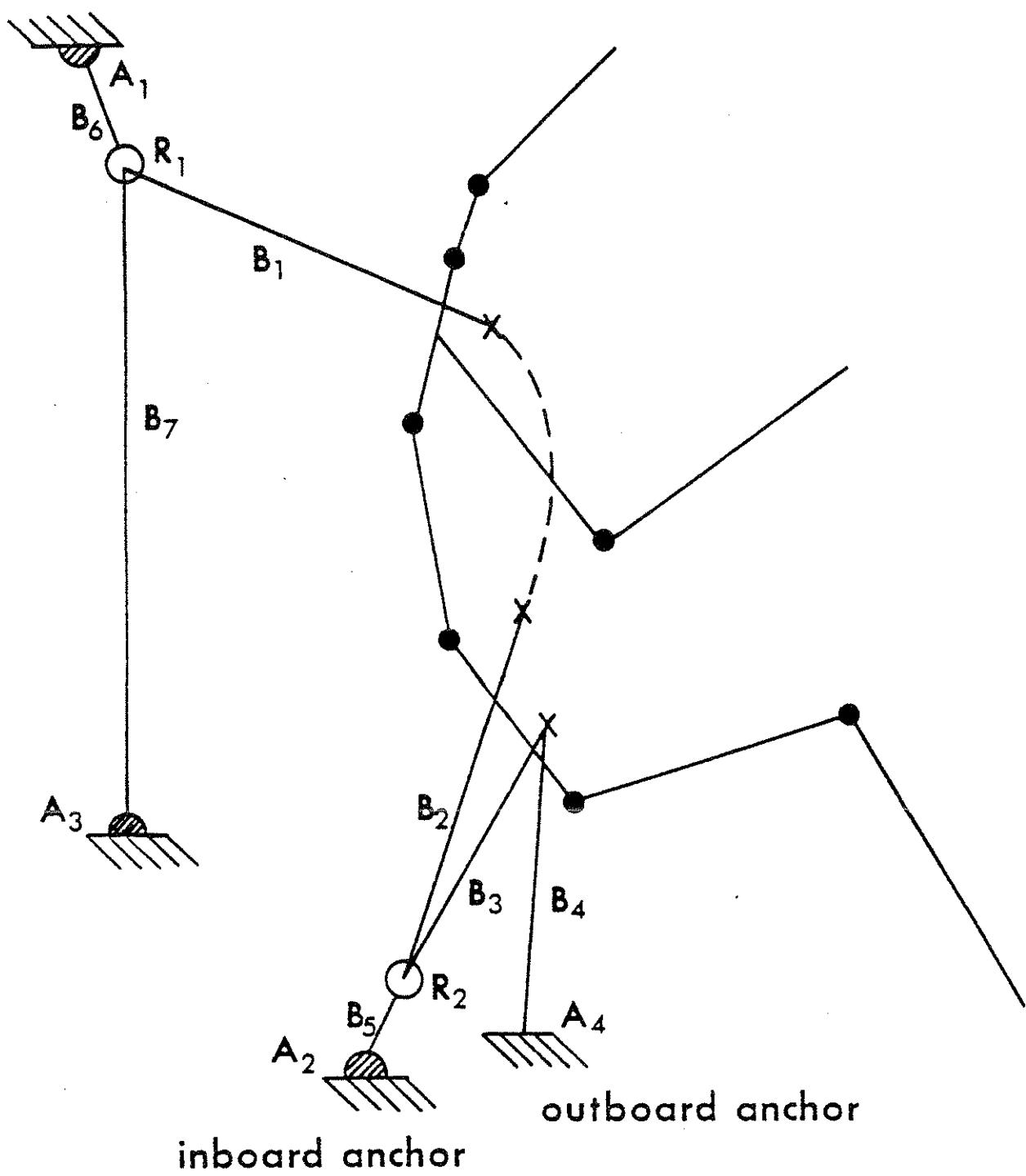


Figure 90. Advanced Belt System

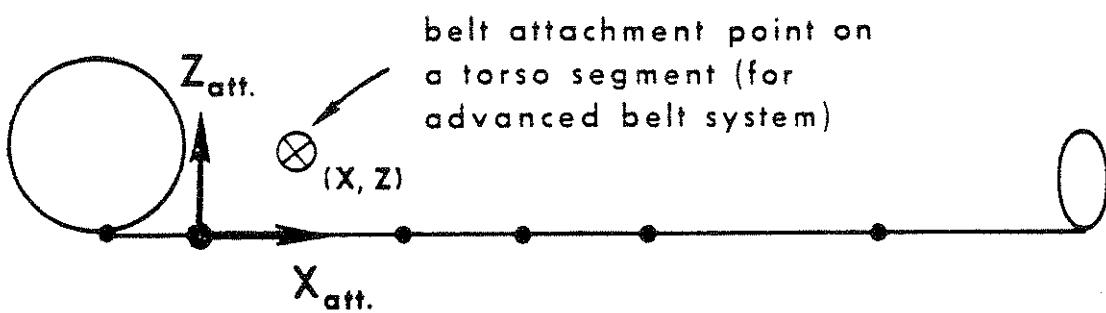


Figure 91. Belt Attachment Point Coordinates for Advanced Belt-Restraint Submodel

Field 2 allows the user to supply either force-strain or force deflection input data for the belt segments of the advanced belt system. The two types of data may not be mixed.

The value in Field 3 indicates which torso segment is attached to by the lower torso belt. Fields 4 and 5 define out-of-plane separations for the torso belt and lap belt attachment points. These values are needed only if the "free slipping" options are turned "on" by the values in Fields 6 and 7; in this case the out-of-plane length is used in order to determine total belt length.

Card 718

This card is needed whenever the rings of the defined belt system have the possibility of moving within the vehicle. The values in the two fields of this card are control parameters for the subroutine (RELAX) which determines the ring location for a force balance at any instant of time. The method of relaxation [19, 20, 21] is used to solve a system, in this case of order 2, of simultaneous, nonlinear algebraic equations. The general method is to systematically reduce to zero a set of functions of the unknowns—in this case, cart-relative x and z ring coordinates—by adjusting the values of the unknowns. When the functions, called residuals, have been reduced to zero, the current values of the unknowns constitute the solution vector. Convergence is tested by examining the nearness to zero of the sum of the squares of the residuals.

Field 2 should contain an upper limit on the number of relaxation steps allowed per ring per evaluation. (This value should probably be at least 10.)

If convergence is not attained within this number of steps, then the calling program (BELT2) is returned to and the best solution vector obtained through this number of steps will be used. Execution is not terminated but a warning is printed out.

Field 3 contains a value for the maximum acceptable force imbalance at the ring for either the x or z direction (in the vehicle system).

Card 719

No more than three values will ever be needed on this card. All quantities relate to interbelt influence for the torso belts. A footnote on Card 719 summarizes which fields are required for the four possible INFLNC options.

Fields 1 and 2 contain friction coefficients for the normal-force friction option. Field 3 also is used for this option. The larger of the torso belt forces will always be reduced by a calculated adjustment (see Section 2.5.2.3 for analysis pertaining to all parameters on this card); the smaller force will be increased by any fraction of this amount depending on the value, from 0. to 1., entered in Field 3.

For the normal-force friction option, the belt subroutine chooses the influencer and influencee at each time evaluation on the basis of which torso belt force is larger or smaller. This is true also of the force difference saturation option. In contrast, if the percentage influence option is selected, the user must specify which of the torso belts is the influencer and influencee. Field 4 controls this. Fields 5-7 are used for these alternate options and the meanings of the parameters are fully explained in Section 2.5.2.3.

Card 720

The four vehicle anchors (see Figure 90) for the advanced belt system may be of several types. The first four fields of this card specify the anchor type for anchors 1 to 4, respectively. A zero means that the anchor is free. Normally, this would mean that either the anchor or the associated belt is absent or "pre-broken." If a 1. is entered, then belt 4, 5, 6, or 7 fastens securely to the anchor. If a 2. is entered, then belt 5, 6, or 7 leads to an inertia reel fixed at the anchor location. Only anchors 1-3 may be of this type. The reel may be of the webbing-sensitive or vehicle-sensitive type, as specified on Cards 721-723. A 3. means that belts 1, 2, or 3 leading to the anchor are either fixed to the frame or ring or instead pass through a ring which is fixed to the vehicle frame at the anchor location. Note that if the ring is not fixed to the vehicle frame, then it is of necessity fixed to one end of a "ring strap" belt segment (belt number 5 or 6), i.e., the associated ring strap must in such case be present.

There are two rings in the system. Lengths of webbing pass through the rings but may be considered: 1) to be fixed to the ring; 2) to slide with normal-force friction through the ring; or, 3) to slip freely. These options are controlled by Fields 5 and 6. Options 2 and 3 should give equivalent results if the friction coefficient for option 2 is zero. If the normal friction option has been selected for a ring, then the friction coefficient must be entered in Field 7 or 8.

Figures 92 and 93 illustrate all possible ANCHOR and RING specifications.

Cards 721-723

If an inertia reel has been requested for anchor 1, 2, or 3, then properties of the inertia reel are entered on one of these cards. The reels may be either vehicle sensitive or webbing sensitive. If vehicle sensitive, then the "lock" condition can be specified either as a lock time or as a

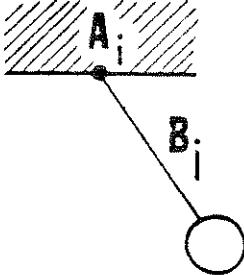
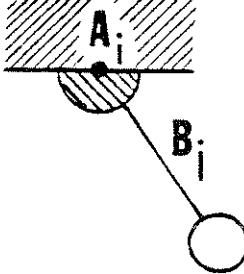
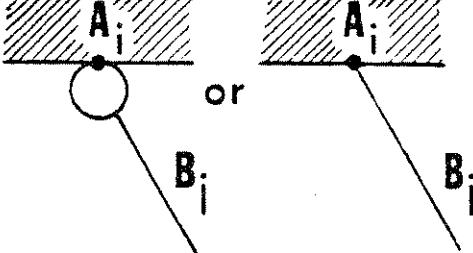
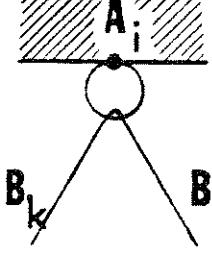
SCHEMATIC	ANCHOR TYPE DESIGNATION	ALLOWED INDEX VALUES
 no belt	ANCHOR _i = 0	i = 1, 2, 3, 4
	ANCHOR _i = 1	i = 1, j = 6 i = 2, j = 5 i = 3, j = 7 i = 4, j = 4 (no ring)
	ANCHOR _i = 2	i = 1, j = 6 i = 2, j = 5 i = 3, j = 7
	ANCHOR _i = 3	i = 1 or 3, j = 1, RING ₁ = 1 i = 2, j = 2 and/or 3, RING ₂ = 1 i = 4, j = 4
	ANCHOR _i = 3	i = 1, j = 1, k = 7, RING ₁ = 2 or 3 i = 2, j = 2, k = 3, RING ₂ = 2 or 3

Figure 92. Belt Anchor Type Designation for Anchor "i"

SCHEMATIC	RING TYPE DESIGNATION	ALLOWED INDEX VALUES
 or 	RING _i = 1	$i = 1, j = 1, \text{ANCHOR}_1 = 3$ $i = 2, j = 2 \text{ or } 3, \text{ANCHOR}_2 = 3$ $i = 2, j = 2 \text{ and } 3, \text{ANCHOR}_2 = 3$
	RING _i = 1	$i = 1, j = 1, i = 6, \text{ANCHOR}_1 = 1 \text{ or } 2$ $i = 1, j = 1, i = 7, \text{ANCHOR}_3 = 1 \text{ or } 2$ $i = 1, j = 1, i = 6 \text{ and } 7, \text{ANCHOR}_1 \text{ and } \text{ANCHOR}_3 = 1 \text{ or } 2$ $i = 2, j = 2, i = 5, \text{ANCHOR}_2 = 1 \text{ or } 2$ $i = 2, j = 2, i = 3 \text{ and } 5, \text{ANCHOR}_2 = 1 \text{ or } 2$
	RING _i = 2 or 3	$i = 1, j = 1, k = 7, \text{ANCHOR}_1 = 3 \text{ (or } 0\text{)}$ $i = 2, j = 2, k = 3, \text{ANCHOR}_2 = 3$
	RING _i = 2 or 3	$i = 1, j = 1, k = 7, i = 6, \text{ANCHOR}_1 = 1 \text{ or } 2$ $i = 2, j = 2, k = 3, i = 5, \text{ANCHOR}_2 = 1 \text{ or } 2$

Figure 93. Designation of Ring-Belt Relationship for Slip Point "i"

pair of values for maximum vehicle pitch and maximum resultant acceleration at the anchor location. If webbing sensitive, then the reel can be made to lock either on the basis of a limiting velocity or acceleration for belt feed-out.

Standard values for some of these lock-condition parameters are: vehicle sensitive resultant acceleration, 0.4 g, and pitch angle, 14°; webbing sensitive belt feed-out acceleration, 0.6 to 0.9 g's. (See References 15 through 18.)

Cards 800-817

The energy-absorbing steering assembly system cards are mostly self-contained. But the analytical symbols used for all quantities in Section 2.8 are given on these cards so easy reference may be made if necessary to the figures and text for the analysis.

Cards 900-909

The airbag system cards are likewise mostly self-contained. References may be made to figures in the analysis section and to the one on Card 909. Reasonable values for all parameters on Cards 901-903 are indicated in the Defaults column. See Figure 94 for definition of occupant contact lines.

Card 1000

This card marks the end of the input data deck which is supplied to the input processor and signifies that work on the input deck is to begin.

Card 1001, 1002

These two cards together with the other cards numbered greater than 1000 comprise the control information to the output processor. The function of the first two cards is to specify the output subjects or categories which are desired and the order in which these are to appear. This is accomplished by listing the categories desired in the order desired using a series of possibly mixed individual listings and group listings. An individual listing consists of a

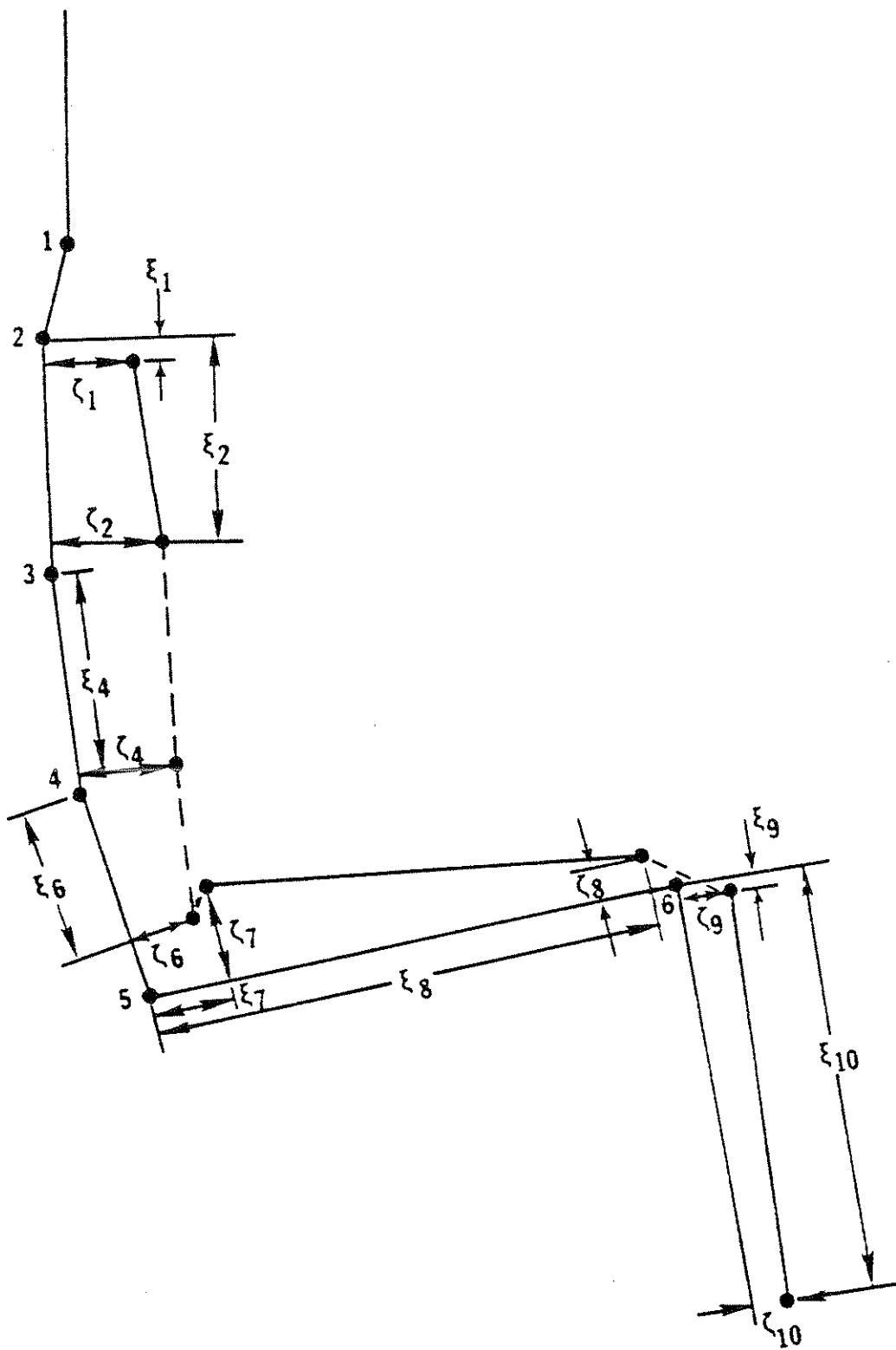


Figure 94. Airbag Contact Lines on Occupant

one- or two-digit category number followed by a comma. Leading zeros may be present and blanks are ignored. As many of these listings as needed may be used. Numbered categories are listed in Table 11 following the description of Cards 107-111.

If there is a group of category numbers in either ascending or descending order which are contiguous, a group listing may be employed to streamline the specification of the string of numbers. The group listing consists of the category number of the end of the string which is to be printed first followed by a dash, hyphen, or negative sign (card 11 punch) followed by the category number which is to appear last. Again, leading zeros may be present and blanks are ignored wherever they appear. Card 1002 is treated as an extension of Card 1001 using only the first seventy-two columns of both cards. If these cards are omitted, all categories are requested in the default ordering indicated on the 1001-card layout in Table 7. If columns 1 and 2 contain "-1", the default ordering minus category 0 will result. The terminating comma on the final listing may optionally be omitted.

Card 1003

This card controls the auxiliary output from the output processor. The first field (IDB) controls auxiliary printout from the HIC routine concerning all the scans made in determining a HIC value. The second field (K0) doubles as a switch and a specification of the Fortran logical device number for a separate printout of peak and three-millisecond average acceleration calculation values. If zero, it is interpreted as a switch which is off. If non-zero, it is interpreted as a switch which is on and its value used for the logical device number.

The third field controls a forced recomputation of filtered accelerations and special indices. Normally, these computations take place only in the first run of OUT after a run of GO.

The fourth and fifth fields describe the particulars of an accelerometer mounted on the upper leg centerline. (See Section 4.6.2.5.)

Card 1004

The first four fields of this card contain information governing the application of numerical filters to head, chest, and hip accelerations. A detailed explanation of the operation of the digital filter employed in this model is found in Section 4.6.2.3. The first three fields are filtering parameters used to control the filter operation. The fourth parameter controls the method of extension of the acceleration data beyond the run time span. The mirror image causes the completed data to be an even function around the end points. The polar image causes the completed data to be odd at each end point if the function value at the endpoint is considered zero. (See Figure 142.) The polar image is thought to be superior normally.

The last four fields of this card control the calculation of the HIC Index. An explanation of these parameters will be found in Section 4.6.2.4.

Cards 1100-1107

Specification of the test values used to determine violations of joint range of motion limitations. The high test value must not be less than the low test value algebraically. If both high and low values are zero, the test is not carried out.

Cards 1200-1201

Specification of the test values used to determine violations of a standard range of values for each individual quantity. A complete list of the quantities together with an explanation will be found in Section 4.6.2.1. The testing is carried out only if the test value is greater than zero.

Cards 1202

Specification of the names of the ellipses which will represent the face and chest for purposes of the standard tests.

Card 1300

A general explanation of the Type A Comparison together with a complete list of variables to which it may be applied will be found in Section 4.6.2.2. The first two fields are filled with the category and column numbers found in Table 114 in Section 4.6.2.2. The two identifiers are the names which are required to make unique a request for a contact variable. In the case that a category 2 or 3 variable has been requested, the first identifier must be the name of the region for which the particular variable is to be tested. In the case a category 4 variable has been requested, the identifiers must be set to the ellipse and line names, the two ellipse names, or the belt name and blanks for each case respectively. Belt names are assigned by the model and are listed in Table 115 found in Section 4.6.2.2. The high test value must be greater than or equal to the low test value. Negative values are allowed.

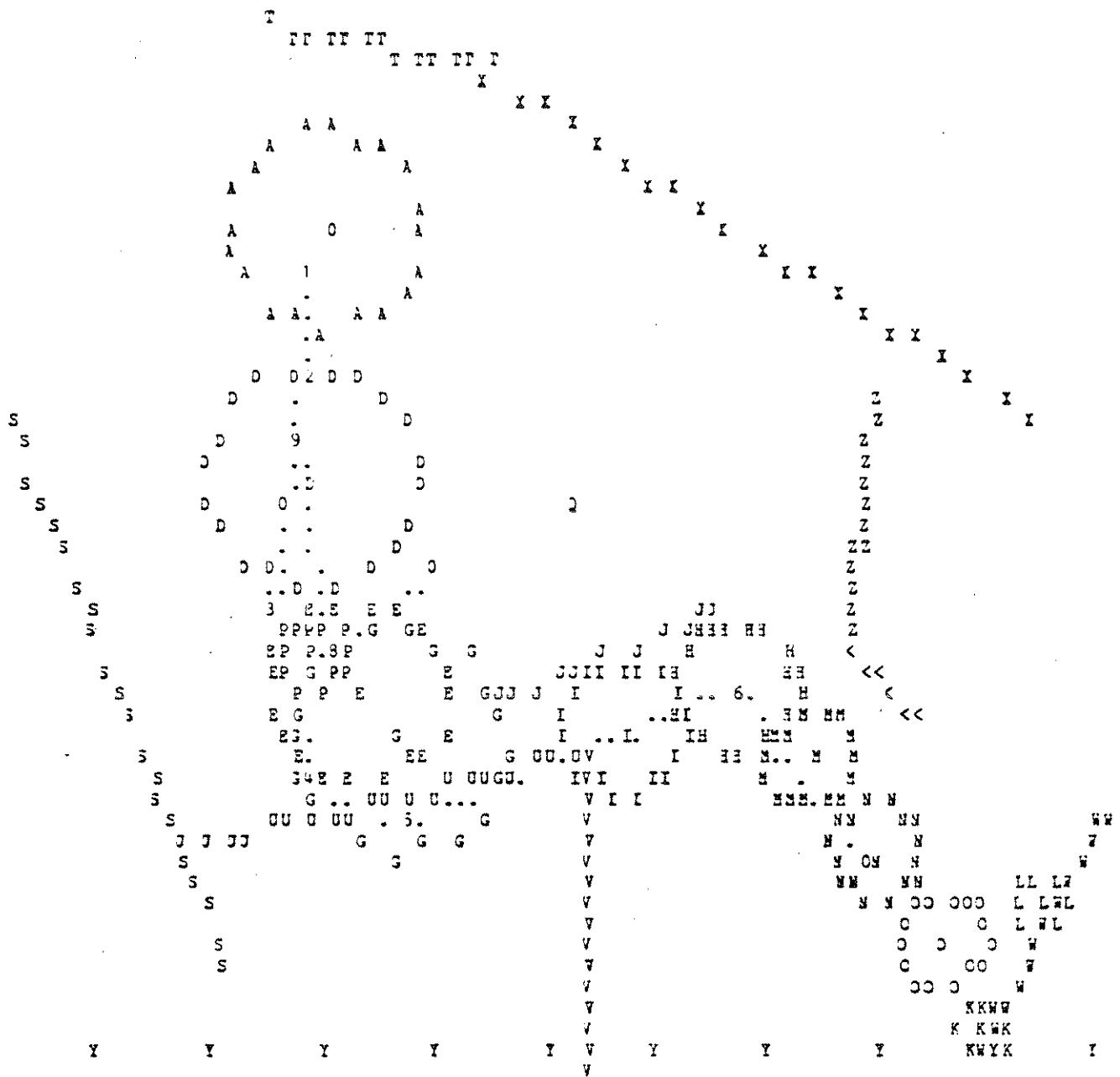
Cards 1400-1401

A general explanation of the Type B Comparison will be found in Section 4.6.2.2. The first six fields of each of these cards are filled in the same manner as the corresponding six fields on Card 1300 and all comments apply. The seventh field of each of these cards is used to match the 1400 Card to the 1401 Card. Each card specifies a variable for a Type B comparison, which tests one variable against another variable. Hence it is necessary to supply a matched Card 1400 and Card 1401 set in order to complete the specification of a Type B comparison. If Field seven in both cards is left blank, then the number used to match is assigned based on the number of occurrences of that type of card. All the instances of Card 1400 for which Field seven is blank are numbered in the order read and likewise with Card 1401, and the matching is done on the assigned occurrence number. The numbers for matching need not be consecutive, only the same.

Cards 1500-1501

These two cards contain the various switches and parameters which control the production of the stick figure printer plots. Figure 95 is an example of printer-plot output. Up to 27 such plots can be obtained for a simulation. These will be in a time sequence similar to frames of a motion-picture film.

STICK FIGURE PAINTER PLOT FRAME FOR TIME= 60.00 MSEC.



Coordinate ranges for plot are X = 0.0 (at left) to 64.00 (at right) and Z = 2.24 (at bottom) to -41.24 (at top). Scale factor is (in) = 4.923 (in), X and Z point resolution errors equal respectively 0.246 and 0.410 (in) in scale.

Figure 95. Example of Printer Plot Output

The switch in Field one of Card 1500 causes horizontal and vertical lines to be plotted through the origin of the vehicle system. If field two is zero, and the input and output processors are run without "GO," the user will get a printer plot based on the input data alone. Fields three through six define the area in vehicle coordinates to be plotted.

On Card 1501, Fields one, seven, eight, and nine deserve special comment. The number of plots in Field one together with the values in Fields eight and nine are ignored if Field seven is left blank or zero. In this case only the times specifically listed on Card 1502 (of which there may be up to three in the deck) are plotted. If Field seven is non-zero, Field one contains the number of plots, Field eight contains the first time to be plotted and Field nine contains the time increment to be applied to obtain the plot time until the number of plots is reached.

Card 1502

This card is used to specify individual time points at which plots are to be produced. There may be up to three instances of this card containing a maximum of twenty-seven values. The values must be in ascending order in time.

Card 1600

This card marks the end of the input data deck which is supplied to the output processor and signifies that work on the production of output is to begin.

3.3 DESCRIPTION OF NORMAL OUTPUT

Section 3.2 describes the use of Cards 107-111 for controlling the storage of potential program output quantities. Potential output is stored or disregarded on the basis of a switch setting for each of 45 normal output categories.* These are listed in Table 11. Section 3.2 also describes the use of Cards 1001 and 1002 for specifying which of the stored output categories are to be printed and in what order. Categories 0 and 41 to 45 constitute special output which is discussed in detail in Section 4.4.2. A brief summary of these options, however, is given in this section after the following discussion of the normal output category options.

Category 1 output consists of the acceleration profiles (input) and the integrated velocities and displacements. Note that x and z output is in a mixture of units—_inches for displacements, mph for velocities, and g's for accelerations. x and z output gives the motion of the vehicle origin with respect to the inertial frame regardless of whether input accelerations are accelerometer readings or absolute.

Category 2 output summarizes the "activity" at the defined regions of the vehicle interior. Forces against the region are resolved into special region coordinates (Figure 38) and summed over all segments. If structural deformation is allowed (Card 402), then the third and fourth output items summarize the overall deformation as an average over the segment endpoints. The columns labeled "Endpoint Movement" give the coordinates of the region endpoints in either the vehicle frame or inertial frame, depending on the value of Field 6 of the region 402-Card and as indicated in the Category 2 page heading.

A detailed description of line segment movement is given by Category 3 output. The endpoint coordinates of each of the first five line segments in the region are printed. As for Category 2, coordinates are with respect to the vehicle or inertial frame depending on Field 6 of the region 402-Card.

*Categories 1-40 and 46-50.

There are three types of Category 4 output. The first describes contact interaction between a line segment and a contact-sensing ellipse. The columns labeled "On Line" give the position (and velocity) of the point of contact measured along the line segment from its first endpoint. The last four columns give the coordinates of the point of maximum penetration by the ellipse in the vehicle and body segment frames. The second type describes contact between body ellipses. Deflections, rates, and force are printed in the first five columns. The remaining columns give the coordinates of the ellipse centers and of the contact point in the inertial and body segment systems, respectively. The third type describes belt forces. Columns one and two are always belt deflection and rate even though belt material properties may have been specified in terms of strain. Column three, with the heading "Ring Equilibrium Tension," is used only for the advanced belt system. This is the belt segment tension for force balance at a slip ring, whether or not the ring is anchored to the vehicle. This force includes the effect of friction at the ring. Column four is labeled "Unadjusted Tension." For the MODROS belt system, this is simply the belt segment tension. For the advanced belts, this is the tension determined from considering the ring positions as quasi-anchor points, without adjustment for friction between occupant and webbing. The positive or negative adjustment for this friction is in column five, labeled, "Tension Adjustment." (This column will contain all zeros for MODROS belts.) For the MODROS system the "Resultant Force" in the next column is the magnitude of the combined lap belt force vectors; it is identical to the belt tension of column four for the torso belts. For the advanced belt system, the resultant belt force is determined from columns 3, 4, and 5. "Resultant Heading" in the next column is the belt angle, measured by counterclockwise rotation from the vehicle x-axis of a line from the anchor point to the attachment point. For the MODROS lap belt combination, the heading is that of the resultant force vector. Advanced belt system tensions and deflections are in three-dimensional space, not merely projections onto the occupant plane.

Neck reaction forces are printed for Category 5. The signs of all shear forces will be consistent with positive shear on the neck for head-neck flexion. Non-zero neck mass causes compressive forces on the neck at the upper and lower neck joints to be different.

Filtered and unfiltered accelerations and injury criteria come from categories 6-9. These output pages are self-explanatory.

Categories 10-12 give body segment angles, velocities, and accelerations in vehicle or inertial frames. Angles are defined in accordance with Figure 78. Categories 13 and 14 give body joint coordinates and velocities relative to the vehicle system. Additional joint coordinates are printed in Categories 21 and 22.

Total torques at the joints are printed for Category 15. It is perhaps worth noting that "Shoulder at Torso" means joint 9 in Figures 1 and 4, and "Shoulder at Arm" means joint 7. The only torque contribution for joint 9 is from muscle tension. All torque components can contribute at joint 7 and the relative angle upon which the torques are based is between the upper arm and upper torso lines, not the shoulder element and upper torso. Absorbed energies for joints and also for the neck and shoulder lengths are printed for Category 16.

Category 17 output consists of body kinetic energies. It should be noted that neck element kinetic energy (if non-zero) is distributed between the head and torso in proportion to α (Card 202).

Categories 18 to 20 print airbag submodel results. Category 18 prints the thermodynamic variables which describe the state of the airbag; the headings are self-explanatory. The airbag generates forces on five body segments which act normal to the contact lines on the occupant (Figure 94). The total force has two components: a) pressure force; b) bag membrane force. These are printed for Category 19. The total force on each of the body elements is resolved into x and z components, relative to the vehicle, and moments about

the body element CG's. These are printed for Category 20.

Neck joint coordinates and velocities are printed for Category 21. The neck length is printed also. Similar quantities for the shoulder come from Category 22.

The contents of Categories 23 to 29 are joint torque and absorbed energy components. These pages are self-explanatory.

Categories 30 to 32 give the vehicle-relative x and z components of the total external (non-gravitational) force on each of the body elements. Occupant contact with the vehicle interior can contribute for all eight body elements. The belt restraint forces, whether from the simple or advanced system, contribute to the torso elements only. Airbag contributions are to the head, torso elements, and upper leg. The steering column forces contribute to the head and torso elements. Reaction forces at joints are not included.

The motion of the steering column subsystem is printed for Category 33 and 34. In particular the first six columns for Category 33 locate the points in the system which sense contact by the occupant. (See Figures 55 and 56.) Upper and lower column extensions and angles are printed for Category 34. Category 35 prints body contact forces against the steering wheel and reaction forces within the steering column system. The vehicle-relative force and moment components acting on the occupant result from Category 36.

Category 37 prints all components of internal force in the neck and shoulder length elements. This page is self-explanatory.

Muscle tension may act at nine joints and in both length elements (neck and shoulder). The dynamic muscle tension torques and forces are printed for Category 38. Associated dissipated energy is printed for category 30.

Category 40 output consists of femur and tibia axial and shear forces. These values are determined on the basis of analysis done by Danforth (Ref. 24).

(Also, see Ref. 25.) This analysis is included in Volume 3, Section 4.6.2.5.

Options 41 through 44 constitute an updated version of the parameter assessment capabilities used in earlier HSRI two- and three-dimensional crash victim simulators. Options 41 through 43 yield output which identifies the quantity, the peak value, the time at which the peak occurs, the time duration during which the quantity exceeds an inputted test value together with the points in time at which the quantity exceeds and then returns below the test value. Option 41 causes both a high and low test against upper and lower test values. If a zero test value is specified, the test is not made. Option 45 is for a printer-plot man and vehicle interior presented at specified time points at which regular printout occurs. Details of these options will be found in Section 4.4.2. Figure 95 shows example printer-plot output.

Options 46, 47, and 48 are for head center-of-gravity, chest center-of gravity, and hip-joint motions. x and z displacements, velocities, and accelerations are printed for each category, and rotational motion is also printed for the head and chest segments. Options 49 and 50 yield output of joint relative angles and relative angle velocities, respectively.

3.4 SAMPLE INPUT AND OUTPUT

The purpose of this section is to give the engineer who is learning to use the MVMA 2-D model a "hands-on" feeling for input data sets required by the model. A complete and careful reading of Section 3.4 prior to a first attempt at developing a data set is highly recommended. A careful reading would probably benefit even users already familiar with the MVMA 2-D model.

This section has been reproduced virtually intact from Module 13 of the MVMA 2-D Tutorial System [8]. "Module" references in this section are for the Tutorial System.

Data decks are described and assembled in this section for the following two simulations:

1. a 30-mph frontal barrier crash with vehicle interior deformation and a dummy passenger restrained only by a knee bar; and,
2. a crash with similar occupant and vehicle configurations except that the occupant is restrained additionally by a torso harness.

3.4.1 Introduction

It is normally convenient to construct a data set card by card, beginning with Card 100 and proceeding through Card 1600. However, a complete data set can also be viewed as a collection of subsets which may be dealt with individually. In this section, discussion of the construction of data sets is in terms of eighteen largely independent subsets. These are identified in Figure 96 . Data subsets developed for one simulation can be assembled with subsets developed for other simulations to yield a complete data deck for a new simulation. As long as the user keeps in mind and takes account of the various dependencies between some of the subsets, a completely satisfactory composite data deck will result.

3.4.2 Input Data for Example 1

The first example to be considered is simulation of a 30-mph frontal barrier crash with a dummy passenger restrained only by a knee bar. The frontal portion of the vehicle interior displaces toward the occupant. Figure 97 is a schematic of the occupant and vehicle interior configuration at crash onset. The following sections (3.4.2.1 through 3.4.2.11) discuss the construction of the data set for Example 1, which is shown in its entirety in Figure 109 .

Arbitrary Decomposition of MVMA 2-D Data Set Into Subsets

DATA SUBSET	CARD NUMBERS
Title Cards	100, 200, ..., 900
General Controls for IN and GO	101, 102, 103
Debugging Printout Controls	104, 105
Categories of Output Variables to be Stored	107 - 111
Vehicle Motion	601 - 604
Occupant Description	201 - 242
Occupant Position	217, 301-304
Vehicle Interior	401 - 411
Friction Characteristics	412
Allowed or Disallowed Contact Interactions	106
Belt Restraint System	218, 501, 701-723
Airbag Restraint System	901 - 909
End of Data Deck for INP	1000
Categories of Output Variables to be Printed	1001, 1002
HIC, Femur Loads, and Filtering	1003, 1004
Potential Injury Indicators	1100 - 1401
Printer-Plot Stick Figure Time Sequence	1500 - 1502
End of Data Deck for OUTP	1600

FIGURE 96 Arbitrary Decomposition of MVMA 2-D Data Set Into Subsets

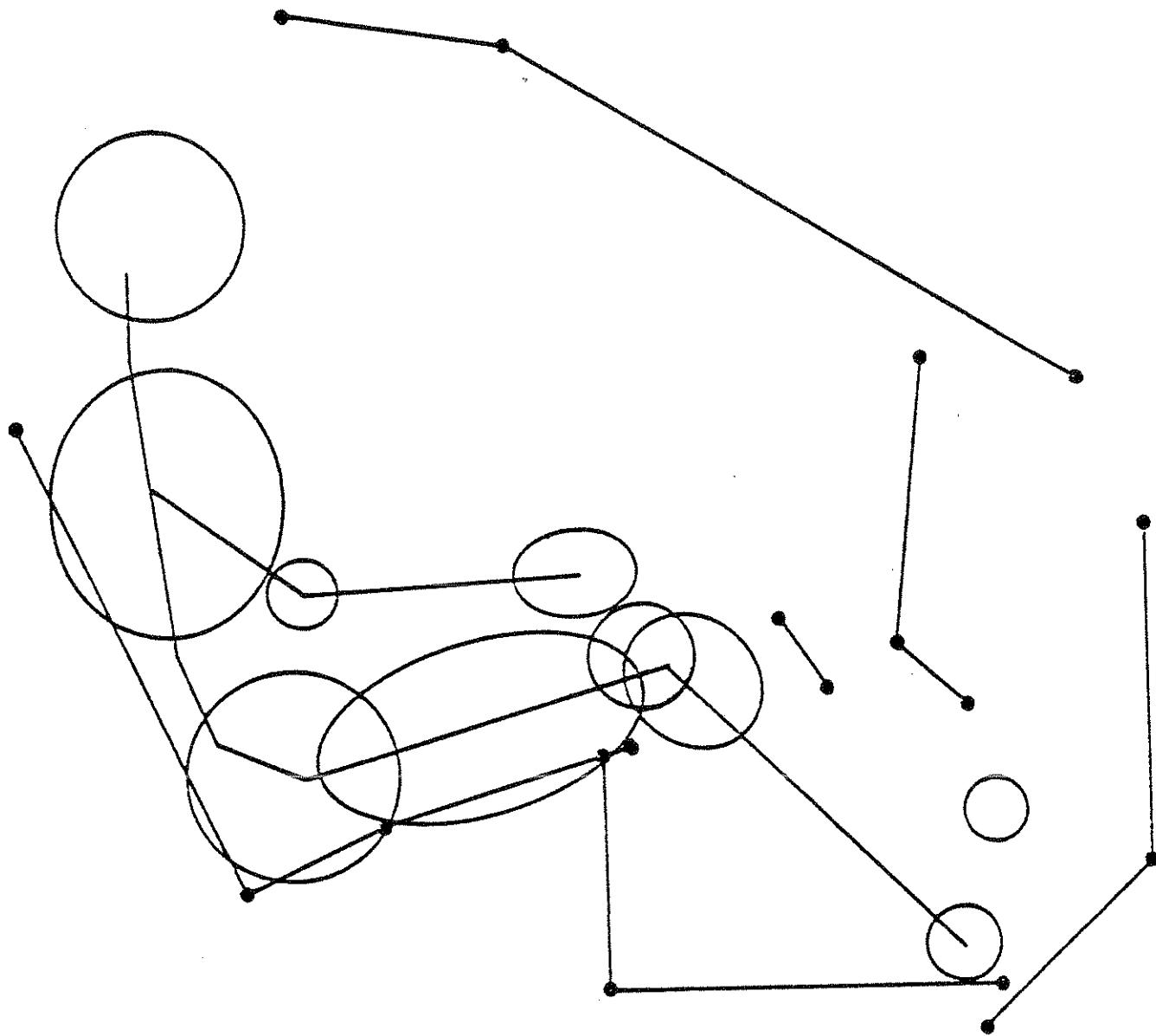


FIGURE 97 Occupant and Vehicle Interior Configuration for Example 1

3.4.2.1 Title Cards. Each page of output for a simulation is headed by titles which may be supplied on Cards 100, 200, 300, ..., 900. These cards are discussed in Module 12. The 100-Card is for a "run title," which should be centered in the first 72 columns and which will appear on the first line of each page of printout. (See Figure 98). The second line of page heading consists of the concatenated content of Cards 200, 300, ..., 900. Each of these cards is normally used for description of a specific simulation characteristic. For example, as indicated in Volume 2 of the MVMA 2-D report, the 700-Card normally describes the type of belt restraint system used. However, there are no restrictions on the content of these cards. The 19-column subtitle fields of Cards 200, 300, ..., 700 plus the 17-column field of either Card 800 or Card 900 (only one may be used) can be used together for any 131-character description of the simulation.

The title cards for Example 1 have been grouped together at the beginning of the data set except for the 200- and 300-cards, which have both been used for occupant description and are placed with the occupant data cards (see Figure 102). It might be again noted, as explained in Module 1, that data cards can be positioned within the data deck in any order, without attention to card identification number. Exceptions to this are the 1000- and 1600-cards, which serve as "end-of-data-deck" markers and must be the last cards of the data decks for the Input and Output Pre-processors INP and OUTP.

3.4.2.2 General Controls for IN and GO. A number of general controls are required for the operation of the Input (IN) and Execution (GO) Processors. These are on Cards 101, 102, and 103, which are discussed in Modules 4, 5, 6, 9, 10, and 12.* Some of the most important of these controls specify: 1) the system of units (metric or English) for the simulation; 2) crash duration, integration time step, and time increment for printing of output; 3) use or non-use of the various restraint system options; 4) interpretation of "inhibition cards" for allowed or disallowed contact interactions; and 5) limits for the algorithm which

*The user is referred to Table 9 for aid in finding discussion in Modules 2 through 12 of the parameter in any data card field.

MVMA 2-D TUTORIAL EXAMPLE #1									
KNEE BAR									100
3CC. COMP. DISPL.									400
30MPH FRONT BARRIER									500
NO BELTS									500
									700

FIGURE 98 Title Cards for Example 1

1.	1.	32.174	0.	0.	200.	1.	5.	10.	101
0.	0.	0.	0.	0.	10.	.000001	5.		102
.2	.05	100000.	15000.	10.	.05	10.	1.	1.	103

FIGURE 99 General Controls for IN and GO for Example 1

determines shared-deflection force balance. Simulation Examples 1 and 2 of this section are both for 200 msec duration, one msec integration time step, and five msec printout interval. The simulations are made with English system data. Figure 99 shows Cards 101 through 103.

3.4.2.3 Vehicle Motion. The vehicle motion, or more precisely, occupant compartment motion, is described with Cards 601 through 604. This prescription of the "crash history" is the subject of Module 8. Cards for the 30-mph frontal barrier crash of Example 1 are shown in Figure 100. Initial position and velocity values for vehicle horizontal, vertical, and pitch coordinates are on Card 601, together with two coordinates for an accelerometer location. The remaining cards specify acceleration histories for the three vehicle degrees of freedom.

The horizontal motion for this example, illustrated by the acceleration profile in Figure 101, is defined by twenty-three time-acceleration points on cards following the 602-card. The crash represented is for an impact velocity of 30 mph, a ΔV of 32.83 mph, 33.9 g's peak acceleration, and a stopping distance (or "crush") of 21.8 inches.

3.4.2.4 Occupant Description. Most of the Cards 201 through 242 are used for prescribing occupant parameters. Cards 201 through 216 plus 227 through 242 describe mass and moment of inertia properties for the body links, link lengths, and joint properties. Cards 219 and 220 define ellipses which represent the contact-sensing profile of the body. Loading and unloading characteristics of body materials are prescribed on Cards 221 through 226.* The data in Figure 102 are preliminary data compiled by HSRI from several sources for a GM Hybrid II dummy. Toe and heel ellipses have been positioned for a foot in a flexed configuration since the MVMA 2-D model does not include an articulation at the ankle joint.

Values pertinent to initial joint torques are on Card 217 (see Section 3.4.2.5). Head and chest accelerometers are located by values on the 218-Card (see Figure 122).

* See Modules 2, 3, 4, and 6 for discussion of occupant parameters.

0.	44.	0.	0.	0.	0.	0.	0.	501
23.	1.	1.	-1.4	7.	-33.9	12.	2.8	602
0.	-1.7	1.	-21.2	21.5	-12.4	28.	-9.2	
13.5	3.9	18.	-24.0	36.	-9.9	37.	-9.9	
32.	-24.0	33.	-31.8	50.	-25.9	54.	-27.2	
42.	-26.9	47.	-29.0	76.	-6.9	90.	-1.4	
58.	-32.2	61.	0.	300.	0.			
100.	-1.4	120.						603
2.	1.	1.						
0.	0.	300.	0.					604
2.	1.	0.	300.	0.				
0.	0.							

FIGURE 100 Vehicle Motion Cards for Example 1

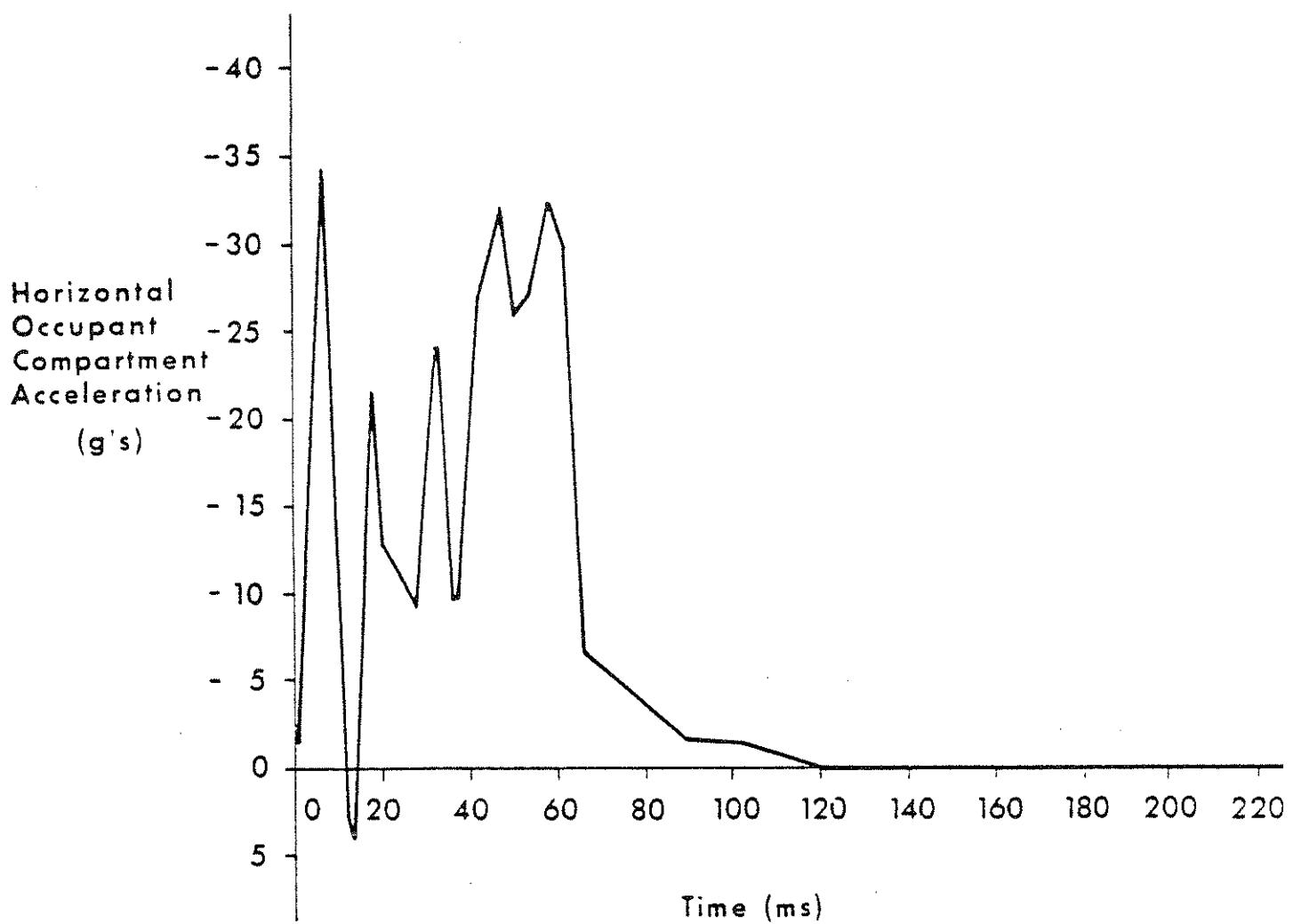


FIGURE 101 Horizontal Component of Vehicle Acceleration for Example 1

GM HYBRID II DUMMY
 (PRELIMINARY DATA)

1.1	13.44	3.4	5.	15.8		10.3	3.25	-.88	200
2.75	7.	1.7	4.2	8.2	9.3	5.	5.8	.5	300
.0259	.0051	.0052	.0992	.0932	.0518	.022	.0256	.007	201
.108	1.97	.04	1.53	1.38	2.82	.18	.62		202
12.8	.58	0.	.52	17.4	1.		-25.	.35	204
12.9	.58	0.	.52	17.4	1.		-22.	.35	205
72.	15.	0.	.66	1000.	1.	-8.	-25.5	.35	206
102.5	-7.624	.1944	.66	1000.	1.	-33.999	-34.001	.35	207
84.44	-4.810	.1053	0.	850.	1.	-49.999	-50.001	.5	208
0.	29.8	0.	0.	204.	1.	135.	0.	.5	209
0.	10.	0.	0.	222.	1.	28.	-197.	.5	210
0.	10.	0.	0.	64.	1.	0.	-165.	.5	211
751.	0.	757.	1.98						212
20.	230.	0.	0.			2.		.5	213
38.	.58	0.	.52	0.	1.	-1.		.16	214
38.	.58	0.	.52	0.	1.	2.		.16	215
751.	0.	757.	1.98						216
HEAD				1.	3.				242
THORAX		CHESTMATL		2.	1.				219
HIP		HIPMATL		4.	1.				219
THIGH				5.	1.				219
KNEE				5.	1.				219
SHANK				6.	1.				219
HEEL				6.	2.				219
TOE				6.	2.				219
ELBOW				7.	1.				219
HAND				8.	3.				219
HEAD	0.	.5		4.	4.				220
THORAX	-.5	-.68		5.52	4.44				220
HIP	-.12	0.		4.5	4.5				220
THIGH	-.5	-.1		7.	3.				220
KNEE	7.	-.4		2.25	2.25				220
SHANK	-7.54	0.		3.	2.4				220
HEEL	8.57	0.		1.2	1.2				220
TOE	5.61	-.5.16		1.2	1.2				220
ELBOW	5.3	0.		1.5	1.5				220
HAND	5.6	-.4		2.72	1.52				220
CHESTMATL	0.	0.		0.	100.	101.	0.	0.	221
CHESTMATL	5.					CSTAT	IZERO	CGR	222
CGR	-1.	.1							223
CGR	0.	1.							224
CGR	.01	.64							224
CGR	.3	.5							224
CGR	1.35	.45							224
CSTAT	0.	0.							225
CSTAT	.01	1125.							225
CSTAT	.05	1460.							225
CSTAT	.3	1350.							225
CSTAT	.4	1260.							225
CSTAT	1.1	1260.							225
CSTAT	4.25	12600.							225
IZERO	-1.	0.							226
HIPMATL	0.	0.	0.	100.	101.	0.	0.	0.	221
HIPMATL	5.				CSTAT	IZERO	CGR		222

FIGURE 102 Occupant Parameter Cards for Example 1

3.4.2.5 Occupant Position. The seated occupant at "time zero" for Example 1 is shown in Figure 97. Data are required for initial positioning of the occupant. In addition, a value is needed for the initial velocity for each occupant degree of freedom (see Module 7). As the occupant for Example 1 is initially at rest within the occupant compartment, which is normally the case for crash simulations, these initial velocities -- fourteen fields of Cards 302, 303, and 304 -- are all 0. in the data of Figure 103.

The initial position data are on Cards 217, 301, 303, and 304. First, initial position values are required for the fourteen occupant degrees of freedom. These are the initial link angles (301), neck length (303), shoulder position (304), and horizontal and vertical locations within the occupant compartment of the upper torso center of gravity (303). For the two example simulations, initial link angles and upper torso CG location were estimated from scale drawings of the "time zero" occupant and vehicle-interior configurations, so the values in Figure 103 produce only approximate initial occupant equilibrium. The resulting total initial upward force on the occupant, for example, is 207.1 lb, which does not equal the occupant weight, 163.7 lb. The initial imbalance is not great enough to significantly affect the simulation results.

Values on Card 217 are for the so-called "joint equilibrium angles." The values in the example data have been selected to equal initial relative joint angles, which may be determined by subtracting link angles on Card 301. As explained in Module 2, this results in zero initial values for the linear components of joint torques.

3.4.2.6 Vehicle Interior. A vehicle interior with which the occupant is to interact must be prescribed by the user. Two types of data are required. The first of these describes the geometrical profile of the interior in the plane of occupant motion. (See Module 5.) The primary elements of this description are the endpoint coordinates of line segments which comprise so-called vehicle-interior "regions," a "region" being a set of connected straight-line segments having the same material properties. Figure 104 shows the vehicle interior profile defined for Example 1. Region and segment names are indicated,

-11.	-8.	-18.	-34.	-50.	0.	0.	0.		217
78.5	97.5	115.5	149.5	19.5	-45.	-41-	3-	89.5	301
0.	0.	0.	0.	0.	0.	0.	0.	0.	302
12.2	0.	-21.4	0.	3.23	0.-				303
0.	0.	0.	0.						304

FIGURE 103 Occupant Position Cards for Example 1

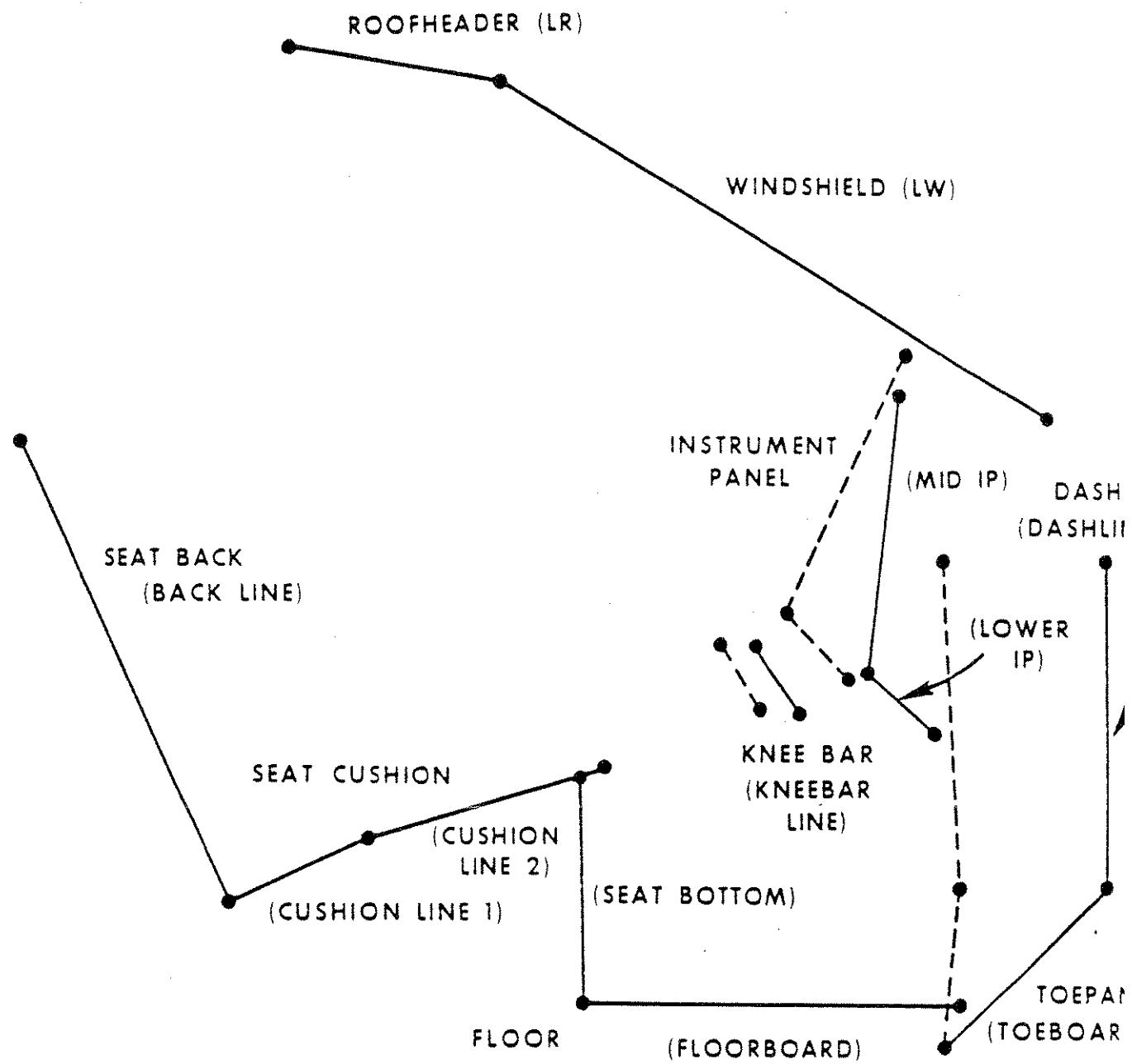


FIGURE 104 Vehicle Interior Profile for Example 1

segment names in parentheses. Solid lines indicate positions of line segments before frontal interior penetration into the occupant compartment, which begins at 40 ms. All penetration occurs between 40 and 80 ms, and the dashed lines represent the deformed vehicle interior. Note that the toeboard segment decreases considerably in length. There is no restriction that segment lengths be held constant while undergoing motion. Data for one of the penetrating regions of the vehicle interior, the INSTRUMENT PANEL region, are illustrated in Figure 105. The INSTRUMENT PANEL profile is defined entirely by Cards 401, 402, 409, 410, and 411.

The second type of data required for the vehicle interior describes material characteristics, i.e., loading and unloading properties of regions of the defined profile. Data are on Cards 403 through 408. With regard to material specifications in Figure 105 for the INSTRUMENT PANEL, there are two points worthy of note. First, the use of the name IZERO on Card 404 for the inertial spike curve illustrates that curve names may be shared by materials; no inertial spike data (Card 408) appear here for material IPMAT since the inertial spike curve IZERO is defined elsewhere in the data set for a different material (see Card 226 in Figure 102). It is also allowable to specify the same material name for different regions or ellipses while defining the material properties only once within the data set. Second, the dependence of the R-ratio (for energy restitution) on maximum deformation is indicated on the 406-Cards and has been established to be compatible with the G-ratio (for permanent deformation) on Cards 405 and the loading curve from Cards 407. This is important to guarantee proper unloading behavior for the material. Determination of G- and R-ratio compatibility is described in Module 6, Part 2.

3.4.2.7 Friction Characteristics. Frictional forces between the occupant and elements of the vehicle interior can be large enough to have a considerable effect on the magnitude and direction of the resultant force vector at the interaction interface. It is therefore important in simulations to account for frictional forces accurately. The user of the MVMA 2-D model assigns each body ellipse and each vehicle interior region to a "friction class;" this is done with entries on Cards 219 and 402. Coefficients of friction are specified

INSTRUMENT PANEL	IPMAT	0.	1.	1.	1.			401
INSTRUMENT PANEL	IPMAT2.	4.	1.	0.	0.			402
MID IP	INSTRUMENT PANELS.	0.	1.	1.	1.			409
MID IP	4.							410
MID IP	0.	44.9	-27.3	43.7	-15.9			411
MID IP	40.	44.9	-27.3	43.7	-15.9			411
MID IP	80.	45.6	-29.3	40.6	-18.9			411
MID IP	300.	45.6	-29.3	40.6	-18.9			411
LOWER IP	INSTRUMENT PANELS.	.5	1.	2.				409
LOWER IP	4.							410
LOWER IP	0.	43.7	-15.9	46.9	-12.8			411
LOWER IP	40.	43.7	-15.9	46.9	-12.8			411
LOWER IP	80.	40.6	-18.9	42.6	-14.9			411
LOWER IP	300.	40.6	-18.9	42.6	-14.9			411

IPMAT	0.	0.	0.	100.	101.	0.	0.	403
IPMAT	5.	0.	0.	0.	IPSTAT	IZERO	IPGR	404
IPGR	0.	0.						405
IPGR	2.	.75						405
IPGR	40.	.75						405
IPGR	0.	1.						406
IPGR	1.	.25						406
IPGR	2.	.1						406
IPGR	8.	.1						406
IPGR	8.4	.15						406
IPSTAT	0.	0.						407
IPSTAT	.165	80.						407
IPSTAT	.375	480.						407
IPSTAT	.665	750.						407
IPSTAT	.780	760.						407
IPSTAT	1.25	500.						407
IPSTAT	1.75	580.						407
IPSTAT	2.54	225.						407
IPSTAT	2.87	255.						407
IPSTAT	3.44	300.						407
IPSTAT	4.54	380.						407
IPSTAT	4.63	250.						407
IPSTAT	8.	250.						407
IPSTAT	12.	3850.						407

FIGURE 105 Data Cards for Definition of Geometrical Profile and Material Properties for a Typical Region

on 412-Cards for combinations of ellipse and region friction classes. Figure 106 shows the 412-Cards in the data set for Example 1. There is one card for each pairing of friction classes represented in the set of contact interactions which can occur in this simulation. For any simulation, coefficients of friction will default to 0. for any pairing not represented by a 412-card. Note that the first data card in Figure 106 includes coefficients for tangential forces proportional to the first and second powers of deflection, as explained in Module 6-2. For this example, the values represent plowing resistance to relative motion between the SEAT CUSHION and SEAT BACK regions and contacting body ellipses.

3.4.2.8 Interaction "Inhibition" Cards. Modules 4 and 5 discuss the use of 106-Cards for specification of allowed or disallowed combinations of potentially-interacting body ellipses and vehicle interior regions. "Allowed" combinations are normally specified when the number of probable interactions is less than the number of improbable interactions. This is judged to be the case for the first simulation example, so twenty-one allowed interactions have been specified between the ten body ellipses and nine vehicle-interior regions. These are shown in Figure 107. One card has been included for an allowed interaction between body ellipses THIGH and THORAX.

3.4.2.9 Belt Restraint System. Example 1 is a simulation for an unrestrained occupant. As an illustration that it is unnecessary to remove restraint system data from the data deck for such a simulation, belt system data cards are included in the complete data deck for Example 1 shown in Figure 109. (These are Cards 218, 501 and 701 through 709). It is necessary only to set the belt system usage switch in field 1 of Card 102 to its "off" value, zero.

3.4.2.10 End of Data Deck for INP. The last card in the data deck for the Input Processor, INP, must be the 1000-Card. It is blank except for the card identification number in columns 77 through 80. (See Figure 109.)

1.	1.	.25	.125	.125	412
1.	2.	.5			412
1.	3.	.5			412
1.	4.	.4			412
2.	2.	.8			412
3.	1.	.4			412
3.	2.	.5			412
3.	4.	.4			412
3.	5.	.67			412
3.	6.	.9			412

FIGURE 106 Data Cards for Coefficients of Friction for Example 1

HEAD	ROOFHEADER	106
HEAD	WINDSHIELD	106
HEAD	INSTRUMENT PANEL	106
THORAX	SEAT BACK	106
THORAX	SEAT CUSHION	106
THORAX	INSTRUMENT PANEL	106
HIP	SEAT BACK	106
HIP	SEAT CUSHION	106
HIP	FLOOR	106
THIGH	SEAT CUSHION	106
KNEE	INSTRUMENT PANEL	106
KNEE	KNEE BAR	106
SHANK	INSTRUMENT PANEL	106
SHANK	KNEE BAR	106
HEEL	FLOOR	106
HEEL	DASH	106
TOE	DASH	106
HEEL	TOEPAN	106
TOE	TOEPAN	106
HAND	SEAT CUSHION	106
HAND	INSTRUMENT PANEL	106
THIGH	THORAX	106

FIGURE 107 Interaction "Inhibition" Cards for Example 1

3.4.2.11 Output Processor Controls. Cards 1001 through 1600 constitute a separate data deck from Cards 100 through 1000, described in the preceding sections and read by the Input Pre-Processor. Cards 1001 through 1600 are read by the Output Pre-Processor. These cards control post-processing and printout of data calculated and stored by the Dynamic Solution Processor (or "Execution Processor," GO). These data and data generated by the Input Processor are stored in four external files (see Module 12); as long as the files are maintained intact, they can be processed by the Output Processor any number of times, using different control Cards 1001 through 1600.

***** Output Categories for Printout. The entire Output Pre-Processor data deck for Example 1 consists of seven cards. These are shown in Figure 108 . The first two cards, 1001 and 1002, are used for specification of categories of calculated data for which printout is desired and the order of printout for these categories. The fifty

categories of results which may be printed are identified by Category Number in Table 11.

The ordering

for printout shown for Example 1 in Figure 108 is identical to the default ordering which would result if the 1001- and 1002-Cards were omitted from the data deck.* All categories are requested for Example 1. Requests for printout for categories for which no data are stored will be ignored by the Output Processor.

***** HIC, Femur Loads, and Filtering. Various data explained in Module 12 are required on Cards 1003 and 1004 for the post-processor functions of filtering of occupant accelerations and determination of HIC and femur loads.

***** Potential Injury Indicators. In addition to HIC and femur loads, other potential injury indicators can be determined and printed by the Output Processor. These are also discussed in Module 12. They are requested by using Cards 1100 through 1401, none of which are included in the data deck for Example 1.

* The default ordering minus printout of the input data summary, Category 0, can be obtained by using a 1001-Card which contains only "-1" in columns one and two.

0, 1, 46-48, 10-14, 21, 22, 37, 38, 49, 50, 15, 23-26, 2-5, 18-20, 33-36, 30-32, 16,	1001
27-29, 39, 17, 40, 6-9, 45	1002
0. 0. 11.55 .025	1003
40. 500. 560. 0. .85 201. 5. 5.	1004
0. 0. -3. 62. 5. -44. 10. 0.	1500
21. 0. 0. 1. 1. 0. 1. 0. 10.	1501
	1600

FIGURE 108 Output Processor Data Deck for Example 1

***** Printer-Plot Stick Figures. As explained in Module 12, a time sequence of printer-plot pages can be produced which depict the occupant and all lines of the vehicle interior. A control for storing data required for production of this printout is on Card 101, read by the Input Pre-Processor and shown in Figure 99. Controls for producing the printout are read from Cards 1500 through 1502 by the Output Pre-Processor. The most important data on these cards are margin coordinates which frame the printer-plot image within the vehicle coordinate system and the simulation times to be included in the time sequence of printouts.

***** End of Data Deck for OUTP. As for the Input Pre-Processor data deck, a single card is required to mark the end of the Output Pre-Processor data deck. It is Card 1600, which is blank except for the card identification number.

3.4.3 Selected Output from Simulation Example 1

Selected pages of printout from the MVMA 2-D Crash Victim Simulator are shown as Figures 110 through 124. Figure 109 contains the data cards for Example 1 which generated the simulation results shown.

The MVMA 2-D model has undergone continuous development and improvement since its inception, and it is expected that it will continue to undergo change. Consequently, numerical results in Figures 110 through 124 should not be compared with results that MVMA 2-D users might obtain by using the data set for Example 1 for simulation with their own installations of the model. Rather, these figures are to be viewed as illustrative of the format of MVMA 2-D printout.*

3.4.3.1 Data Set Echo. Both the Input and Output Pre-Processors always produce "echoes" of their data decks. An example page from the Input Pre-Processor "echo" for Example 1 is shown as Figure 110. The eight-column data fields are separated by asterisks.

3.4.3.2 Summary of Input Data. Figure 111 is an example page of printout of a summary of the input data. The entire input data summary for Example 1 is 63 pages. This printout is produced whenever category 0 is requested on the 1001-Card.

*Results in Figures 114, 115, 116, 120, and 121 are not consistent with other results since they were taken from a different simulation.

3.4.3.3 Printer-Plot Stick Figure Sequence. The data decks for Example 1 cause printer-plot stick figure output to be generated for each 10 ms of simulation time. Selected "frames" of the time sequence are shown as Figure 112.

3.4.3.4 Printout of Numerical Results. Nine example pages of printout of numerical results are shown in Figures 113 through 124. The definition of most output variables is clear. However, aid is provided for the user in interpreting output in Section 3.3.

Only two special notes will be made here regarding output variables. First, femur and tibia loads (Figure 122) must be interpreted as for two legs combined. That is, values for one leg are obtained by dividing by two. Second, GMR Severity Indices are calculated for head and chest in addition to values for the standard Gadd Severity Index. The GMR index is defined in a section of Volume 3 entitled, "Special Indices." It differs from Gadd index in that its calculation involves raising acceleration values to powers which vary with acceleration level rather than the constant power 2.5.

MVMA 2-D TUTORIAL EXAMPLE #1									
KNEE BAR									
DCG, COMP, DISPL.									
30MPH FRONT BARRIER									
NO BELTS									
1.	1.	32.174	0.	0.	200.	1.	5.	13.	100
0.	0.	0.	0.	0.	0.	10.	.000001	5.	400
.2	.05	100000.	15000.	10.	.05	10.	1.	1.	500
0.	44.	0.	0.	0.	0.	0.	0.	0.	500
23.	1.	1.							700
0.	-1.7	1.	-1.4	7.	-33.9	12.	2.8		101
13.5	3.9	18.	-21.2	21.5	-12.4	28.	-9.2		102
32.	-24.0	33.	-24.0	36.	-9.9	37.	-9.9		103
42.	-26.0	47.	-31.8	50.	-25.9	54.	-27.2		501
58.	-32.2	61.	-29.0	76.	-6.9	90.	-1.4		502
100.	-1.4	120.	0.	300.	0.				
2.	1.	1.							503
0.	0.	300.	0.						
2.	1.								504
0.	0.	300.	0.						
GM HYBRID II DUMMY									
(PRELIMINARY DATA)									
1.1	13.44	3.4	5.	15.8		10.3	3.25	-.38	200
2.75	7.	1.7	4.2	9.2	9.3	5.	5.8	.5	300
.0250	.0051	.0052	.0092	.0932	.0518	.022	.0256	.007	201
.108	1.07	.04	1.53	1.38	2.82	.18	.62		202
12.8	.58	0.	.52	17.4	1.		-25.	.35	204
12.9	.58	0.	.52	17.4	1.		-22.	.35	205
72.	15.	0.	.56	1000.	1.	-8.	-25.5	.35	206
102.5	-7.624	.1944	.66	1000.	1.	-33.999	-34.001	.35	207
84.44	-4.810	.1053	0.	850.	1.	-49.999	-50.001	.5	208
0.	29.8	0.	0.	204.	1.	135.	0.	.5	209
0.	10.	0.	0.	222.	1.	28.	-197.	.5	210
0.	10.	0.	0.	64.	1.	0.	-165.	.5	212
751.	0.	757.	1.98						213
20.	230.	0.	0.			2.		.5	214
38.	.58	0.	.52	0.	1.	-1.		.16	215
38.	.58	0.	.52	0.	1.	2.		.16	216
751.	0.	757.	1.98						242
HEAD									
THORAX	CHESTMATEL		1.	3.					219
HIP	HIPMATEL		2.	1.					219
THIGH			4.	1.					219
KYEE			5.	1.					219
SHANK			6.	1.					219
HEEL			6.	2.					219
TDF			6.	2.					219
ELBOW			7.	1.					219
HAND			8.	3.					219
HEAD	0.	.5	4.	4.					220
THORAX	-.5	-.68	5.52	4.44					220
HIP	-.12	0.	4.5	4.5					220
THIGH	-.5	-.1	7.	3.					220
KYEE	7.	-.4	2.25	2.25					220
SHANK	-7.54	0.	3.	2.4					220
HEEL	8.57	0.	1.2	1.2					220
TDF	5.61	-5.16	1.2	1.2					220
ELBOW	5.3	0.	1.5	1.5					220
HAND	5.6	-.4	2.72	1.52					220
CHESTMATEL	0.	0.	0.	100.	101.	0.	0.		221

FIGURE 109 Complete Data Set for Simulation Example 1 (page 1 of 6)

C1FSTMATE	5.				CSTAT	IZERO	CGR	222
CGR	-1.	.1						223
CGR	0.	1.						224
CGR	.01	.64						224
CGR		.5						224
CGR		.45						224
CSTAT		0.						225
CSTAT	.001	1125.						225
CSTAT	.005	1460.						225
CSTAT	.3	1350.						225
CSTAT	.4	1260.						225
CSTAT	.1	1260.						225
CSTAT	.25	12600.						225
IZERO		0.						226
HIPMATE	0.	0.	0.	100.	101.	0.	0.	221
HIPMATE	5.				CSTAT	IZERO	CGR	222
-11.	-8.	-18.	-34.	-50.	0.	0.	0.	217
78.5	97.5	115.5	149.5	19.5	-45.	-41.	3.	301
0.	0.	0.	0.	0.	0.	0.	0.	302
12.2	0.	-21.4	0.	3.29	0.			303
0.	0.	0.	0.					304
SEAT BACK		SEAT MATERIAL	0.	1.	1.	1.		401
SEAT BACK	1.		1.	0.	0.			402
SEAT MATERIAL	0.	0.	1.6	3.5	4.	0.	0.	403
SEAT MATERIAL	5.				SSEAT	IZERO	GRSEAT	404
GRSEAT	.1							405
GRSEAT	.5							406
SSEAT	0.							407
SSEAT		150.						407
SSEAT		400.						407
SSEAT		2000.						407
SSEAT		4000.						407
SSEAT		0.						407
BACK LINE		SEAT BACK	5.	0.	-1.	1.		409
BACK LINE	1.							410
BACK LINE	-1.	6.2	-25.8	15.44	-4.96			411
SEAT CUSHION		SEAT MATERIAL	0.	1.	1.	1.		401
SEAT CUSHION	2.		1.	0.	0.			402
CUSHION		SEAT CUSHION	5.	.164	1.	1.		409
CUSHION	1.							410
CUSHION	-1.	15.44	-4.96	28.	-9.92			411
CUSHION		SEAT CUSHION	5.	.5	-1.	2.		409
CUSHION	2.							410
CUSHION LINE 2	-1.	28.	-9.92	32.24	-10.64			411
FLOOR		FMATL	0.	1.	1.	1.		401
FLOOR	2.		1.	0.	0.			402
SEAT BOTTOM		FLOOR	5.	0.	-1.	1.		409
SEAT BOTTOM	1.							410
SEAT BOTTOM	-1.	31.2	-8.	31.2	-.84			411
FLOORBOARD		FLOOR	5.	0.	-1.	2.		409
FLOORBOARD	1.							410
FLOORBOARD	-1.	31.2	-.84	49.	-.84			411
TOEPAN		FMATL	0.	1.	1.	1.		401
TOEPAN	1.		1.	0.	0.			402
TOEBOARD		TOEPAN	5.	0.	1.	1.		409
TOEBOARD	1.							410
T38004200	0.	47.3	1.1	54.7	-5.4			411
T38004200	0.	47.3	1.1	54.7	-5.4			411
T38004200	0.	47.3	1.1	47.9	-5.4			411
T38004200	0.	47.3	1.1	47.9	-5.4			411

FIGURE 1 Complete Data Set for Simulation Example 1 (page 2 of 6)

	SHEET METAL	0.	1.	1.	1.						
KNEE BAR	1.	3.	1.	0.	0.		401				
KNEE BAR	1.	3.	1.	0.	0.		402				
SHEET METAL	0.	0.	.5	8.	9.	10000.	10000.	403			
SHEET METAL	5.					SSHEET	IZERO	GRSHEET	404		
GR SHEET 0.	0.								405		
GR SHEET 0.5	0.								405		
GR SHEET 5.5	0.0								405		
GR SHEET 0.	1.								406		
GR SHEET .5	1.								406		
GR SHEET 2.	.7								406		
GR SHEET 4.	.2								406		
GR SHEET 5.5	.15								406		
GR SHEET 8.	.1								406		
GR SHEET 9.	.01								406		
SSHEET 0.	0.								407		
SSHEET 2.	1500.								407		
SSHEET 4.	1500.								407		
SSHEET 5.5	10000.								407		
SSHEET 8.	10000.								407		
SSHEET 9.	0.								407		
KNEEBAR LINE	KNEE BAR	5.	0.5	1.	1.				409		
KNEEBAR LINE	4.								410		
KNEEBAR LINE	0.	40.4	-13.2	38.9	-16.4				411		
KNEEBAR LINE	60.	40.4	-13.2	38.9	-16.4				411		
KNEEBAR LINE	80.	38.9	-13.2	37.4	-16.4				411		
KNEEBAR LINE	300.	38.9	-13.2	37.4	-16.4				411		
ROOFHEADER	RMATL	0.	1.	1.	1.				401		
ROOFHEADER	1.	6.	1.	0.	0.				402		
LR	ROOFHEADER	5.	0.	1.	1.				409		
LR	1.								410		
LR	-1.	18.2	-43.4	28.0	-41.7				411		
WINDSHIELD	WINDSHILD GLASSO.			1.	1.	1.			401		
WINDSHIELD	1.	5.	1.	0.	0.				402		
LW	WINDSHILD	5.	0.	1.	1.				409		
LW	1.								410		
EW	-1.	27.8	-41.3	51.6	-26.3				411		
INSTRUMENT PANELIPMAT		0.	1.	1.	1.				401		
INSTRUMENT PANEL2.	4.	1.	0.	0.					402		
MID IP	INSTRUMENT PANEL5.	0.	1.	1.	1.				409		
MID IP	4.								410		
MID IP	0.	44.9	-27.3	43.7	-15.9				411		
MID IP	40.	44.9	-27.3	43.7	-15.9				411		
MID IP	80.	45.6	-29.3	40.6	-18.9				411		
MID IP	300.	45.6	-29.3	40.6	-18.9				411		
LOWER IP	INSTRUMENT PANEL5.	.5	1.	2.					409		
LOWER IP	4.								410		
LOWER IP	0.	43.7	-15.9	46.8	-12.8				411		
LOWER IP	40.	43.7	-15.9	46.8	-12.8				411		
LOWER IP	80.	40.6	-18.9	42.6	-14.9				411		
LOWER IP	300.	40.6	-18.9	42.6	-14.9				411		
DASH	DASHMATL	0.	1.	1.	1.				401		
DASH	1.	2.	1.	0.	0.				402		
DASHLINE	DASH	5.	0.	1.	1.				409		
DASHLINE	4.								410		
DASHLINE	0.	54.7	-5.6	54.2	-20.1				411		
DASHLINE	40.	54.7	-5.6	54.2	-20.1				411		
DASHLINE	80.	47.9	-5.6	47.4	-20.1				411		
DASHLINE	300.	47.9	-5.6	47.4	-20.1				411		
DASHMATL	0.	0.	0.	100.	101.	0.	0.	DSTAT	IZERO	DGR	403
DASHMATL	5.										404

FIGURE 109 Complete Data Set for Simulation Example 1 (page 3 of 6)

DGR	0.	0.						405
DGR	.001	.01						405
DGR	10.	.01						405
DGR	0.	1.						406
DGR	.001	.91						406
DGR	.75	.8						406
DGR	1.5	.5						406
DGR	10.	.3						406
DSTAT	0.	0.						407
DSTAT	0.75	2100.						407
DSTAT	1.5	9000.						407
DSTAT	40.	9000.						407
RHATL	0.	0.	0.	100.	101.	0.	0.	403
RHATL	5.	0.	0.	0.	RSTAT	IZERO	DGR	404
RSTAT	-1.	1200.	-65.36	67.38	-29.36	4.78		407
WINDSHIELD GLASS	.5	1.	0.	100.	101.	0.	0.	403
WINDSHIELD GLASS	5.	0.	0.	0.	WSTAT	WI	WGR	404
WGR	0.	0.						405
WGR	.5	0.						405
WGR	.51	.65						405
WGR	1.	.75						405
WGR	6.	.8						405
WGR	0.	1.						406
WGR	.5	1.						406
WGR	.51	.1						406
WGR	1.	.05						406
WGR	6.	.01						406
WSTAT	-1.	108.8	50.0	-10.9	1.			407
WI	-1.	3000.	1000.	-8000.	4000.			408
IPHAT	0.	0.	0.	100.	101.	0.	0.	403
IPHAT	5.	0.	0.	0.	IPSTAT	IZERO	IPGR	404
IPGR	0.	0.						405
IPGR	2.	.75						405
IPGR	40.	.75						405
IPGR	0.	1.						406
IPGR	1.	.25						406
IPGR	2.	.1						406
IPGR	8.	.1						406
IPGR	8.4	.15						406
IPSTAT	0.	0.						407
IPSTAT	.165	80.						407
IPSTAT	.375	480.						407
IPSTAT	.665	750.						407
IPSTAT	.780	760.						407
IPSTAT	1.25	500.						407
IPSTAT	1.75	580.						407
IPSTAT	2.54	225.						407
IPSTAT	2.87	255.						407
IPSTAT	3.64	300.						407
IPSTAT	4.54	380.						407
IPSTAT	4.63	250.						407
IPSTAT	8.	250.						407
IPSTAT	12.	3850.						407
FHATL	0.	0.	0.	100.	101.	0.	0.	403
FHATL	5.	0.	0.	0.	FSTAT	IZERO	FGR	404
FGR	0.	0.						405
FGR	2.	.7						405
FGR	0.	1.						406
FGR	2.	.2						406
FSTAT	0.	0.						407

FIGURE 109 Complete Data Set for Simulation Example 1 (page 4 of 6)

FSTAT	.25	100.							407
FSTAT	.5	400.							407
FSTAT	.75	1200.							407
FSTAT	1.	2400.							407
FSTAT	1.5	4000.							407
FSTAT	2.	4600.							407
FSTAT	3.	5000.							407
FSTAT	4.	5200.							407
FSTAT	6.	5400.							407
FSTAT	10.	5600.							407
FSTAT	16.	10000.							407
1.	1.	.25	.125	.125					412
1.	2.	.5							412
1.	3.	.5							412
1.	4.	.4							412
2.	2.	.8							412
3.	1.	.4							412
3.	2.	.5							412
3.	4.	.4							412
3.	5.	.67							412
3.	6.	.9							412
HEAD		POOFHEADER							106
HEAD		WINDSHIELD							106
HEAD		INSTRUMENT PANEL							106
THORAX		SEAT BACK							106
THORAX		SEAT CUSHION							106
THORAX		INSTRUMENT PANEL							106
HIP		SEAT BACK							106
HIP		SEAT CUSHION							106
HIP		FLOOR							106
THIGH		SEAT CUSHION							106
KNEE		INSTRUMENT PANEL							106
KNEE		KNEE BAR							106
SHANK		INSTRUMENT PANEL							106
SHANK		KNEE BAR							106
HEEL		FLOOR							106
HEEL		DASH							106
TOE		DASH							106
HEEL		TOEPAN							106
TOE		TOEPAN							106
HAND		SEAT CUSHION							106
HAND		INSTRUMENT PANEL							106
THIGH		THORAX							106
2.75	7.	0.	0.	0.	1.8	-1.96	14.12	-5.07	218
0.	0.	0.	0.	0.	-33.52	17.	-1.2		501
100.	0.	15.13	-.00178	6600.	6600.	10.			701
40 STRENGTH				14.04	-.00172	2.	1.		702
6% WEBBING #1					6% WEBBING #2				703
6% WEBBING #1		0.	0.	0.16	14.36	15.04	0.	0.	704
6% WEBBING #1		5.				SBELTI	IZERO	GBELTI	705
GBELTI	0.	0.							706
GBELTI	.16	0.							706
GBELTI	1.37	.56							706
GBELTI	6.15	.05							706
GBELTI	40.	.95							706
GBELTI	0.	1.							707
GBELTI	1.37	.33							707
GBELTI	2.06	.19							707
GBELTI	6.15	.05							707
GBELTI	40.	.05							707

FIGURE 109 Complete Data Set for Simulation Example 1 (page 5 of 6)

SBELT1	0.	0.								708
SRELTI	.533	1500.								708
SRFLT1	9.91	2000.								708
SRFLT1	11.28	5300.								708
SRFLT1	14.36	6600.								708
SBELT1	15.04	0.								708
6% WERRING #2	0.	0.	.155	13.85	14.51	0.	0.			704
6% WERRING #2	5.					SBELT2	IZERO	GRELTI		705
SRELTI	0.	0.								708
SRELTI	.396	1150.								708
SRFLT2	9.56	1650.								708
SRELTI	10.9	5300.								708
SRFLT2	13.85	6600.								708
SRFLT2	14.51	0.								708
NO STRENGTH	0.	0.	0.	10.	11.	0.	0.			704
NO STRENGTH	5.					SNOSTR	IZERO	GNOSTR		705
GNOSTR	-1.	0.								706
GNOSTR	-1.	1.								707
SNOSTR	-1.	0.								708
										1000
0, 1, 46-48, 10-14, 21, 22, 37, 38, 49, 50, 15, 23-26, 2-5, 18-20, 33-36, 30-32, 16,										1001
27-29, 39, 17, 40, 6-9, 45										1002
0.	0.	0.	11.55	.025						1003
40.	500.	560.	0.	.85	201.	5.	5.			1004
0.	0.	-3.	62.	5.	-44.	10-	0.			1500
21.	0.	0.	1.	1.	0-	1.	0.	10..		1501
										1600

FIGURE 109 Complete Data Set for Simulation Example 1 (page 6 of 6)

```

1 100 *      *      *      *      *      *      *      *      *      *      *
2 400 *      KNEE *BAR      *      *      *      *      *      *      *      *
3 500 *OCC. COM*P. DISPL*.      *      *      *      *      *      *      *
4 600 *30MPH PB*ONT BARR*IER      *      *      *      *      *      *      *
5 700 *      NO B*ELTS      *      *      *      *      *      *      *      *
6 101 *1.      *1.      *32.174 *0.      *0.      *200.      *1.      *5.      *10.      *
7 102 *0.      *0.      *0.      *0.      *0.      *0.      *10.      *.000001 *5.      *
8 103 *.2      *.05      *100000. *15000. *10.      *.05      *10.      *1.      *1.      *
9 601 *0.      *44.      *0.      *0.      *0.      *0.      *0.      *0.      *0.      *
10 602 *23.      *1.      *1.      *1.      *1.      *1.      *1.      *1.      *1.      *
11      *      0.0 *      -1.70*      1.00*      -1.40*      7.00*      -33.90*      12.00*      2.80*      0.0      *
12      *      13.50*      3.90*      18.00*      -21.20*      21.50*      -12.40*      28.00*      -9.20*      0.0      *
13      *      32.00*      -24.00*      33.00*      -24.00*      36.00*      -9.90*      37.00*      -9.90*      0.0      *
14      *      42.00*      -26.90*      47.00*      -31.80*      50.00*      -25.90*      54.00*      -27.20*      0.0      *
15      *      58.00*      -32.20*      61.00*      -29.00*      76.00*      -6.90*      90.00*      -1.40*      0.0      *
16      *      100.00*      -1.40*      120.00*      0.0 *      300.00*      0.0 *      0.0 *      0.0 *      0.0      *
17 603 *2.      *1.      *1.      *1.      *1.      *1.      *1.      *1.      *1.      *
18      *      0.0 *      0.0 *      300.00*      0.0 *      0.0 *      0.0 *      0.0 *      0.0 *      0.0      *
19 604 *2.      *1.      *1.      *1.      *1.      *1.      *1.      *1.      *1.      *
20      *      0.0 *      0.0 *      300.00*      0.0 *      0.0 *      0.0 *      0.0 *      0.0 *      0.0      *
21 200 *GM HYBRI*D II DUM*MY      *      *      *      *      *      *      *      *      *      *
22 300 *(PRELIMINARY DAT*A)      *      *      *      *      *      *      *      *      *      *
23 201 *1.1      *13.44      *3.4      *5.      *15.8      *      *10.3      *3.25      *-.88      *
24 202 *2.75      *7.      *1.7      *4.2      *8.2      *9.3      *5.      *5.8      *.5      *
25 203 *.0259      *.0951      *.0052      *.0982      *.0932      *.0518      *.022      *.0256      *.007      *
26 204 *.198      *1.97      *.04      *1.53      *1.38      *2.82      *.18      *.62      *      *
27 205 *12.8      *.58      *0.      *.52      *17.4      *1.      *      *25.      *.35      *
28 206 *12.8      *.58      *0.      *.52      *17.4      *1.      *      *22.      *.35      *
29 207 *72.      *15.      *0.      *.66      *1000.      *1.      *      *25.5      *.35      *
30 208 *102.5      *-7.624      *.1944      *.66      *1000.      *1.      *      *33.999      *34.001      *.35      *
31 209 *94.44      *-4.810      *1.053      *0.      *850.      *1.      *      *49.999      *50.001      *.5      *
32 210 *0.      *29.8      *0.      *0.      *204.      *1.      *135.      *0.      *.5      *
33 211 *0.      *10.      *0.      *0.      *222.      *1.      *      *197.      *.5      *
34 212 *0.      *10.      *0.      *0.      *64.      *1.      *0.      *      *165.      *.5      *
35 213 *751.      *0.      *757.      *1.98      *      *      *      *      *      *      *
36 214 *20.      *230.      *0.      *0.      *      *      *      *2.      *      *.5      *
37 215 *38.      *.58      *0.      *.52      *0.      *1.      *      *1.      *      *.16      *
38 216 *38.      *.58      *0.      *.52      *0.      *1.      *      *2.      *      *.16      *
39 242 *751.      *0.      *757.      *1.98      *      *      *      *      *      *      *
40 219 *HEAD      *      *      *      *      *      *      *      *      *      *
41 219 *THORAX      *      *CHESTMAT*L      *      *      *      *      *      *      *      *
42 219 *HIP      *      *HIPMATL      *      *      *      *      *      *      *      *
43 219 *THIGH      *      *      *      *      *      *      *      *      *      *
44 219 *KNEE      *      *      *      *      *      *      *      *      *      *
45 219 *SHANK      *      *      *      *      *      *      *      *      *      *
46 219 *HEEL      *      *      *      *      *      *      *      *      *      *
47 219 *TOE      *      *      *      *      *      *      *      *      *      *
48 219 *ELBOW      *      *      *      *      *      *      *      *      *      *
49 219 *HAND      *      *      *      *      *      *      *      *      *      *
50 220 *HEAD      *      *0.      *.5      *      *      *      *      *      *      *
51 220 *THORAZ      *      *-.5      *-.68      *5.52      *4.44      *      *      *      *
52 220 *HIP      *      *-.12      *0.      *4.5      *4.5      *      *      *      *
53 220 *THIGH      *      *-.5      *-.1      *7.      *3.      *      *      *      *
54 220 *KNEE      *      *7.      *-.4      *2.25      *2.25      *      *      *      *
55 220 *SHANK      *      *-7.54      *0.      *3.      *2.4      *      *      *      *
56 220 *HEEL      *      *8.57      *0.      *1.2      *1.2      *      *      *      *
57 220 *TOE      *      *5.61      *-5.16      *1.2      *1.2      *      *      *      *
58 220 *ELBOW      *      *5.3      *0.      *1.5      *1.5      *      *      *      *
59 220 *HAND      *      *5.6      *-.4      *2.72      *1.52      *      *      *

```

FIGURE 110 Input Processor Data Deck Echo for Example 1 (example page)

JUN 24, 1977 00:30
GM HYBRID II DURANT (PRELIMINARY DATA)

NWMA 2-D TUTORIAL EXAMPLE A)
KNEE BAR OCC. CORP. DISPL. JOSEPH FRONT BARRIER NO BELTS
PAGE 3-00
NWMA 2-D, VER. 3

BODY PARAMETERS

BODY SEGMENT LENGTHS (IN)	END-OF-LINK TO CENTER-OF-MASS LENGTHS (IN)	MASS OF BODY SEGMENTS (LBS SEC ⁻² IN)
HEAD LENGTH*	1.10	HEAD MASS* 0.03
UPPER TORSO LENGTH*	13.44	CHEST MASS* 0.10
MIDDLE TORSO LENGTH*	3.40	MIDDLE TORSO MASS* 0.01
LOWER TORSO LENGTH*	5.00	LOWER TORSO MASS* 0.10
HIP-KNEE LENGTH*	15.80	HIP-UPPER LEG CM LENGTH* 4.20
UPPER TORSO-SHOULDERS*	0.0	KNEE-LOWER LEG CM LENGTH* 9.30
SHOULDER-ELBOW LENGTH*	10.30	UPPER ARM (BOTH ARMS)* 5.00
X REST POINT OF SHOULDER*	3.25	LOWER ARM (BOTH ARMS)* 5.00
Z REST POINT OF SHOULDERS*	-0.68	HEAD-NECK MASS* 0.03
		UPPER TORSO-NECK MASS* 0.00

MOMENTS OF INERTIA (ABOUT CM) (LBS SEC⁻² IN)

	INITIAL LINK ANGLES (FOR ZERO TORQUE) (DEG)	INITIAL BODY LINK ANGLES (RELATIVE TO VEHICLE) (DEG)	INITIAL ANGULAR VELOCITIES (RELATIVE TO VEHICLE) (DEG/SEC)
HEAD	0.20	-11.00	76.50
UPPER TORSO	1.97	-8.00	97.50
MIDDLE TORSO	0.04	-18.00	115.50
LOWER TORSO	1.53	-34.00	149.50
UPPER LEG	1.30	-50.00	19.50
LOWER LEG	2.82	0.0	-45.00
UPPER ARM	0.18	0.0	-41.00
LOWER ARM	0.62	0.0	3.00
NECK	0.0	0.0	0.0

OCCUPANT JOINT PARAMETERS

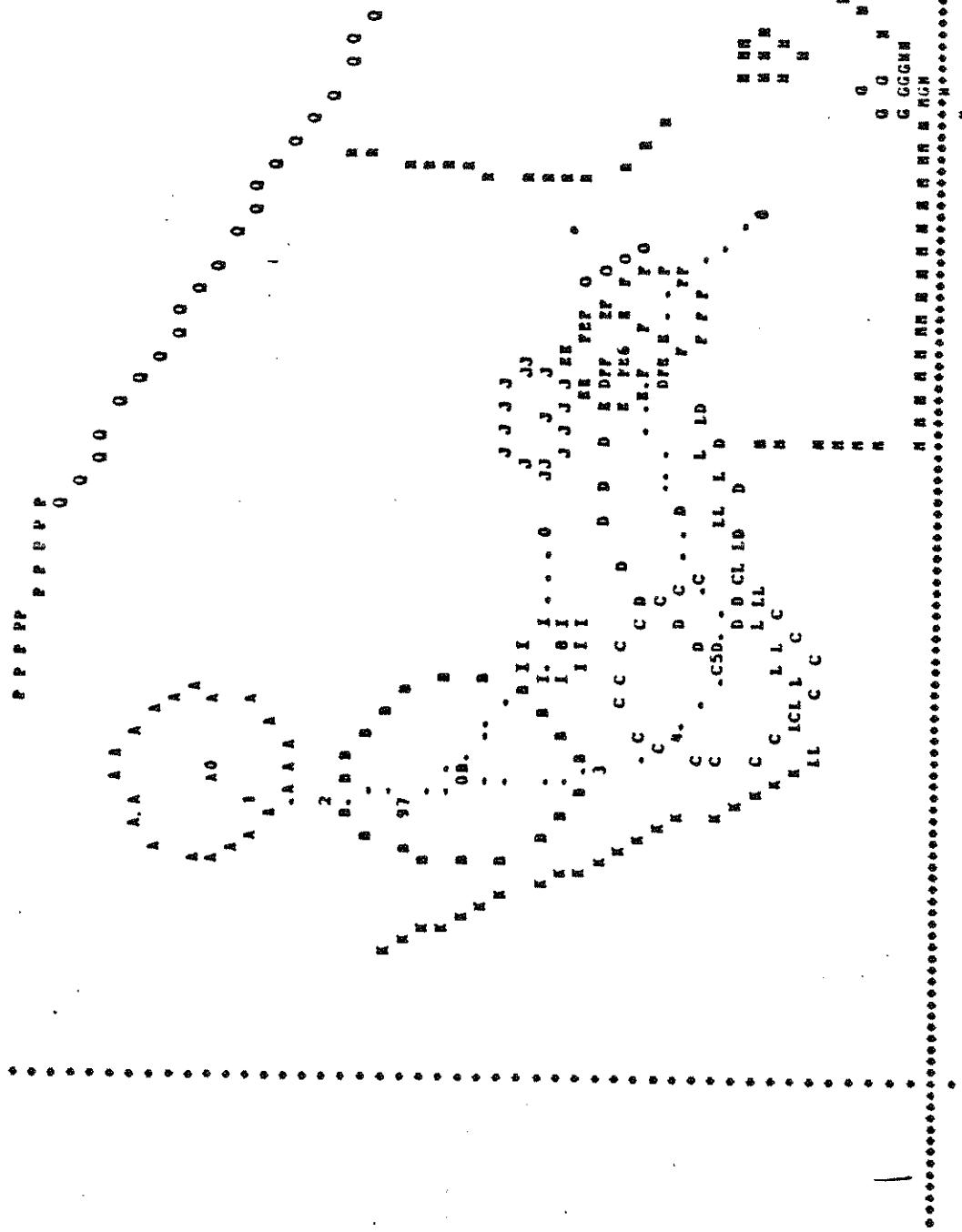
	LINEAR ANGULAR DEFLECTION COEF. (IN-185/DEG)	QUADRATIC ANGULAR DEFLECTION COEF. (IN-185/DEG ²)	CUBIC ANGULAR DEFLECTION COEF. (IN-185/DEG ³)	CONSERVED-ABSORBED ENERGY RATIO
HEAD-NECK FORWARD	1.80	0.58	0.0	0.15
NECK-UPPER TORSO FORWARD	32.00	0.58	0.0	0.35
UPPER SPINE	72.00	15.00	0.0	0.35
LOWER SPINE	102.50	-7.62	0.19	0.35
HIP	01.44	-4.01	0.11	0.50
KNEE	0.0	29.80	0.0	0.50
UPPER ARM-UPPER TORSO	0.0	10.00	0.0	0.50
ELBOW	0.0	10.00	0.0	0.50
HEAD-NECK REAR	30.00	0.58	0.0	0.16
NECK-UPPER TORSO REAR	751.00	0.0	757.00	NA
SHOULDER (EXTENSIBLE)*	20.00	210.00	0.0	0.50
NECK (COMPRESSIBLE)*	751.00	0.0	757.00	NA

* UNITS FOR THE NECK (EXTENSIBLE), (COMPRESSIBLE) AND SHOULDER (EXTENSIBLE) PARAMETERS ARE GIVEN IN THE ROW BELOW
(L0/L0)
(LB/LB²)

FIGURE 111 Summary of Input Data (example page)

JUN 24, 1977 02:00:20
ON HYBRID II DUTCH (PRELIMINARY DATA) KNEE BAR WNA 2-D TUTORIAL EXAMPLE 01
KNEE BAR OCC. COMP. DISPLAY. JUMP FRONT BARRIER NO BELTS
PAGE 033-45
WNA 2-D, TAB. 3

STICK FIGURE PRINTER PLOT FRAME FOR TIME= 30.00 SEC.



COORDINATE RANGES FOR PLOT ARE X= -6.56 (AT LEFT) TO 65.56 (AT RIGHT) AND Z= -5.00 (AT BOTTOM) TO 5.00 (AT TOP)
SCALE FACTOR IS (1IN) = 5.547 (IN) . X AND Z POINT RESOLUTION ERRORS EQUAL RESPECTIVELY 0.277 AND 0.362 (1IN) IN SCALE.

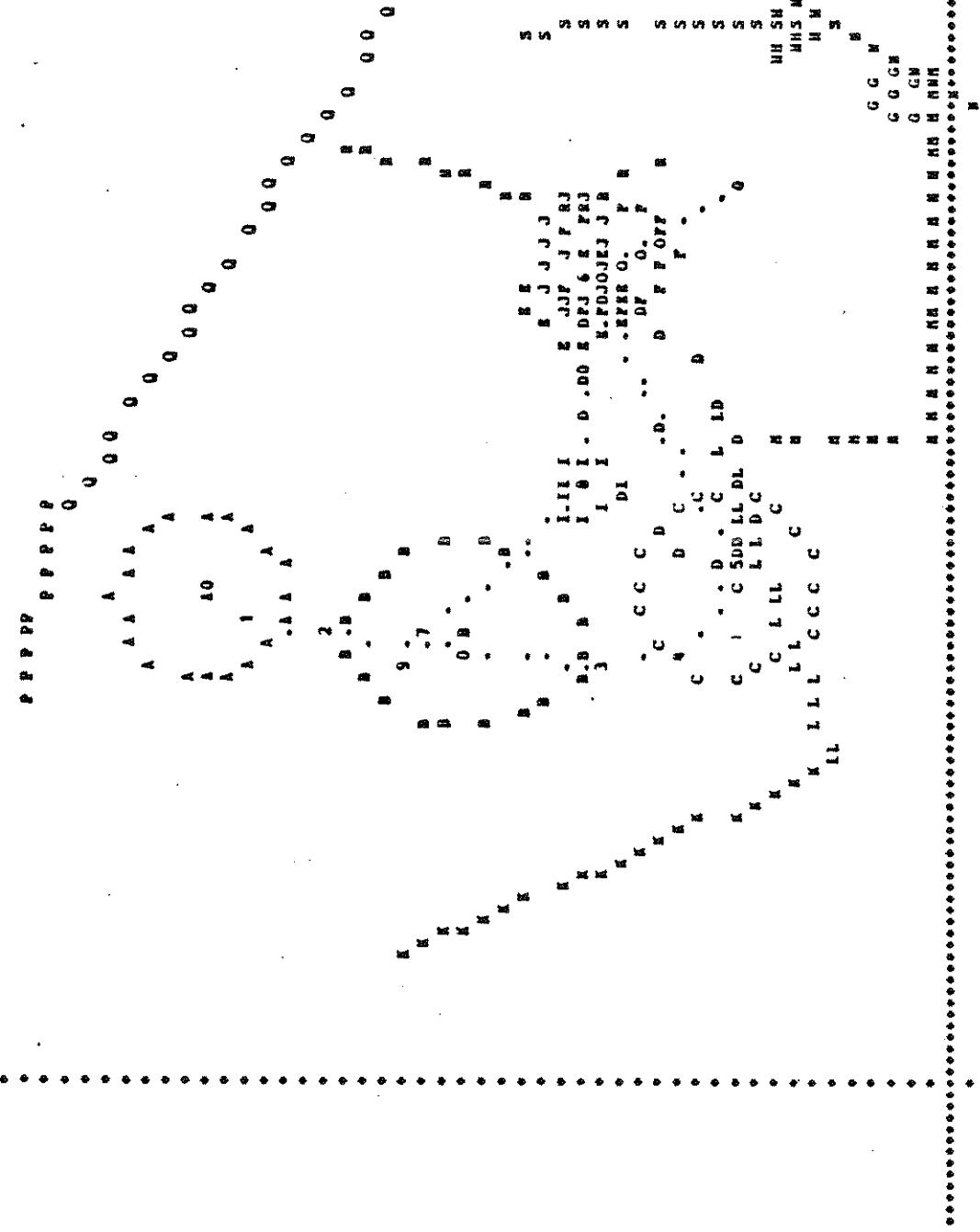
FIGURE 112b Printer-Plot Time Sequence for Example 1 (30 ms)

JUN 26, 1977 02:00:20
CG MIRIAD II DURANT (Preliminary Data)

PAGE 116-45
MVA 2-D TUTORIAL EXAMPLE 6
MVA 2-D, VER. 3

KNOWN DATA OCC. CONF. DISPLAY. JOSEPH FRONT BARRIER NO BELTS

STICK FIGURE PRINTER PLOT FRAME FOR TIME= 60.00 SEC.



COORDINATE RANGE FOR PLOT ARE X= -6.56 (AT LEFT) TO 6.56 (AT RIGHT) AND Z= 2.00 (AT BOTTOM) TO -4.00 (AT TOP)
SCALE FACTOR IS (IN) = 5.547 (IN) . X AND Z POINT RESOLUTION ERRORS EQUAL RESPECTIVELY 0.277 AND 0.462 (IN) IN SCALE.

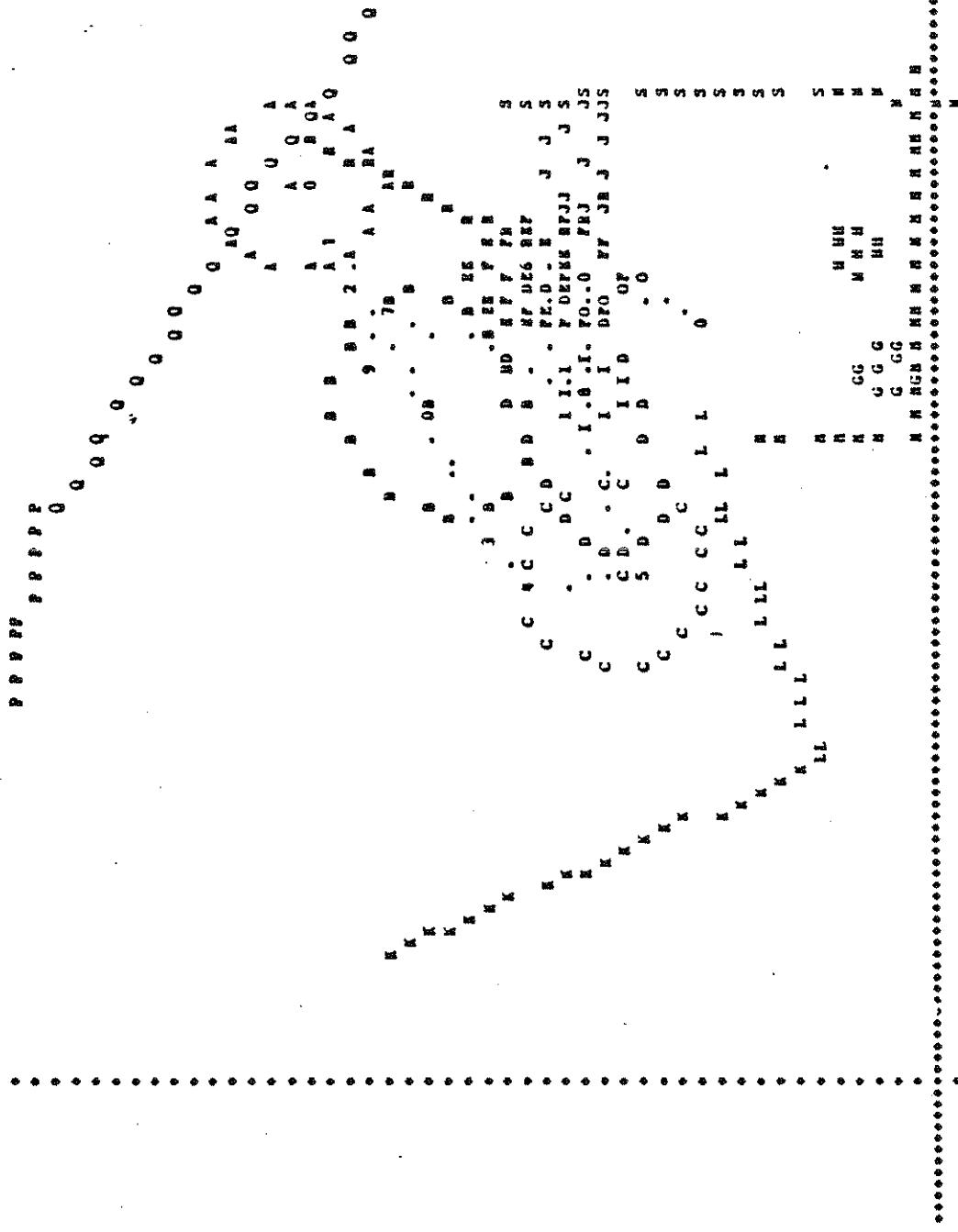
FIGURE 112c Printer-Plot Time Sequence for Example 1 (60 ms)

JUN 26, 1977 01:20
CMM UNAPID II DURAY (PUBLIMATIC DATA)

PAGE 140-65
MIGA 2-D TUTORIAL EXAMPLE 61
MIGA 2-D, VER. 3

MIGA 2-D OCC. COMP. DISPLAY. JOHNS FRONT BARBERS NO GBLTS

STICK FIGURE PRINTER PLOT FOR TIME= 100.00 SEC.



COORDINATE RANGES FOR PLCT ARE X= -6.56 (AT LEFT) TO 65.56 (AT RIGHT) AND Z= 5.00 (AT BOTTOM) TO -44.00 (AT TOP)
SCALE FACTOR IS (IN) .5547 (IN) . X AND Z POINT RESOLUTION ERRORS EQUAL RESPECTIVELY .0.277 AND .0.462 (IN) IN SCALE.

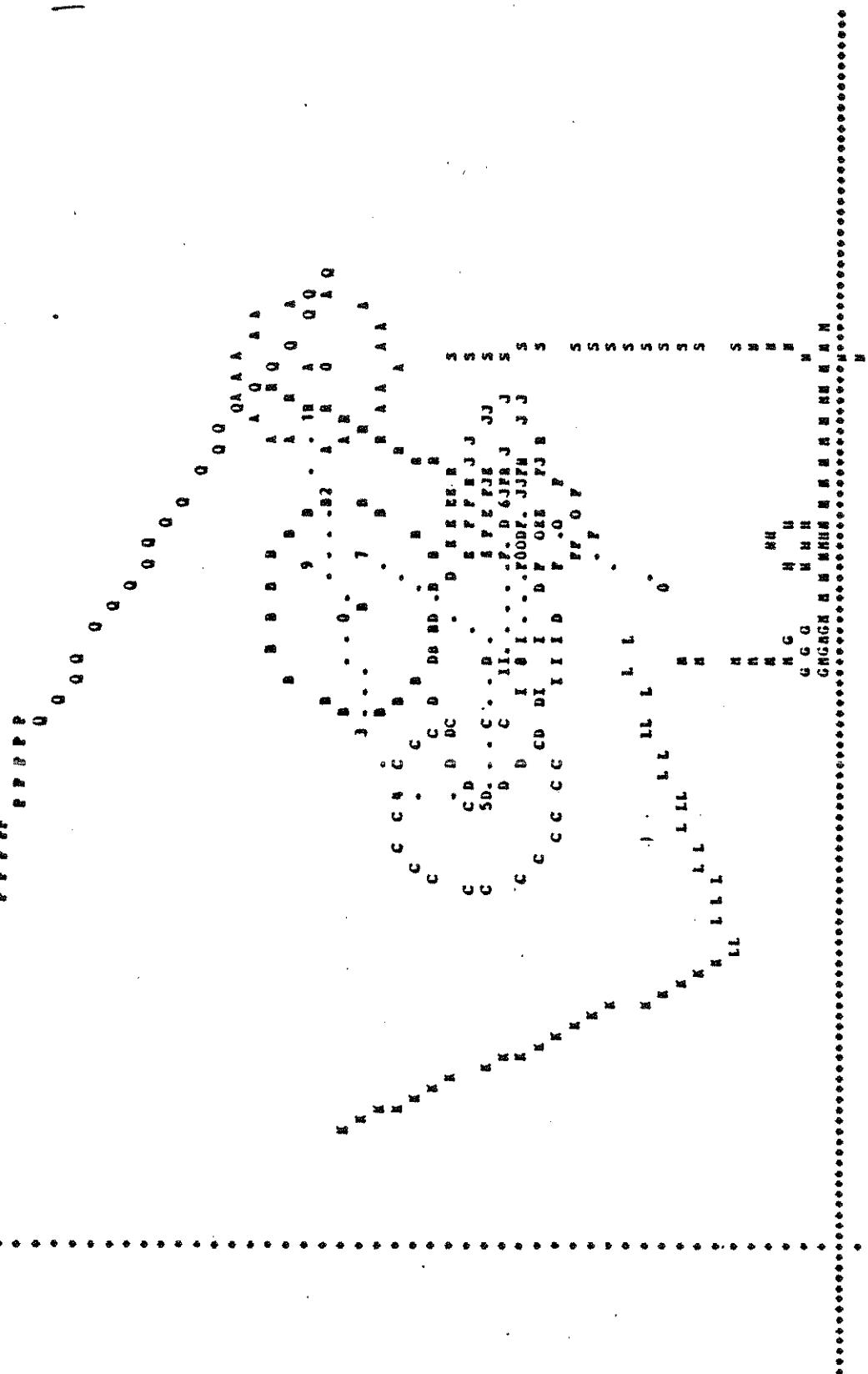
FIGURE 112e Printer-Plot Time Sequence for Example 1 (100 ms)

JUN 24, 1977 02:00:20
GAG HYBRID III DUNNY (PREGNANT DATA)

ENVA 2-D TUTORIAL EXAMPLE 61 KNEE BAR OCC. COMP. DISPLAY. 10MP

WING BAR 2-D TUTORIAL EXAMPLE 61
OCC. COMP. DISPLAY. JONSPH FRONT BARRIER
NO BELTS

MAYA 2-D, 1981.



COORDINATE WHEELS FOR PLOT AREA I - 6.56 (AT LEFT) TO 45.56 (AT RIGHT) AND Z= 5.00 (AT BOTTOM) TO -44.00 (AT TOP)
SCALE FACTOR IS .0100 = .554 (IN) / .554 (IN) X AND Z POINT RESOLUTION ERRORS EQUAL RESPECTIVELY .0.277 AND .0.462 (IN) IN SCALE.

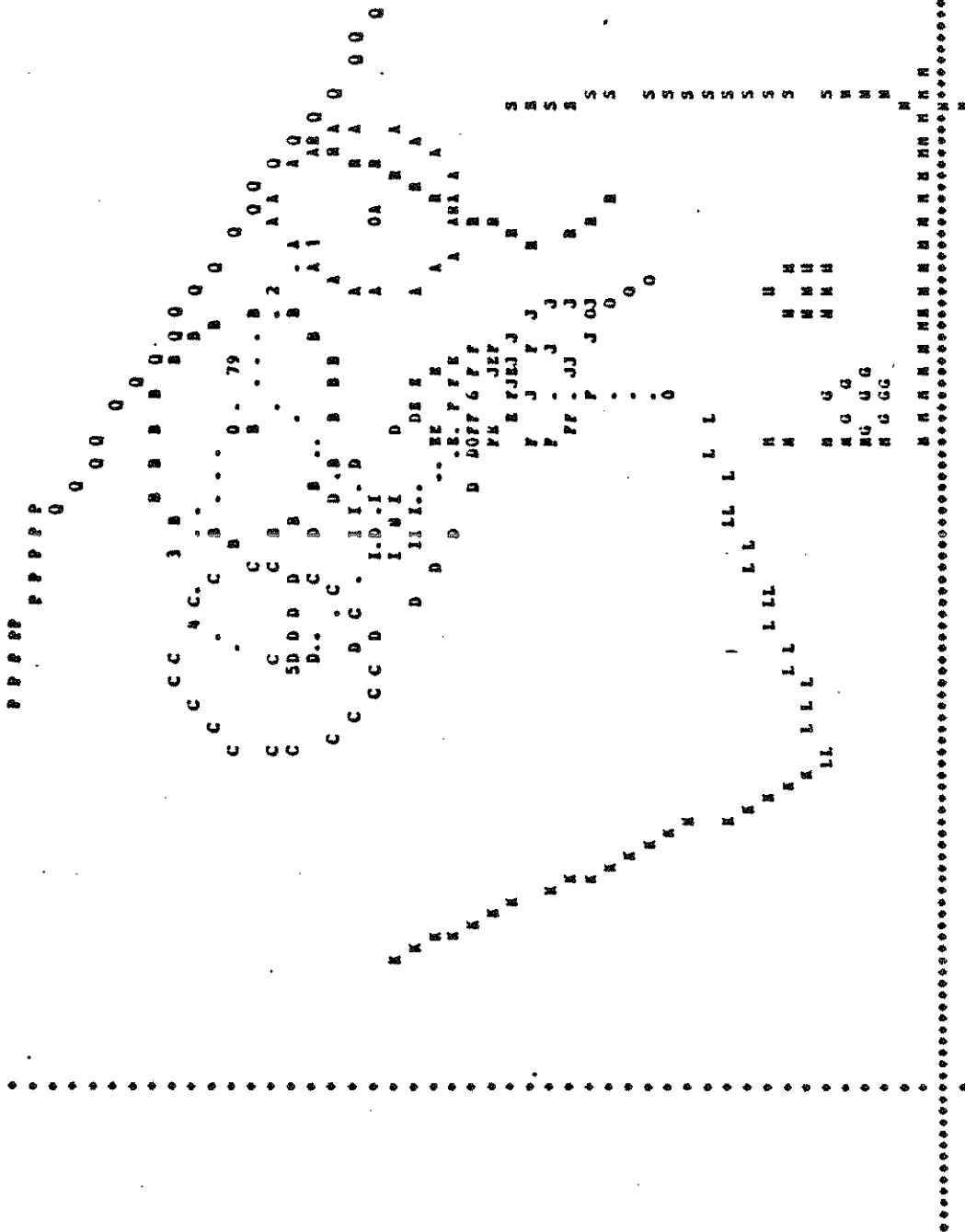
FIGURE 11.2f Printer-Plot Time Sequence for Example 1 (120 ms)

JUN 24, 1977 02:00:20
GM MURRAY II DUNAY (PRELIMINARY DATA)

AVRA 2-D TUTORIAL EXAMPLE 6

KNURE BAR COUNP. CUNP. DISPL. 10A/PW FRONT BARRIER NO BELTS
AVRA 2-D, VERS. 3

STICK FIGURE PAINTER PLOT FRAMES FOR TIME= 200.00 SEC.



COORDINATE RANGES FOR PLOT ARE X = -6.56 (AT LEFT) TO 65.56 (AT RIGHT) AND Z = 5.00 (AT BOTTOM) TO -5.00 (AT TOP)
SCALE FACTOR IS (1M) = 5.547 (1M). X AND Z PAPER RESOLUTION ERRORS EQUAL RESPECTIVELY 0.277 AND 0.162 (1M) IN SCALE.

FIGURE 112h Printer-Plot Time Sequence for Example 1 (200 ms)

JUN 24, 1977 02:00:20
GM HYBRID II DUMMY (PRELIMINARY DATA)

PAGE 64-01
HYNA 2-D TUTORIAL EXAMPLE #1
KNEE BAR OCC. COMP. DISPL. 30MPH FRONT BARRIER
MVEA 2-D, VER. 3

VEHICLE RESPONSE

TIME (SEC)	DISPL. (INCHES)	HORIZONTAL VELOCITY (MPH)	ACCEL. (G'S)	DISPL. (INCHES)	VERTICAL VELOCITY (FT/SEC)	ACCEL. (G'S)	ANGLE (DEGREES)	PITCH VELOCITY (RAD/SEC)	ACCEL. (RAD/SEC**2)
0.0	0.0	30.00	-1.70	0.0	0.0	0.0	0.0	0.0	0.0
5.00	2.61	28.89	-23.07	0.0	0.0	0.0	0.0	0.0	0.0
10.00	5.02	26.14	-11.89	0.0	0.0	0.0	0.0	0.0	0.0
15.00	7.31	26.04	-4.47	0.0	0.0	0.0	0.0	0.0	0.0
20.00	9.54	24.38	-16.17	0.0	0.0	0.0	0.0	0.0	0.0
25.00	11.62	23.02	-10.68	0.0	0.0	0.0	0.0	0.0	0.0
30.00	13.60	21.80	-16.60	0.0	0.0	0.0	0.0	0.0	0.0
35.00	15.42	19.54	-14.60	0.0	0.0	0.0	0.0	0.0	0.0
40.00	17.08	18.07	-20.10	0.0	0.0	0.0	0.0	0.0	0.0
45.00	18.55	15.17	-29.04	0.0	0.0	0.0	0.0	0.0	0.0
50.00	19.73	11.92	-25.90	0.0	0.0	0.0	0.0	0.0	0.0
55.00	20.66	8.98	-28.45	0.0	0.0	0.0	0.0	0.0	0.0
60.00	21.30	5.62	-30.07	0.0	0.0	0.0	0.0	0.0	0.0
65.00	21.66	2.68	-23.11	0.0	0.0	0.0	0.0	0.0	0.0
70.00	21.79	0.55	-15.74	0.0	0.0	0.0	0.0	0.0	0.0
75.00	21.78	-0.77	-8.37	0.0	0.0	0.0	0.0	0.0	0.0
80.00	21.60	-1.47	-5.33	0.0	0.0	0.0	0.0	0.0	0.0
85.00	21.32	-1.95	-3.36	0.0	0.0	0.0	0.0	0.0	0.0
90.00	21.34	-2.21	-1.40	0.0	0.0	0.0	0.0	0.0	0.0
95.00	21.14	-2.37	-1.40	0.0	0.0	0.0	0.0	0.0	0.0
100.00	20.92	-2.52	-1.40	0.0	0.0	0.0	0.0	0.0	0.0
105.00	20.70	-2.65	-1.05	0.0	0.0	0.0	0.0	0.0	0.0
110.00	20.46	-2.75	-0.70	0.0	0.0	0.0	0.0	0.0	0.0
115.00	20.21	-2.01	-0.35	0.0	0.0	0.0	0.0	0.0	0.0
120.00	19.96	-2.03	-0.00	0.0	0.0	0.0	0.0	0.0	0.0
125.00	19.71	-2.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0
130.00	19.47	-2.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0
135.00	19.22	-2.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0
140.00	19.07	-2.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0
145.00	18.72	-2.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0
150.00	18.47	-2.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0
155.00	18.22	-2.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0
160.00	17.97	-2.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0
165.00	17.72	-2.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0
170.00	17.47	-2.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0
175.00	17.23	-2.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0
180.00	16.98	-2.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0
185.00	16.73	-2.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0
190.00	16.48	-2.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0
195.00	16.23	-2.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0
200.00	15.98	-2.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0

FIGURE 113 Vehicle Motion for Example 1

OCT 18, 1978 02:51:55
GM HYBRID II DUMMY (PRELIMINARY DATA)

NVNA 2-D THOPTIAL EXAMPLE #1
KNEE EAR OCC. COMP. DISPL. 30MPH FRONT BARRIER
NO BELTS (7-77) PAGE 65-

HEAD CENTER OF MASS MOTION

(POSITIONS AND VELOCITIES RELATIVE TO VEHICLE FRAME) (ACCELERATIONS RELATIVE TO INERTIAL FRAME)

TIME (MSEC)	X-VEL. (IN/SEC)	X-ACCRL. (G'S)	Z-VEL. (IN/SEC)	Z-ACCRL. (G'S)	HEAD ANGLE (DEG)	ANG. VEL. (DEG/SEC)	ANG. ACC. (RAD/SEC ²)
0.0	12.94	0.0	-34.19	0.0	78.50	0.0	-0.20
5.00	12.97	20.29	-1.965	-34.09	0.476	6.59	-551.04
10.00	13.20	69.32	-1.804	-34.09	0.52	-9.45	-556.95
15.00	13.56	71.71	-1.755	-24.09	-0.148	-27.66	-566.14
20.00	13.98	151.85	-1.811	-34.10	-0.533	-2.27	-580.18
25.00	14.56	126.56	-1.833	-34.12	-0.652	-44.44	-588.09
30.00	15.24	149.50	-1.733	-34.14	-0.705	-59.41	-596.04
35.00	16.38	190.11	-1.468	-7.08	-0.943	-75.22	-596.04
40.00	17.10	218.32	-0.517	-34.19	-1.469	-94.22	-607.21
45.00	18.32	275.19	1.907	-14.25	-2.648	-116.07	-584.23
50.00	19.86	341.27	4.840	-20.74	-3.291	-109.48	-450.39
55.00	21.71	406.64	9.350	-34.33	-3.291	-122.48	-243.80
60.00	23.95	482.77	9.613	-34.77	-3.12	-139.87	133.93
65.00	26.54	598.85	7.028	-34.91	-3.540	-181.86	13.58
70.00	29.47	594.65	2.850	-34.90	-14.496	-249.73	-7.06
75.00	32.36	541.53	-81.864	-34.90	-22.410	-314.73	-86.51
80.00	34.96	520.33	-5.005	-34.61	-26.240	-314.76	-2854.46
85.00	37.54	506.22	-19.047	-33.90	-111.70	-37.40	-1547.61
90.00	45.90	465.36	-28.412	-31.98	159.05	-93.22	-1652.52
95.00	46.62	380.94	-62.636	-30.70	13.709	69.99	-510.69
100.00	46.97	43.73	26.057	-29.54	204.03	43.26	-2040.28
105.00	44.89	211.67	-10.902	-28.60	173.61	-15.327	-3087.70
110.00	45.90	177.36	-34.519	-27.01	143.79	-12.955	-1035.27
115.00	46.62	107.90	-41.030	-27.12	132.74	19.37	-2413.62
120.00	46.97	33.86	-33.042	-26.49	259.38	-16.455	-906.97
125.00	47.01	-14.06	-16.823	-51.99	204.03	-26.712	-2474.69
130.00	46.88	-31.99	-2.747	-25.96	173.61	-15.327	-30.43
135.00	45.99	46.72	-25.21	-25.54	143.79	-12.955	-1927.01
140.00	46.58	-25.37	-3.321	-25.21	132.74	-12.955	-1927.01
145.00	46.45	-31.47	6.088	-26.49	117.15	-11.867	-11601.15
150.00	46.01	-4.6	-8.099	-24.73	94.38	-11.908	-2840.28
155.00	45.99	-35.02	-5.561	-24.61	73.75	-8.932	-2413.62
160.00	45.67	-1.268	-5.561	-24.58	59.57	-6.156	-127.29
165.00	45.24	-6.05	0.717	-24.63	27.77	-3.34	-1292.02
170.00	45.03	-6.520	0.127	-25.21	132.74	-5.796	-2166.98
175.00	44.68	-63.85	9.577	-25.21	117.15	-11.867	-817.05
180.00	44.36	-63.86	-1.876	-24.63	48.29	-6.04	-525.40
185.00	44.04	-67.47	-2.649	-24.74	34.14	-8.869	-242.87
190.00	43.69	-69.37	-3.498	-24.87	26.84	-10.014	-600.85
195.00	43.35	-66.02	2.711	-24.61	15.35	-11.44	-157.31
200.00	43.02	-61.20	3.030	-24.58	2.77	-9.321	-568.16

(see footnote, section 3.4.3)

FIGURE 114 Head Center of Mass Motion for Example 1

TIME (MSEC)	X (IN)	Y (IN)	Z (IN)	X-ACCEL. (IN/SEC.)		Y-ACCEL. (IN/SEC.)		Z-VEL. (IN/SEC.)		Z-ACCEL. (G'S)	
				(G'S)	(IN)	(G'S)	(IN)	(G'S)	(IN)	(G'S)	(IN)
0.0	12.20	0.0	0.0	-9.586	-21.40	0.0	-0.603	-0.603	0.0	0.549	4.549
5.00	12.22	19.59	-13.974	-12.40	-21.40	-1.30	-1.30	-1.30	-1.30	-4.632	4.632
10.00	12.44	66.20	-14.432	-21.41	-21.41	-1.95	-1.95	-1.95	-1.95	-4.429	4.429
15.00	12.78	65.93	-14.642	-21.42	-21.42	-3.06	-3.06	-3.06	-3.06	4.164	4.164
20.00	13.16	92.93	-14.832	-21.44	-21.44	-4.57	-4.57	-4.57	-4.57	3.799	3.799
25.00	13.69	114.00	-15.116	-21.46	-21.46	-6.64	-6.64	-6.64	-6.64	3.212	3.212
30.00	14.28	132.00	-15.392	-21.50	-21.50	-9.72	-9.72	-9.72	-9.72	1.979	1.979
35.00	15.03	167.34	-16.552	-21.56	-21.56	-13.89	-13.89	-13.89	-13.89	-1.530	1.530
40.00	15.92	185.66	-18.232	-21.64	-21.64	-20.25	-20.25	-20.25	-20.25	-0.689	0.689
45.00	16.90	218.25	-18.678	-21.75	-21.75	-24.12	-24.12	-24.12	-24.12	-2.277	2.277
50.00	18.08	252.02	-22.005	-21.88	-21.88	-30.31	-30.31	-30.31	-30.31	-0.621	0.621
55.00	19.39	271.06	-10.819	-22.06	-22.06	-40.69	-40.69	-40.69	-40.69	-7.453	7.453
60.00	20.81	297.95	-8.731	-22.28	-22.28	-44.67	-44.67	-44.67	-44.67	-1.668	1.668
65.00	22.36	321.35	-6.256	-22.50	-22.50	-43.57	-43.57	-43.57	-43.57	-1.040	1.040
70.00	24.01	336.52	-2.967	-22.72	-22.72	-44.10	-44.10	-44.10	-44.10	-0.063	0.063
75.00	25.72	344.20	-16.667	-22.93	-22.93	-40.96	-40.96	-40.96	-40.96	-1.972	1.972
80.00	27.42	333.17	-23.945	-23.10	-23.10	-23.55	-23.55	-23.55	-23.55	-0.655	0.655
85.00	29.02	303.93	-29.137	-23.17	-23.17	-31.24	-31.24	-31.24	-31.24	-4.402	4.402
90.00	30.42	259.43	-29.820	-23.14	-23.14	-13.40	-13.40	-13.40	-13.40	-6.862	6.862
95.00	31.51	159.57	-44.250	-23.25	-23.25	-10.59	-10.59	-10.59	-10.59	-3.352	3.352
100.00	32.24	133.70	-16.108	-23.78	-23.78	-101.82	-101.82	-101.82	-101.82	-9.972	9.972
105.00	32.83	150.93	-17.277	-24.27	-24.27	-92.02	-92.02	-92.02	-92.02	-0.514	0.514
110.00	33.26	68.27	-17.384	-24.68	-24.68	-74.66	-74.66	-74.66	-74.66	-1.896	1.896
115.00	33.54	46.56	-8.863	-25.93	-25.93	-65.55	-65.55	-65.55	-65.55	-3.327	3.327
120.00	33.74	34.70	-13.128	-25.35	-25.35	-62.85	-62.85	-62.85	-62.85	-12.330	12.330
125.00	33.89	22.06	-3.773	-25.68	-25.68	-67.94	-67.94	-67.94	-67.94	-3.043	3.043
130.00	33.96	12.12	-6.468	-26.03	-26.03	-71.31	-71.31	-71.31	-71.31	-1.000	1.000
135.00	33.99	-1.77	-7.545	-26.39	-26.39	-74.03	-74.03	-74.03	-74.03	-1.891	1.891
140.00	33.95	-15.19	+5.792	-26.77	-26.77	-78.89	-78.89	-78.89	-78.89	-5.143	5.143
145.00	33.85	-22.32	-1.559	-27.19	-27.19	-87.39	-87.39	-87.39	-87.39	-5.247	5.247
150.00	33.73	-23.67	-9.232	-27.65	-27.65	-95.56	-95.56	-95.56	-95.56	-4.495	4.495
155.00	33.61	-24.37	0.278	-28.14	-28.14	-100.26	-100.26	-100.26	-100.26	-4.891	4.891
160.00	33.49	-24.79	0.378	-28.65	-28.65	-104.73	-104.73	-104.73	-104.73	-16.043	16.043
165.00	33.36	-26.84	1.073	-29.19	-29.19	-108.54	-108.54	-108.54	-108.54	-15.071	15.071
170.00	33.23	-28.67	3.600	-29.74	-29.74	-111.91	-111.91	-111.91	-111.91	-12.160	12.160
175.00	33.09	-27.36	3.627	-30.29	-30.29	-109.44	-109.44	-109.44	-109.44	-12.303	12.303
180.00	32.95	-25.74	4.936	-30.83	-30.83	-106.75	-106.75	-106.75	-106.75	-14.043	14.043
185.00	32.83	-22.95	5.411	-31.35	-31.35	-101.98	-101.98	-101.98	-101.98	-15.219	15.219
190.00	32.73	-20.27	6.618	-31.84	-31.84	-95.37	-95.37	-95.37	-95.37	-0.492	0.492
195.00	32.63	-18.17	-2.294	-32.39	-32.39	-90.63	-90.63	-90.63	-90.63	-0.180	0.180
200.00	32.58	-20.58	-1.778	-32.75	-32.75	-87.96	-87.96	-87.96	-87.96	-0.180	0.180

(see footnote, section 3.4.3)

FIGURE 11.5 Chest Center of Mass Motion for Example 1

HIP MOTION

(POSITIONS AND VELOCITIES RELATIVE TO VEHICLE FRAME)
(ACCELERATIONS RELATIVE TO INERTIAL FRAME)

TIME (MS/PC)	X (IN)	X-VEL. (IN/SEC)	X-ACCEL. (IN/SEC ²)	Z-VEL. (IN/SEC)	Z-ACCEL. (IN/SEC ²)
0.0	18.81	0.0	-0.538	-9.41	-1.626
5.00	18.64	17.57	4.479	0.0	1.380
10.00	19.96	63.13	4.151	-9.41	-2.67
15.00	19.38	61.15	3.734	-9.42	1.484
20.00	19.74	85.98	3.225	-9.44	-2.96
25.00	20.22	104.15	2.502	-9.45	-3.57
30.00	20.77	116.39	2.502	-9.47	1.136
35.00	21.44	147.88	-1.449	-9.49	0.893
40.00	22.21	151.32	-11.577	-9.53	-0.460
45.00	22.97	157.04	-21.461	-9.58	-0.815
50.00	23.75	145.58	-36.379	-9.63	-2.461
55.00	24.39	107.11	-54.473	-9.65	1.121
60.00	24.82	67.82	-53.964	-9.67	-1.885
65.00	25.07	32.35	-44.454	-9.69	-6.03
70.00	25.14	-2.29	-36.416	-9.72	0.298
75.00	25.06	-26.37	-10.904	-9.86	4.745
80.00	24.92	-26.54	3.927	-9.88	-8.828
85.00	24.80	-19.98	4.721	-11.33	-16.825
90.00	24.73	-7.30	9.254	-11.33	-14.022
95.00	24.75	13.56	0.292	-9.83	-12.099
100.00	24.86	26.66	-7.208	-10.10	-12.099
105.00	24.91	-16.03	-36.866	-10.52	-12.099
110.00	24.67	-73.60	-18.051	-11.09	-13.978
115.00	24.20	-72.53	11.041	-11.83	-14.423
120.00	23.97	-49.62	11.304	-12.73	-16.3.72
125.00	23.76	-36.83	2.687	-13.80	-16.3.72
130.00	23.59	-33.18	1.303	-14.86	-199.57
135.00	23.43	-31.37	2.751	-15.81	-182.16
140.00	23.27	-20.51	-0.082	-16.73	-186.66
145.00	23.12	-31.06	-0.479	-17.66	-186.52
150.00	22.96	-32.39	-1.025	-18.59	1.924
155.00	22.79	-33.75	-1.575	-19.52	1.868
160.00	22.62	-35.57	-2.751	-20.42	3.419
165.00	22.44	-36.85	-0.082	-21.30	-171.31
170.00	22.25	-38.29	0.202	-22.13	11.255
175.00	22.06	-38.62	1.003	-22.94	3.774
180.00	21.86	-39.12	1.575	-23.71	3.757
185.00	21.67	-39.33	-2.148	-24.46	4.653
190.00	21.47	-39.16	-0.458	-24.46	5.091
195.00	21.28	-39.55	1.387	-25.18	4.979
200.00	21.09	-36.93	1.453	-26.56	-7.010

(see footnote, section 3.4.3)

FIGURE 116 Hip Motion for Example 1

JUN 24, 1977 02:00:20
GM HYBRID II DUMMY (PRELIMINARY DATA)

PAGE 65-10
NVHA 2-D TUTORIAL EXAMPLE #1
KNEE BAR OCC. COMP. DISPL. 30MPH FRONT BARRIER NO BELTS NVHA 2-D, VER

TIME	BODY LINK ANGLES (DEGREES) (RELATIVE TO VEHICLE)					
	NECK	UPPER TORSO	MID TORSO	LOW TORSO	UPPER LEG	LOWER LEG
0.0	78.50	89.50	115.50	149.50	19.50	-45.00
5.0	79.48	89.46	115.43	149.54	19.47	-45.00
10.0	78.39	89.43	115.42	149.50	19.38	-45.02
15.0	78.24	89.32	115.43	149.61	19.26	-45.06
20.0	78.02	89.15	115.39	149.61	19.13	-45.11
25.0	77.72	88.92	115.27	149.60	18.99	-45.16
30.0	77.16	88.61	115.04	149.56	18.83	-45.17
35.0	76.90	88.30	114.65	149.50	18.63	-45.14
40.0	76.29	87.60	114.09	149.39	18.45	-45.33
45.0	75.61	87.05	94.18	112.98	19.29	-47.69
50.0	74.94	86.10	91.87	110.09	190.49	22.12
55.0	74.28	84.58	88.20	107.34	167.23	25.63
60.0	71.92	82.47	82.97	102.11	145.06	20.03
65.0	72.91	79.00	76.43	95.30	141.16	32.31
70.0	71.19	74.91	68.79	87.91	135.61	35.71
75.0	69.89	70.71	60.40	79.37	120.60	17.60
80.0	70.10	67.90	52.00	70.76	120.07	10.00
85.0	68.66	61.23	43.87	62.19	113.17	37.29
90.0	65.42	57.51	35.75	54.07	107.44	34.90
95.0	56.91	49.75	29.60	40.51	103.15	29.18
100.0	40.47	34.64	25.42	44.61	100.93	19.60
105.0	27.24	27.16	21.32	40.00	90.60	10.56
110.0	16.17	20.12	17.67	36.45	93.01	1.65
115.0	8.62	15.00	14.27	32.64	87.24	0.49
120.0	4.10	10.96	10.74	28.23	83.56	-1.00
125.0	1.24	7.92	7.10	25.45	81.21	-2.40
130.0	-1.05	5.47	3.50	22.02	79.05	-4.12
135.0	-3.25	3.25	0.04	19.18	79.01	-6.05
140.0	-5.39	0.96	-3.27	17.17	78.61	-8.09
145.0	-7.50	-1.56	-6.31	15.95	78.41	-10.17
150.0	-9.81	-4.31	-8.94	15.17	78.12	-12.27
155.0	-12.67	-7.25	-10.96	14.57	77.76	-14.39
160.0	-16.21	-10.21	-12.55	14.00	77.49	-16.50
165.0	-20.29	-13.37	-13.00	13.54	76.60	-18.62
170.0	-24.04	-16.81	-14.76	13.09	75.99	-20.72
175.0	-29.55	-20.37	-15.52	12.54	74.98	-22.83
180.0	-33.98	-23.68	-16.23	11.93	73.94	-24.94
185.0	-37.96	-26.64	-16.91	11.10	72.48	-27.08
190.0	-41.56	-29.22	-17.57	10.12	70.97	-29.22
195.0	-44.72	-31.34	-18.35	9.21	69.59	-31.40
200.0	-47.47	-33.24	-19.19	0.28	68.38	-33.60
						-90.74

FIGURE 117 Body Link Angles for Example 1

JUN 24, 1977 02:00:20
ON HYBRID II DUMKE (PRELIMINARY DATA)

PAGE 67-12
HYBRID II OCC. COMP. DISPL. 30MPH FRONT BARRIER NO BELTS HYBRID II, VER.

ACCELERATION OF BODY LINK ANGLES

(DEG/SEC²)

(RELATIVE TO INERTIAL FRAME)

TIME	HEAD	NECK	UPPER TORSO	MID TORSO	LOW TORSO	UPPER LEG	LOWER LEG	SHOULDERS	UPPER ARM	LOWER ARM
0.0	-0.00	2938.40	-3248.21	2979.45	4793.00	-3645.51	-492.10	---	-0.02	-0.00
5.0	25057.73	-223567.69	127969.00	-527872.88	144061.08	-13590.84	7348.74	---	-30930.30	13606.55
10.0	29682.09	-233040.44	127000.50	-473227.00	90707.13	702.02	5714.10	---	-39166.94	13556.36
15.0	2892.93	-2333876.63	127401.56	-475440.25	91601.69	933.72	6171.09	---	-39402.73	13480.65
20.0	30796.70	-237296.81	126878.81	-477046.81	92156.98	1007.69	6765.30	---	-34780.67	10397.41
25.0	31069.69	-237716.81	125609.25	-478322.31	92567.88	613.75	7717.16	---	-40171.68	13262.19
30.0	29287.09	-233949.06	121251.13	-484735.19	99429.08	-1695.69	9112.70	---	-19912.01	566.06
35.0	27216.75	-229205.13	116945.88	-481020.30	* 96750.00	-4410.46	4634.	26	-20102.70	261.85
40.0	-33603.26	205130.31	-141076.01	460340.63	-134661.63	48405.60	-112490.75	---	-19932.46	-227.75
45.0	-24479.03	159981.75	-130632.50	415852.69	-00942.63	91546.75	-375308.94	---	-19197.52	-1011.97
50.0	-14550.74	124966.88	-136105.69	249910.44	-70707.81	29565.52	-103277.44	---	-16947.72	-2294.53
55.0	9319.91	-161231.31	7410.38	-317691.06	-7141.34	-1596.45	59359.55	---	-13162.18	-4054.77
60.0	1737.15	-170728.31	22284.50	-306341.13	-40286.15	57256.60	48043.56	---	-245495.88	34980.09
65.0	1540.49	-15355.75	20247.05	-271429.44	-33563.59	19158.34	26113.03	---	-58629.13	-17853.61
70.0	-3405.37	-136127.00	36042.57	-275813.69	-16945.75	-80090.50	23158.45	---	10040.09	-31443.95
75.0	163792.25	205956.06	-50444.42	194833.13	-76179.06	-49146.36	-7571.30	---	106407.75	-26885.63
80.0	-96307.94	7449.24	-49430.32	234451.81	-19378.71	-42606.08	-22981.67	---	-66920.06	14910.29
85.0	-89125.44	57954.28	-579392.48	198039.13	91107.65	-54579.84	-34902.36	---	-223432.44	25324.41
90.0	-54890.81	33071.97	-59382.70	172857.94	66169.88	-60121.92	-41618.49	---	35846.19	-22015.46
95.0	-401964.38	80345.63	32022.68	-564191.50	246550.50	-66229.80	-8456.13	---	223792.94	4476.54
100.0	191133.19	32120.41	20808.85	-13572.79	12974.57	12510.36	51409.51	---	71766.19	-4169.37
105.0	56210.55	73014.13	113071.79	-49897.39	-15452.50	84620.00	141207.38	---	341246.68	-14371.46
110.0	157107.06	73777.63	11517.83	30420.26	6924.27	104007.06	324180.50	---	34541.01	-8421.68
115.0	123205.38	60756.10	-86320.77	-3753.19	98050.81	56939.26	-196156.98	---	50151.01	-10198.30
120.0	72155.31	-16942.92	26096.33	-85527.69	61915.59	-4262.55	-11681.44	---	50917.07	-14588.93
125.0	30849.06	-21004.46	23278.25	-83631.31	62059.53	-27827.26	40552.36	---	20514.27	-17491.39
130.0	2101.89	9876.37	5073.38	25513.01	21175.43	-8123.35	-5669.99	---	-4410.66	-29606.40
135.0	2242.21	-3047.31	5569.14	34190.18	10117.61	-4420.91	-2017.41	---	-41723.62	-42299.68
140.0	2271.97	-9536.70	10364.16	32448.52	8191.64	-1620.30	-567.06	---	-62486.91	-43318.28
145.0	-9534.13	-13067.22	10931.00	23101.40	-9146.64	27.79	886.93	---	-45861.91	-27245.51
150.0	-21600.26	-3365.79	18227.15	21133.92	-11020.30	473.08	1876.43	---	22844.40	-2654.75
155.0	-27103.10	13101.14	3114.47	72380.44	-26001.77	3929.86	2620.24	---	27059.45	-665.82
160.0	-34574.75	16094.84	75.71	76495.44	-30401.41	4961.23	3133.62	---	29287.47	731.46
165.0	-34013.00	16916.27	-1945.95	73574.13	-35436.34	5397.42	3340.20	---	30517.90	1711.29
170.0	-23751.43	-70955.06	78437.54	-262697.88	53586.14	-12580.36	4993.33	---	31289.14	1908.91
175.0	32005.65	-177129.69	110062.56	-376707.00	60659.88	-14978.75	6152.11	---	-19076.87	-4740.37
180.0	39366.07	-179379.80	110533.00	-307197.56	70593.01	-15331.14	6615.40	---	-19074.18	-3640.73
185.0	40900.61	-104915.63	111065.75	-305713.50	72637.19	-15013.99	6929.22	---	-20506.63	-2494.64
190.0	22963.36	34291.00	-19406.22	52206.05	-664.37	300.91	-719.20	---	-21528.57	-1297.61
195.0	8957.54	52111.74	-23009.35	68026.94	-13645.16	1325.42	-806.49	---	-22236.98	2.06
200.0	7900.23	151368.13	-109302.94	439708.08	-106996.69	20469.91	-5362.71	---	-21304.69	1470.21

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FIGURE 118 Body Link Angle Accelerations for Example 1

JUN 24, 1977 04:00:20
ON HYBRID II DUMMY (PRELIMINARY DATA)

PAGE 95-03
MVHA 2-D TUTORIAL EXAMPLE #1
KNEE BAR OCC. COMP. DISPLAY. 30 MPH FRONT BARRIER
MVHA 2-D, VER.

TIME	A X	A Y	A Z	MID IP X	MID IP Y	MID IP Z	LOWER IP X	LOWER IP Y	LOWER IP Z	1 X	1 Y	1 Z	2 X	2 Y	2 Z	3 X	3 Y	3 Z	4 X	4 Y	4 Z	5 X	5 Y	5 Z
0.0	44.90	-27.30	43.70	-15.90	46.80	-12.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.00	44.90	-27.30	43.70	-15.90	46.80	-12.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10.00	44.90	-27.30	43.70	-15.90	46.80	-12.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.00	44.90	-27.30	43.70	-15.90	46.80	-12.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20.00	44.90	-27.30	43.70	-15.90	46.80	-12.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25.00	44.90	-27.30	43.70	-15.90	46.80	-12.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30.00	44.90	-27.30	43.70	-15.90	46.80	-12.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35.00	44.90	-27.30	43.70	-15.90	46.80	-12.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40.00	44.90	-27.30	43.70	-15.90	46.80	-12.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45.00	44.90	-27.30	43.70	-15.90	46.80	-12.80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50.00	45.07	-27.80	42.91	-16.65	45.75	-13.32	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
55.00	45.16	-28.05	42.54	-17.02	45.23	-13.59	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60.00	45.25	-28.30	42.15	-17.40	44.70	-13.95	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
65.00	45.34	-28.55	41.76	-17.77	44.14	-14.11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70.00	45.42	-28.80	41.30	-18.15	43.65	-14.37	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
75.00	45.51	-29.05	40.99	-18.52	43.13	-14.64	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80.00	45.60	-29.30	40.60	-18.90	42.60	-14.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
85.00	45.60	-29.30	40.60	-18.90	42.60	-14.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
90.00	45.60	-29.30	40.60	-18.90	42.66	-14.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
95.00	45.60	-29.30	40.60	-18.90	42.60	-14.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
100.00	45.60	-29.30	40.60	-18.90	42.60	-14.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
105.00	45.60	-29.30	40.60	-18.90	42.60	-14.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
110.00	45.60	-29.30	40.60	-18.90	42.60	-14.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
115.00	45.60	-29.30	40.60	-18.90	42.60	-14.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
120.00	45.60	-29.30	40.60	-18.90	42.60	-14.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
125.00	45.60	-29.30	40.60	-18.90	42.60	-14.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
130.00	45.60	-29.30	40.60	-18.90	42.60	-14.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
135.00	45.60	-29.30	40.60	-18.90	42.60	-14.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
140.00	45.60	-29.30	40.60	-18.90	42.60	-14.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
145.00	45.60	-29.30	40.60	-18.90	42.60	-14.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
150.00	45.60	-29.30	40.60	-18.90	42.60	-14.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
155.00	45.60	-29.30	40.60	-18.90	42.60	-14.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
160.00	45.60	-29.30	40.60	-18.90	42.60	-14.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
165.00	45.60	-29.30	40.60	-18.90	42.60	-14.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
170.00	45.60	-29.30	40.60	-18.90	42.60	-14.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
175.00	45.60	-29.30	40.60	-18.90	42.60	-14.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
180.00	45.60	-29.30	40.60	-18.90	42.60	-14.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
185.00	45.60	-29.30	40.60	-18.90	42.60	-14.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
190.00	45.60	-29.30	40.60	-18.90	42.60	-14.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
195.00	45.60	-29.30	40.60	-18.90	42.60	-14.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
200.00	45.60	-29.30	40.60	-18.90	42.60	-14.90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

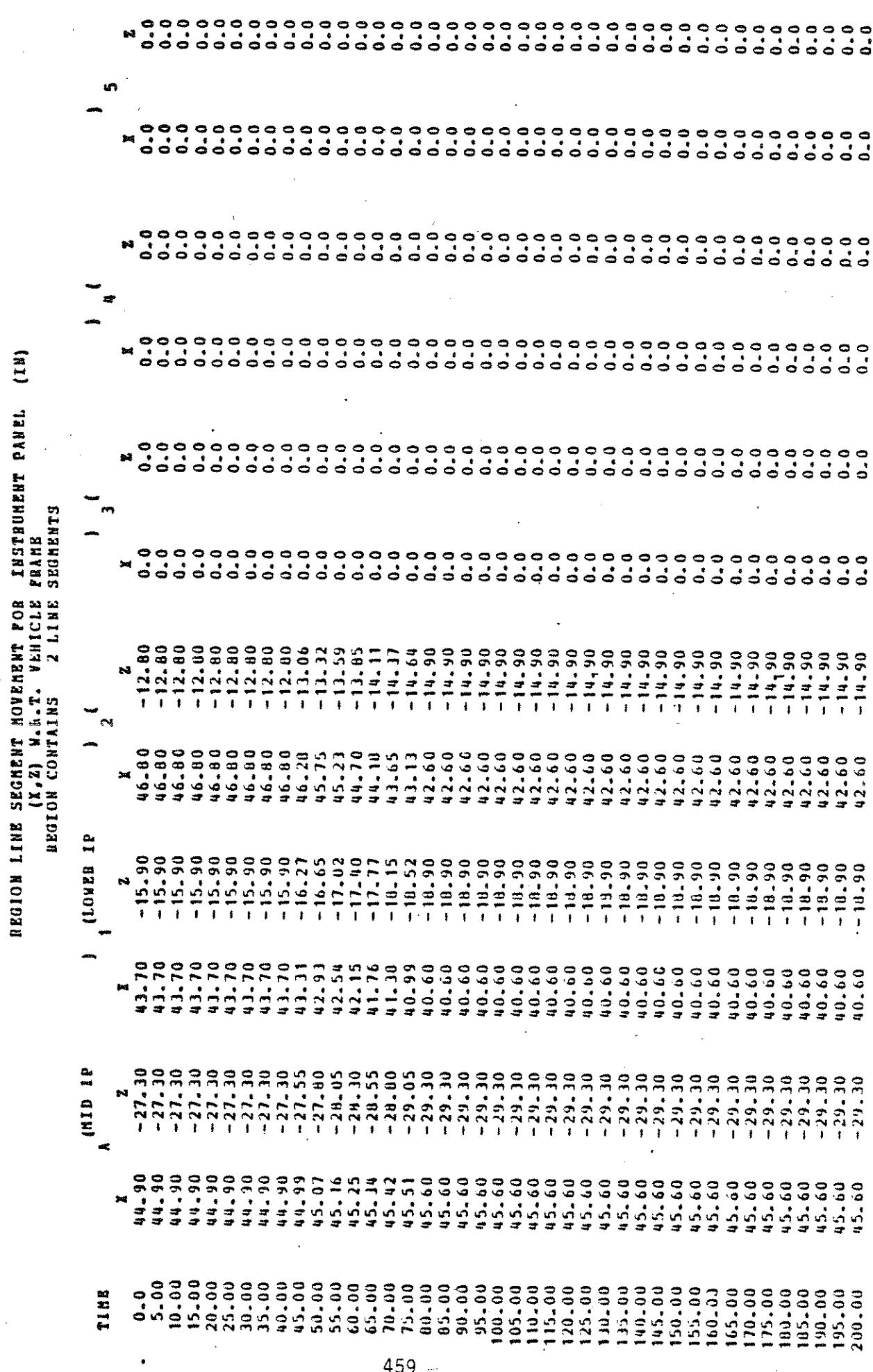


FIGURE 119 Example Region Line Segment Movement from Example 1

CONTACT INTERACTION BETWEEN

ELLIPSE HIP

LINING CUSHION LINE 1 WHICH IS AN ELEMENT OF REGION SEAT CUSHION

AND

MADE OF HIPPATL

INITIAL LINE LENGTH = 13.50 (IN) EDGE CONSTANT = 3.164

TIME (SEC)	LINK (IN)	ELLIPSE (IN)	LINE (IN/SEC)	ELLIPSE (IN/SEC)	FORCE (LB)	RATE (IN/SEC)	NORMAL (LB)	TANGNT. (LB)	CONTACT LOCATION ON LINE			CONTACT LOCATION IN SPACE			CONTACT LOCATION ON BODY SEG.		
									POSITION (INCHIN.)	RATE (IN/SEC)	X (IN)	Y (IN)	Z (IN)	X (IN)	Y (IN)	Z (IN)	
0.0	0.87	0.00	0.	0.	174.4	0.0	0.0	0.	0.311	0.	19.67	-5.69	3.43	2.77	2.77	2.77	
5.00	0.80	0.00	5.	0.	176.2	80.6	0.313	17.	22.31	-5.69	3.43	2.77	2.77	2.77	2.77		
10.00	0.95	0.00	21.	0.	198.0	95.5	0.328	59.	24.94	-5.70	3.43	2.77	2.77	2.77	2.77		
15.00	1.67	1.66	0.30	20.	231.4	120.9	0.351	57.	27.54	-5.72	3.42	2.77	2.77	2.77	2.77		
20.00	21.00	1.19	0.33	29.	268.6	153.2	0.376	81.	30.13	-5.73	3.42	2.78	2.78	2.78	2.78		
25.00	1.33	0.03	34.	0.	318.4	214.1	0.410	98.	32.70	-5.75	3.42	2.77	2.77	2.77	2.77		
30.00	1.51	0.00	38.	0.	374.6	272.7	0.449	112.	35.23	-5.77	3.43	2.77	2.77	2.77	2.77		
35.00	1.73	0.00	46.	0.	544.8	458.3	0.496	141.	37.72	-5.81	3.43	2.77	2.77	2.77	2.77		
40.00	1.95	0.01	45.	0.	802.4	782.1	0.549	145.	40.13	-5.86	3.43	2.76	2.76	2.76	2.76		
45.00	2.19	0.01	50.	1.	1071.1	1203.0	0.604	150.	42.38	-5.91	3.45	2.74	2.74	2.74	2.74		
50.00	2.42	0.03	44.	6.	1332.8	1747.4	0.659	128.	44.15	-5.94	3.48	2.70	2.70	2.70	2.70		
55.00	2.51	0.15	36.	1415.1	2075.7	0.705	106.	45.92	-5.98	3.54	2.62	2.62	2.62	2.62	2.62		
60.00	2.49	0.29	-3.	18.	156.4	2116.3	0.737	73.	47.02	-6.04	3.64	2.49	2.49	2.49	2.49		
65.00	2.48	0.33	-3.	-2.	1318.3	2191.5	0.759	47.	47.66	-6.11	3.79	2.22	2.22	2.22	2.22		
70.00	2.42	0.27	-22.	-21.	1146.5	1712.6	0.773	29.	47.93	-6.29	3.98	1.85	1.85	1.85	1.85		
75.00	2.24	0.14	-50.	-32.	579.2	724.2	0.782	25.	47.91	-6.63	4.18	1.34	1.34	1.34	1.34		
80.00	1.63	0.07	-104.	-22.	209.5	196.5	0.793	37.	47.78	-7.13	4.32	0.74	0.74	0.74	0.74		
85.00	1.26	0.06	-127.	-3.	133.5	84.2	0.809	51.	47.61	-7.75	4.38	0.15	0.15	0.15	0.15		
90.00	0.57	0.04	-151.	-3.	41.3	15.4	0.832	69.	47.45	-8.52	4.37	-0.32	-0.32	-0.32	-0.32		
95.00	0.0	0.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	
100.00	0.6	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	
105.00	0.6	0.3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	
110.00	2.9	0.3	2.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	
115.00	6.0	0.3	0.	2.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	
120.00	0.0	0.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	
125.00	0.0	0.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	
130.00	0.0	0.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	
135.00	0.0	0.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	
140.00	0.0	0.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	
145.00	0.0	0.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	
150.00	0.0	0.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	
155.00	0.0	0.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	
160.00	0.0	0.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	
165.00	0.0	0.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	
170.00	0.0	0.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	
175.00	0.0	0.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	
180.00	0.0	0.0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	

FIGURE 120 Example (A) Ellipse-Line Contact Interaction from Example 1
(see footnote, section 3.4.3)

OCT 18, 1978 02:51:55
GM HYBRID II DUMMY (PRELIMINARY DATA) KNEE DAY OCC. COMP. DISPL. JUMPIN FRONT BARRIER NO BELTS

INITIAL LINE LENGTH = 20.13 (IN) EDGE CONSTANT = 0.0
MVNA 2-D TUTORIAL EXAMPLE #1
KNEE DAY OCC. COMP. DISPL. JUMPIN FRONT BARRIER NO BELTS (7-77)
PAGE 114-04

CONTACT INTERACTION BETWEEN

ELLIPSE HEAD ASSUMED TO BE RIGID

AND

LINE LM WHICH IS AN ELEMENT OF REGION WINDSHIELD

MADE OF WINDSHIELD GLASS
LINE LM CONTACT INTERACTION BETWEEN

INITIAL LINE LENGTH = 20.13 (IN) EDGE CONSTANT = 0.0

TIME (MSEC)	REFLECTION LINE (IN)	LINE ELLIPSE (IN)	RATE (IN/SEC)	ELLIPSIZ (IN/SEC)	NORMAL (LD)	FORCE TANGNTL. (LD)	CONTACT LOCATION ON LINE			CONTACT LOCATION IN SPACE			CONTACT LOCATION ON BODY SUR.		
							POSITION (KONDIM.)	RATE (IN/SEC)	X (IN)	Y (IN)	Z (IN)	X (IN)	Y (IN)	Z (IN)	
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
5.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
10.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
15.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
20.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
25.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
30.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
35.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
40.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
45.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
50.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
55.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
60.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
65.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
70.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
75.00	0.67	0.0	19.5	0.0	950.5	636.0	0.247	518.	55.00	-30.17	-2.91	-0.33	-0.33	-0.33	
80.00	1.45	0.0	14.0	0.0	234.9	157.4	0.238	525.	58.30	-37.46	-3.91	-0.35	-0.35	-0.35	
85.00	2.11	0.0	11.0	0.0	369.2	247.4	0.432	528.	60.73	-36.60	-3.91	-0.24	-0.24	-0.24	
90.00	2.55	0.0	5.0	0.0	463.2	315.3	0.525	518.	63.90	-35.57	-3.97	-0.0	-0.0	-0.0	
95.00	2.67	0.0	5.0	0.0	489.6	328.1	0.614	462.	64.90	-36.34	-4.00	-0.45	-0.45	-0.45	
100.00	2.67	0.0	-1.0	0.0	449.0	391.4	0.685	375.	66.49	-33.29	-3.87	-1.59	-1.59	-1.59	
105.00	2.60	0.0	-12.0	0.0	130.2	87.2	0.739	286.	67.46	-32.42	-3.55	-2.34	-2.34	-2.34	
110.00	2.55	0.0	-14.0	0.0	65.0	44.1	0.786	237.	68.32	-31.67	-3.13	-2.98	-2.98	-2.98	
115.00	2.40	0.0	-47.0	0.0	46.4	31.1	0.022	170.	68.07	-30.99	-2.76	-3.40	-3.40	-3.40	
120.00	2.04	0.0	-77.0	0.0	4.4	3.0	0.046	97.	69.01	-30.37	-2.46	-3.63	-3.63	-3.63	
125.00	1.67	0.0	-6.0	0.0	0.0	0.0	0.050	0.	68.83	-29.85	-2.29	-3.70	-3.70	-3.70	
130.00	1.27	0.0	-77.0	0.0	0.0	0.0	0.063	0.	68.48	-29.43	-2.11	-3.90	-3.90	-3.90	
135.00	0.92	0.0	-6.0	0.0	0.0	0.0	0.065	0.	68.10	-29.10	-1.93	-4.00	-4.00	-4.00	
140.00	0.63	0.0	-52.0	0.0	0.0	0.0	0.067	0.	67.74	-28.02	-1.76	-4.09	-4.09	-4.09	
145.00	0.39	0.0	-44.0	0.0	0.0	0.0	0.068	0.	67.37	-28.61	-1.63	-4.17	-4.17	-4.17	
150.00	0.19	0.0	-36.0	0.0	0.0	0.0	0.065	0.	66.96	-28.40	-1.42	-4.24	-4.24	-4.24	
155.00	0.03	0.0	-26.0	0.0	0.0	0.0	0.058	0.	66.47	-26.45	-1.22	-4.31	-4.31	-4.31	
160.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	66.10	-25.10	-1.13	-4.00	-4.00	-4.00	
165.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	65.74	-24.02	-1.03	-3.90	-3.90	-3.90	
170.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	65.33	-23.05	-0.90	-3.80	-3.80	-3.80	
175.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	64.90	-22.08	-0.77	-3.70	-3.70	-3.70	
180.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.	64.47	-21.12	-0.64	-3.57	-3.57	-3.57	

FIGURE 121 Example (B) Ellipse-Line Contact Interaction from Example 1

JUN 24, 1977 02:00:20
GA HYBRID II DUMBBY (PRELIMINARY DATA)

PAGE 124-40
HYMA 2-D TUTORIAL EXAMPLE #1
KNEE BAR OCC. COMP. DISP.
FEMUR AND TIBIA LOADS
(LB)
WITH FEMUR SENSOR LOCATED 11.55 (IN) FROM RIP

TIME	AXIAL		SHEAR		AXIAL		TIBIA	
	AT SENSOR	AT KNEE	AT KNEE	AT KNEE	AT FOOT	AT KNEE	AT FOOT	
0.0	0.1	4.6	-34.6	2.5	0.0	7.3	0.0	
5.00	-92.2	-40.3	-66.6	-85.1	0.5	-64.0	0.5	
10.00	-131.2	-60.8	14.8	-82.3	22.9	-56.9	22.9	
15.00	-131.0	-64.8	5.5	-77.6	39.4	-51.4	39.4	
20.00	-131.9	-61.1	-2.2	-72.2	55.2	-46.0	55.2	
25.00	-131.2	-60.0	-6.6	-69.5	67.1	-44.6	67.1	
30.00	-138.2	-52.9	-39.8	-69.5	84.6	-47.0	84.6	
35.00	-168.6	-59.5	-56.9	470.8	1232.9	1145.5	2704.2	
40.00	321.6	420.3	-498.8	-1091.0	996.4	903.9	2001.4	
45.00	655.0	864.9	864.9	-724.0	1600.0	1130.0	1600.0	
50.00	1027.6	1383.9	1383.9	-572.7	2543.9	710.6	1662.8	
55.00	1623.2	2162.4	2162.4	-1065.1	-60.3	104.9	-228.6	
60.00	1517.9	2035.3	2035.3	-971.8	107.4	107.4	-60.3	
65.00	670.8	1048.9	1048.9	221.0	-190.2	175.7	0.0	
70.00	26.2	99.0	99.0	-151.4	133.8	175.7	0.0	
75.00	106.1	159.5	159.5	-102.7	0.0	175.7	0.0	
80.00	0.0	71.6	71.6	-255.7	0.0	175.7	0.0	
85.00	85.00	90.4	90.4	-201.3	175.8	175.8	0.0	
90.00	90.00	212.7	212.7	-236.7	108.8	108.8	-19.3	
95.00	95.00	233.2	233.2	-361.1	-624.0	-624.0	-579.1	
100.00	100.00	73.9	2.4	-70.9	-1599.5	-1599.5	-1462.1	
105.00	105.00	1237.8	1627.2	-70.9	1367.9	1367.9	3261.2	
110.00	110.00	5027.1	5048.4	-1605.8	-750.1	-750.1	2049.2	
115.00	115.00	1262.3	1406.7	-1605.8	-259.7	-259.7	519.7	
120.00	120.00	-577.4	-750.1	-750.1	-332.6	-332.6	-96.6	
125.00	125.00	-178.9	-178.9	-160.7	62.6	62.6	132.3	
130.00	130.00	97.7	97.7	-101.9	-26.7	-26.7	105.1	
135.00	135.00	-15.7	-15.7	-31.7	-31.7	-31.7	92.4	
140.00	140.00	155.00	155.00	-32.4	-32.4	-32.4	92.4	
145.00	145.00	160.00	160.00	-43.9	-43.9	-43.9	0.0	
150.00	150.00	165.00	165.00	-50.0	-50.0	-50.0	0.0	
155.00	155.00	170.00	170.00	-54.7	-54.7	-54.7	0.0	
160.00	160.00	175.00	175.00	-58.7	-58.7	-58.7	0.0	
165.00	165.00	180.00	180.00	-63.6	-63.6	-63.6	0.0	
170.00	170.00	185.00	185.00	-66.9	-66.9	-66.9	0.0	
175.00	175.00	190.00	190.00	-77.9	-77.9	-77.9	0.0	
180.00	180.00	195.00	195.00	-89.1	-89.1	-89.1	0.0	
185.00	185.00	200.00	200.00	-94.0	-94.0	-94.0	0.0	
190.00	190.00	195.00	195.00	-98.7	-98.7	-98.7	0.0	
195.00	195.00	200.00	200.00	-23.9	-23.9	-23.9	0.0	
200.00	200.00	-25.4	-26.5	-26.4	-26.4	-26.4	-58.6	

FIGURE 122 Femur and Tibia Loads for Example 1

JUN 24, 1977 02:00:20
GM HYBRID II DUMMY (Preliminary Data)

KNEE BAR OCC. COMP. DISPL. 30MPH FRONT BARRIER NO BELTS
HYNA 2-D TUTORIAL EXAMPLE #1
PAGE 125-06
HYNA 2-D, VER. 3

TIME	HEAD	UNFILTERED ACCELERATIONS (G's)			CHEST	HIP	RESULTANT	X	Y	Z	RESULTANT
		S-I	R	A-P							
0.0	A-P	0.980	1.000	0.495	-0.667	0.825	-0.543	-1.605	1.69	-1.605	-1.69
5.00	-0.199	0.877	2.598	-13.023	-3.607	13.513	-7.311	-3.560	8.13	-3.560	8.13
10.00	-2.445	0.351	2.606	-12.607	-5.371	13.703	-6.601	1.691	6.61	1.691	6.61
15.00	-2.663	0.011	2.617	-12.485	-5.667	13.711	-7.084	1.495	7.24	1.495	7.24
20.00	-2.750	-0.003	2.750	-12.269	-6.024	13.668	-7.651	1.286	7.75	1.286	7.75
25.00	-2.813	-0.073	2.814	-12.003	-6.445	13.623	-8.456	0.991	8.51	0.991	8.51
30.00	-2.748	-0.390	2.776	-11.642	-6.751	13.458	-9.708	-0.115	9.70	-0.115	9.70
35.00	-2.701	-1.103	2.991	-10.557	-0.369	13.471	-12.670	-1.231	12.73	-1.231	12.73
40.00	-1.134	-4.373	4.510	10.622	-0.935	18.646	-10.521	1.756	10.66	-10.521	10.66
45.00	-1.060	-5.153	5.457	19.145	0.700	19.150	-21.853	0.728	21.86	-21.853	21.86
50.00	-1.015	-5.419	6.627	22.133	-1.132	22.173	-35.665	-1.752	35.70	-1.752	35.70
55.00	-0.429	-4.341	9.481	10.842	-6.295	12.537	-56.717	1.99	56.80	1.99	56.80
60.00	-10.226	1.000	10.275	0.828	-0.296	0.833	-54.579	5.142	54.82	5.142	54.82
65.00	-11.206	12.104	16.495	6.004	0.950	6.079	-45.198	-6.229	45.62	-6.229	45.62
70.00	-11.306	24.231	26.719	2.150	-0.393	2.196	-36.477	-19.870	41.53	-19.870	41.53
75.00	56.073	94.900	110.235	12.636	12.000	17.426	-10.007	-14.942	18.44	-14.942	18.44
80.00	0.875	9.974	10.012	11.738	21.866	25.824	-0.685	-12.888	12.90	-12.888	12.90
85.00	9.894	20.242	22.530	14.280	27.413	30.910	-4.391	-15.541	16.14	-15.541	16.14
90.00	13.299	35.806	38.196	14.253	27.616	31.077	9.313	-15.512	10.09	-15.512	10.09
95.00	44.284	-4.257	44.480	-11.873	9.229	35.108	5.461	-32.311	32.77	-32.311	32.77
100.00	45.479	33.763	56.642	4.549	13.903	14.628	-5.946	2.210	6.34	2.210	6.34
105.00	14.325	5.420	15.316	-4.470	28.843	29.187	-59.711	12.448	60.99	12.448	60.99
110.00	21.388	41.426	46.621	-4.260	16.458	17.001	-5.284	7.810	9.43	7.810	9.43
115.00	12.403	44.020	45.713	-3.349	6.051	7.623	19.113	-1.730	19.19	-1.730	19.19
120.00	11.993	29.908	32.223	-0.590	3.992	4.026	9.071	-3.616	9.77	-3.616	9.77
125.00	9.071	11.695	16.002	1.392	0.206	0.402	4.707	-4.425	6.46	-4.425	6.46
130.00	8.464	2.364	8.787	3.746	7.309	8.213	2.324	1.906	3.00	1.906	3.00
135.00	6.523	-0.424	6.597	3.895	7.597	8.532	1.156	3.210	3.43	3.210	3.43
140.00	6.026	3.664	7.054	3.959	5.553	6.020	0.193	3.904	3.90	3.904	3.90
145.00	6.681	7.871	10.294	4.691	2.200	5.181	-0.540	3.972	4.00	3.972	4.00
150.00	6.463	7.646	10.012	4.534	0.244	4.540	-0.951	3.459	3.58	3.459	3.58
155.00	5.117	3.769	6.372	5.612	0.349	5.622	-1.703	4.906	5.19	4.906	5.19
160.00	1.190	-0.649	3.451	5.076	-0.164	5.078	-2.191	5.009	5.46	5.009	5.46
165.00	-1.762	-2.546	3.097	4.155	-1.129	4.362	-2.460	4.058	5.44	4.058	5.44
170.00	0.619	-1.543	1.747	-10.363	-7.022	12.518	0.444	-5.550	5.56	-5.550	5.56
175.00	-0.777	6.008	6.058	-12.334	-10.253	16.039	0.620	-7.161	7.18	-7.161	7.18
180.00	0.111	7.204	7.205	-13.245	-10.712	17.035	0.844	-7.429	7.47	-7.429	7.47
185.00	0.339	4.197	4.210	-13.012	-10.663	16.450	0.952	-7.271	7.33	-7.271	7.33
190.00	1.342	-0.110	1.346	-0.765	-1.817	1.972	1.318	2.332	2.67	1.318	2.332
195.00	1.970	-2.370	3.082	-0.101	2.335	2.330	-0.107	2.826	3.03	1.097	2.826
200.00	2.001	-2.149	2.936	13.604	6.315	15.071	-3.436	12.620	13.07	-3.436	13.07

FIGURE 123 Unfiltered Head, Chest, and Hip Accelerations for Example 1

SEVERITY INDICES FOR UNFILTERED ACCELERATIONS

TIME	HEAD		CHEST		NO BELTS		NO BELT	
	A-P	S-I	R	S-I	R	S-I	R	S-I
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.00	0.02	0.00	0.02	0.01	0.01	0.10	1.76	0.03
10.00	0.09	0.00	0.00	0.01	0.01	1.54	0.34	0.08
15.00	0.13	0.00	0.14	0.01	0.05	4.44	5.15	0.08
20.00	0.19	0.00	0.20	0.01	0.18	7.31	0.61	0.13
25.00	0.26	0.00	0.26	0.02	0.25	10.08	0.96	0.23
30.00	0.32	0.00	0.33	0.02	0.27	12.70	1.39	0.22
35.00	0.38	0.01	0.39	0.02	0.28	15.11	1.95	0.25
40.00	0.40	0.09	0.51	0.02	0.20	17.22	2.72	0.27
45.00	0.41	0.45	0.70	0.03	0.20	20.98	3.18	0.47
50.00	0.45	0.71	1.22	0.04	0.23	20.53	3.19	0.92
55.00	0.96	0.99	2.15	0.04	0.20	38.26	3.19	1.74
60.00	2.35	1.06	3.69	0.05	0.29	42.69	3.82	4.96
65.00	4.22	1.79	6.65	0.07	0.30	44.30	4.03	5.15
70.00	6.35	9.41	17.03	0.09	0.90	45.08	4.04	52.36
75.00	60.00	232.11	332.96	42.90	202.04	250.77	45.46	4.04
80.00	71.35	292.79	417.04	44.38	239.40	312.54	48.37	11.00
85.00	71.90	296.62	422.13	44.39	238.61	312.91	52.13	26.57
90.00	76.66	318.40	449.03	44.44	241.69	320.41	56.17	47.67
95.00	147.63	328.93	535.66	92.19	245.32	377.27	689.44	50.99
100.00	244.74	347.77	666.76	161.54	250.31	493.44	692.16	53.03
105.00	261.00	356.92	690.96	165.44	251.32	504.04	692.24	64.32
110.00	269.47	375.09	720.22	165.86	257.60	516.02	692.41	76.10
115.00	274.60	419.30	802.39	166.13	200.04	556.32	692.54	77.61
120.00	277.09	406.09	854.60	166.16	304.79	576.74	693.74	77.91
125.00	279.29	497.45	869.95	166.19	305.02	578.60	691.10	78.37
130.00	280.40	498.66	872.77	166.19	305.03	578.72	693.27	78.95
135.00	281.35	498.66	873.54	166.19	305.03	578.72	693.42	79.76
140.00	281.93	498.69	874.06	166.19	305.04	578.72	693.57	80.36
145.00	282.32	499.17	875.22	166.20	305.04	578.73	693.76	80.53
150.00	282.60	500.12	877.00	166.20	305.05	578.74	693.99	80.54
155.00	283.40	500.53	878.10	166.20	305.05	578.75	694.34	80.54
160.00	283.61	500.26	878.36	166.20	305.06	578.75	694.67	80.54
165.00	284.67	500.50	878.45	166.20	305.06	578.75	694.90	80.54
170.00	285.67	500.63	878.51	166.21	305.06	578.75	695.14	80.62
175.00	285.77	878.67	166.21	305.06	578.76	697.37	81.13	80.62
180.00	286.60	501.40	879.31	166.23	305.07	578.76	700.18	81.65
185.00	286.68	501.62	879.74	166.23	305.07	578.76	701.14	82.26
190.00	286.70	501.96	879.80	166.24	305.07	578.76	704.44	85.91
195.00	286.72	501.00	879.86	166.24	305.08	578.76	704.44	85.96
200.00	286.76	501.93	879.95	166.24	305.08	578.76	704.64	86.05

FIGURE 124 Severity Indices for Unfiltered Accelerations for Example 1

3.4.4 Input Data for Example 2

The second example data set includes the same 30-mph frontal barrier crash acceleration profile as used for Example 1. Simulation Example 2 is similar to Example 1 in other ways also. It uses the same occupant description data subset and the occupant is positioned within the vehicle in an identical manner. The vehicle interior used is basically the same. The primary difference between Examples 1 and 2 is that while both occupants are restrained by a knee bar, the occupant in Example 2 is additionally restrained by a torso harness. There are a number of other differences in the data sets. None of these should affect the crash dynamics; they have been included to illustrate various program options.

3.4.4.1 Belt Restraint System. The three-belt submodel described in Module 9 is used for this simulation. Since simulation Example 1 was for an occupant unrestrained by belts, the belt system usage switch in field 1 of Card 102 was set to 0. For Example 2, however, Card 102 in Figure 128 is seen to have a 2. in field 1. This indicates usage of the three-belt submodel with both lap and torso restraints. Since it is desired for this simulation to have only the torso harness and the knee bar as restraints, and not a lap belt, the belt system data subset shown in Figure 125 includes some specifications worthy of note.

While any of the seven belt segments of the Advanced Belt-Restraint Submodel may be included or omitted from a belt system design, the Three-Belt Submodel is not as flexible. It must include either both lap belt and torso harness or the lap belt alone. Therefore, in the data subset shown, in order to effectively eliminate the lap belt, a belt material named NO STRENGTH is defined by 704- and 705-Cards and is prescribed a zero stiffness with a 708-Card. This belt material is assigned to the lap belt on Card 702.

The torso belts are each pre-tensioned to 5 lb. This is done by assigning negative values for initial slack on Cards 701 and 702. Belt anchor locations and attachment points on the occupant are prescribed on Cards 501 and 218.

2.75	7.	0.	0.	0.	1.8	-1.96	14.12	-5.07	218
0.	0.	0.	0.	0.	-33.52	17.	-1.2		501
100.	0.	15.13	-0.00178	6600.	6600.	10.			701
NO STRENGTH					14.04	-0.00172	2.	1.	702
6% WEBBING #1					6% WEBBING #2				703
6% WEBBING #1	0.	0.	0.16	14.36	15.04	0.	0.		704
6% WEBBING #1	5.					SBELT1	IZERO	G8ELT1	705
GAELT1	0.	0.							706
SBELT1	.16	0.							706
SBELT1	1.37	.56							706
SBELT1	6.15	.95							706
SBELT1	40.	.95							706
SBELT1	0.	1.							706
SBELT1	1.37	.33							707
SBELT1	2.06	.19							707
SBELT1	6.15	.05							707
SBELT1	40.	.05							707
SBELT1	0.	0.							707
SBELT1	.533	1500.							708
SBELT1	9.01	2000.							708
SBELT1	11.28	5300.							708
SBELT1	14.36	6600.							708
SBELT1	15.04	0.							708
6% WEBBING #2	0.	0.	.155	13.85	14.51	0.	0.		708
6% WEBBING #2	5.					SBELT2	IZERO	G8ELT1	705
SBELT2	0.	0.							708
SBELT2	.396	1150.							708
SBELT2	9.56	1650.							708
SBELT2	10.9	5300.							708
SBELT2	13.85	6600.							708
SBELT2	14.51	0.							708
NO STRENGTH	0.	0.	0.	10.	11.	0.	0.		704
NO STRENGTH	5.					SNOSTR	IZERO	GNOSTR	705
GNOSTR	-1.	0.							706
GNOSTR	-1.	1.							707
SNOSTR	-1.	0.							708

FIGURE 125 Belt Restraint System Cards for Example 2

3.4.4.2 Auxiliary Debugging Printout. Module 12 explains the use of 104- and 105-Cards for obtaining "debugging" printout of intermediate results from the Execution Processor. Time-dependent, multi-level switches may be set for sixteen divisions of program variables. Figure 126 illustrates specifications for debugging printout for Example 2 from 0 to 3 ms and from 198 to 200 ms inclusive. Printout beginning at times zero will be for switches 1, 7, 9, 10, 11, and 16 at levels 3, 1, 3, 3, 2, and 2, respectively. At 1.1 ms, switches 7 and 16 are set to 0, and at 3.1 ms all debugging printout is suppressed. At 198 ms, all sixteen switches are set at level 1; debugging printout continues through the end of the simulation (200 ms for Example 2) since the switches are not reset to 0. Field 9 of Card 104 is set to 1. in order to limit debugging printout to each final evaluation for the four-step Runge-Kutta integration. A "packing dictionary," which is often useful in interpreting debugging printout, is requested by defaulting the ninth field of Card 105 to 0. by omission of the card from the data deck.

3.4.4.3 Output Variable Storage. Section 3.4.2.11 has explained the use of Cards 1001 and 1002 for specifying categories of calculated data for which printout is desired. It should be kept in mind that in order for the Output Processor to print out variables in response to specifications on Cards 1001 and 1002, those variables must first be stored in an external file. Specification of categories which are to be stored during execution of the "GO" processor for possible later printout is made separately through use of Cards 107 through 111. For Example 1, these cards were omitted from the data deck and thus, by default, all categories were stored for printout. However, the data deck for Example 2 includes the cards shown in Figure 127. Only variables for categories for which a "0." is specified will be written to the external file for possible printout. Use of Cards 107 through 111 is explained in Module 12.

3.4.4.4 Other "Example 2" Modifications. Additional differences between the data decks for Example 1 and Example 2 include the following. (These can be seen in comparing the appropriate sections of their complete data decks, which are shown in Figures 109 and 128.) First, the vehicle interior for Example 2 does not include the ROOFHEADER,

0. C004F8021.1 C000F8003.1 00000000198. 555555551. 104

FIGURE 126 Debugging Printout Specifications for Example 2

0.	1.	1.	0.	0.	0.	1.	0.	1.	107
0.	0.	0.	0.	0.	0.	1.	1.	1.	108
1.	1.	0.	0.	0.	0.	0.	0.	1.	109
1.	1.	0.	0.	0.	1.	1.	1.	1.	110
0.	1.	1.	0.	0.	0.	0.	0.	0.	111

FIGURE 127 Specifications for Storage of Output Categories for Example 2

WINDSHIELD, and INSTRUMENT PANEL regions. Second, the 106-Cards are absent from the data deck, and interaction "inhibition" controls on Card 102 are redefined so that all potential ellipse-line interactions are investigated. Third, the THORAX and HIP ellipses have been made rigid since materials were defined for them for Example 1 only because of the possibility of THORAX-INSTRUMENT PANEL and HIP-FLOOR interactions. Finally, printout of the summary of the input data is often not desired; it is suppressed for Example 2 by removing Category 0 from the string on Card 1001. Alternatively, a 1001-Card containing only "-1" in columns one and two could have been used. This requests the default ordering for Categories 1 through 40 and 46 through 50 with omission of printout of the input data summary, Category 0.

3.4.5 Selected Output from Simulation Example 2

Selected pages of printout produced by the complete Example 2 data deck in Figure 128 are shown as Figures 129 through 134. These are: a printer-plot stick figure sequence; example debugging printout; belt system data; body link angle accelerations; head, chest, and hip accelerations; and HIC and Severity Indices.

MVMA 2-D TUTORIAL EXAMPLE #2

KNEE BAR
CCC. CRIMP. DISPL.
30MPH FRONT BARRIER
FORCE-LIM. HARNESS
NO LAP BELT

1.	1.	32.174	0.	0.	200.	1.	5.	10.	100
2.	0.	0.	0.	1.	10.	10.	.000001	5.	400
.2	.05	100000.	15000.	10.	.05	10.	1.	1.	500
0.	C004FB021.1		C000FB003.1		00000000108.		555555551.		600
0.	1.	1.	0.	0.	0.	1.	0.	1.	700
0.	0.	0.	0.	0.	0.	1.	1.	1.	800
1.	1.	0.	0.	0.	0.	0.	0.	1.	101
1.	1.	0.	0.	0.	1.	1.	1.	1.	102
0.	1.	1.	0.	0.	0.	1.	1.	1.	103
0.	1.	1.	0.	0.	0.	0.	0.	1.	104
1.	1.	0.	0.	0.	0.	0.	0.	1.	107
1.	1.	0.	0.	0.	1.	1.	1.	1.	108
0.	1.	1.	0.	0.	0.	0.	0.	0.	109
0.	1.	1.	0.	0.	0.	0.	0.	0.	110
0.	44.	0.	0.	0.	0.	0.	0.	0.	111
0.	23.	1.	1.						601
0.	-1.7	1.	-1.4	7.	-33.9	12.	2.8		602
13.5	3.9	18.	-21.2	21.5	-12.4	28.	-9.2		
32.	-24.0	33.	-24.0	36.	-9.9	37.	-9.9		
42.	-26.9	47.	-31.8	50.	-25.9	54.	-27.2		
58.	-32.2	61.	-29.0	76.	-6.9	90.	-1.4		
100.	-1.4	120.	0.	300.	0.				603
2.	1.	1.							
0.	0.	300.	0.						604
2.	1.	1.							
0.	0.	300.	0.						
GM HYBRID II DUMMY									
(PRELIMINARY DATA)									
1.1	13.44	3.4	5.	15.8		10.3	3.25	-.88	201
2.75	7.	1.7	4.2	8.2	9.3	5.	5.8	.5	202
.0250	.0951	.0052	.0992	.0932	.0518	.022	.0256	.007	203
.198	1.97	.04	1.53	1.39	2.92	.18	.62		204
12.9	.58	0.	.52	17.4	1.		-25.	.35	205
12.9	.58	0.	.52	17.4	1.		-22.	.35	206
72.	15.	0.	.66	1000.	1.	-8.	-25.5	.35	207
102.5	-7.624	.1944	.66	1000.	1.	-33.999	-34.001	.35	208
84.44	-4.810	.1053	0.	850.	1.	-49.999	-50.001	.5	209
0.	29.8	0.	0.	204.	1.	135.	0.	.5	210
0.	10.	0.	0.	222.	1.	28.	-197.	.5	211
0.	10.	0.	0.	64.	1.	0.	-165.	.5	212
751.	0.	757.	1.98						213
20.	230.	0.	0.			2.		.5	214
38.	.58	0.	.52	0.	1.	-1.		.16	215
38.	.58	0.	.52	0.	1.	2.		.16	216
751.	0.	757.	1.98						242
HEAD				1.	3.				219
THORAX				2.	1.				219
HIP				4.	1.				219
THIGH				5.	1.				219
KNEE				5.	1.				219
SHANK				6.	1.				219
HEEL				6.	2.				219
TOE				6.	2.				219
ELBOW				7.	1.				219
HAND				8.	3.				219
HEAD	0.	.5	4.	4.					220
THORAX	-.5	-.68	5.52	4.44					220
HIP	-.12	0.	4.5	4.5					220
THIGH	-.5	-.1	7.	3.					220

FIGURE 128 Complete Data Set for Simulation Example 2 (page 1 of 5)

KNEE	7.	-4	2.25	2.25					220
SHANK	-7.54	0.	3.	2.4					220
HEEL	8.57	0.	1.2	1.2					220
TOE	5.61	-5.16	1.2	1.2					220
ELBOW	5.3	0.	1.5	1.5					220
HAND	5.6	-4	2.72	1.52					220
CHESTMATEL	0.	0.	0.	100.	101.	0.	0.		221
CHESTMATEL	5.				CSTAT	IZERO	CGR		221
CGR	-1.	.1							222
CGR	0.	1.							223
CGR	.01	.64							224
CGR	.3	.5							224
CGR	1.35	.45							224
CSTAT	0.	0.							225
CSTAT	.01	1125.							225
CSTAT	.05	1460.							225
CSTAT	.3	1350.							225
CSTAT	.4	1260.							225
CSTAT	1.1	1260.							225
CSTAT	4.25	12600.							225
IZERO	-1.	0.							226
HIPMATEL	0.	0.	0.	100.	101.	0.	0.		221
HIPMATEL	5.				CSTAT	IZERO	CGR		222
-11.	-8.	-34.	-50.	0.	0.	0.	0.		217
78.5	97.5	115.5	149.5	19.5	-45.	-41.	3.	89.5	301
0.	0.	0.	0.	0.	0.	0.	0.	0.	302
12.2	0.	-21.4	0.	3.29	0.				303
0.	0.	0.	0.						304
SEAT BACK	SEAT MATERIAL	0.	1.	1.	1.	1.			401
SEAT BACK	1.	1.	1.	0.	0.				402
SEAT MATERIAL	0.	0.	1.6	3.5	4.	0.	0.		403
SEAT MATERIAL	5.				SSEAT	IZERO	GRSEAT		404
GRSEAT	-1.	.1							405
GRSEAT	-1.	.5							406
SSEAT	0.	0.							407
SSEAT	.8	150.							407
SSEAT	1.6	400.							407
SSEAT	3.	2000.							407
SSEAT	3.5	4000.							407
SSEAT	4.	0.							407
BACK LINE	SEAT BACK	5.	0.	-1.	1.				409
BACK LINE	1.								410
BACK LINE	-1.	6.2	-25.8	15.44	-4.96				411
SEAT CUSHION	SEAT MATERIAL	0.	1.	1.	1.				401
SEAT CUSHION	2.	1.	1.	0.	0.				402
CUSHION LINE 1	SEAT CUSHION	5.	.164	1.	1.				409
CUSHION LINE 1	1.								410
CUSHION LINE 1	-1.	15.44	-4.96	28.	-9.92				411
CUSHION LINE 2	SEAT CUSHION	5.	.5	-1.	2.				409
CUSHION LINE 2	1.								410
CUSHION LINE 2	-1.	28.	-9.92	32.24	-10.64				411
FLOOR	FMATEL	0.	1.	1.	1.				401
FLOOR	2.	2.	1.	0.	0.				402
SEAT BOTTOM	FLOOR	5.	0.	-1.	1.				409
SEAT BOTTOM	1.								410
SEAT BOTTOM	-1.	31.2	-8.	31.2	-.84				411
FLOORBOARD	FLOOR	5.	0.	-1.	2.				409
FLOORBOARD	1.								410
FLOORBOARD	-1.	31.2	-.84	49.	-.84				411
TOEPAN	FMATEL	0.	1.	1.	1.				401

FIGURE 128 Complete Data Set for Simulation Example 2 (page 2 of 5)

TOEPAN	1.	2.	1.	0.	0.	1.		402
TOEBOARD	TOEPAN		5.	0.	1.	1.		409
TOEBOARD	4.							410
TOEBOARD	0.	47.3	1.1	54.7	-5.5			411
TOEBOARD	40.	47.3	1.1	54.7	-5.5			411
TOEBOARD	80.	47.3	1.1	47.9	-5.5			411
TOEBOARD	300.	47.3	1.1	47.9	-5.5			411
KNEE BAR	SHEET METAL		0.	1.	1.	1.		401
KNEE BAR	1.	3.	1.	0.	0.			402
SHEET METAL	0.	0.	.5	8.	0.	10000.	10000.	403
SHEET METAL	5.				SSHEET	IZERO	GRSHEET	404
GRSHEET	0.	0.						405
GRSHEET	0.5	0.						405
GRSHEET	5.5	0.9						405
GRSHEET	0.	1.						406
GRSHEET	.5	1.						406
GRSHEET	2.	.7						406
GRSHEET	4.	.2						406
GRSHEET	5.5	.15						406
GRSHEET	9.	.1						406
GRSHEET	9.	.01						406
SSHEET	0.	0.						407
SSHEET	2.	1500.						407
SSHEET	4.	1500.						407
SSHEET	5.5	10000.						407
SSHEET	9.	10000.						407
SSHEET	9.	0.						407
KNEEBAR LINE	KNEE BAR		5.	0.5	1.	1.		409
KNEEBAR LINE	4.							410
KNEEBAR LINE	0.	40.4	-13.2	38.9	-16.4			411
KNEEBAR LINE	60.	40.4	-13.2	39.9	-16.4			411
KNEEBAR LINE	80.	38.9	-13.2	37.4	-16.4			411
KNEEBAR LINE	300.	39.9	-13.2	37.4	-16.4			411
DASH	DASHMATL		0.	1.	1.	1.		401
DASH	1.	2.	1.	0.	0.			402
DASHLINE	DASH		5.	0.	1.	1.		409
DASHLINE	4.							410
DASHLINE	0.	54.7	-5.6	54.2	-20.1			411
DASHLINE	40.	54.7	-5.6	54.2	-20.1			411
DASHLINE	90.	47.9	-5.6	47.4	-20.1			411
DASHLINE	300.	47.9	-5.6	47.4	-20.1			411
DASHMATL	0.	0.	0.	100.	100.	0.	0.	403
DASHMATL	5.					DSTAT	IZERO	DGR
DGR	0.	0.						404
DGR	.001	.01						405
DGR	10.	.01						405
DGR	0.	1.						405
DGR	.001	.91						405
DGR	.75	.8						406
DGR	1.5	.5						406
DGR	10.	.3						406
DSTAT	0.	0.						407
DSTAT	0.75	2100.						407
DSTAT	1.5	9000.						407
DSTAT	40.	9000.						407
FMATL	0.	0.	0.	100..	100..	0.	0.	403
FMATL	5.	0.	0.	0..	FSTAT	IZERO	FGR	404
FGR	0.	0.						405
FGR	2.	.7						405
FGR	0.	1.						406

FIGURE 128 Complete Data Set for Simulation Example 2 (page 3 of 5)

FGR	2.	.2							406
FSTAT	0.	0.							407
FSTAT	.25	100.							407
FSTAT	.5	400.							407
FSTAT	.75	1200.							407
FSTAT	1.	2400.							407
FSTAT	1.5	4000.							407
FSTAT	2.	4600.							407
FSTAT	3.	5000.							407
FSTAT	4.	5200.							407
FSTAT	6.	5400.							407
FSTAT	10.	5600.							407
FSTAT	16.	10000.							407
1.	1.	.25	.125	.125					407
1.	2.	.5							412
1.	3.	.5							412
1.	4.	.4							412
2.	2.	.8							412
3.	1.	.4							412
3.	2.	.5							412
3.	4.	.4							412
3.	5.	.67							412
3.	6.	.9							412
2.75	7.	0.	0.	0.	1.8	-1.96	14.12	-5.07	412
0.	0.	0.	0.	0.	-33.52	17.	-1.2		218
100.	0.	15.13	-0.00178	6600.	6600.	10.			501
NO STRENGTH					14.04	-0.00172	2.	1.	701
6% WEBBING #1					6% WEBBING #2				702
6% WEBBING #1	0.	0.	0.	0.16	14.36	15.04	0.	0.	703
6% WEBBING #1	5.						SBELT1	IZERO	704
GBELT1	0.	0.							705
GBELT1	.16	0.							706
GBELT1	1.37	.56							706
GBELT1	6.15	.95							706
GBELT1	40.	.95							706
GBELT1	0.	1.							706
GBELT1	1.37	.33							707
GBELT1	2.06	.19							707
GBELT1	6.15	.05							707
GBELT1	40.	.05							707
SBELT1	0.	0.							707
SBELT1	.533	1500.							708
SBELT1	9.91	2000.							708
SBELT1	11.28	5300.							708
SBELT1	14.36	6600.							708
SBELT1	15.04	0.							708
6% WEBBING #2	0.	0.	.155	13.85	14.51	0.	0.	0.	708
6% WEBBING #2	5.						SBELT2	IZERO	704
SBELT2	0.	0.							705
SBELT2	.396	1150.							708
SBELT2	9.56	1650.							708
SBELT2	10.9	5300.							708
SBELT2	13.85	6600.							708
SBELT2	14.51	0.							708
NO STRENGTH	0.	0.	0.	10.	11.	0.	0.	0.	708
NO STRENGTH	5.						SNOSTR	IZERO	704
GNOSTR	-1.	0.							705
GNOSTR	-1.	1.							706
SNOSTR	-1.	0.							707
SNOSTR	-1.	0.							708

FIGURE 128 Complete Data Set for Simulation Example 2 (page 4 of 5)

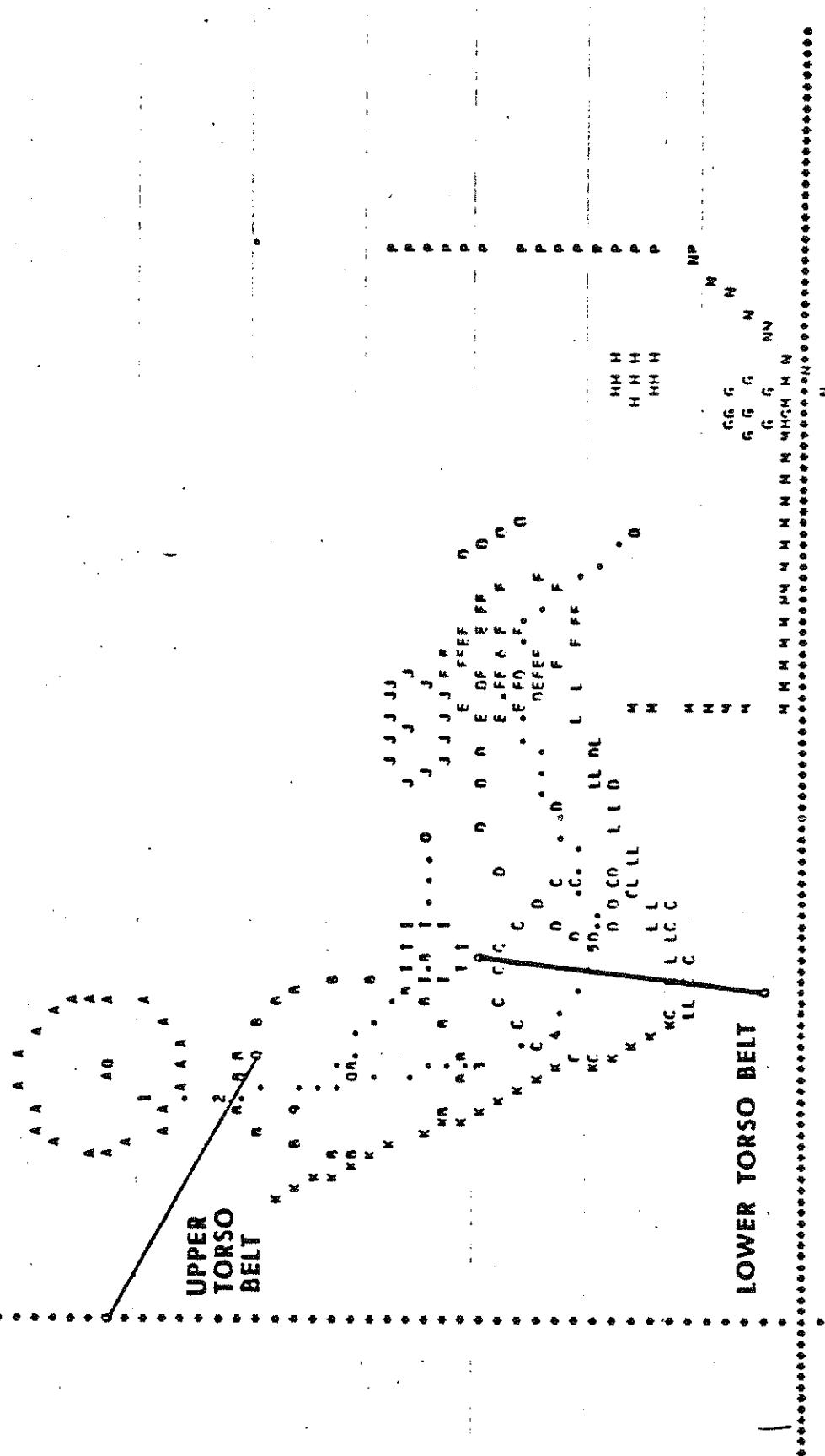
1,46-48,10-14,21, 22,37,38,49,50,15,23-26,2-5, 18-20,33-36,30-32,16,
27-29,39,17,40,6-9,45 1001
0. 0. 0. 11.55 .025 1002
40. 500. 560. 0. .85 201. 5. 5. 1003
0. 0. -3. 62. 5. -44. 10. 0. 1004
21. 0. 0. 1. 1. 0. 1. 0. 10. 1500
1501
1502
1503

FIGURE 128 Complete Data Set for Simulation Example 2 (page 5 of 5)

JUN 24, 1970 02:02:15
NO HUMAN PRELIMINARY DATA

HVMA 2-D TUTORIAL EXAMPLE #2
KNEE-FRONT HARNESS NO LA-BELT
DISPL. CONP. 0.000
30MM FRONT BARRIER FORCE-LHM. HARNESS NO LA-BELT

STICK FIGURE PRINTER PLOT FRAME END TIME= 0.0 msfc.

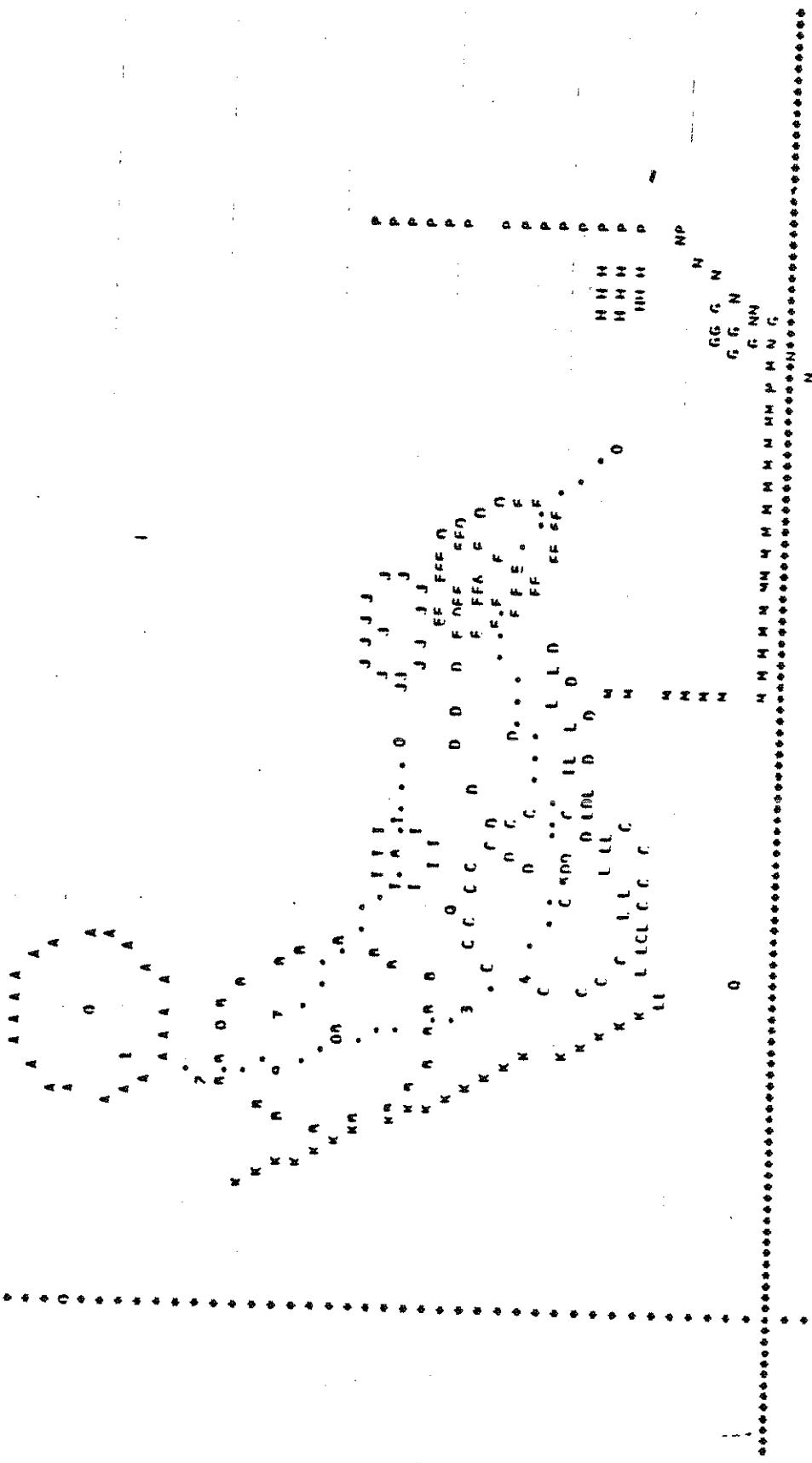


CORRECTIVE RANGES FOR PLOT ARE X= -4.96 TO 69.56 (AT LEFT) AND Y= 5.00 (AT MIDDLE) TO -44.00 (AT TOP)
SCALE FACTOR IS 1.00 = 5.547 (IN). X AND Z POINT POSITION ERRORS EQUAL RESPECTIVELY 0.217 AND 0.462 (IN) IN SCALE.

FIGURE 129a Printer-Plot Time Sequence for Example 2 (0 ms)

JUN 24 1977 02102115
64 INVESTIGATIVE DATA

KYMA 2-D PLOTTER PLOT TIME SEQUENCE DATA
KNEE ROLL
NCC. CIVIL. DISPL. 304PM FRONT HARNESS FORCE-LIM. HARNESS NO TAP MET
STIRK FIGURE PLOTTER PLOT FRAME FOR TIMEA 40.00 MSEC.



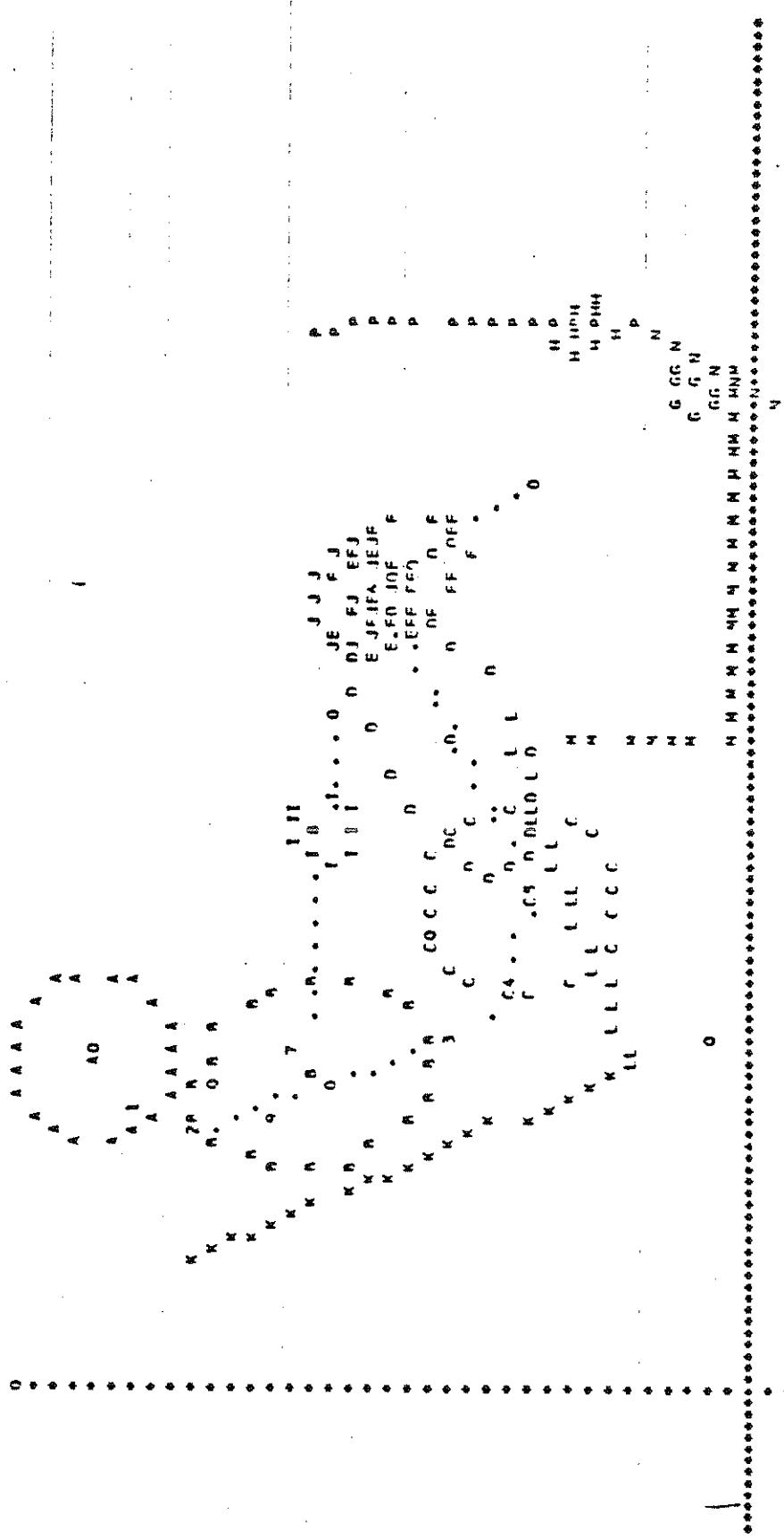
COORDINATE CHANGES AND PLOT ARE AS FOLLOWS:
SCALE FACTOR IS 1 INCH = 5.447 (IN). X AND Z PLOT RESOLUTION EQUALS 70 -44.00 (AT TOP)
FIGURE 129b Printer-Plot Time Sequence for Example 2 (40 ms)

JUN 24, 1977 02102115
GK HYATT II DRAFT (PRELIMINARY DATA)

HUNA 2-0 TUNNEL EXAMPLE #2

PAGE 47-45

SIXTY-FIVE PAPER PRINTS FROM TIME 60.00 MSEC.

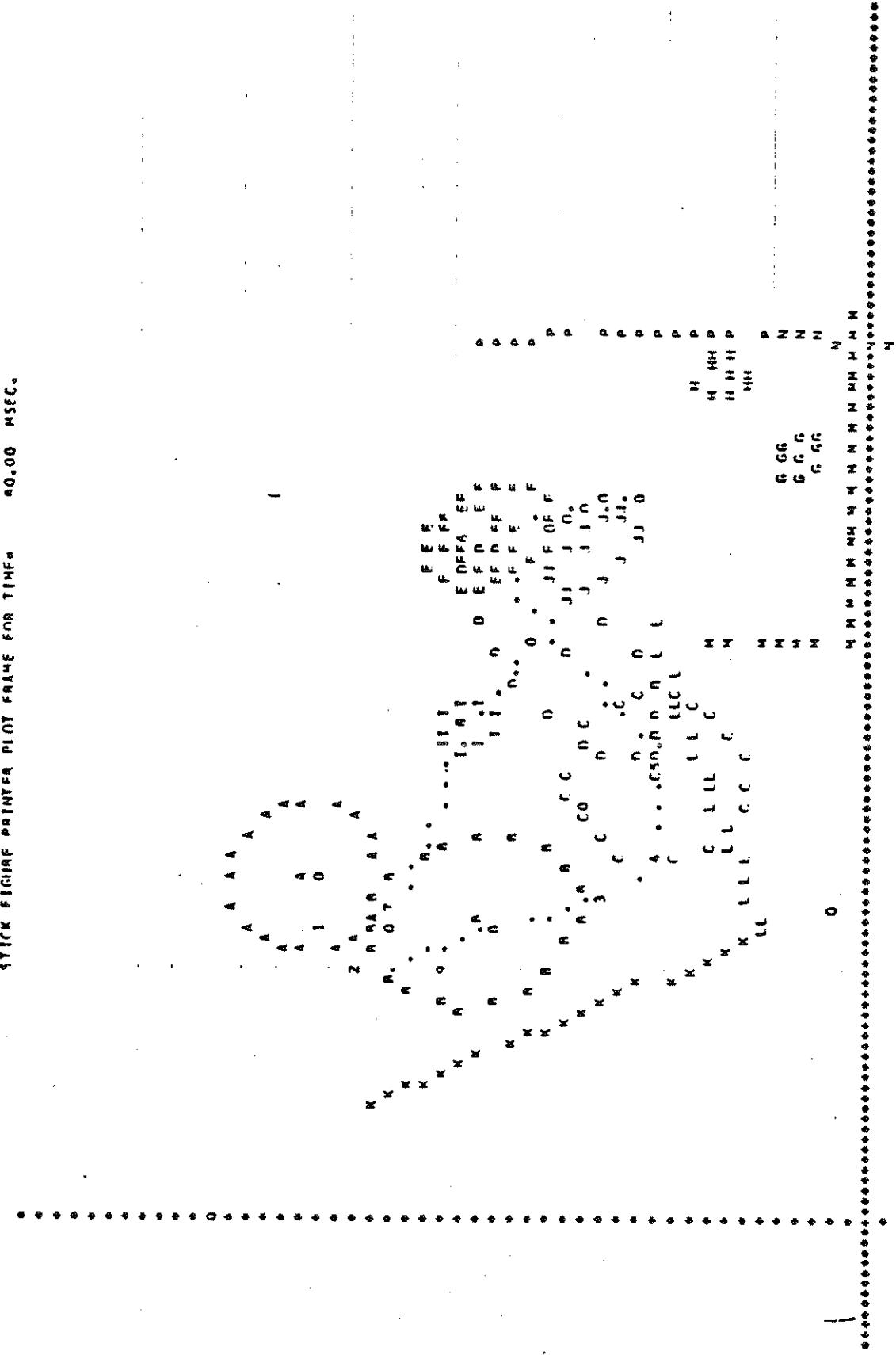


COORDINATE RANGES FOR PLANT APF X = -A.4 TO A.4 (AT RIGHT) AND Z = 1.00 (AT ROTATION) IN -A.40 ON (AT TOP).
 SCALE FACTOR IS 1.001 ± 0.007 (1IN). X AND Z POINT RECONCILIATION ERRORS EQUAL RESPECTIVELY 0.277 AND 0.462 (1IN) IN STAGE

FIGURE 129c Printer-Plot Time Sequence for Example 2 (60 ms)

JUN 24, 1977 02:02:15
GM HYBRID II HYBRID (PDI) INSTRUMENT DATA

KVHMA 2-0 TUTORIAL EXAMPLE #2
KNEE BAR
ACC. CHNP. DISPL. 30MPH FRONT BARRIER FORCE-LAW, HARNESS NO LAP BELT
STICK FIGURE PRINTER PLOT FRAME FOR TIME = 40.00 msec.

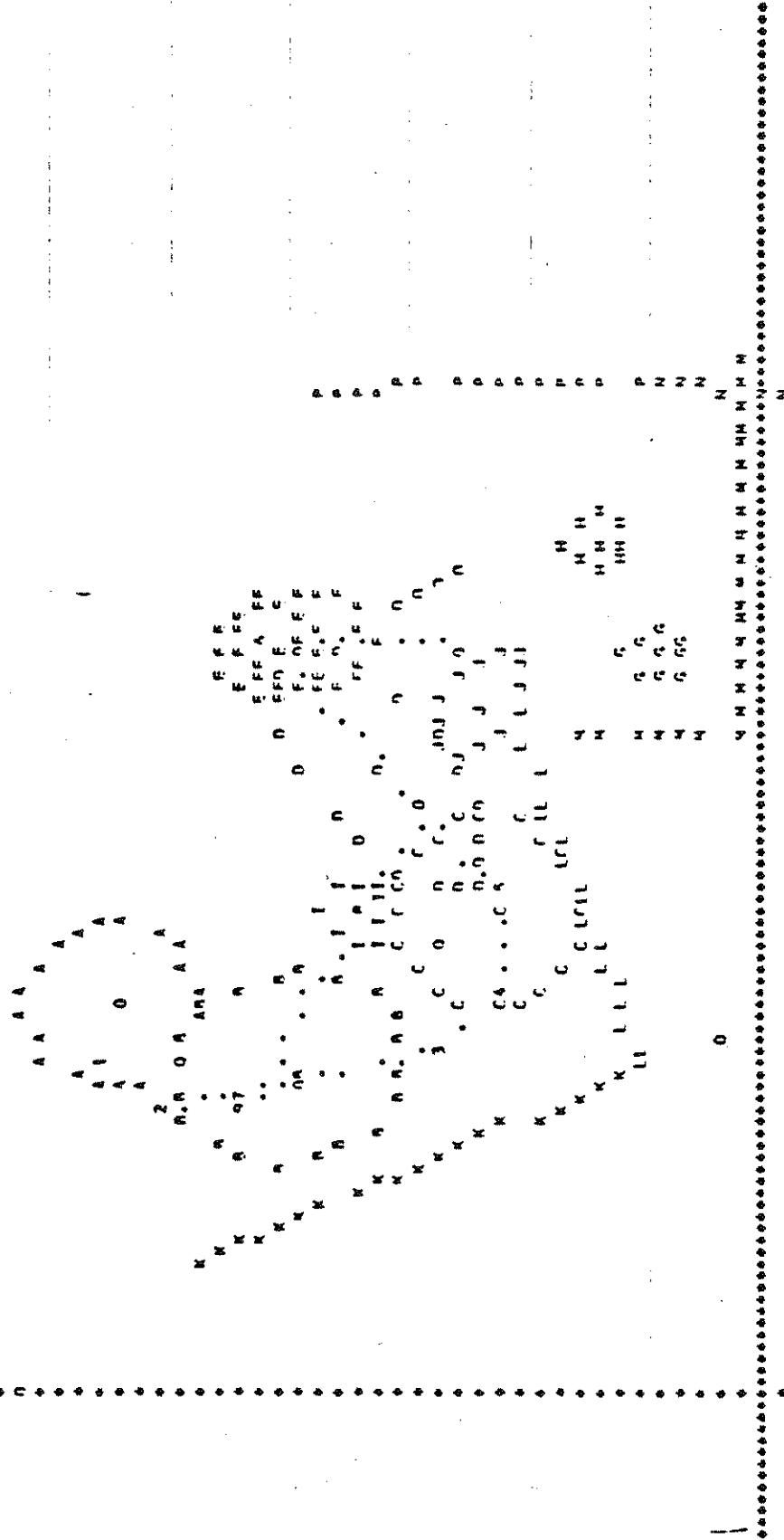


COORDINATE RANGES FOR PLOT ARE X = -6.50 (AT LEFT) TO 65.00 (AT RIGHT) AND Z = -3.00 (AT BOTTOM) TO 44.00 (AT TOP)
SCALE FACTOR IS 1IN = 5.547 (IN). X AND Z POINT RESOLUTION EQUAL RESPECTIVELY 0.277 AND 0.467 (IN) IN SCALE.

FIGURE 129d Printer-Plot Time Sequence for Example 2 (80 ms)

JUN 24, 1977 02:02:15
64 Martin II (Initial Preliminary Data) KNEE RAN
PAGE 91-45
EXAMPLE 82
30MM FRONT HARRIER FORCE-114. HARNESS W/ LIP ACTIV

STICK FIGURE PRINTOUT PLOT FRAME FOR TIME = 100.00 msec.



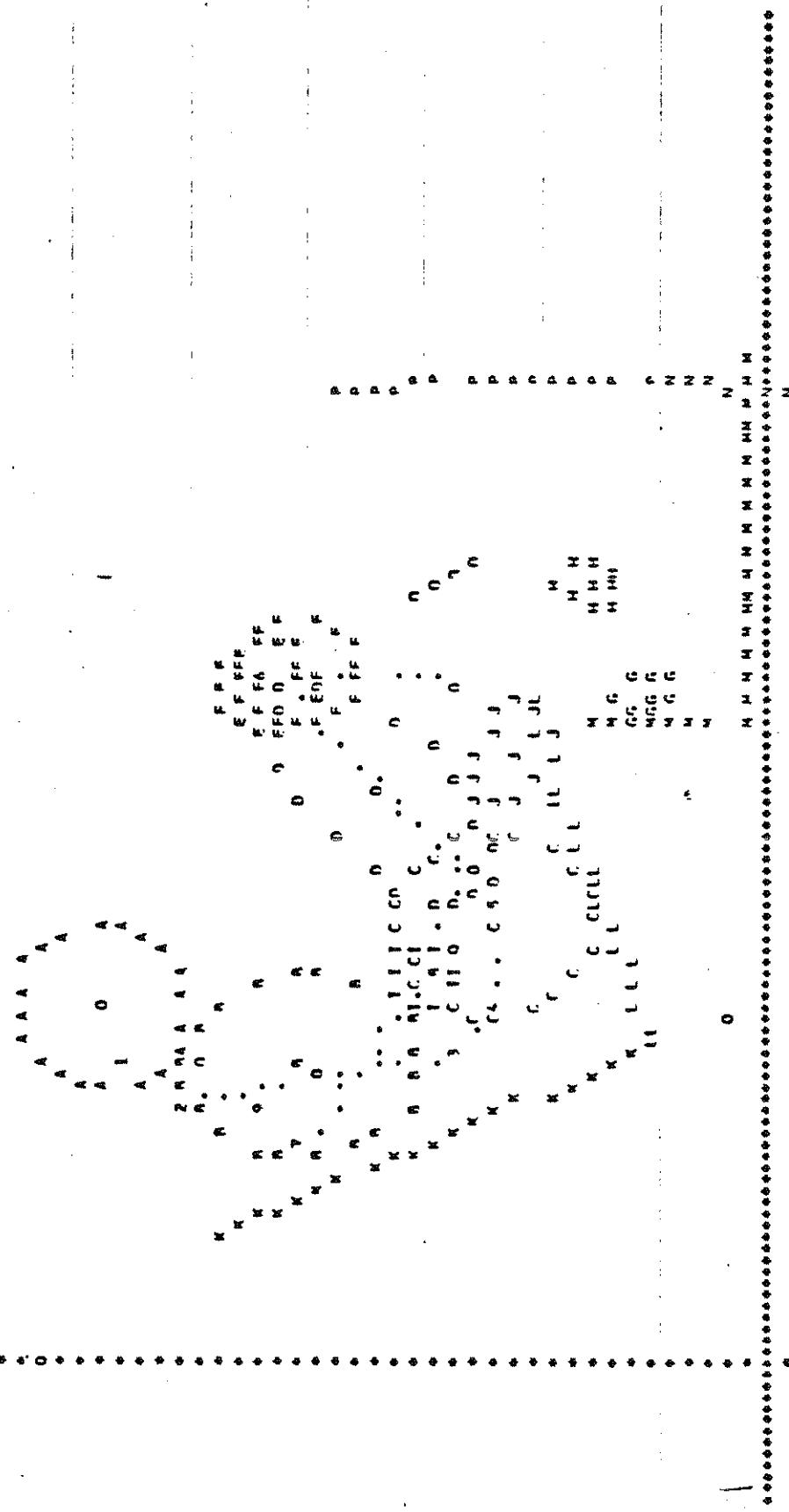
COORDINATE DATA FOR PLOT AND X= -6.56 (AT LEFT) TO 66.56 (AT RIGHT) AND Y= -4.00 (AT BOTTOM) TO 4.00 (AT TOP)
SCALE FACTOR IS 1.00 = 5.547 (IN). X AND Y joint positions final respectively 0.277 AND 0.462 (IN) IN SCALE.

FIGURE 129e Printer-Plot Time Sequence for Example 2 (100 ms)

JUN 24, 1977 0210Z 15
GM INSTRUMENTS II (INSTRUMENT PRELIMINARY DATA) HUMA 2-D TUTORIAL EXAMPLE #2
KNIFE BAR CHAM. CHAM. DISPL. 304EH FRONT HARNESS FORCE-1IN. HARNESS NO LAP RET.

STICK FIGURE PRINTER PLOT FRAME FOR TIME = 120.00 MSECS.

PAGE 53-49
PAGE 53-49



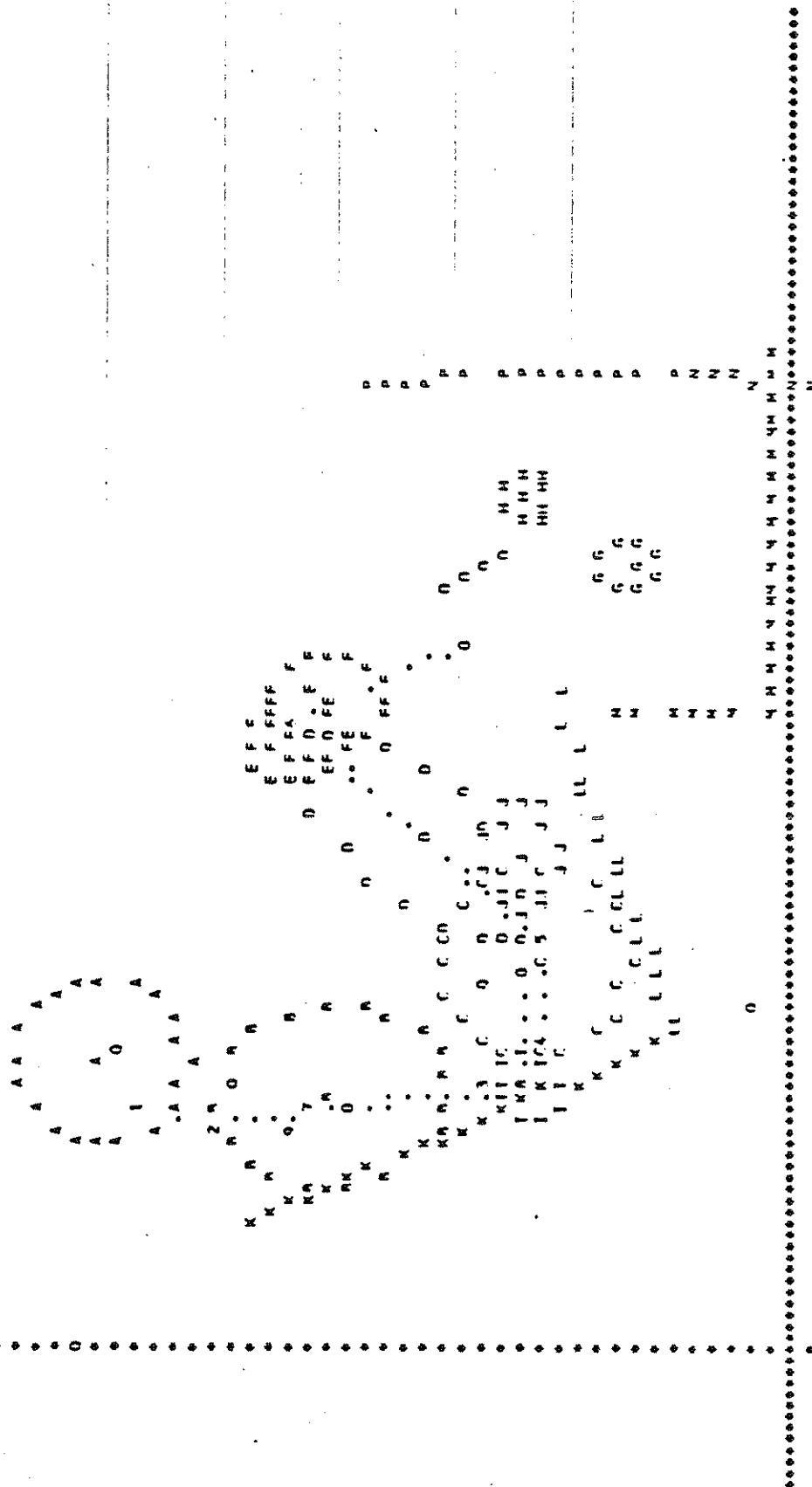
COORDINATE RANGES FOR PLOT ARE X = -1.00 TO 1.00 (AT LEFT) AND Y = 1.00 (AT ANKLES) TO -1.00 (AT TOP)
SCALE FACTOR IS FINI = 5.447 (IN) X AND Z DURING ACCELERATION FRAMES EQUAL RESPECTIVELY 0.277 AND 0.462 (IN) IN SCALE.

FIGURE 129f Printer-Plot Time Sequence for Example 2 (120 ms)

JUN 24 1977 02102115
64 WYBARD II NINAHY (PRELIMINARY DATA) KNEE PAD

MVVA 2-D TUTORIAL EXAMPLE #2 PAGE 56-49
KNEE PAD PRELIMINARY DATA AFG. CARS. CARS. 304PH FRONT RARRIER FORCE-LIM. HARNESS NO LAP BELT

STICK FIGURE PRINTER PLOT FRAME FOR TIME= 150.00 msec.

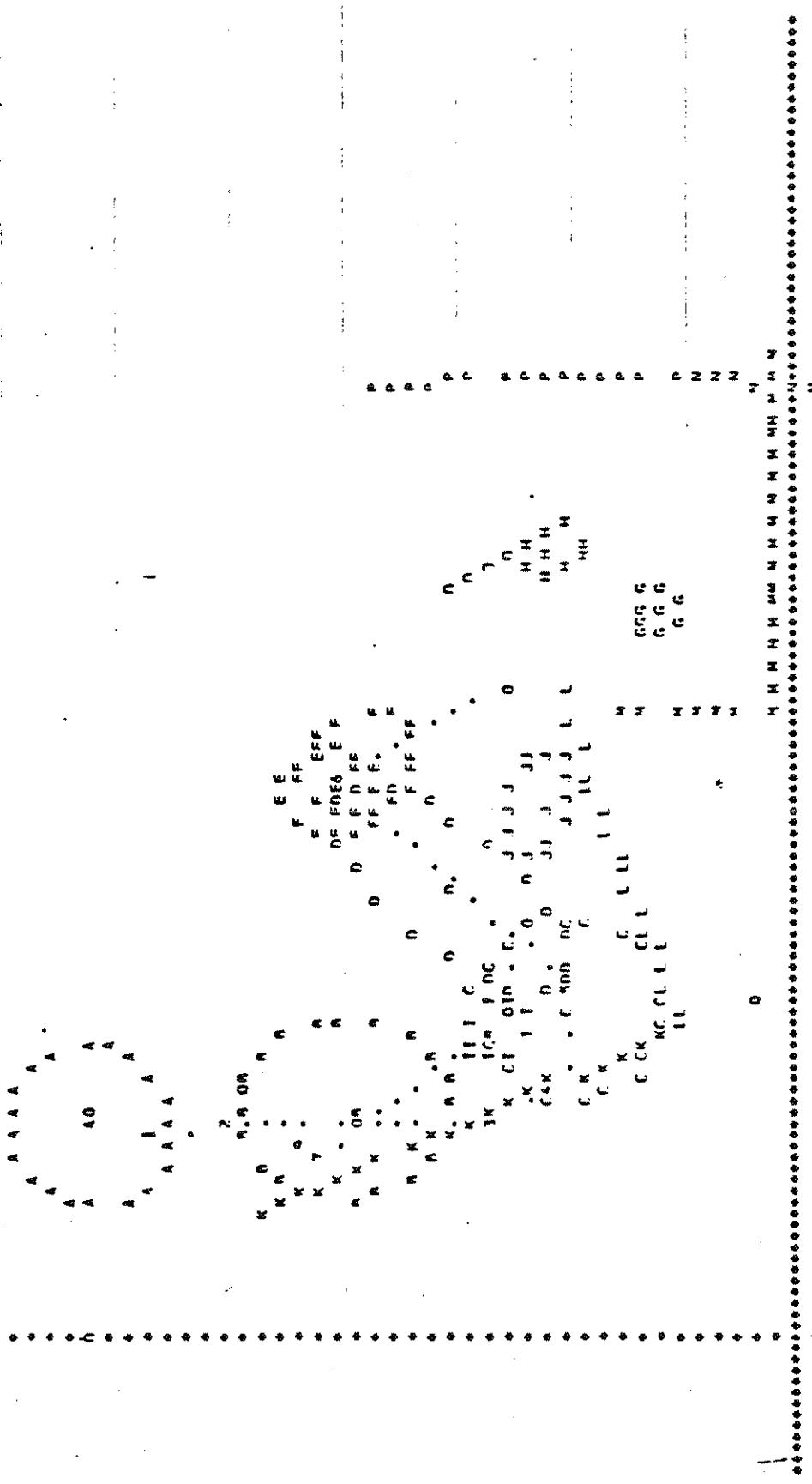


COORDINATE VALUES FOR PLOT ARE X= -6.5A (AT LEFT) TO 6.5A (AT RIGHT) AND Y= 5.00 (AT BOTTOM) TO -44.00 (AT TOP)
SCALE FACTOR IS 6100 = 0.547 (IN), X AND Y SCALE RESOLUTION EQUAL RESPECTIVELY 0.211 AND 0.462 (IN) IN SCALE.
FIGURE 129g Printer-Plot Time Sequence for Example 2 (150 ms)

JUN 24, 1970 02:13
EQUIMENT ID NUMBER (SELECT ININARY DATA)

WUFF 940 HYDRA 2-0 TUTORIAL EXAMPLE #7
NCF= 0.277, CDF= 0.462, DSET = 0.00, HARNESS = 0.0, LAD = 0.0

STICK FIGURE PRINTFOR PLUT FRAME FOR TIME= 200.00 MSFC.



CHANGINGWAVE RANGES FOR PLUT ARE $R = 0.54$ (LAD 0.00) AND $R = 0.00$ (LAD 0.00) (LAD TYPE)
SCALE FACTOR IS (IN) = 5.947 (IN). X AND Z POINTS RECORDED FROM FONET RESPECTIVELY
0.277 AND 0.462 (IN) IN SCALE.

FIGURE 129h Printer-Plot Time Sequence for Example 2 (200 ms)

483

JUN 24, 1977 02:15
IN HAVING II PRIMARY DATA)

MVMA 2-D TUTORIAL EXAMPLE #2
KNFF RAR
CONTACT FORCES FRQ WHEEL TOPSO BELT HARNESS NO LAP BELT
PAGE 15-04
30MMH FRONT HARNESS HARNESS NO LAP BELT

TIME	CONTACTING	DEFLECTION	RING FOUL.	UNADJUSTED TENSION	TENSION ADJUSTMENT	RESULTANT FORCE	RESULTANT HEADING	ABSORBED ENERGY
(MSEC)	(IN)	(IN/SEC)	(IN)	(IN)	(IN)	(IN)	(DEGRESS)	(FT-LBS)
0.0	0.002	-0.0	0.0	5.009	0.0	5.009	0.009	-26.485
5.00	0.027	13.419	0.0	74.543	0.0	74.543	-26.436	0.0
10.00	0.186	38.526	0.0	523.294	0.0	523.294	-26.087	0.0
15.00	0.309	8.115	0.0	869.567	0.0	869.567	-25.743	0.0
20.00	0.340	12.848	0.0	957.781	0.0	957.781	-25.671	0.0
25.00	0.411	15.907	0.0	1157.504	0.0	1157.507	-25.816	0.0
30.00	0.467	11.172	0.0	1315.537	0.0	1315.537	-26.311	0.0
35.00	0.522	12.541	0.0	1459.501	0.0	1460.600	-27.084	0.0
40.00	0.527	2.651	0.0	1500.744	0.0	1500.743	-28.119	0.0
45.00	0.618	40.872	0.0	1505.512	0.0	1505.611	-29.259	0.0
50.00	0.652	81.395	0.0	1522.442	0.0	1522.442	-30.136	0.0
55.00	1.407	90.309	0.0	1546.596	0.0	1546.596	-30.713	0.0
60.00	1.947	116.695	0.0	1576.393	0.0	1575.393	-30.916	0.0
65.00	2.479	97.409	0.0	1603.780	0.0	1603.779	-30.774	0.0
70.00	2.810	40.056	0.0	1621.412	0.0	1621.411	-30.419	0.0
75.00	2.891	-5.705	0.0	1619.998	0.0	1619.997	-29.749	0.0
80.00	2.847	-10.305	0.0	1518.239	0.0	1518.209	-28.483	0.0
85.00	2.751	-27.063	0.0	1300.570	0.0	1300.570	-27.197	0.0
90.00	2.598	-34.075	0.0	941.934	0.0	941.903	-26.268	0.0
95.00	2.400	-19.016	0.0	613.058	0.0	613.058	-25.720	0.0
100.00	2.192	-45.534	0.0	281.315	0.0	281.315	-25.470	0.0
105.00	1.050	-63.019	0.0	0.0	0.0	0.0	0.0	0.0
110.00	1.763	-36.056	0.0	0.0	0.0	0.0	0.0	0.0
115.00	1.502	-34.579	0.0	0.0	0.0	0.0	0.0	0.0
120.00	1.304	-47.994	0.0	0.0	0.0	0.0	0.0	0.0
125.00	1.149	-50.707	0.0	0.0	0.0	0.0	0.0	0.0
130.00	0.987	-55.345	0.0	0.0	0.0	0.0	0.0	0.0
135.00	0.621	-63.877	0.0	0.0	0.0	0.0	0.0	0.0
140.00	0.352	-55.047	0.0	0.0	0.0	0.0	0.0	0.0
145.00	0.085	-53.025	0.0	0.0	0.0	0.0	0.0	0.0
150.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
155.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
160.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
165.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
170.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
175.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
180.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
185.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
200.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

FIGURE 131

Belt System Response for Example 2

JUN 24, 1977 02:15
GM HYBRID III DUMMY (DAFL14M1 DATA)

PAGE 4-1
KNEE BAR
MUMA 2-0 TUTORIAL EXAMPLE #2
NCF. CNDP. NISDP. 30MPH FRONT BARRIER FORCF-LIV. HARNESS
NO LAP BELT

ACCELERATION OF BODY LINK ANGLES

INSEG/SFCS#71

(RELATIVE TO VEHICLE)

TIME	HEAD	NFCX	UPPER TORSO	MIN TORSO	LOW TORSO	UPPER LEG	LOWER LEG	SIMUL. OFR	UPPER ARM	LOWER ARM
0.0	-0.08	24.72 .72	-33.60 .19	41.87 .97	47.91 .00	-3.654 .55	-5.32 .20	-33.69 .39	-0.02	0.00
5.0	-16.27 .90	20.21 .23 .63	-12.20 .72 .75	5.11 .93 .63	-13.62 .17 .05	9.19 .21 .16	-6.74 .21 .21	-12.29 .74 .75	3.936 .98	-13.61 .33 .07
10.0	-6.09 .37 .50	16.14 .21 .50	-10.14 .21 .34	5.35 .45 .75	-14.47 .15 .25	5.84 .0 .45	-9.16 .0 .0	-5.85 .77 .1 .00	19.15 .5 .12	-12.15 .52
15.0	-5.07 .02 .54	24.22 .20 .45	-1.36 .62 .19	11.41 .47 .81	5.53 .9 .62	-3.80 .8 .45	4.6 .1 .6	-6.18 .0 .59 .00	19.95 .30	-1.93 .4 .06
20.0	4.09 .02 .30	-1.32 .30 .13	7.67 .80 .38	-2.71 .22 .94	9.01 .05 .56	-3.81 .8 .76	6.79 .0 .20	-6.41 .30 .02	23.00 .53	-7.04 .1 .26
25.0	11.43 .30 .43	-10.21 .44 .25	6.98 .78 .74	-2.16 .63 .56	9.01 .05 .94	-5.30 .4 .78	10.34 .0 .03	-10.63 .36 .75	27.69 .3 .31	-4.51 .2 .86
30.0	9.46 .74 .41	-1.30 .53 .19	8.15 .64 .56	-2.61 .25 .63	9.00 .00 .50	-5.86 .3 .14	11.66 .0 .36	-12.39 .20 .00	-23.74 .4 .63	6.08 .1 .46
35.0	-1.36 .72 .41	-10.52 .02 .44	8.62 .82 .39	-2.51 .46 .05	8.61 .82 .56	-8.04 .2 .09	11.73 .0 .34	5.07 .85 .32	-15.50 .7 .76	6.86 .1 .76
40.0	-1.40 .26 .40	0.18 .67 .69	-6.24 .21 .32	24.20 .03 .19	-6.30 .10 .93	1.37 .0 .45	-4.27 .45 .56	-12.75 .53 .39	7.42 .62 .50	-20.21 .6 .74
45.0	3.04 .98 .34	-2.21 .20 .58	4.30 .16 .52	-3.13 .23 .07	7.13 .25 .88	10.73 .22 .25	-3.23 .13 .10	-3.54 .46 .82 .25	23.10 .64 .31	-8.07 .6 .25
50.0	7.04 .03 .16	-3.22 .24 .15	-3.63 .17 .09	-4.44 .56 .77	22.6 .8 .92	8.02 .66 .49	-3.62 .09 .50	-9.65 .00 .50	11.01 .54 .31	-7.31 .4 .94
55.0	-1.10 .99 .90	-10.77 .95 .50	31.52 .71 .12	-2.60 .02 .15 .31	27.70 .3 .77	10.74 .0 .67	26.91 .6 .59	6.47 .55 .68	-32.67 .77 .00	24.84 .6 .93
60.0	-1.64 .56 .34	-1.53 .28 .24	3.02 .02 .44	-2.95 .57 .10 .06	1.23 .72 .99	5.82 .06 .93	5.93 .42 .38	5.49 .96 .00 .88	-20.70 .21 .68	-13.95 .2 .23
65.0	-0.21 .08 .56	2.25 .40 .05	-7.15 .99 .44	1.00 .11 .06	-7.47 .77 .06	7.54 .4 .13	3.05 .20 .02	-6.05 .6 .24	1.93 .04 .21	-17.87 .78 .50
70.0	-5.10 .52 .16	5.65 .10 .04	-9.15 .19 .39	21.47 .96 .13	-4.57 .51 .32	-6.51 .10 .31	3.97 .73 .69	-7.12 .12 .50	-7.22 .13 .63	-1.60 .26 .04
75.0	-0.01 .10 .25	4.10 .74 .37	-6.31 .15 .07	-2.69 .02 .96	-2.29 .01 .02	-5.17 .34 .41	-3.0 .0 .03	-4.17 .57 .72 .00	-4.4 .10 .01	34.00 .0 .56
80.0	3.07 .10 .19	0.13 .68 .75	-3.81 .17 .10	2.05 .20 .13	-4.44 .04 .70	-2.56 .90 .43	-1.15 .8 .93	-7.82 .71 .75	-12.42 .79 .76	22.72 .61 .44
85.0	9.24 .20 .19	1.56 .27 .31	1.27 .81 .25	-1.34 .65 .64	3.50 .07 .38	-1.34 .40 .30	-7.97 .7 .40	-1.07 .09 .5 .25	0.00 .0 .56	20.05 .4 .71
90.0	1.12 .00 .31	2.97 .38 .05	3.25 .27 .42	-1.31 .74 .44	6.78 .00 .44	-7.99 .8 .20	1.23 .10 .14	-2.94 .79 .0 .6	1.97 .35 .65	1.07 .1 .18
95.0	1.15 .03 .34	4.65 .70 .52	-2.19 .63 .40	1.17 .93 .13	-3.49 .62 .05	6.43 .34 .96	1.17 .9 .11	-1.00 .67 .87 .63	1.17 .95 .10	0.63 .0 .92
100.0	5.15 .79 .57	-7.60 .2 .69	2.02 .82 .15	-8.23 .03 .08	-5.24 .2 .32	1.63 .63 .62	1.52 .4 .59	-2.80 .15 .50 .00	1.75 .03 .61	2.17 .9 .20
105.0	31.65 .2 .58	1.15 .32 .64	2.71 .21 .50	-1.03 .94 .53	-5.31 .8 .95	2.04 .0 .11	1.72 .5 .59	-20.85 .40 .0 .0	1.83 .5 .8 .71	4.89 .0 .96
110.0	2.00 .45 .16	-4.39 .24 .30	1.21 .61 .70	-2.21 .11 .75	-5.05 .7 .43	4.13 .20 .36	3.19 .5 .20 .5 .6	3.04 .2 .96	1.86 .3 .95	1.07 .1 .18
115.0	1.20 .22 .72	1.14 .40 .43	-7.79 .73 .45	9.59 .04 .75	-3.64 .95 .58	4.39 .8 .23	2.06 .03 .63	1.05 .29 .2 .0	-6.74 .72 .13	3.42 .60 .45
120.0	-1.22 .00 .49	7.29 .36 .13	-2.77 .25 .04	1.40 .65 .50	-5.07 .37 .55	-2.71 .4 .30	-5.65 .2 .54	3.51 .14 .23	-12.72 .79 .00	3.71 .0 .23 .25
125.0	1.13 .07 .13	7.06 .25 .00	-4.04 .05 .37	2.08 .07 .81	-4.27 .74 .27	-4.57 .1 .51	-8.28 .4 .20	7.83 .77 .68	-11.04 .90 .31	1.10 .4 .51
130.0	-1.13 .66 .64	1.15 .31 .00	-7.00 .00 .36	2.70 .46 .13	-7.77 .55 .98	-4.97 .6 .86	-3.24 .6 .11	2.14 .22 .8 .81	-4.53 .40 .0 .6	-1.28 .71 .89
135.0	-0.01 .33 .09	0.92 .02 .06	-6.00 .29 .29	2.33 .92 .06	-6.65 .29 .69	-5.03 .5 .92	-9.01 .0 .35	5.22 .19 .3 .0	2.17 .74 .6 .7	-3.15 .98 .70
140.0	-1.74 .01 .50	1.01 .80 .13	-6.44 .21 .43	2.50 .53 .63	-7.24 .97 .38	-4.57 .2 .51	-2.04 .5 .40	4.64 .82 .2 .63	3.10 .00 .6 .1	-3.07 .92 .24
145.0	-1.73 .72 .78	1.00 .56 .06	-7.02 .35 .00	2.71 .78 .88	-7.41 .22 .11	-3.77 .0 .93	-9.61 .0 .38	-6.10 .00 .88 .88	4.16 .50 .56	-2.72 .0 .38
150.0	-1.26 .43 .90	1.14 .31 .88	-7.30 .31 .34	2.75 .65 .50	-7.15 .03 .06	-2.84 .3 .00	-9.57 .5 .76	-5.69 .65 .3 .9	1.10 .48 .31	-2.20 .23 .6 .9
155.0	-0.21 .10 .14	1.15 .79 .69	-7.65 .51 .75	2.69 .00 .81	-7.07 .34 .44	2.21 .1 .19	-3.71 .38 .0 .3	-3.13 .55 .6 .38	2.09 .17 .6 .9	-4.42 .37 .4 .9
160.0	-2.78 .07 .24	1.61 .21 .44	-9.20 .43 .31	2.86 .55 .69	-7.09 .4 .63	1.48 .63 .13	-1.34 .17 .2 .44	-2.49 .06 .3 .94	2.17 .11 .0 .56	-6.26 .4 .53
165.0	-6.23 .7 .63	9.60 .4 .60	-6.04 .32 .60	2.12 .20 .00	-6.00 .09 .91	5.57 .6 .13	-2.55 .9 .2 .93	-2.25 .07 .6 .51	-2.25 .07 .6 .51	-1.80 .96 .44
170.0	-2.80 .67 .37	1.64 .63 .56	-9.27 .38 .56	2.62 .92 .06	-7.17 .08 .38	5.48 .6 .44	-1.50 .6 .77	-1.35 .75 .6 .13	-1.21 .94 .30	-1.21 .94 .30
175.0	1.36 .0 .27	7.02 .91 .00	-5.26 .68 .13	1.71 .72 .38	-5.97 .04 .55	3.94 .5 .74	-6.80 .3 .27	2.18 .4 .26 .1 .3	-3.31 .10 .54	-4.74 .4 .58
180.0	-1.63 .10 .37	1.04 .02 .01	-6.17 .33 .41	1.05 .27 .44	-6.03 .0 .52	4.75 .0 .87	-8.51 .0 .39	2.04 .3 .36 .6 .3	-5.38 .52 .9 .1	2.57 .8 .55
185.0	-1.14 .06 .09	3.64 .90 .67	-4.31 .20 .99	1.69 .20 .66	-5.31 .19 .63	3.09 .3 .68	-6.78 .2 .53	1.64 .28 .8 .1	-6.45 .38 .4 .0	0.34 .3 .79
190.0	-4.41 .45 .44	0.99 .50 .06	-6.03 .33 .63	2.59 .10 .50	-6.34 .74 .78	3.24 .7 .14	-1.22 .22 .3 .6	-8.54 .3 .0 .6	-8.05 .15 .6 .3	1.47 .15 .36
195.0	-5.46 .12 .62	7.78 .16 .75	2.95 .84 .69	-6.31 .56 .43	1.55 .1 .25	-1.31 .67 .94	-1.27 .60 .7 .25	-7.60 .3 .69	1.625 .7 .81	1.625 .7 .81
200.0	-5.74 .33 .13	-9.19 .82 .18	-9.17 .37 .00	3.65 .51 .71	-6.87 .4 .13	-1.35 .27 .80	-1.15 .96 .6 .56	-8.26 .1 .88	-8.26 .1 .88	-4.49 .2 .33

FIGURE 132 Body Link Angle Accelerations for Example 2

UNFILTERED ACCELERATIONS (G's)

TIME	HEAD	CHEST			HIP		
		S-I	RESULTANT	A-O	S-I	RESULTANT	X
0.0	-0.150	C. 0.90	1.000	0.509	-0.425	0.966	-0.518
5.00	-0.636	2.316	2.418	15.631	2.216	15.797	4.520
10.00	-1.005	6.604	24.932	0.574	24.938	3.780	0.245
15.00	0.050	3.715	8.866	16.601	2.610	16.897	-3.808
20.00	6.461	11.974	13.553	6.086	2.497	6.578	-9.625
25.00	7.532	17.971	10.393	9.752	3.024	10.512	-10.930
30.00	0.025	21.209	23.132	10.614	1.414	10.708	-12.352
35.00	12.569	21.906	25.755	11.606	-1.616	11.807	-13.244
40.00	14.608	21.556	26.456	22.050	2.479	22.984	-11.268
45.00	11.017	17.527	20.702	2.205	-0.956	2.404	-23.092
50.00	12.242	6.441	13.842	14.756	-2.040	15.564	-12.133
55.00	13.367	-0.401	13.063	14.637	-16.063	22.405	-40.477
60.00	15.017	-2.433	15.246	17.071	-23.002	20.190	-45.842
65.00	21.183	5.609	23.173	38.481	-26.318	46.420	-46.803
70.00	24.224	18.416	30.551	35.913	-30.799	47.302	-47.160
75.00	26.035	26.130	35.502	1.211	-20.776	20.001	-17.057
80.00	21.507	15.624	26.301	19.642	-4.248	20.096	-7.904
85.00	19.247	18.808	26.697	14.027	3.114	14.368	-9.682
90.00	12.624	10.748	21.395	6.045	4.907	8.531	-10.522
95.00	7.346	14.498	16.252	11.571	8.369	14.290	-4.068
100.00	6.279	8.196	9.236	1.691	2.110	2.711	-7.711
105.00	3.161	5.133	6.023	-3.673	2.149	4.256	-0.693
110.00	1.475	2.308	2.740	4.767	0.369	10.511	-2.424
115.00	0.934	2.418	2.550	5.106	5.273	7.405	-2.106
120.00	2.577	7.992	9.307	6.513	4.361	7.430	-2.321
125.00	-0.165	10.471	10.472	7.051	5.042	0.026	2.665
130.00	0.806	9.491	9.525	8.300	7.050	10.072	13.022
135.00	-0.411	5.363	5.359	7.629	5.466	0.306	3.424
140.00	-0.162	2.118	2.228	8.852	6.274	10.849	4.389
145.00	-0.910	1.425	1.492	1.359	0.307	6.518	2.068
150.00	-1.082	0.903	0.925	2.178	7.303	6.534	0.450
155.00	-3.106	0.302	3.346	6.825	6.751	9.017	5.324
160.00	-2.302	1.092	2.644	4.457	8.051	9.209	3.060
165.00	-6.986	1.425	5.089	2.075	4.352	5.216	3.461
170.00	-3.765	-0.016	3.765	1.409	5.510	5.688	0.071
175.00	-7.416	-1.646	7.597	-1.666	0.410	1.716	-0.044
180.00	-9.234	-4.779	9.621	-2.749	1.598	3.180	0.023
185.00	-10.048	-5.402	12.248	-2.155	-0.754	2.284	0.336
190.00	-9.628	-4.738	10.757	2.174	2.710	3.481	-0.367
195.00	-9.920	-1.540	9.061	7.527	3.451	8.281	-3.027
200.00	-6.942	1.556	7.114	13.099	5.634	14.269	-3.220

FIGURE 133

Unfiltered Head, Chest, and Hip Accelerations for Example 2

JUN 24, 1977 02:15
64 Hypo in 11 mils (no ELLI) (Navy DATA)

444A 2-D TUTORIAL EXAMPLE #2
KNUFF BAR
3 SEC. AVG.
PEAK = 35.502 AT TIME = 75.00
SEVERITY INDEX
GMR MODIFIED S.I.

SEVERITY Indices FOR UNFILTERED ACCELERATIONS

TIME	A-P	S-I	RESULTANT		A-P GMR MODIFIED S.I.	S-I GMR MODIFIED S.I.	RESULTANT
			A-P RESULTANT	S-I RESULTANT			
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.00	0.02	0.00	0.02	0.00	0.01	0.04	3.40
10.00	0.22	0.01	0.23	0.01	0.02	0.06	12.46
15.00	1.32	0.02	1.39	0.01	0.02	0.07	20.53
20.00	2.30	0.00	1.55	0.02	0.04	0.16	31.74
25.00	3.04	0.41	9.40	0.02	0.21	0.35	31.50
30.00	4.22	12.07	20.31	0.03	0.41	0.26	32.00
35.00	6.18	22.91	32.59	0.06	1.41	0.24	34.24
40.00	10.14	34.12	52.44	0.15	2.90	0.29	36.43
45.00	13.56	45.42	67.35	0.23	4.00	0.37	47.30
50.00	15.52	48.50	73.00	0.25	4.65	0.37	50.92
55.00	18.40	49.62	76.54	0.33	5.65	0.42	56.01
60.00	22.54	48.65	70.39	0.42	6.65	0.48	60.73
65.00	30.62	50.71	88.66	1.10	3.66	0.95	63.32
70.00	43.81	51.61	107.12	2.59	3.79	1.10	129.02
75.00	57.74	62.93	139.45	4.27	5.46	21.17	140.98
80.00	60.38	75.70	166.51	6.49	6.42	27.12	141.76
85.00	79.96	81.36	194.92	6.22	6.68	29.07	149.04
90.00	86.30	86.94	201.15	6.39	7.37	32.15	150.05
95.00	86.52	96.69	210.41	6.40	7.83	32.82	151.17
100.00	86.94	98.62	213.30	6.40	7.45	32.96	151.94
105.00	97.10	100.47	214.22	6.41	7.65	32.97	151.03
110.00	97.13	103.57	216.37	6.41	7.65	32.97	152.13
115.00	97.14	105.61	216.43	6.41	7.66	32.97	152.62
120.00	97.16	106.93	216.79	6.42	7.46	32.97	152.93
125.00	97.17	101.35	216.25	6.42	7.67	32.89	153.49
130.00	97.17	103.09	218.01	6.43	7.69	32.90	154.72
135.00	97.17	103.99	218.92	6.44	7.69	32.90	155.69
140.00	97.35	104.04	219.10	6.44	7.60	32.91	156.25
145.00	97.52	104.09	219.39	6.45	7.60	32.91	157.55
150.00	97.14	102.05	218.70	6.46	7.72	32.92	159.45
155.00	97.13	102.04	218.61	6.46	7.70	32.91	159.41
160.00	97.25	102.07	220.06	6.47	7.73	32.92	159.46
165.00	97.35	104.07	221.13	6.46	7.71	32.92	159.50
170.00	97.52	104.09	223.17	6.46	7.71	32.92	159.39
175.00	97.17	102.07	226.44	6.49	7.73	32.98	159.57
180.00	97.13	102.04	227.41	6.51	7.74	33.00	160.46
185.00	93.95	102.06	227.41	6.51	7.74	33.00	161.41
200.00	92.90	228.27	228.27	8.51	7.74	33.00	162.23

FIGURE 134

Severity Indices for Unfiltered Accelerations

for Example 2

