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DYNAMICS OF THE PIN PALLET RUNAWAY ESCAPEMENT

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ARRADCOM

110 p.

JUNE 1978

US ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
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This investigation developed a workable computer simulation of the pin pallet runaway escapement which can provide the basis for the analysis and synthesis of various safing and arming devices. The dynamics of the various regimes of escapement motion are modelled. Coupled motion, impact, and free motion are considered. Sensing equations for the determination of the instantaneous positions of the pallet pin and the escape-wheel form the basis of the controls in the computer program.

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20. The simulation is applied to the timing of the mechanism of the M525 fuze with an assumption of constant input torque to the escape-wheel. The influence of changes on such parameters as escape-wheel torque, pallet moment of inertia, center distance, pallet radius, etc., are explored in detail by appropriate computer runs. Agreement has been found with existing experimental data. Finally, recommendations for continued work are given.

ACKNOWLEDGMENT

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INTRODUCTION

It was the aim of the present investigation to develop a realistic and workable computer simulation of the dynamic behavior of the pin pallet runaway escapement which can be used in the analysis and synthesis of various safing and arming devices. This goal has been achieved.

This report describes and formulates the dynamics of the various regimes of motion which form the basis for the simulation. The computer program and its controls are presented in detail. The simulation is applied to the time delay mechanism of the M525 fuze and the influence of various parameter changes is explored. Previous experimentation and practical experience with this mechanism confirmed the results of the computations. Finally, recommendations for continued work are given. The previous work done in this field is listed in references 1-15.

SIMULATION OF PIN PALLET RUNAWAY ESCAPEMENT

The present effort on the pin pallet escapement represents an extension of the work of M. E. Anderson and S. L. Redmond (ref. 7). New methods of contact kinematics for coupled motion, of contact sensing, and of computational controls are developed.

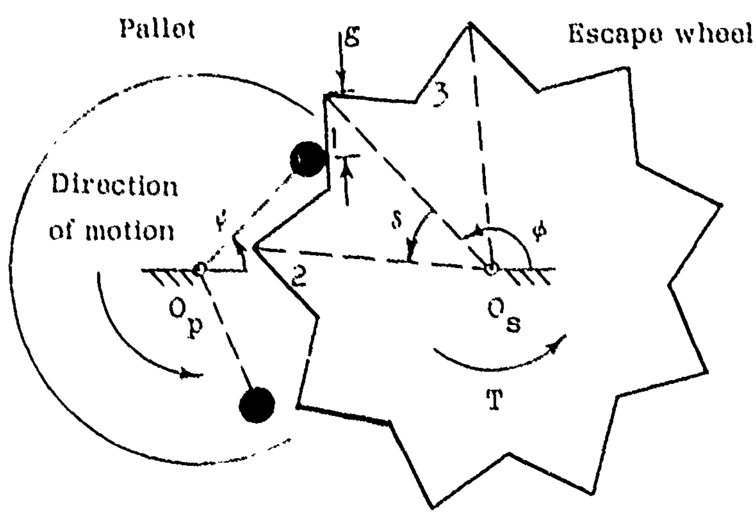


Figure 1. Coupled motion

The following outlines the overall assumptions and derivations for the various regimes of motion. A detailed description of the actual computer program and its controls is then given.

Coupled Motion

Figure 1 shows the upper pallet pin[1] being driven in coupled motion by tooth no. 1 of the escape wheel (top contact). The escape-wheel angle φ is defined by the line from the escape-wheel pivot O_s to the tip (without radius) of the contacting tooth (or the one about to make contact) and the line connecting O_s to the pallet pivot O_p. Similarly, the angle ψ, which is defined by the line from O_p to the active pallet pin center (top or bottom) and the center line, describes the motion of the pallet. The escape wheel is driven by the constant moment T in the positive direction of rotation. While it is assumed that friction acts on the pallet pin/escape wheel tooth interface, it is neglected at both pivots since investigation showed that its effects are negligible when the pivots are of the usual small diameter.

The quantity g, which represents the distance from the contact point to the tip of the escape-wheel tooth, is used to determine the end of coupled motion. Appendix A contains derivations for this expression, as well as all other kinematic quantities associated with coupled motion. Appendix B, with the help of appendix C, gives the derivation of the differential equation of coupled motion in terms of the escape-wheel angle φ (eq. B-10).

Free Motion

When coupled motion is finished (i.e., $g = 0$) or when separation of contact occurs after impact, the escape wheel and pallet move independently of each other in free motion. Figure 2 shows this free motion for the bottom phase of the action, i.e. the bottom pallet pin is about to make contact with tooth no. 2 of the escape-wheel. The constant torque T continues to act on the escape-wheel, while the motion of the pallet depends only on its initial conditions. Again, any frictional retarding moments at the pivots are neglected. Position sensing during free motion is based on g', the distance of the pallet pin center from the tip of the escape-wheel

[1]This report uses the word upper when referring to entrance motion and lower when referring to exit motion.

tooth (parallel to the face of the tooth) and f, the distance between the pallet pin and tooth surfaces normal to the tooth). Expressions for these quantities are derived in appendix D. The differential equations for the free motion of the pallet and the escape-wheel are derived in appendix E.

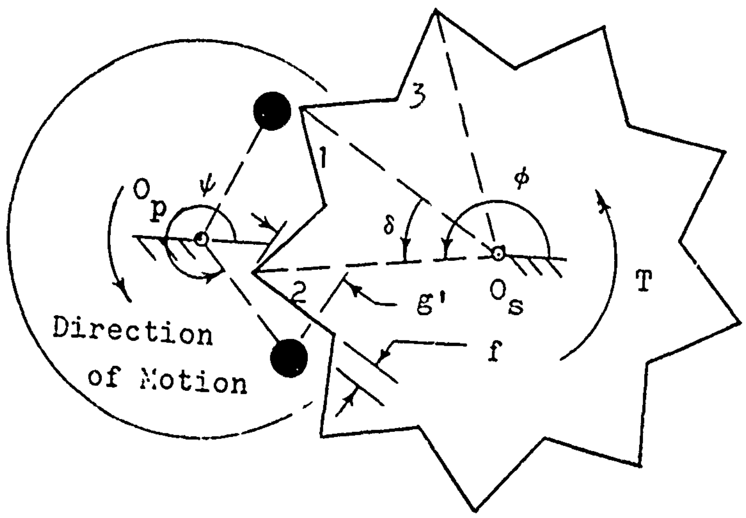


Figure 2. Free motion

Impact

Impact follows free motion whenever f equals zero, g' is smaller than zero, and the relative velocity between the contacting surfaces warrants it. Such an impact usually reverses the motion of the pallet (fig. 3) and under certain circumstances also reverses the motion of the escape-wheel temporarily. While the impact equations, derived in appendix F, allow for both normal and tangential impulses to produce changes in the angular momenta of the pallet and escape-wheel, the computer program presented here neglects the tangential impulse for the sake of simplicity. The classical coefficient of restitution formulation is used to account for the energy loss during impact.

Figure 4 shows free motion for the subsequent top phase of the motion, i.e. the top pallet pin is about to make contact with tooth no. 3 of the escape-wheel.

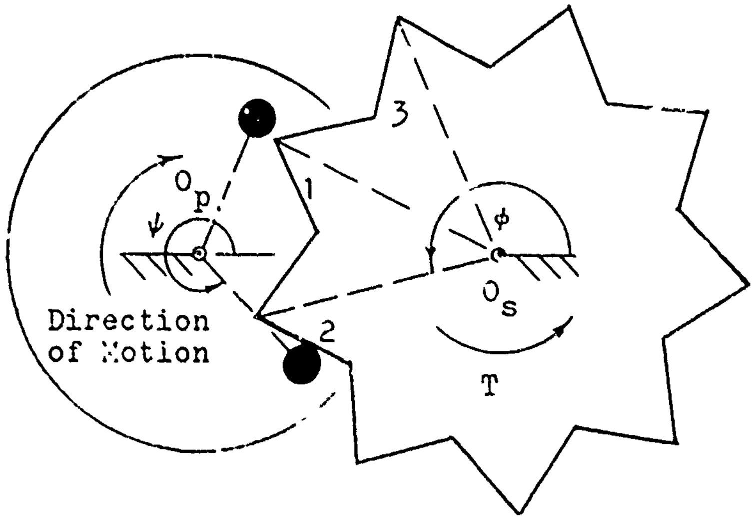


Figure 3. Impact

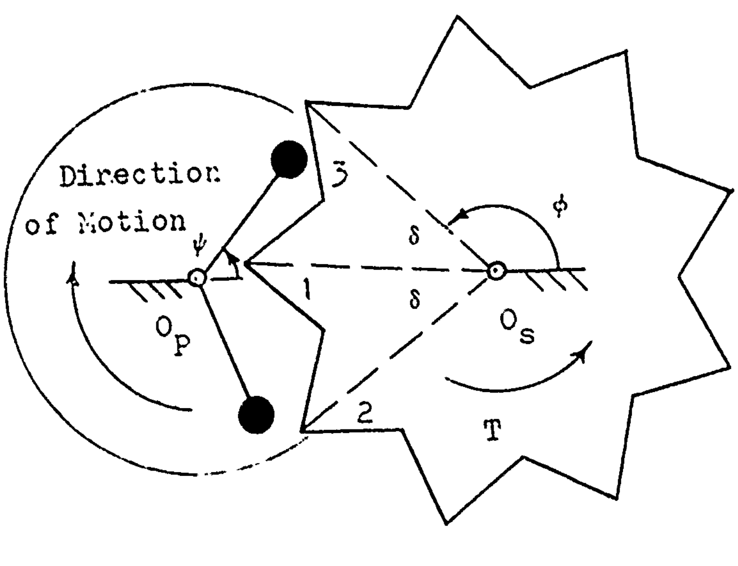


Figure 4. Impending top contact

All kinematic and dynamic expressions are derived in such a manner that they are valid for top and bottom action. The simulation recognizes only contact on the front faces of the escape-wheel teeth. Pathological conditions, such as impact on the tips or the back faces of the escape-wheel teeth are not considered. (The control quantities g and g' make it clear that when such a condition exists the computation can be discontinued.)

Escapement Nomenclature

Figure 5 shows a schematic representation of the pin pallet escapement and indicates its basic geometric nomenclature.

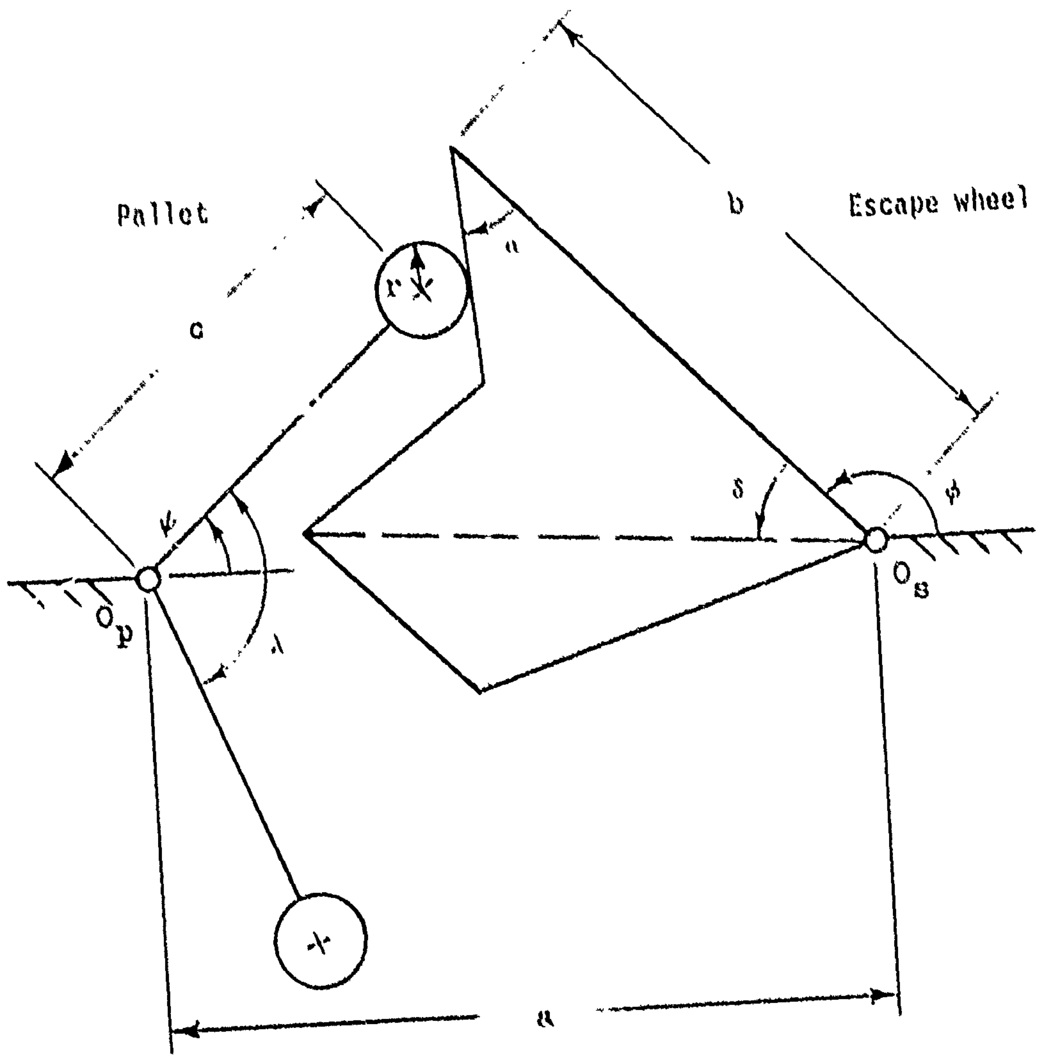


Figure 5. Escapement nomenclature

a = Distance between pivot points O_p and O_s

b = Escape wheel radius

c = Pallet radius (equal on top and on bottom for simplicity)

r = Pallet pin radius (equal for top and bottom)

α = Escape-wheel tooth half angle

δ = Angle between escape-wheel teeth

φ = Angular position of escape-wheel

ψ = Angular position of pallet

DESCRIPTION OF COMPUTER PROGRAM

The following gives the essential steps of the computer program as listed in appendix G[2]. The flow chart of the program is shown in figure 6. The choice of variable designations was made in such a way that they differ as little as possible from the nomenclature used in the various derivations in appendixes A to F and H.

The main program starts the simulation with top contact coupled motion at a starting angle $\varphi = 135°$ (called PHID in the computer program) and a cumulative escape-wheel angle PHITOT of 0°. The choice of this starting angle is connected with the geometry of the example mechanism used ($\varphi_M = 132.487°$ for the example mechanism).

Coupled Motion (location 100)

To solve the differential equation of coupled motion (see equation (B-10) of appendix B) the main program calls on an available fourth-order Rungé-Kutta routine.[3] The subroutine FCT computes all needed values and presents the second-order differential equation in terms of two first-order ones to RKGS. PHI (1) and PHI (2) represent the angle φ and the angular velocity $\dot{\varphi}$, respectively. The associated subroutine OUTP is responsible for printing out the results of the integration together with the current values of time, g, $\dot{g}$, ψ, $\dot{\psi}$, and PHITOT. In addition, it has the task of deciding whether coupled motion is to be continued. Coupled motion is continued

a. as long as $g < 0$. (See equation (A.12) and note, that because of the nature of the coordinate system, g is always negative while the pallet pin makes contact with the escape-wheel tooth.) And,

[2] The program shown is written in FORTRAN for the CDC System at ARRADCOM, Dover, NJ. It is also available in a slightly modified form for the IBM System/360 at the City College of New York.

[3] RKGS Routine, IBM System/360 Scientific Subroutine Package, (360A-CM-OX3) Version III.

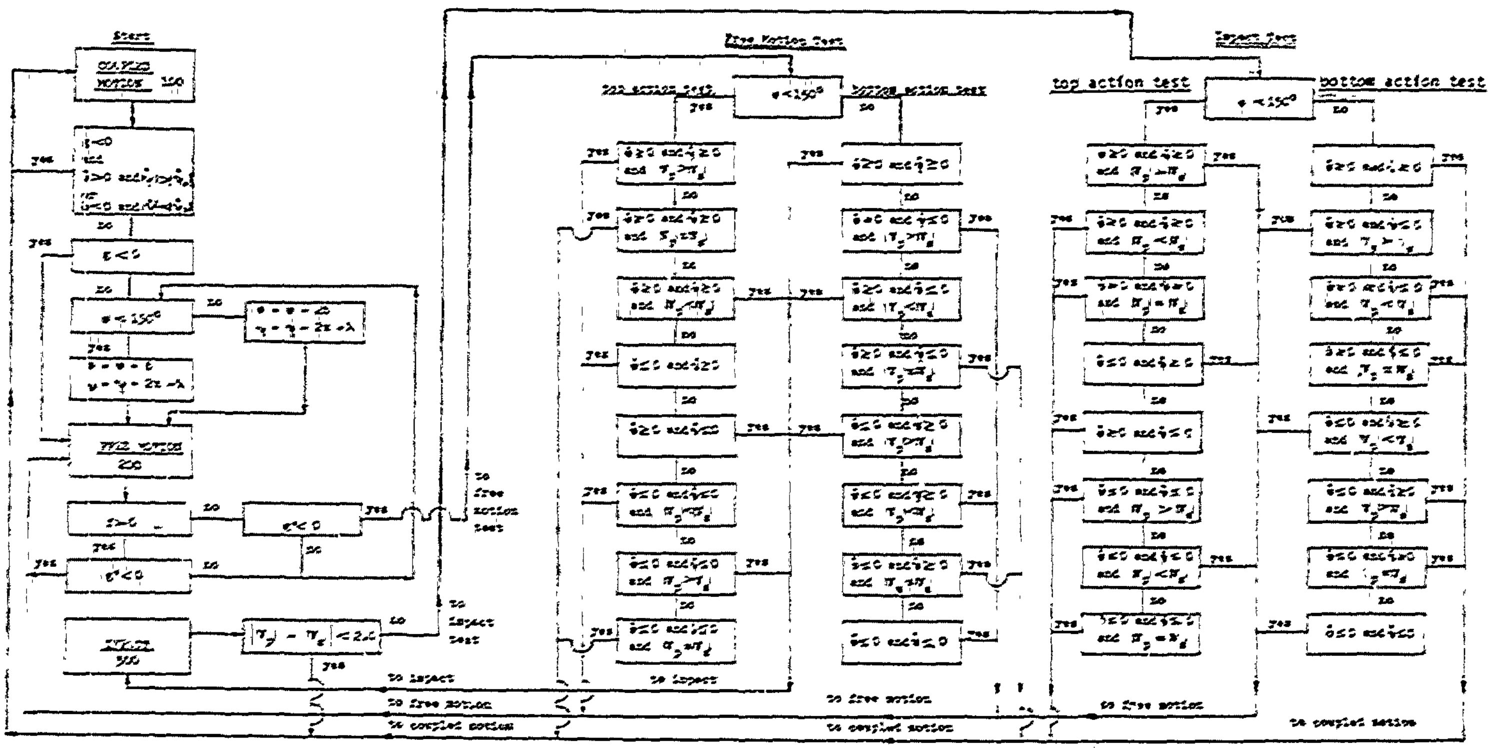


Figure 6. Flow chart for simulation of runaway escapement

b. for a positive (counterclockwise) rotation of the escape-wheel, if the succeeding absolute value of $\dot{\psi}$ (DPSI) is larger than the one obtained from the preceding computation (called DPSIP). These values of $\dot{\psi}$ are computed with the help of equation (A.18), which assumes closure. This condition is necessary, since in coupled motion when $\dot{\varphi}$ is positive the escape-wheel can only drive the pallet, not slow it down. If such a slowdown is indicated, it means that pallet and escape-wheel have separated and free motion will take place. Or,

c. for a negative rotation of the escape-wheel (which may occur after impact), a succeeding absolute value of $\dot{\psi}$ must be smaller than the preceding one. If for some reason the escape-wheel should speed up and cause the computation to show a larger succeeding value of $\dot{\psi}$, it would also serve as an indication that closure has terminated and free motion has started.

To make this process less sensitive, the last two conditions will only be violated when the absolute magnitude $|\dot{\psi}| \geq 1$ rad/sec.

Thus, when control is returned to the main program, it is either because the pallet pin has left the end of the tooth and there is no further possibility of coupled motion or the pin has disengaged from the inside of the tooth. In either case, free motion results and control is eventually shifted to the subroutine FREE (location 200). This is done directly if $g < 0$. In the case that $g < 0$, the main program must decide whether the preceding computations have been made for top or for bottom action and whether the next contact will occur on top or on bottom. In the sample mechanism, $g = 0$ when φ is approximately 146° for top action and approximately 207° for bottom action. (The values of φ_0 for top and bottom action are located in the section on the example mechanism). If $\varphi \leq 150°$, all possibility for top contact is ended and φ must be incremented by the tooth angle δ (see figures 2 and 5), while ψ must be incremented by the angle $(2\pi - \lambda)$. For $\varphi > 150°$, top contact is expected at the end of bottom action and φ must be decremented by the angle 2δ (see figure 4, where the new top tooth no. 3 comes into action). At the same time, the pallet angle ψ must be decremented by $(-2\pi + \lambda)$. These indexing operations have no effect on the continuous computation of the cumulative escape-wheel angle PHITOT.

Free Motion (Location 200)

After transferring the initial values for time, angles, and angular velocities from the main program, the subroutine FREE computes the subsequent positions and angular velocities of pallet and escape-wheel in free motion according to equations (E.2), (E.3), and (E.7) and (E.8), respectively, for time increments of 10^{-5} seconds. In addition to the above variables, PHITOT is also continually computed and caused to be printed out. The decision, whether or not to remain in this subroutine, is made with the help of the sensing variables, f (according to equation (D-7)) and g' (according to equation (D-11) and now called GP).

If $f > 0$ and $g' \leq 0$, free motion is continued without indexing. If $f > 0$ and $g' > 0$, free motion is also continued, but since contact is no longer possible for the component pair for which the previous computations were made, indexing takes place. This is accomplished in the same manner as described before.

If $f < 0$, control is returned unconditionally to the main program. If it finds that $g' > 0$, indexing takes place and control is given back to the subroutine, FREE. When $f \leq 0$, contact is about to take place or has just occurred. The program must decide whether this contact just represents a close approach, which will be followed by further free motion, whether it represents an impending impact, or whether it is the beginning of coupled motion. To this end, the quantities V_p and V_s (see equations (F.22) and (F.23)) are computed for the top and bottom free motion tests.[4] The first three cases of the top free motion test of the main program are illustrated in figure 7. With both angular velocities ($\dot{\varphi}$ is PHI (2) and $\dot{\psi}$ is DPSI) positive, the following three possibilities exist:

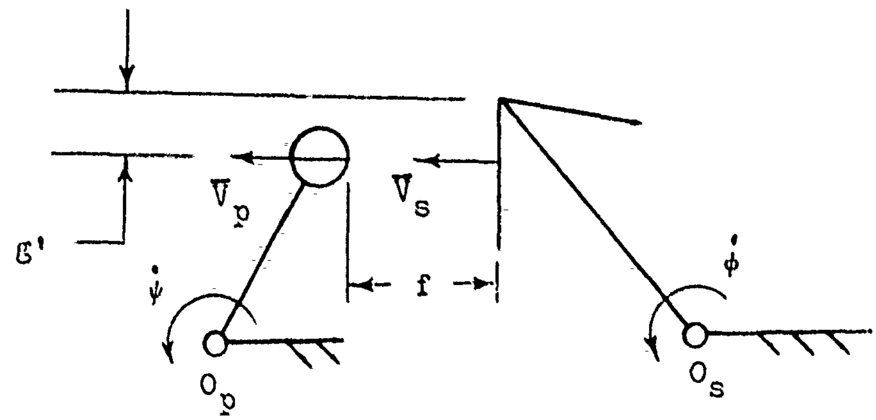
1. If $|V_p| > |V_s|$, the contacting surfaces will separate again, free motion will result, and control must be transferred to subroutine FREE (location 200).

2. If $|V_p| = |V_s|$, the escape-wheel will start driving the pallet in coupled motion, and control must be transferred to subroutine RKGS (location 99 initiates RKGS).

[4]Under the present circumstances, if $\varphi < 150°$, only top contact can follow; if $\varphi > 150°$, bottom contact will occur.

3. If $|V_p| < |V_s|$, impact will occur, and control must be given to subroutine IMPACT (location 300).

The remainder of the top free motion tests and the bottom free motion tests are constructed along similar lines for different combinations of angular velocity directions.



($\dot{\varphi}$ and $\dot{\psi}$ are positive. Distance f is enlarged.)

Figure 7. Top free motion test

Impact (Location 300)

The subroutine IMPACT uses the current values of the angular velocities $\dot{\varphi}_i$ and $\dot{\psi}_i$ and computes the post impact angular velocities $\dot{\varphi}_f$ and $\dot{\psi}_f$, applying equations (F.20) and (F.21). (Note that the tangential impact has been neglected and, therefore, $E_2 = D_1$ and $F_2 = A_1$).

After control is returned to the main program, it is decided whether free or coupled motion follows the impact. This is accomplished by considering the post-impact contact point velocities, V_p and V_s, in the impact tests, which are similar to the free motion tests.

If the contact velocities are vectorially equal to each other or if the absolute value of the difference of their absolute magnitudes is less than 2.0 in/sec (5.08 cm/sec), control is transferred to coupled motion. If these velocities are such that they indicate a subsequent separation, which is more usual, computation is transferred to free motion.

The computation is terminated when either t = .1 seconds or when PHITOT $\geq$ 315°. These conditions are related to the sample mechanism which runs less than .1 seconds for 310° of escape-wheel rotation.

EXAMPLE MECHANISM

The pin pallet escapement of the M525 fuze is used as the example mechanism. The following, first, gives the dimensions of the basic escapement (standard configuration) and then discusses certain other data and computed values which are of importance in the computer simulation.

Dimensions of the Mechanism

The standard geometric configuration has the following dimensions:

a = .1931 inches (mean center distance) (.4905 cm)

b = .15838 inches (.40229 cm)

c = .09683 inches (.24595 cm)

r = .01365 inches (.03467 cm)

α = 40°

β = 60° (see figure H-1 in appendix H)

λ = 109.337°

δ = 40°

N = 9 (number of teeth of escape-wheel)

I_p = $.91 \times 10^{-7}$ lb-sec^2-in. (moment of inertia IPAL of pallet) (1.03×10^{-8} N - sec^2-m)

I_s = $.17 \times 10^{-7}$ lb-sec^2-in. (moment of inertia ISTAR of escape-wheel) (1.92×10^{-9} N - sec^2 - m)

Gear Train Driving Escapement

The escapement of the M525 fuze is driven by a clock spring through a step-up gear train with a ratio of 45.98. The timing function of the fuze, which involves a delay of between 2 to 4 seconds, is accomplished once the spring driven input gear has rotated through 310°. This corresponds to a 45.98 times greater escape-wheel rotation. Since the motion becomes stablilized after one cycle of the pallet (corresponding to approximately 40° of escape-wheel rotation), one obtains an excellent idea of the total time by computing the response time for 310° of escapement rotation and multiplying this result by the aforementioned gear ratio (see the section on results for standard configuration).

Standard Torque Used in the Simulation

Measurements on actual fuzes showed that the initial torque on the escape-wheels varied between .0177 (2.000×10^{-3} m-N) and .031 in-lb (3.503×10^{-3} m-N). Since the angle of rotation of the input gear is small, the decrease in torque during the rotation is also relatively small. Therefore, a constant torque was assumed in the simulation. Its standard value was chosen to be .0177 in-lb (2.000×10^{-3} m-N).

Other Dimensions Associated With Standard Configuration

For purposes of control in the computer program the following other dimensions are of interest.

The maximum absolute value attainable for the dimension g for the given escapement is computed according to equation (H-4) of appendix H:

$$g_{MAX} = -.05467 \text{ inches } (-.1389 \text{ cm})$$

The associated values of the escape-wheel angle φ_M are obtained with the use of equation H-10. For top action

$$\varphi_M = 132.487°$$

Because of this value, initial coupled motion is started at 135°. (See the section on the computer program.) For bottom action, this angle becomes:

$$\varphi_M = 187.518°$$

The corresponding values for the pallet angles ψ_M are found through the use of equation (A.8) appendix A and are computed with g = -.05467 and α = 40°. For top action,

$$\psi_M = 39.491°$$

and for bottom action,

$$\psi_M = 320.396°$$

These values serve as valuable checks on the computer output.

The escape-wheel angles φ_o corresponding to g = O, i.e. the position when the pallet pin leaves the tooth in coupled motion, are obtained according to equation (H-12). For top action,

$$\varphi_o = 146.328°$$

Because of this angle, decisions concerning indexing, the free motion and impact tests are based on whether the angle φ is smaller or larger than 150°. (See the section on the description of the computer program.) For bottom action, this angle becomes

$$\varphi_o = 206.512°$$

The corresponding pallet angles are

ψ_o = 60.138° for top action, and

ψ_o = 299.869° for bottom action, respectively.

Finally, it is important to know the center distance between pallet and escape-wheel for which disengagement will occur. According to equation (G.14)

$$a_{dis} = .208 \text{ inches } (.528 \text{ cm})$$

RESULTS FOR STANDARD CONFIGURATION

Appendix I shows computer output for the first, second and eighth cycles of a run for the standard configuration with a coefficient of friction, $\mu = .3$, and a coefficient of restitution, $\varepsilon = .25$ (run no. 46). Table 1 summarizes the results of the first two and one half cycles. In appendix I, a cycle is defined as the interval between first contacts on top. In tables 1 and 3 the interval is between the last contacts on top.) As discussed earlier, top motion in the coupled mode initiates the program. In the subsequent first bottom action, the first impact is followed by free motion while the second impact leads to coupled motion by virtue of the cut-off criterion. Starting with the second top contact, both top and bottom action consists of two impacts followed by free motion. The subsequent third impact produces little rebound of the pallet pin and thus is the beginning of coupled motion which lasts until the pallet pin leaves the tooth.

The various impacts cause reversals in escape-wheel motion. In the actual mechanism, this backward rotation is limited by the possibility of the pin making contact with the backface of the next escape-wheel tooth. The program does not provide for the presence of this condition and any contact of this type makes itself known only if during or after the first impact, the escape-wheel angle $\varphi < 132.487°$ for top action or $\varphi < 187.518°$ for bottom action. If such a reversal of the escape-wheel takes place during coupled motion, g will be less than -.05467 in. (-.1284 cm). (See the section on other dimensions of the standard configuration for discussion of the above values.)

Inspection of table 1 shows that this condition first occurs in cycle no. 3 for top contact, i.e. $\varphi = 132.480°$. Table 2 gives the values of the maximum reversal angles for the first eight cycles. While these reversals of the escape-wheel angle never reach critical values for bottom action, they exceed critical values a number of times for top action. (The geometry lends itself more for this condition with respect to top action.)

The fact that the absolute value of g_{MAX} will be exceeded in certain configurations will be accepted or more dissipative values for μ and ε will have to be used[5]. The discussion in the section on the influence of parameter changes in the total fuze time will show that a slight increase of the center distance a decreases the absolute value of g at maximum reversal to well below g_{MAX}. This correlates with the results for $\mu = .3$ and $\varepsilon = 0$ given below.

Table 1 shows that the stability of motion is essentially established during the first cycle. The time interval per cycle, now counted between the instants when the pallet pin leaves the top tooth, is shown to be .00774 and .00773 seconds. Subsequent intervals (not shown here) are .00773, .00775, .00785, .00784, and .00773 seconds. The total time of the fuze may be obtained with the help of the time at PHITOT ≈ 310°. Appendix I shows that t(310.362°) = .06058 seconds. Thus, the total fuze delay time becomes .06058 x 45.98 = 2.79 seconds. (See the section on the example mechanism.) This result is well within the fuze requirement of between 2 to 4 seconds.

Appendix J gives portions of the computer output when the standard configuration was run with $\varepsilon = 0$, while $\mu = .3$ was kept (run no. 70). Table 3 summarizes the events of the first 3½ cycles and table 4 lists the maximum reversal values of the escape-wheel for eight cycles.

As expected, the fully inelastic coefficient of restitution causes the initial impacts to be followed by coupled motion. Now, $g < g_{MAX}$ at all times. (Again, the reversals are smaller for bottom action.) As in the first program above, the motion stabilizes immediately with cycle intervals of .00725, .00730 and .00725 seconds. Subsequent intervals, not shown here, are .00726, .00729 and .00726 seconds. The total fuze delay time is computed with t(PHITOT = 310.600°) = .05699 seconds (see appendix J). This results in 2.62 seconds.

[5] Since no high speed motion pictures of the M525 are available, it is not known whether contact with the backside of the escape-wheel tooth is ever made.

Table 1. Summary of events in the first 2½ cycles for standard configuration with μ = .3 and ε = .25 (Program No. 46)

	Type of action	Escape-wheel angle φ (deg)	Time (sec)	Time interval (sec)	Total escape-wheel angle (deg)
Top:	start of coupled motion	135.000	0.00000		0.000
	start of free motion (end of tooth)	146.491	0.00340[1]		11.491
Bottom:	impact followed by free motion	194.179	0.00382		19.179
	maximum return motion (free) continued free motion	192.911	0.00402		17.911
	impact followed by coupled motion (cut-off criterion: $\lVert V_p\rvert - \lvert V_S \rVert < 2$)	193.366	0.00415		18.366
	maximum return motion (coupled)	193.281	0.00425		18.281
	start of free motion (end of tooth)	206.844	0.00645		31.844
Top:	impact followed by free motion	135.522	0.00688		40.522
	maximum return motion (free) continued free motion	133.361	0.00714		38.361
	impact followed by free motion	133.435	0.00720		38.435
	maximum return motion	133.214	0.00724		38.214
	impact followed by coupled motion (cut-off criterion)	133.214	0.00724		38.214
	maximum return motion (coupled)	133.540	0.00753		37.540
	start of free motion (end of tooth)	146.514	0.01114[2]	0.00774[3]	51.514
Bottom:	impact followed by free motion	193.802	0.01154		58.802
	maximum return motion (free) continued free motion	192.321	0.01176		57.321
	impact followed by free motion	192.803	0.01189		57.803
	maximum return motion (free) continued free motion	192.749	0.01193		57.749
	impact followed by coupled motion (cut-off criterion)	192.790	0.01197		57.790
	start of free motion (end of tooth)	206.768	0.01417		71.768
Top:	impact followed by free motion	135.519	0.01460		80.519
	maximum return motion (free) continued free motion	132.297	0.01487		78.297
	impact followed by free motion	133.394	0.01493		78.394
	maximum return motion (free)	133.165	0.01497		78.165
	impact followed by coupled motion (cut-off criterion)	133.165	0.01497		78.165
	maximum return motion (coupled)	132.480	0.01526		77.480
	start of free motion (end of tooth)	146.496	0.01887[4]	0.00773[5]	91.496

[1] Start of first cycle
[2] End of first cycle, start of second cycle
[3] Time interval for first cycle
[4] End of second cycle
[5] Time interval for second cycle

Table 2. Maximum reversal angles and associated values of g for standard configuration with $\mu = .3$ and $\varepsilon = .25$ (Program No. 46)

Cycle No.	Top action: Maximum reversal angle, φ ($\varphi_M = 132.487°$)	Top action: g (in.) ($g_M = -.05467$)	Bottom action: Maximum reversal angle, φ ($\varphi_M = 187.518°$)	Bottom action: g[1] (in.) ($g_M = -.05467$)
1			192.910	
2	132.540	-.0547 (-.1389 cm)	192.321	
3	132.480	-.0549 (-.1394 cm)	192.303	
4	132.312	-.0555 (-.1410 cm)	192.320	
5	132.305	-.0555 (-.1410 cm)	192.485	
6	132.094	-.0562 (-.1427 cm)	191.837	
7	131.593	-.0580 (-.1473 cm)	192.078	
8	132.634	-.0543 (-.1379 cm)	192.315	

[1]Not applicable. Occurs during free motion.

Table 3. Summary of events in the first 3½ cycles for standard configuration with $\mu = .3$ and $\varepsilon = 0$ (Program No. 70)

	Type of action	Escape-wheel angle φ (deg)	Time (sec)	Time interval (sec)	Total escape-wheel angle (deg)
Top:	start of coupled motion	135.000	0.00000		0.000
	start of free motion	146.491	0.00340[1]		11.491
Bottom:	impact followed by coupled motion	194.179	0.00382		19.179
	maximum return motion (coupled)	193.776	0.00404		18.776
	start of free motion	206.789	0.00622		31.789
Top:	impact followed by coupled motion	135.416	0.00665		40.416
	maximum return motion (coupled)	133.957	0.00711		38.957
	start of free motion	146.743	0.01065[2]	0.00725[3]	51.743
Bottom:	impact followed by coupled motion	193.636	0.01104		58.636
	maximum return motion (coupled)	193.083	0.01129		58.083
	start of free motion	207.171	0.01354		72.171
Top:	impact followed by coupled motion	135.168	0.01395		80.168
	maximum return motion (coupled)	133.504	0.01443		78.504
	start of free motion	146.383	0.01795[4]	0.00730[5]	91.383
Bottom:	impact followed by coupled motion	194.198	0.01837		99.198
	maximum return motion (coupled)	193.698	0.01861		98.698
	start of free motion	206.601	0.02077		111.601
Top:	impact followed by coupled motion	135.600	0.02121		120.600
	maximum return motion	134.171	0.02167		119.171
	start of free motion	146.856	0.02521[6]	0.00725[7]	131.856

[1] Start of first cycle
[2] End of first cycle, start of second cycle
[3] Time interval for first cycle
[4] End of second cycle, start of third cycle
[5] Time interval for second cycle
[6] End of third cycle
[7] Time interval for third cycle

Table 4. Maximum reversal angles and associated values of g for standard configuration with $\mu = .3$ and $\varepsilon = 0$ (Program No. 70)

	Top action		Bottom action	
Cycle No.	Maximum reversal angle, φ ($\varphi_M = 132.487°$)	g (in.) ($g_M = -.05467$)	Maximum reversal angle, φ ($\varphi_M = 187.518°$)	g^1 (in.) ($g_M = -.05467$)
1			193.776	-.0401 (-.1019 cm)
2	133.957	-.0495 (-.1257 cm)	193.083	-.0418 (-.1062 cm)
3	133.504	-.0512 (-.1300 cm)	193.698	-.0403 (-.1024 cm)
4	134.171	-.0487 (-.1237 cm)	192.883	-.0423 (-.1074 cm)
5	133.466	-.0513 (-.1303 cm)	193.659	-.0404 (-.1026 cm)
6	134.170	-.0487 (-.1237 cm)	192.883	-.0423 (-.1074 cm)
7	133.466	-.0513 (-.1303 cm)	193.659	-.0404 (-.1026 cm)
8	134.170	-.0487 (-.1237 cm)	192.884	-.0423 (-.1074 cm)

INFLUENCE OF VARIOUS PARAMETER CHANGES ON THE TOTAL FUZE TIME

The following reports on the results of numerous computer runs in which a single input or geometric parameter was varied in order to determine its influence on the total fuze time. In all cases, the individual changes were made with respect to the standard configuration in the section on the example mechanism, with $\mu = .3$ and $\varepsilon = .25$.

Influence of Escape-Wheel Torque

Figure 8 shows the influence of the escape-wheel torque on the fuze time. One may compare these timing results with those obtained from the well-known empirical expression:

$$t_2 = t_1 \sqrt{\frac{T_1}{T_2}}$$

If t_1 and T_1 represent fuze time and torque, respectively, as associated with the standard configuration, one obtains from the above:

For $T_2 = .75\ T_1$: $\quad t_2 = 2.79 \sqrt{\frac{1}{1.25}} = 3.22$ seconds

For $T_2 = 1.25\ T_1$ $\quad t_2 = 2.79 \sqrt{\frac{1}{1.25}} = 2.49$ seconds

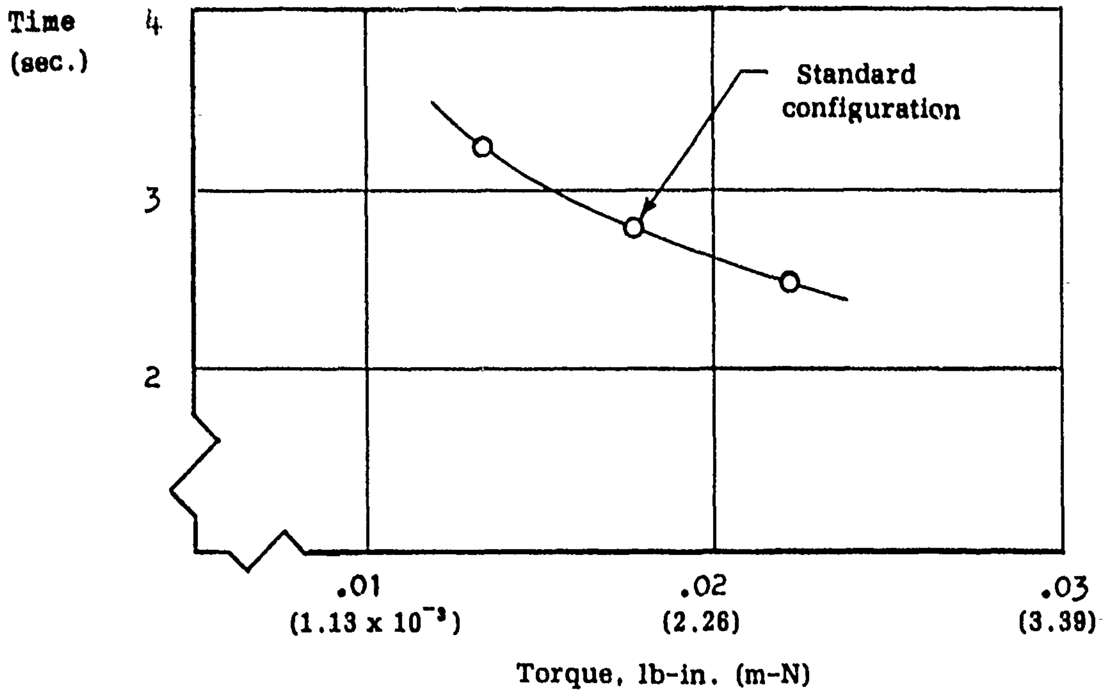
The results of the simulation (runs 47 and 48 of table of figure 8) show excellent agreement with the above. The empirical relationship has been confirmed time and again by experiment.

Influence of Pallet Moment of Inertia

Figure 9 shows that the total fuze delay time increases with an increase of the pallet moment of inertia. The ratio of any two fuze periods is approximately proportional to the ratio of the square roots of the associated pallet inertias. These results are confirmed by the experiments of Anderson and Redmond (ref. 7).

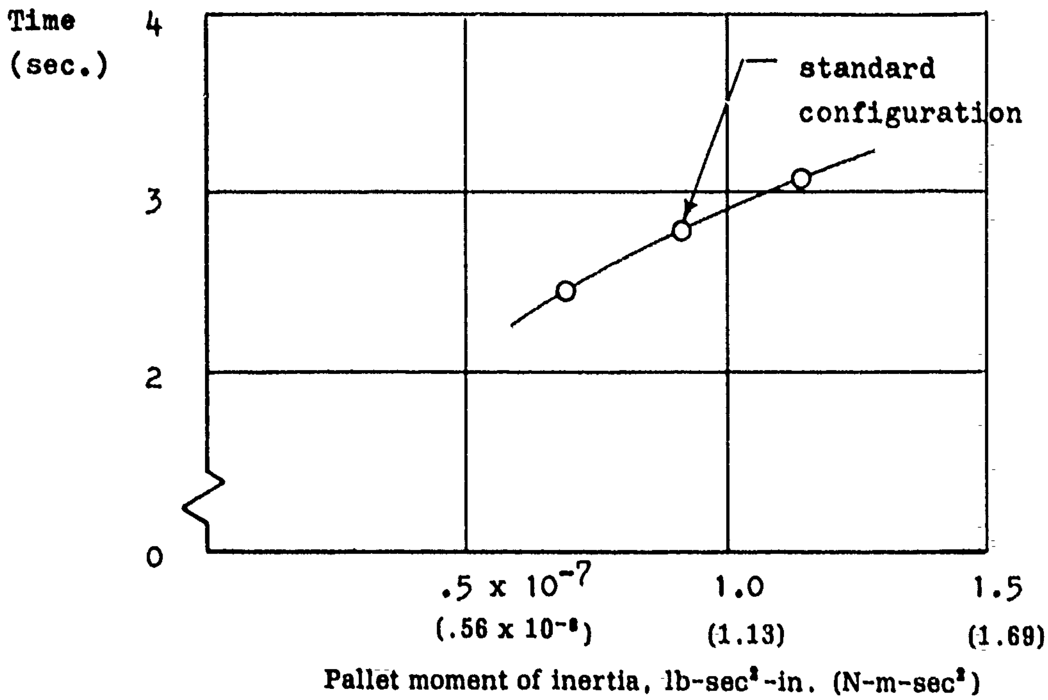
Influence of Pallet Escape-Wheel Center Distance

Figure 10 indicates, for the range explored, that the fuze time increases as the center distance a is increased. For a total increase of .007 inches (.018 cm), the time increase is approximately 7%. This result is



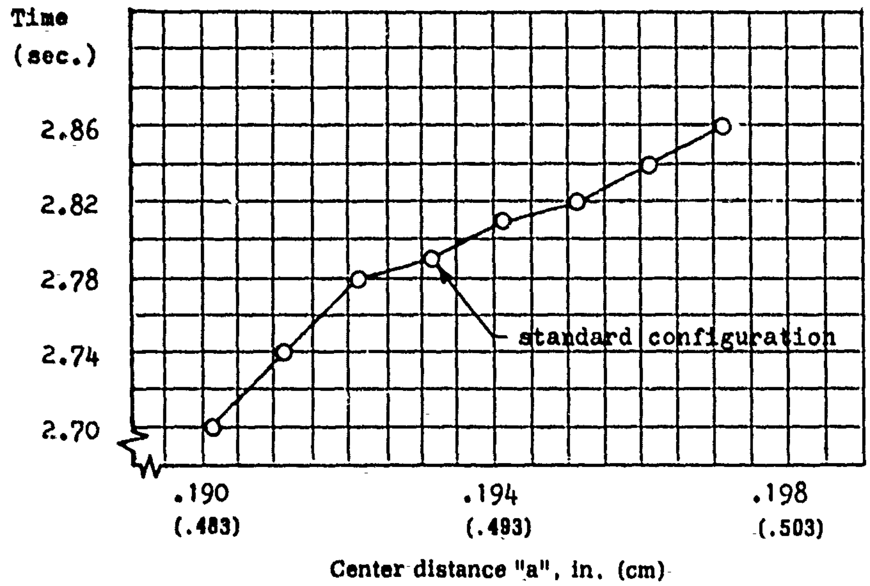
Run no.	Torque (lb-in.)	Total Fuze Time (sec.)
48	.0133 (75% of St.) (1.503×10^{-3} m-N)	3.23
46	.0177 (St.) (2.000×10^{-3} m-N)	2.79
47	.0221 (125% of St.) (2.497×10^{-3} m-N)	2.50

Figure 8. Influence of escape-wheel torque on fuze delay time



Run no.	Moment of inertia of pallet (lb-sec^2-in)	Total fuze time (sec.)
57	.68 x 10^{-7} (7.68 x 10^{-9} N-m-sec^2)	2.46
46	.91 x 10^{-7} (std. conf.) (1.027 x 10^{-8} N-m-sec^2)	2.79
58	1.137 x 10^{-7} (1.283 x 10^{-8} N-m-sec^2)	3.07

Figure 9. Influence of pallet moment of inertia on fuze delay time



Run no.	Center distance "a" (in.)	Total fuze time (sec.)
55	.1901 (.4829 cm)	2.70
54	.1911 (.4854 cm)	2.74
53	.1921 (.4879 cm)	2.78
46	.1931 (std. conf.) (.4905 cm)	2.79
49	.1941 (.4930 cm)	2.81
50	.1951 (.4956 cm)	2.82
51	.1961 (.4981 cm)	2.84
52	.1971 (.5006 cm)	2.86

Figure 10. Influence of pallet escape-wheel center distance on fuze delay time

generally confirmed by the experimentation of Anderson and Redmond (ref. 7), where it is shown that an increase of time is effected as the center distance is increased from a dimension somewhat below nominal.

Influence of Pallet Radius

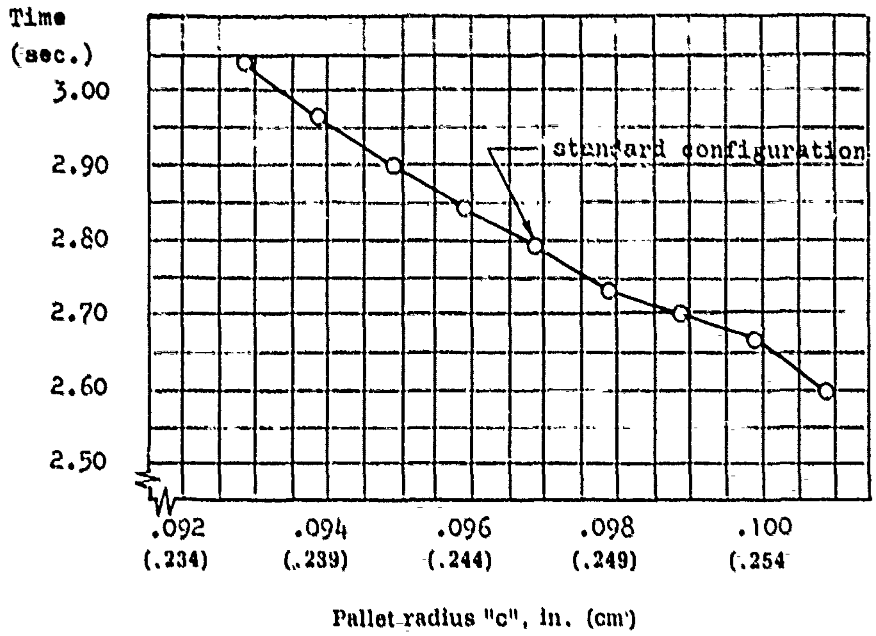
Figure 11 shows a continuous and quite dramatic decrease in fuze period as the pallet radius c is increased by .008 inches (.020 cm). It is believed that this effect is similar to that observed in connection with a decrease in center distance a, i.e. an increase in pallet radius represents an effective decrease of center distance. The experimentation performed in reference 7 gives good correlation with this result of the simulation.

Influence of Coefficient of Friction

Figure 12 indicates that the fuze time increases as the coefficient of friction, associated with coupled motion, is increased. One would expect that an increase of energy dissipation will slow the mechanism.

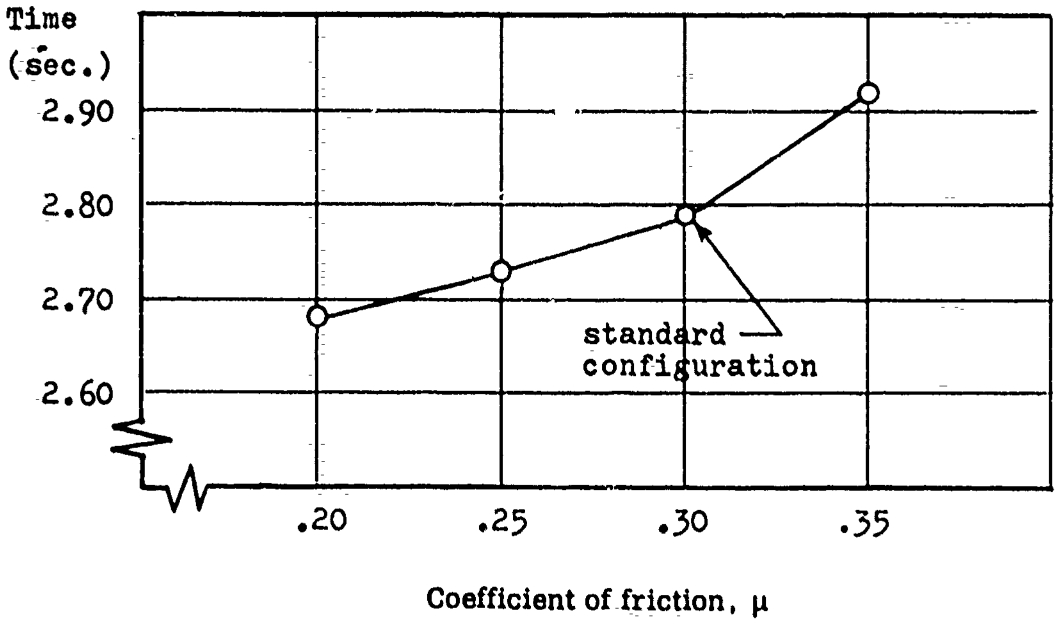
Influence of Coefficient of Restitution

According to figure 13, the fuze time increases considerably as the coefficient of restitution is varied from completely inelastic to partially elastic; i.e. from zero to .5. When $\varepsilon = 0$ (see description of run no. 70 in the section on results for standard configuration), coupled motion follows immediately after impact. In run no. 75 (which is not reproduced in this report), where $\varepsilon = .5$, top action consists of four impacts, three of which are followed by free motion while the fourth is followed by coupled motion. Bottom action shows two impacts with the last one followed by coupled motion. Each of the impacts is followed by considerable escape-wheel reversal. These multiple impacts and associated motion reversals seem to account for the observed increase in fuze time.



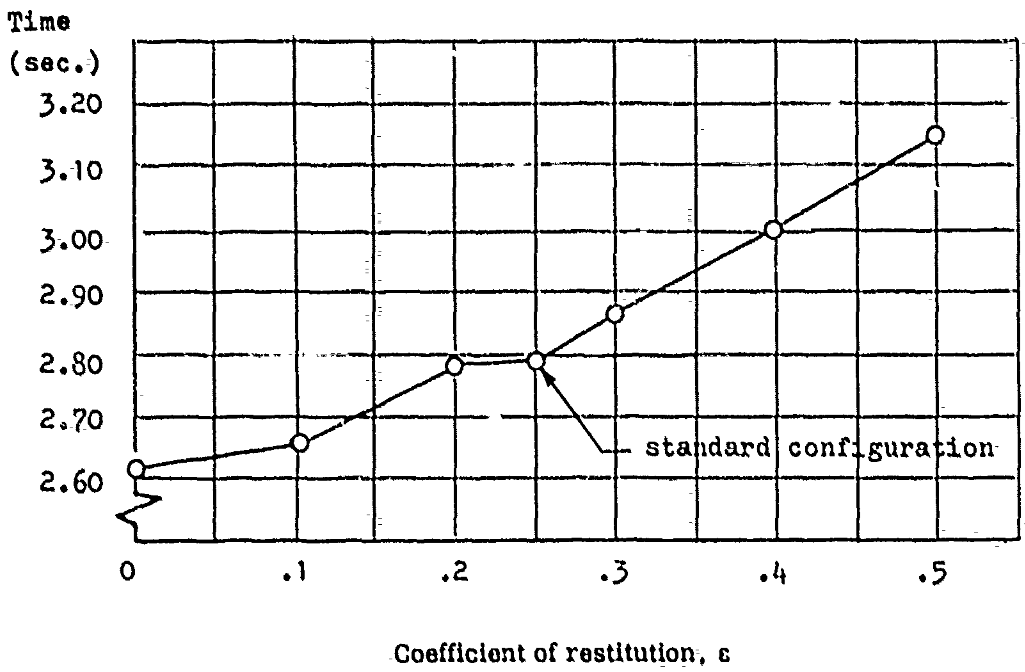
Run no.	Pallet radius "c" (in.)	Total fuze time (sec.)
66	.0928 (.2357 cm)	3.04
65	.0938 (.2383 cm)	2.97
64	.0948 (.2408 cm)	2.90
63	.0958 (.2433 cm)	2.84
46	.0968 (std. conf.) (.2459 cm)	2.79
59	.0978 (.2489 cm)	2.73
60	.0988 (.2510 cm)	2.70
61	.0998 (.2535 cm)	2.67
62	.1008 (.2560 cm)	2.60

Figure 11. Influence of pallet radius on fuze delay time



Run no.	Coefficient of friction, μ	Total fuze time (sec.)
68	.20	2.68
67	.25	2.73
46	.30 (std. conf.)	2.79
69	.35	2.92

Figure 12. Influence of coefficient of friction of coupled motion on fuze delay time



Run no.	Coefficient of restitution, ε	Total fuze time (sec.)
75	.5	3.15
74	.4	3.01
73	.3	2.87
46	.25 (std. conf.)	2.79
72	.2	2.78
71	.1	2.66
70	0.0	2.62

Figure 13. Influence of coefficient of restitution on fuze delay time

DISCUSSION AND RECOMMENDATIONS FOR CONTINUED WORK

There is no doubt that the goal of a workable computer simulation of the pin pallet runaway escapement has been attained. This is mainly due to the fact that every effort was made to keep the program and its controls as simple as possible.

As a consequence of this, there is presently no built-in sensing mechanism that indicates whether the pallet pin makes contact with the backside of an adjacent tooth during free motion. While this abnormality did not occur for the M525 mechanism, there is no assurance that it will never occur.

Secondly, there is the unresolved problem of the somewhat excessive escape-wheel reversal for the standard configuration unless fairly unrealistic values are used for the coefficients of friction and restitution. (Recall the discussion in the section on the results for the standard configuration.) Table 5 shows the extent to which this escape-wheel reversal depends on the center distance between the pallet and escape-wheel pivots.

Clearly, the reversal increases with a decrease in center distance and decreases as the center distance is enlarged. Note, that for a = .1941 inches (.4930 cm), which is .001 in (.0025 cm) above nominal, $|g| < |g_{MAX}|$. Note further, that the disengagement center distance of .208 inches (.528 cm) (see end of the section on the example mechanism) is much larger than the values which have been explored in table 5.

Excessive escape-wheel reversal may be indicative of the fact that the simple impact formulation is not sufficiently descriptive, as shown by Anderson and Redmond (ref. 7) or that the escapement only operates in the expected manner when the center distance is somewhat enlarged from nominal.

To resolve this problem, high speed motion pictures must be taken in order to be able to observe the actual motion. Following this, certain modifications of the impact model may have to be made.

Even if the question of the motion reversal cannot be fully resolved, the present simulation is sufficiently descriptive to undertake the following extensions:

1. Adaptation of the pin pallet runaway escapement simulation to a centrifugally driven mechanism, such as the M577 safe separation device (SSD).*

2. Adaptation of the pin pallet simulation to a spring-driven timing mechanism.

3. Modification of the present model to accommodate the simulation of a plate pallet (verge) type runaway escapement.

*Successful simulations, incorporating the present escapement model, of both the M577 SSD and the M125A1 booster have been recently completed. The results will be given in a future report.

Table 5. Escape-wheel reversal as a function of center distance a

Center distance, a* (in.)	Value of g at maximum reversal during top action (in.)	Program number
.1901 (.4829 cm)	-.0662 (-.1681 cm)	55
.1911 (.4854 cm)	-.0635 (-.1613 cm)	54
.1921 (.4879 cm)	-.0600 (-.1524 cm)	53
.1931 (std. conf.) (.4905 cm)	-.0580 (-.1473 cm)	46
.1941 (.4930 cm)	-.0536 (-.1361 cm)	49
.1951 (.4956 cm)	-.0520 (-.1321 cm)	50
.1961 (.4981 cm)	-.0471 (-.1196 cm)	51
.1971 (.5006 cm)	-.0441 (-.1120 cm)	52

*Dimension a is variable, otherwise dimensions are standard configuration with $\mu = .3$, $\varepsilon = .25$ and $g_{MAX} = -.05467$ in. (-.13886 cm).

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APPENDIX A

KINEMATICS OF COUPLED MOTION

Figure A1 shows the kinematic relationship of the escape-wheel and the pallet during coupled motion.

UNIT VECTORS

The unit vectors $\bar{n}_t$ and $\bar{n}_n$ are along and perpendicular to the contact surface of the escape-wheel tooth in the indicated directions, respectively. Thus,

$$\bar{n}_t = \cos(\varphi - \alpha)\,\bar{i} + \sin(\varphi - \alpha)\,\bar{j} \qquad \text{(A1)}$$

$$\bar{n}_n = -\sin(\varphi - \alpha)\,\bar{i} + \cos(\varphi - \alpha)\,\bar{j} \qquad \text{(A2)}$$

In addition, the unit vectors $\bar{n}_b$, for the escape-wheel, and $\bar{n}_c$, for the line connecting the pallet pivot and the center of the pallet pin, are introduced:

$$\bar{n}_b = \cos\varphi\, i + \sin\varphi\,\bar{j} \qquad \text{(A3)}$$

$$\bar{n}_c = \cos\psi\,\bar{i} + \sin\psi\,\bar{j} \qquad \text{(A4)}$$

INPUT – OUTPUT RELATIONSHIP

The mechanism loop equation is used to determine the pallet angle ψ and the pallet pin location g with respect to the tip of the escape-wheel as functions of the escape-wheel angle φ and the applicable mechanism constants, i.e.

$$\begin{aligned} O = {} & b(\cos\varphi\,\bar{i} + \sin\varphi\,\bar{j}) + g[\cos(\varphi - \alpha)\bar{i} + \sin(\varphi - \alpha)\bar{j}\,] \\ & + r[-\sin(\varphi - \alpha)\bar{i} + \cos(\varphi - \alpha)\bar{j}] - c(\cos\psi\,\bar{i} + \sin\psi\,\bar{j}) \\ & + a\,\bar{i} \end{aligned} \qquad \text{(A5)}$$

The above is rewritten in component form:

$$b\cos\varphi + g\cos(\varphi - \alpha) - r\sin(\varphi - \alpha) - c\cos\psi + a = O \qquad \text{(A6)}$$

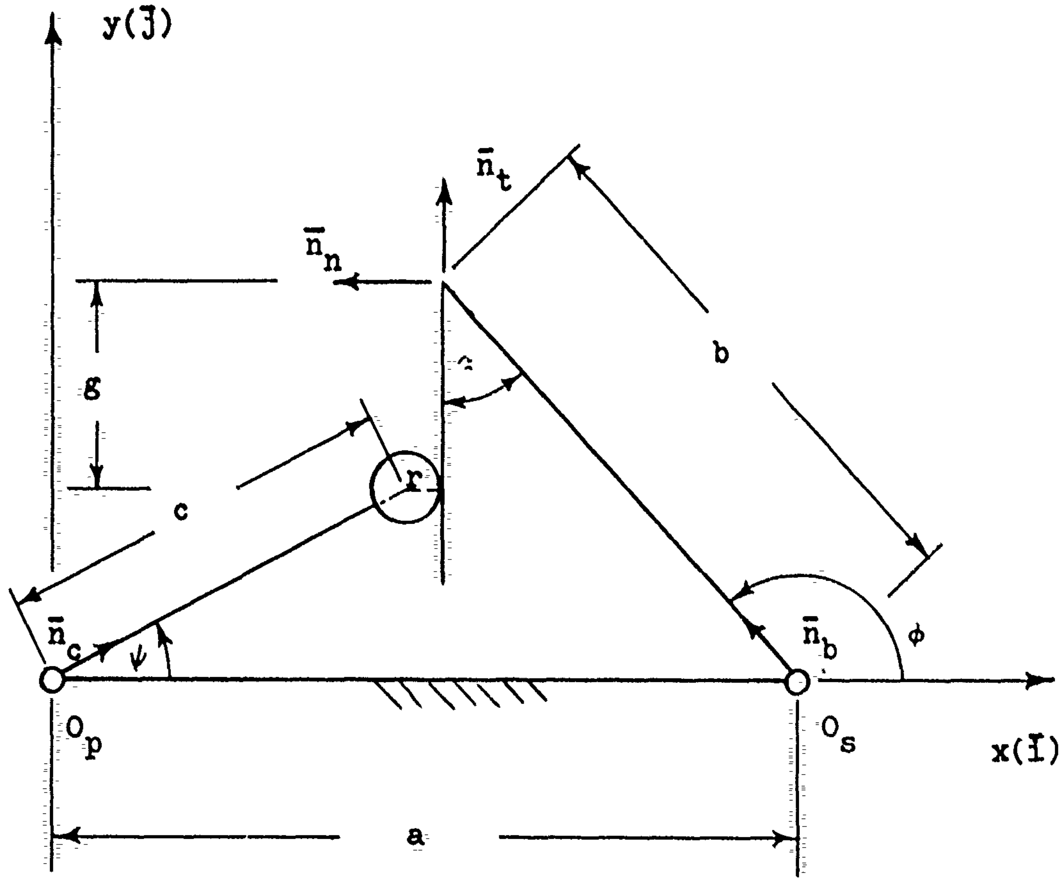

Figure A1. Coupled motion kinematics

$$b \sin \varphi + g \sin(\varphi - \alpha) + r \cos(\varphi - \alpha) - c \sin \psi = 0 \qquad \text{(A7)}$$

The angle ψ is obtained from (A7):

$$\sin \psi = \frac{1}{c} [b \sin \varphi + g \sin(\varphi - \alpha) + r \cos(\varphi - \alpha)] \qquad \text{(A8)}$$

and

$$\cos \psi = \frac{1}{c} \sqrt{c^2 - [b \sin \varphi + g \sin(\varphi - \alpha) + r \cos(\varphi - \alpha)]^2} \qquad \text{(A9)}$$

Substitution of equation (A9) into equation (A6) and subsequent squaring of both sides of the resulting expression leads to:

$$[b \cos \varphi + g \cos(\varphi - \alpha) - r \sin(\varphi - \alpha) + a]^2$$

$$= c^2 - [b \sin \varphi + g \sin(\varphi - \alpha) + r \cos(\varphi - \alpha)]^2 \qquad \text{(A10)}$$

Rearrangement gives:

$$g^2 + g[2b \cos \alpha + 2a \cos(\varphi - \alpha)]$$

$$+ [a^2 + b^2 + r^2 - c^2 + 2br \sin \alpha + 2ab \cos\varphi - 2ar \sin(\varphi - \alpha)]$$

$$= 0 \qquad \text{(A11)}$$

Finally, solution of equation (A11) leads to:

$$g = \frac{-H + \sqrt{H^2 - 4K}}{2} \qquad \text{(A12)}$$

where

$$H = 2[b \cos \alpha + a \cos(\varphi - \alpha)] \qquad \text{(A13)}$$

$$K = a^2 + b^2 + r^2 - c^2 + 2br \sin \alpha + 2ab \cos \varphi - 2ar \sin(\varphi - \alpha) \qquad \text{(A14)}$$

The correct value of g, as obtained from equation (A12), must have the smaller absolute magnitude.

OUTPUT VELOCITIES

Implicit differentiation of equation (A11) furnishes the velocity $\dot{g}$ of the instantaneous contact point on the pallet with respect to the coincident point on the escape-wheel during coupled motion:

$$\dot{g} = \frac{a\,P}{S}\ \dot{\varphi} \tag{A15}$$

where

$$P = b\sin\varphi + g\sin(\varphi - \alpha) + r\cos(\varphi - \alpha) \tag{A16}$$

$$S = g + b\cos\alpha + a\cos(\varphi - \alpha) \tag{A17}$$

Differentiation of equation (A8) leads to the pallet angular velocity during coupled motion:

$$\dot{\psi} = \frac{Q\dot{\varphi} + \dot{g}\sin(\varphi - \alpha)}{(c)\cos\psi} \tag{A18}$$

where

$$Q = b\cos\varphi + g\cos(\varphi - \alpha) - r\sin(\varphi - \alpha) \tag{A19}$$

OUTPUT ACCELERATIONS

Differentiation of equation (A15) results in an expression for the relative acceleration of the contact point on the pallet with respect to that on the escape-wheel:

$$\ddot{g} = \frac{\ddot{\varphi}\,Pa + \dot{\varphi}^2\,Qa + 2\dot{\varphi}\,\dot{g}\,a\sin(\varphi - \alpha) - \dot{g}^2}{S} \tag{A20}$$

Further, differentiation of equation (A18) furnishes an expression for the angular acceleration of the pallet during coupled motion:

$$\ddot{\psi} = \frac{\ddot{\varphi}\,Q - \dot{\varphi}^2 P + 2\dot{g}\,\dot{\varphi}\cos(\varphi - \alpha) + \ddot{g}\sin(\varphi - \alpha)}{c\cos\psi}$$

$$+ \dot{\psi}^2\tan\psi \tag{A21}$$

APPENDIX B

DIFFERENTIAL EQUATION OF COUPLED MOTION

Figure B-1 shows free body diagrams of the pallet and escape-wheel, as they are found during coupled motion. The torque T acts on the escape-wheel. The forces between the escape-wheel and the pallet are represented by the normal forces $\pm\bar{P}_n$ in the direction of $\bar{n}_n$ and the friction forces $\pm(\mu P_n)$ in the direction of $\bar{n}_t$. The sign of the friction forces must be such that when the contact point K on the pallet pin moves in the direction of the positive velocity $\dot{g}$ with respect to the coincident point L on the escape-wheel, the friction force on the pallet pin must act in the negative direction of $\dot{g}$. (Note that $\dot{g}$, as given by equation (A15) in appendix A, has the same direction as the relative velocity $\bar{V}_{K/L}$.)

The frictional resistance at the pivots O_p and O_s is neglected, since the pivot radii are commonly held very small causing the friction moments to become insignificant.

The differential equations of rotation will first be written separately for the pallet and the escape-wheel. Since the output angle ψ is a function of the input angle φ throughout coupled motion, both expressions may be combined by way of the common force magnitudes.

Equation of Motion for the Pallet

$$\bar{D}_1 \times P_n \bar{n}_n + \bar{C}_1 \times \left(-\mu P_n \frac{\dot{g}}{|\dot{g}|}\right) \bar{n}_t = I_p \ddot{\psi} \bar{k} \qquad \text{(B1)}$$

Equation of Motion for the Escape-Wheel

$$\bar{A}_1 \times (-\bar{P}_n) \bar{n}_n + \bar{B}_1 \times \left(\mu P_n \frac{\dot{g}}{|\dot{g}|}\right) \bar{n}_t + T\bar{k} = I_s \ddot{\varphi} \bar{k} \qquad \text{(B2)}$$

The moment arms $\bar{A}_1$, $\bar{B}_1$, $\bar{C}_1$, and $\bar{D}_1$ are given by equations (C6), (C7), (C4), and (C5), respectively. I_p and I_s represent the moments of inertia of the pallet and the escape-wheel with respect to their pivots.

Appropriate vector operations on equations (B1) and (B2) furnish the following scalar expressions:

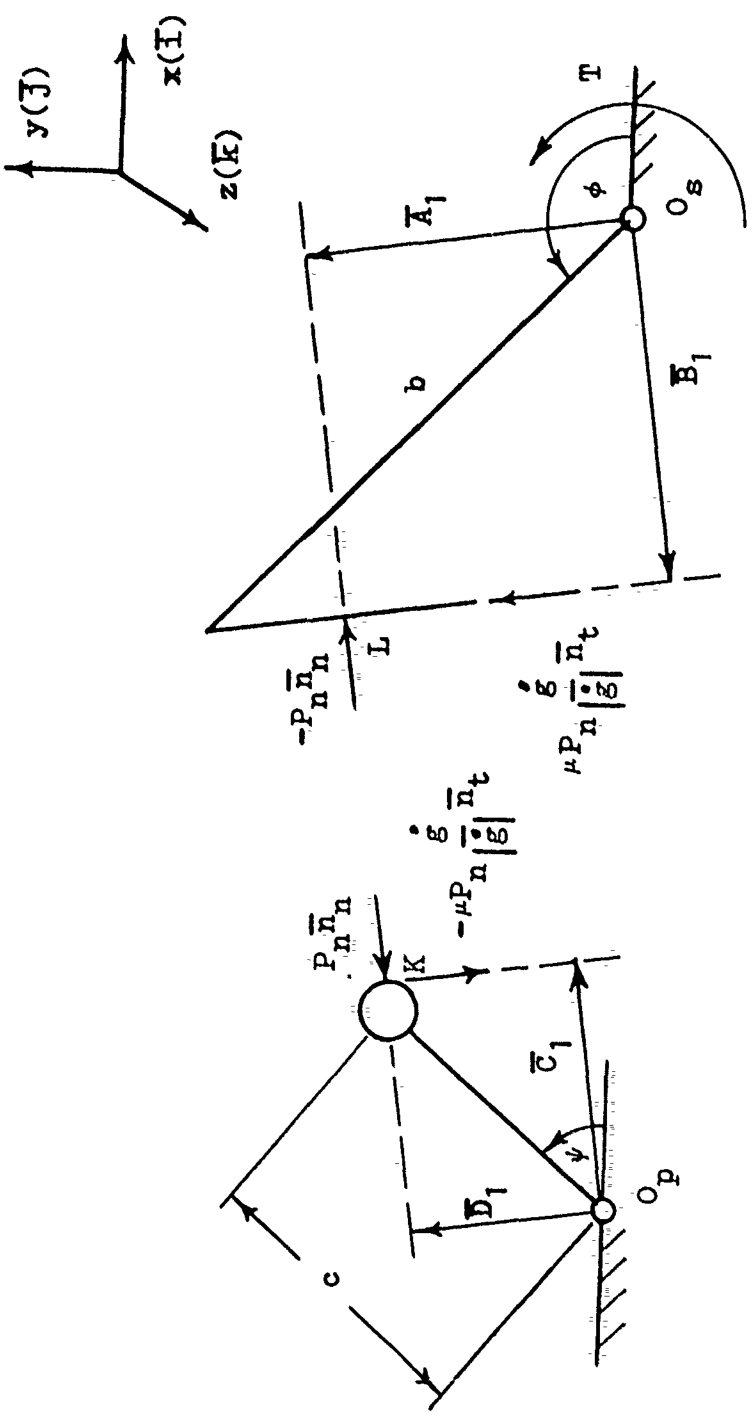

Figure B1. Free body diagram for coupled motion

$$P_n(D_1 - C_1 \mu \frac{\dot{g}}{|\dot{g}|}) = I_p \ddot{\psi} \quad \text{(B3)}$$

and

$$-P_n(A_1 + B_1 \mu \frac{\dot{g}}{|\dot{g}|}) + T = I_s \ddot{\varphi} \quad \text{(B4)}$$

When the above expressions are equated in terms of $\overline{P}_n$, one obtains:

$$\frac{I_p(A_1 + \mu B_1 \frac{\dot{g}}{|\dot{g}|})}{(D_1 - \mu C_1 \frac{\dot{g}}{|\dot{g}|})} \ddot{\psi} + I_s \ddot{\varphi} = T \quad \text{(B5)}$$

The angular acceleration $\ddot{\psi}$ is now expressed in terms of $\ddot{\varphi}$ and $\dot{\varphi}$ with the help of equation (A21) of appendix A. Equations (A15), (A18), and (A20) are utilized to replace $\dot{g}$, $\dot{\psi}$ and $\ddot{g}$, respectively. After considerable simplification, one obtains the following expression for $\ddot{\psi}$:

$$\ddot{\psi} = U\ddot{\varphi} + V\dot{\varphi}^2 \quad \text{(B6)}$$

where

$$U = \frac{Q + \frac{ap}{S} \sin(\varphi - \alpha)}{(c)\cos\psi} \quad \text{(B7)}$$

and

$$V = \frac{1}{c\cos\varphi} \left[\frac{2aP}{S} \cos(\varphi - \alpha) - P + \frac{2a^2P}{S^2} \sin^2(\varphi - \alpha) + \frac{aQ}{S} \sin(\varphi - \alpha) - \frac{a^2P^2}{S^3} \sin(\varphi - \alpha) \right] + \frac{\tan\psi}{c^2 \cos^2\psi} \left[Q + \frac{Pa}{S} \sin(\varphi - \alpha) \right]^2 \quad \text{(B8)}$$

Equation (B6) is now substituted into equation (B5). This results in:

$$\left[I_p U \frac{\left(A_1 + \mu B_1 \frac{\dot{g}}{|\dot{g}|}\right)}{\left(D_1 - \mu C_1 \frac{\dot{g}}{|\dot{g}|}\right)} + I_s \right] \ddot{\varphi} + I_p V \frac{\left(A_1 + \mu B_1 \frac{\dot{g}}{|\dot{g}|}\right)}{\left(D_1 - C_1 \frac{\dot{g}}{|\dot{g}|}\right)} (\dot{\varphi})^2$$

$$= T \qquad \text{(B9)}$$

For computational purposes, equation (B9) is rewritten in the following form:

$$\ddot{\varphi} + W\dot{\varphi}^2 = Y \qquad \text{(B10)}$$

where

$$W = \frac{\frac{I_p V}{E_1}}{\frac{I_p U}{E_1} + \frac{I_s}{F_1}} \qquad \text{(B11)}$$

$$Y = \frac{\frac{T}{F_1}}{\frac{I_p U}{E_1} + \frac{I_s}{F_1}} \qquad \text{(B12)}$$

and

$$E_1 = D_1 - \mu C_1 \frac{\dot{g}}{|\dot{g}|} \qquad \text{(B13)}$$

$$F_1 = A_1 + \mu B_1 \frac{\dot{g}}{|\dot{g}|} \qquad \text{(B14)}$$

APPENDIX C

MOMENT ARMS

DETERMINATION OF MOMENT ARMS $\bar{C}_1$ AND $\bar{D}_1$

Figure C-1 suggests the following loop equation for the determination of the vectors $\bar{C}_1$ and $\bar{D}_1$:

$$c\bar{n}_c - r\bar{n}_n - D_1\bar{n}_n + C_1\bar{n}_n = O \qquad \text{(C1)}$$

When the components in the $\bar{n}_t$ and $\bar{n}_n$ directions are separated, one obtains:

$$c\cos\psi + r\sin(\varphi - \alpha) + D_1\cos(\varphi - \alpha) - C_1\sin(\varphi - \alpha) = O \qquad \text{(C2)}$$

and

$$c\sin\psi - r\cos(\varphi - \alpha) + D_1\sin(\varphi - \alpha) + C_1\cos(\varphi - \alpha) = O \qquad \text{(C3)}$$

Simultaneous solution of the above expressions leads to the following vectorial expressions:

$$\bar{C}_1 = - [r + c\sin(\varphi - \alpha - \psi)]\bar{n}_n \qquad \text{(C4)}$$

and

$$\bar{D}_1 = c\cos(\varphi - \alpha - \psi)\bar{n}_t \qquad \text{(C5)}$$

DETERMINATION OF MOMENT ARMS $\bar{A}_1$ AND $\bar{B}_1$

Inspection of figure C-1 leads to the following expressions for the vectors $\bar{A}_1$ and $\bar{B}_1$:

$$\bar{A}_1 = (b\cos\alpha + g)\bar{n}_t \qquad \text{(C6)}$$

(Note that g is negative during contact.)

Further,

$$\bar{B}_1 = (b\sin\alpha)\bar{n}_n \qquad \text{(C7)}$$

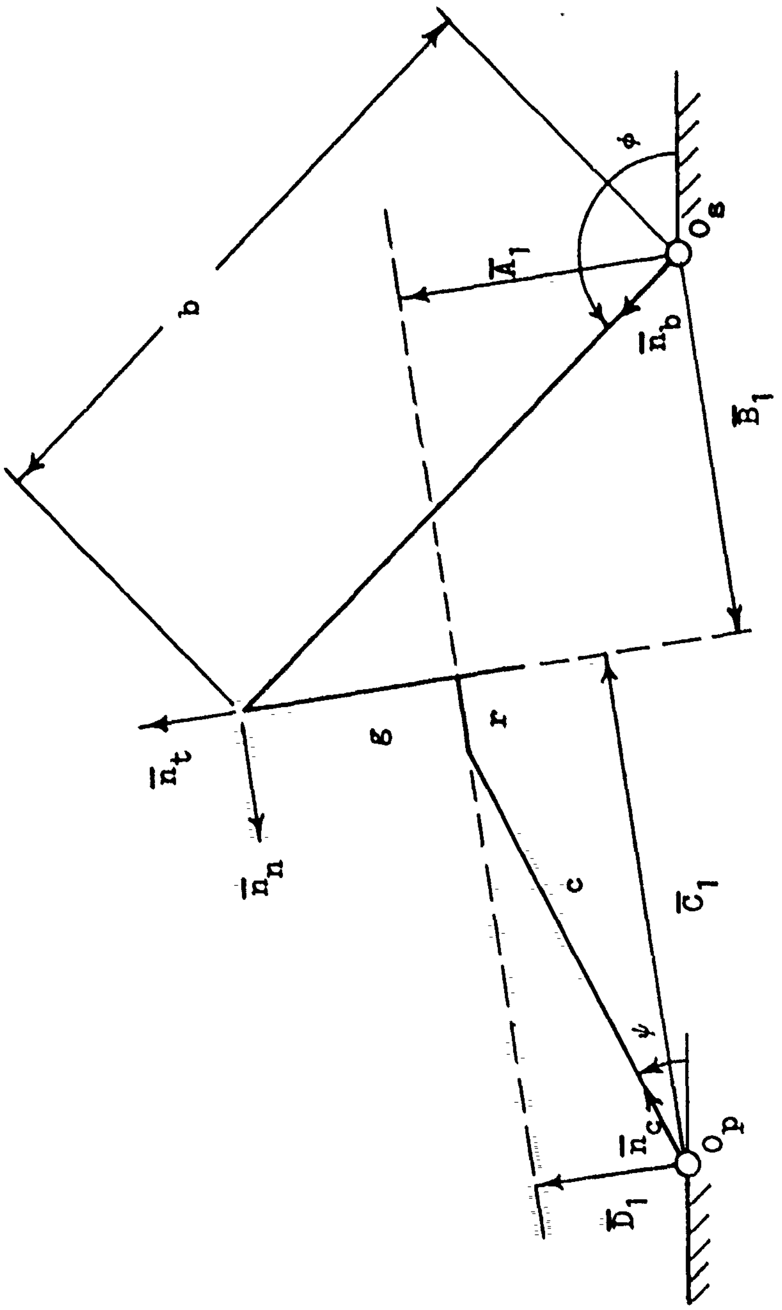

Figure C1. Moment arms

APPENDIX D

CONTACT SENSING EXPRESSIONS

When the mechanism is in free motion, i.e. φ and ψ are independent of each other, it is necessary to know the distances f and g', in figure D-1, to determine the relative positions. The quantity f, which indicates the distance of the pallet pin from the escape-wheel face, vanishes at the instant of impending impact. When contact between the pallet and the escape-wheel becomes impossible, i.e. the pin has left the tooth, $g' \geqq 0$.

By inspection of figure D-1, the loop equation for free motion is given by:

$$b\bar{n}_b + g'\bar{n}_t + (r + f)\bar{n}_n - c\bar{n}_c + a\bar{i} = 0 \qquad \text{(D1)}$$

(Note that φ and ψ are independent variables and are assumed to be known.)

In component form, the above becomes:

$$b\cos\varphi + g'\cos(\varphi - \alpha) - r\sin(\varphi - \alpha) - f\sin(\varphi - \alpha) - c\cos\psi + a = 0 \qquad \text{(D2)}$$

$$b\sin\varphi + g'\sin(\varphi - \alpha) + r\cos(\varphi - \alpha) + f\cos(\varphi - \alpha) - c\sin\psi = 0 \qquad \text{(D3)}$$

Multiply equation (D2) by $\sin(\varphi - \alpha)$

$$\begin{aligned} & b\cos\varphi\sin(\varphi - \alpha) + g'\sin(\varphi - \alpha)\cos(\varphi - \alpha) - r\sin^2(\varphi - \alpha) \\ & \quad -f\sin^2(\varphi - \alpha) - c\cos\psi\sin(\varphi - \alpha) + a\sin(\varphi - \alpha) + a\sin(\varphi - \alpha) \\ & \quad = 0 \end{aligned} \qquad \text{(D4)}$$

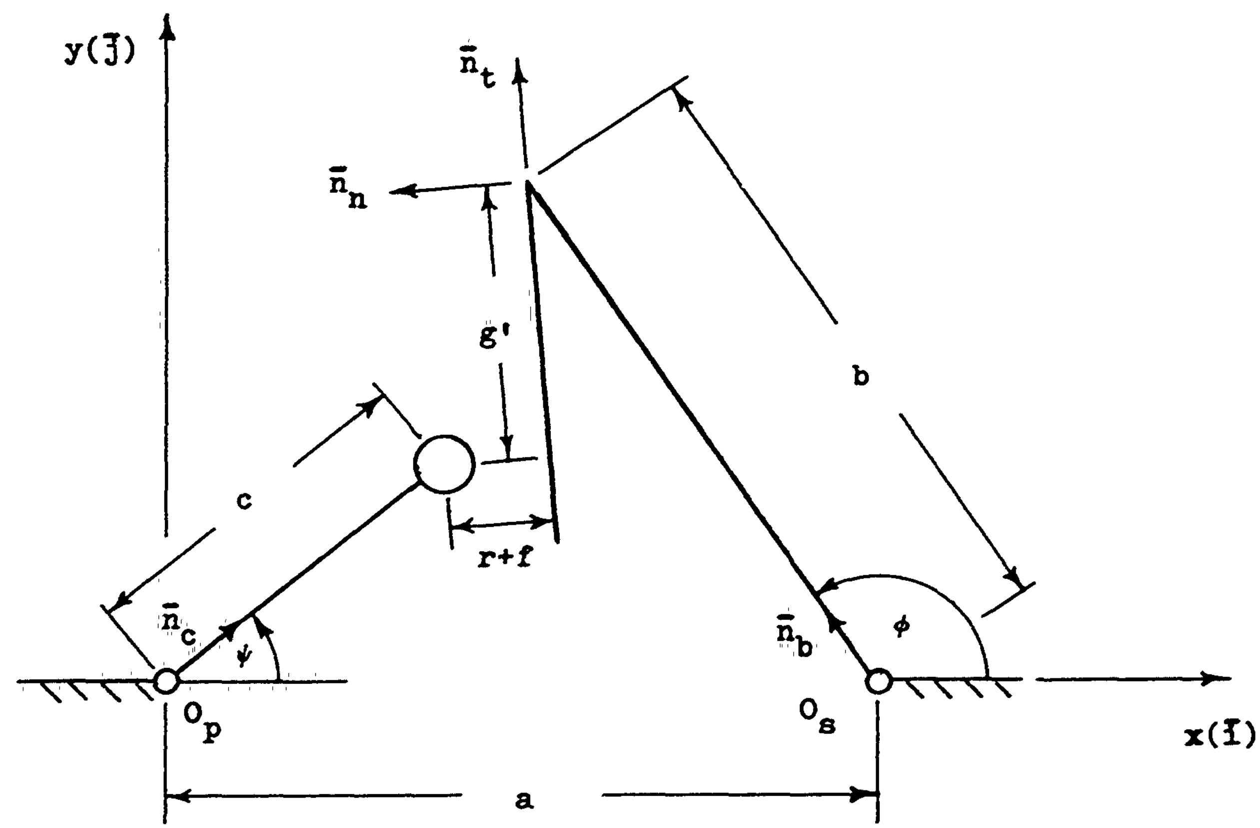

Figure D1. Contact sensing quantities

Further, multiply equation (D3) by $\cos(\varphi - \alpha)$

$$b\sin\varphi\cos(\varphi - \alpha) + g'\sin(\varphi - \alpha)\cos(\varphi - \alpha) + r\cos^2(\varphi - \alpha)$$

$$+ f\cos^2(\varphi - \alpha) - c\sin\psi\cos(\varphi - \alpha) \qquad \text{(D5)}$$

$$= 0$$

Subtract equation (D4) from equation (D5)

$$b\sin[\varphi - (\varphi - \alpha)] + r + f + c\sin[(\varphi - \alpha) - \psi] - a\sin(\varphi - \alpha)$$

$$= 0 \qquad \text{(D6)}$$

This furnishes

$$f = a\sin(\varphi - \alpha) - b\sin\alpha - c\sin[(\varphi - \alpha) - \psi] - r \qquad \text{(D7)}$$

Multiply (D2) by $\cos(\varphi - \alpha)$

$$b\cos\varphi\cos(\varphi - \alpha) + g'\cos^2(\varphi - \alpha) - r\sin(\varphi - \alpha)\cos(\varphi - \alpha)$$

$$- f\sin(\varphi - \alpha)\cos(\varphi - \alpha) - c\cos\psi\cos(\varphi - \alpha)$$

$$+ a\cos(\varphi - \alpha)$$

$$= 0 \qquad \text{(D8)}$$

Multiply (D3) by $\sin(\varphi - \alpha)$

$$b\sin\varphi\sin(\varphi - \alpha) + g'\sin^2(\varphi - \alpha) + r\sin(\varphi - \alpha)\cos(\varphi - \alpha)$$

$$+ f\sin(\varphi - \alpha)\cos(\varphi - \alpha) - c\sin\psi\sin(\varphi - \alpha)$$

$$= 0 \qquad \text{(D9)}$$

Finally, add (D8) and (D9)

$$b\cos[\varphi - (\varphi - \alpha)] + g' - c\cos[\psi - (\varphi - \alpha)] + a\cos(\varphi - \alpha)$$

$$= 0 \qquad \text{(D10)}$$

Thus,

$$g' = c\cos[(\varphi - \alpha) - \psi] - b\cos\alpha - a\cos(\varphi - \alpha) \qquad \text{(D11)}$$

APPENDIX E

FREE MOTION EQUATIONS

During the free motion phase of the mechanism, the pallet moves independently of the escape-wheel.

Again, the frictional resistance at the pivots O_p and O_s are neglected.

FREE MOTION OF PALLET

In the absence of all external torques, the differential equation of motion for the pallet is given by:

$$\ddot{\psi} = 0 \tag{E1}$$

With an initial angular velocity $\dot{\psi}_o$ at the time t_o, when the free motion starts, the angular velocity of the pallet at any time is:

$$\dot{\psi} = \dot{\psi}_o \tag{E2}$$

If $\psi(t_o) = \psi_o$, further integration gives the angular displacement of the pallet at any time t to be:

$$\psi = \dot{\psi}_o (t - t_o) + \psi_o \tag{E3}$$

The time t is counted from the start of the motion of the escapement.

FREE MOTION OF THE ESCAPE-WHEEL

When a constant torque T acts on the escape-wheel, its differential equation of motion is given by:

$$\ddot{\varphi} = \frac{T}{I_s} \tag{E4}$$

and the applicable initial conditions are:

$$\dot{\varphi}(t_o) = \dot{\varphi}_o \tag{E5}$$

and

$$\varphi(t_o) = \varphi_o \tag{E6}$$

Integration of equation (E4) gives the following expression for the angular velocity of the escape-wheel at any time t:

$$\dot{\varphi} = \frac{T}{I_s} (t - t_o) + \dot{\varphi}_o \tag{E7}$$

Further integration furnishes the angular displacement:

$$\varphi = \frac{T}{2I_s} (t - t_o)^2 + \dot{\varphi}_o (t - t_o) + \varphi_o \tag{E8}$$

APPENDIX F

IMPACT EQUATIONS

Before the impact equations can be given, certain velocity expressions associated with the impact points on the pallet and the escape-wheel must be derived. These velocities occur during free motion preceding impact when the angular velocities $\dot{\varphi}$ and $\dot{\psi}$ are independent of each other.

VELOCITIES AT IMPACT POINTS JUST BEFORE IMPACT

Figure F1 shows the velocities of the contact points K and L on the pallet and the escape-wheel, respectively, just before impact. The components in the direction normal to the escape-wheel tooth are:

$$\overline{V}_{pn_i} = \dot{\psi}_i \overline{k} \times D_1 \overline{n}_t \qquad \text{for the pallet} \qquad \text{(F1)}$$

and

$$\overline{V}_{sn_i} = \dot{\varphi}_i \overline{k} \times A_1 \overline{n}_t \qquad \text{for the escape-wheel,} \qquad \text{(F2)}$$

where the subscript i stands for the angular velocities prior to the instant of impact.

The components of velocity in the tangential direction are given by:

$$\overline{V}_{pt_i} = \dot{\psi}_i \overline{k} \times C_1 \overline{n}_n \qquad \text{(F3)}$$

and

$$\overline{V}_{st_i} = \dot{\varphi}_i \overline{k} \times B_1 \overline{n}_n \qquad \text{(F4)}$$

The expressions for the moment arms are obtained from appendix C.

To determine the direction of the tangential impact, the sign of the relative tangential velocity $\overline{V}_t$ must be known. This velocity is given by (refer to equations (F3) and (F4)):

$$\overline{V}_t = \overline{V}_{pt_i} - \overline{V}_{st_i} = \dot{\psi}_i \overline{k} \times C_1 \overline{n}_n - \dot{\varphi}_i \overline{k} \times B_1 \overline{n}_n \qquad \text{(F5)}$$

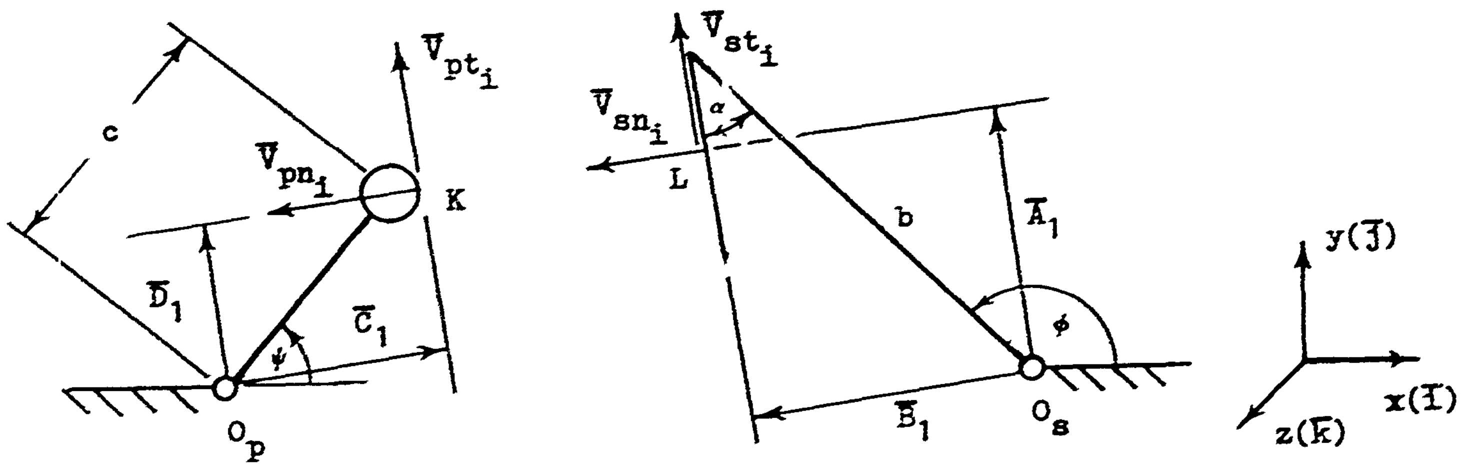

Figure F1. Velocities just before impact

Substituting equations (C4) and (C7) into equation (F5) produces:

$$\bar{V}_t = (\dot{\psi}[r + c\sin(\varphi - \alpha - \psi)] + \dot{\varphi} b \sin\alpha)\,\bar{n}_t \qquad \text{(F6)}$$

IMPACTS ON PALLET AND ESCAPE-WHEEL

The impact simulation is based on the classical angular impulse-momentum model shown in figure F-2 for the pallet and the escape-wheel.

$\bar{P}_n$ represents the normal impulse between the components. Further, a frictional impulse μP_n, which is tangential to the contact surface and has the direction of the velocity $\bar{V}_t$ (see equation (F6)), is assumed because of the angular displacements during impact.

The angular impulse T_τ on the escape-wheel, which is due to the torque T and has the duration τ of the impact phenomenon, is disregarded since it is felt that its magnitude is small when compared to that of the other terms involved. The angular impulse on the pallet then becomes:

$$\bar{J}_p = \bar{D}_1 \times P_n \bar{n}_n + \bar{C}_1 \times - \mu P_n \frac{V_t}{|V_t|} \bar{n}_t \qquad \text{(F7)}$$

After the cross product has been executed, the following equation is obtained:

$$\bar{J}_p = P_n (D_1 - \mu C_1 \frac{V_t}{|V_t|})\,\bar{k} \qquad \text{(F8)}$$

Similarly, the angular impulse on the escape-wheel reduces to:

$$\bar{J}_s = \bar{A}_1 \times (-P_n)\,\bar{n}_n + \bar{B}_1 \times \mu P_n \frac{V_t}{|V_t|} \bar{n}_t \qquad \text{(F9)}$$

This becomes

$$\bar{J}_s = - P_n (A_1 + \mu B_1 \frac{V_t}{|V_t|})\,\bar{k} \qquad \text{(F10)}$$

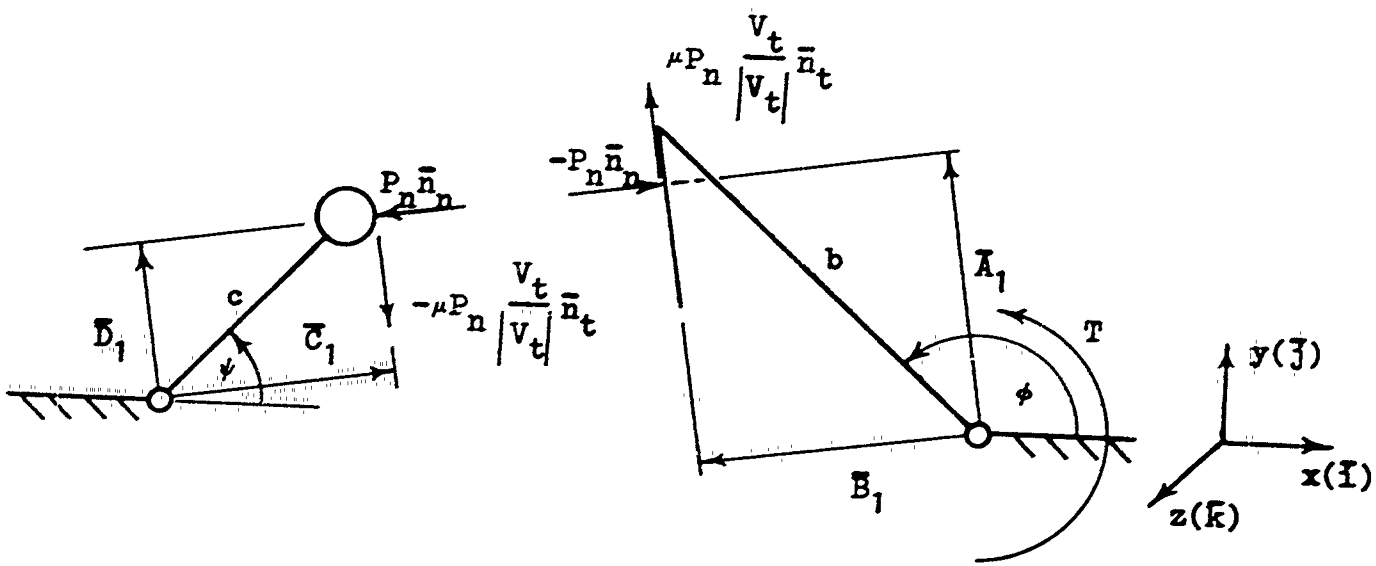

Figure F2. Free body diagram of impact

Equations (F8) and (F10) are now substituted into the following angular momentum equations:

$$I_p(\dot{\psi}_f - \dot{\psi}_i) = \bar{J}_p \tag{F11}$$

and

$$I_s(\dot{\varphi}_f - \dot{\varphi}_i) = \bar{J}_s \tag{F12}$$

The subscript f indicates the angular velocities after impact. Substitution of the scalar portions of equations (F8) and (F10) into equations (F11) and (F12), respectively, as well as the subsequent simultaneous elimination of P_n from both of the resulting expressions, leads to:

$$I_p F_2 \dot{\psi}_f + I_s E_2 \dot{\varphi}_f = I_p F_2 \dot{\psi}_i + I_s E_2 \dot{\varphi}_i \tag{F13}$$

where

$$E_2 = D_1 - \mu C_1 \frac{V_t}{|V_t|} \tag{F14}$$

and

$$F_2 = A_1 + \mu B_1 \frac{V_t}{|V_t|} \tag{F15}$$

To solve for the angular velocities after impact, it is now necessary to make use of the concept of the coefficient of restitution. This coefficient is adapted to the present situation in the following manner:

$$\varepsilon = - \frac{V_{pn_f} - V_{sn_f}}{V_{pn_i} - V_{sn_i}} \tag{F16}$$

Using equations (F1) and (F2) and letting

$$\bar{V}_{pn_f} = \dot{\psi}_f \bar{k} \times D_1 \bar{n}_t \qquad \text{for the pallet} \tag{F17}$$

$$\overline{V}_{sn_f} = \dot{\varphi}_f \, \overline{k} \times A_1 \, \overline{n}_t \qquad \text{for the escape-wheel} \tag{F18}$$

where $\dot{\varphi}_f$ and $\dot{\psi}_f$ are the respective angular velocities of the pallet and the escape-wheel after impact, produces

$$\varepsilon = -\frac{(\dot{\psi}_f D_1 - \dot{\varphi}_f A_1)}{(\dot{\psi}_i D_1 - \dot{\varphi}_i A_1)} \tag{F19}$$

Simultaneous solution of equations (F13) and (F19) furnishes the desired angular velocities after impact.

Thus,

$$\dot{\psi}_f = \frac{\dot{\varphi}_f A_1 - \varepsilon(\dot{\psi}_i D_1 - \dot{\varphi}_i A_1)}{D_1} \tag{F20}$$

and

$$\dot{\varphi}_f = \frac{I_p F_2 \dot{\psi}_i + I_s E_2 \dot{\varphi}_i + \frac{I_p F_2 \varepsilon}{D_1}(\dot{\psi}_i D_1 - \dot{\varphi}_i A_1)}{\frac{I_p F_2 A_1}{D_1} + I_s E_2} \tag{F21}$$

GENERAL EXPRESSIONS FOR THE NORMAL VELOCITIES AT THE IMPACT POINTS

The normal velocities at the impact points of the pallet and the escape-wheel are also used in the logic of the computer program. If $\dot{\varphi}$ and $\dot{\psi}$ represent the angular velocities of the escape-wheel and the pallet just before or after impact, expressions are derived for these velocities using (F1), (F2), (C5), and (C6):

For the pallet

$$V_p = \dot{\psi} c \cos(\varphi - \alpha - \psi) \tag{F22}$$

For the escape wheel

$$V_s = \dot{\varphi}(b\cos\alpha + g) \tag{F23}$$

(Note the simplification of the notation.)

APPENDIX G

COMPUTER PROGRAM

```
      PROGRAM ESCMT(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
      DIMENSION AUX(8,2),PRMT(5),PHI(2),DPHI(2)
      COMMON A,B,C,R,ALPHR,PI,TORK,COFR,IP,IS,EREST,LAMBDA,DELTA,
     1PHITOT,PHIPR
      COMMON/ZETA/PSI,TIME,G,DPSI,DPSIP
      REAL IP,IS,LAMBDA,K
      EXTERNAL FCT,OUTP
C
C     READ IN AND WRITE DATA
C
      READ(5,1)A,B,C,R,ALPHA
    1 FORMAT(5F10.5)
      WRITE(6,2)A,B,C,R,ALPHA
    2 FORMAT(*1*,5X,*A=*,F13.5,5X,*B=*,F13.5,5X,*C=*,F13.5,5X,*R=*,
     1F13.5,5X,*ALPHA=*,F9.4//)
      READ(5,3)TORK,COFR,IP,IS
    3 FORMAT(4E15.5)
      WRITE(6,4)TORK,COFR,IP,IS
    4 FORMAT(*0*,5X,*TORQUE=*,E15.5,5X,*COFR=*,E15.5,5X,*IPAL=*,E15.5,
     15X,*ISTAR=*,E15.5//)
      READ(5,5)EREST,LAMBDA,DELTA
    5 FORMAT(3F10.5)
      WRITE(6,6)EREST,LAMBDA,DELTA
    6 FORMAT(*0*,5X,*EREST=*,F5.2,3X,*LAMBDA=*,F8.3,3X,*DELTA=*,F8.3///)
      PI=3.14159
      Z=PI/180.
      ALPHR=ALPHA*Z
      PHID=135.
      TIME=0.
      PHITOT = 0.
      PHIPR = PHID
C
C     DATA FOR RUNGE KUTTA
C
      PRMT(2)=0.1
      PRMT(3)=0.0001
      PRMT(4)=0.001
      NDIM=2
      PHI(1)=PHID*Z
      PHI(2)=0.
   99 PRMT(1)=TIME
      DPHI(2)=0.5
      DPHI(1)=0.5
      IF(PHITOT .GT. 315.)GO TO 9999
      WRITE(6,7)
    7 FORMAT(*0*,5X,*COUPLED MOTION*)
C
C     COUPLED MOTION
C
  100 CALL RKGS(PRMT,PHI,DPHI,NDIM,IHLF,FCT,OUTP,AUX)
C
C     TEST FOR TOP OR BOTTOM ACTION
C
```

```
      IF(G.LT.0.)GO TO 200
      PHID=PHI(1)/Z
      IF(PHID.LE.150.)GO TO 150
      GO TO 151
  150 PHI(1)=PHI(1)+DELTA*Z
      PHIPR = PHI(1)/Z
      PSI=PSI+2.*PI-LAMBDA*Z
      GO TO 200
  151 PHI(1)=PHI(1)-DELTA*Z*2.
      PHIPR = PHI(1)/Z
      PSI=PSI-2.*PI+LAMBDA*Z
C
C  FREE MOTION
C
  200 CALL FREE(TIME,PHI(1),PHI(2),PSI,DPSI)
C
C
C
      PHID=PHI(1)/Z
      H=2.*(B*COS(ALPHR)+A*COS(PHI(1)-ALPHR))
      K=A**2+B**2+R**2-C**2+2.*B*R*SIN(ALPHR)+2.*A*B
     1*COS(PHI(1))-2.*A*R*SIN(PHI(1)-ALPHR)
      GONE=(-H+SQRT(H**2-4.*K))/2.
      GTWO=(-H-SQRT(H**2-4.*K))/2.
      IF(ABS(GONE).LT.ABS(GTWO))GO TO 204
      G=GTWO
      GO TO 205
  204 G=GONE
  205 PHID=PHI(1)/Z
      GP = C*COS(PHI(1) - ALPHR - PSI) - B*COS(ALPHR) - A*COS(PHI(1)
     1- ALPHR)
      IF(GP .LT. 0.)GO TO 250
      IF(PHID.LE.150.)GO TO 210
      GO TO 215
  210 PHI(1) = PHI(1) + DELTA*Z
      PHIPR = PHI(1)/Z
      PSI = PSI + 2.*PI - LAMBDA*Z
      GO TO 200
  215 PHI(1) = PHI(1) - DELTA*Z*2.
      PHIPR = PHI(1)/Z
      PSI = PSI - 2.*PI + LAMBDA*Z
      GO TO 200
  250 IF(PHID.LE.150.0)GO TO 9
      DPSIP=DPSI
C
C  COMPUTATION OF VELOCITIES VP AND VS FOR BOTTOM FREE MOTION TESTS
C
      AONE=B*COS(ALPHR)+G
      DONE=C*COS(PHI(1)-ALPHR-PSI)
      VP=DONE*DPSI
      VS=AONE*PHI(2)
      WRITE(6,9002)VP,VS
 9002 FORMAT(*0VP=*,F8.3,3X,*VS=*,F8.3)
```

```
C
C     BOTTOM FREE MOTION TESTS
C
      IF(PHI(2).GE.0..AND.DPSI.GE.0.)GO TO 300
      IF(PHI(2).GE.0..AND.DPSI.LE.0..AND.ABS(VP).GT.ABS(VS))GO TO 200
      IF(PHI(2).GE.0..AND.DPSI.LE.0..AND.ABS(VP).LT.ABS(VS))GO TO 300

      IF(PHI(2).GE.0..AND.DPSI.LE.0..AND.ABS(VP).EQ.ABS(VS))GO TO 99

      IF(PHI(2).LE.0..AND.DPSI.GE.0..AND.ABS(VP).GT.ABS(VS))GO TO 300
      IF(PHI(2).LE.0..AND.DPSI.GE.0..AND.ABS(VP).LT.ABS(VS))GO TO 200
      IF(PHI(2).LE.0..AND.DPSI.GE.0..AND.ABS(VP).EQ.ABS(VS))GO TO 99
      IF(PHI(2).LE.0..AND.DPSI.LE.0.)GO TO 200
C
C     COMPUTATION OF VELOCITIES VP AND VS FOR TOP FREE MOTION TESTS
C
    9 AONE=B*COS(ALPHR)+G
      DONE=C*COS(PHI(1)-ALPHR-PSI)
      VP=DONE*DPSI
      VS=AONE*PHI(2)
      WRITE(6,9002)VP,VS
C
C     TOP FREE MOTION TESTS
C
      IF(PHI(2).GE.0..AND.DPSI.GE.0..AND.ABS(VP).GT.ABS(VS))GO TO 200
      IF(PHI(2).GE.0..AND.DPSI.GE.0..AND.ABS(VP).EQ.ABS(VS))GO TO 99

      IF(PHI(2).GE.0..AND.DPSI.GE.0..AND.ABS(VP).LT.ABS(VS))GO TO 300
      IF(PHI(2).LE.0..AND.DPSI.GE.0.)GO TO 200
      IF(PHI(2).GE.0..AND.DPSI.LE.0.)GO TO 300
      IF(PHI(2).LE.0..AND.DPSI.LE.0..AND.ABS(VP).LT.ABS(VS))GO TO 200
      IF(PHI(2).LE.0..AND.DPSI.LE.0..AND.ABS(VP).GT.ABS(VS))GO TO 300

      IF(PHI(2).LE.0..AND.DPSI.LE.0..AND.ABS(VP).EQ.ABS(VS))GO TO 99
C
C     IMPACT
C
  300 CALL IMPACT(PHI(1),PHI(2),PSI,DPSI)
      H=2.*(B*COS(ALPHR)+A*COS(PHI(1)-ALPHR))
      K=A**2+B**2+R**2-C**2+2.*B*R*SIN(ALPHR)+2.*A*B
     1*COS(PHI(1))-2.*A*R*SIN(PHI(1)-ALPHR)
      GONE=(-H+SQRT(H**2-4.*K))/2.
      GTWO=(-H-SQRT(H**2-4.*K))/2.
      IF(ABS(GONE).LT.ABS(GTWO))GO TO 310
      G=GTWO
      GO TO 311
  310 G=GONE
  311 DPSIP=DPSI
      IF(TIME.GT.0.1)GO TO 9999
C
C     TEST FOR BOTTOM ACTION
C
      PHID=PHI(1)/Z
      IF(PHID.LE.150.0)GO TO 12
C
C     COMPUTATION OF VELOCITIES VP AND VS FOR BOTTOM IMPACT TESTS
C
C
```

```
      AONE=B*COS(ALPHR)+G
      DONE=C*COS(PHI(1)-ALPHP-PSI)
      VP=DONE*DPSI
      VS=AONE*PHI(2)
      WRITE(6,9002)VP,VS
      IF(ABS(ABS(VP)-ABS(VS)).LT. 2.0)GO TO 99
C
C  BOTTOM IMPACT TESTS
C
      IF(PHI(2).GE.0..AND.DPSI.GE.0.)GO TO 99
      IF(PHI(2).GE.0..AND.DPSI.LE.0..AND.ABS(VP).GT.ABS(VS))GO TO 200
      IF(PHI(2).GE.0..AND.DPSI.LE.0..AND.ABS(VP).LT.ABS(VS))GO TO 99

      IF(PHI(2).GE.0..AND.DPSI.LE.0..AND.ABS(VP).EQ.ABS(VS))GO TO 99

      IF(PHI(2).LE.0..AND.DPSI.GT.0..AND.ABS(VP).LT.ABS(VS))GO TO 200
      IF(PHI(2).LE.0..AND.DPSI.GT.0..AND.ABS(VP).GT.ABS(VS))GO TO 99
      IF(PHI(2).LE.0..AND.DPSI.GT.0..AND.ABS(VP).EQ.ABS(VS))GO TO 99
      IF(PHI(2).LE.0..AND.DPSI.LE.0.)GO TO 200
C
C  COMPUTATION OF VELOCITIES VP AND VS FOR TOP IMPACT TESTS
C
   12 AONE=B*COS(ALPHR)+G
      DONE=C*COS(PHI(1)-ALPHP-PSI)
      VP=DONE*DPSI
      VS=AONE*PHI(2)
      WRITE(6,9002)VP,VS
      IF(ABS(ABS(VP)-ABS(VS)).LT. 2.0)GO TO 99
C
C  TOP IMPACT TESTS
C
      IF(PHI(2).GE.0..AND.DPSI.GE.0..AND.ABS(VP).GT.ABS(VS))GO TO 200
      IF(PHI(2).GE.0..AND.DPSI.GE.0..AND.ABS(VP).LT.ABS(VS))GO TO 99
      IF(PHI(2).GE.0..AND.DPSI.GE.0..AND.ABS(VP).EQ.ABS(VS))GO TO 99
      IF(PHI(2).LE.0..AND.DPSI.GE.0.)GO TO 200
      IF(PHI(2).GE.0..AND.DPSI.LE.0.)GO TO 99
      IF(PHI(2).LE.0..AND.DPSI.LE.0..AND.ABS(VP).GT.ABS(VS))GO TO 99

      IF(PHI(2).LE.0..AND.DPSI.LE.0..AND.ABS(VP).LT.ABS(VS))GO TO 200

      IF(PHI(2).LE.0..AND.DPSI.LE.0..AND.ABS(VP).EQ.ABS(VS))GO TO 99
 9999 STOP
      END
```

```
      SUBROUTINE FCT(T,PHI,DPHI)
      REAL IP,IS,LAMBDA,K
      COMMON A,B,C,R,ALPHR,PI,TORK,COFR,IP,IS,EREST,LAMBDA,DELTA,
     1PHITOT,PHIPR
      DIMENSION PHI(2),DPHI(2),PRMT(5)
      H=2.*(B*COS(ALPHR)+A*COS(PHI(1)-ALPHR))
      K=A**2+B**2+R**2-C**2+2.*B*R*SIN(ALPHR)+2.*A*B
     1*COS(PHI(1))-2.*A*R*SIN(PHI(1)-ALPHR)
      GONE=(-H+SQRT(H**2-4.*K))/2.
      GTWO=(-H-SQRT(H**2-4.*K))/2.
      IF(ABS(GONE).LT.ABS(GTWO))GO TO 10
      G=GTWO
      GO TO 11
   10 G=GONE
   11 P=B*SIN(PHI(1))+G*SIN(PHI(1)-ALPHR)+R*COS(PHI(1)-ALPHR)
      Q=B*COS(PHI(1))+G*COS(PHI(1)-ALPHR)-R*SIN(PHI(1)-ALPHR)
      S=G+B*COS(ALPHR)+A*COS(PHI(1)-ALPHR)
      GDOT=PHI(2)*A*P/S
      PSI=ASIN(P/C)
      IF(PSI.LT.0.)GO TO 12
      GO TO 13
   12 PSI=2.*PI-ABS(PSI)
   13 AONE=B*COS(ALPHR)+G
      BONE=B*SIN(ALPHR)
      CONE=R+C*SIN(PHI(1)-ALPHR-PSI)
      DONE=C*COS(PHI(1)-ALPHR-PSI)
      IF(GDOT.EQ.0.)GO TO 20
      GO TO 30
   20 EONE=DONE
      FONE=AONE
      GO TO 40
   30 EONE=DONE-COFR*CONE*GDOT/ABS(GDOT)
      FONE=AONE+COFR*BONE*GDOT/ABS(GDOT)
   40 CONTINUE
      U=(Q+SIN(PHI(1)-ALPHR)*P*A/S)/(C*COS(PSI))
      V=(Q+A*P*SIN(PHI(1)-ALPHR)/S)**2*TAN(PSI)/(C**2*
     1(COS(PSI))**2)+(1./(C*COS(PSI)))*(2.*A*P*COS(PHI(1)-ALPHR)/S
     2-P+2.*A**2*P*(SIN(PHI(1)-ALPHR))**2/S**2+A*Q*SIN(PHI(1)
     3-ALPHR)/S-A**2*P**2*SIN(PHI(1)-ALPHR)/S**3)
      W=(IP*V/EONE)/(IP*U/EONE+IS/FONE)
      Y=(TORK/FONE)/(IP*U/EONE+IS/FONE)
      DPHI(1)=PHI(2)
      DPHI(2)=Y-W*PHI(2)**2
      RETURN
      END
```

```
      SUBROUTINE OUTP(T,PHI,DPHI,IHLF,NDIM,PRMT)
      REAL IP,IS,LAMBDA,K
      DIMENSION PHI(2),DPHI(5),PRMT(5)
      COMMON A,B,C,R,ALPHR,PI,TORK,COFR,IP,IS,EREST,LAMBDA,DELTA,
     1PHITOT,PHIPR
      COMMON/ZETA/PSI,TIME,G,DPSI,DPSIP
      Z=180./PI
      IF(T.EQ.0.)DPSIP=0.
      PHID=PHI(1)*Z
C
C COMPUTE PSID
C
      DELPHI = PHID - PHIPR
      PHITOT = PHITOT + DELPHI
      PHIPR = PHID
      H=2.*(B*COS(ALPHR)+A*COS(PHI(1)-ALPHR))
      K=A**2+B**2+R**2-C**2+2.*B*R*SIN(ALPHR)+2.*A*B
     1*COS(PHI(1))-2.*A*R*SIN(PHI(1)-ALPHR)
      GONE=(-H+SQRT(H**2-4.*K))/2.
      GTWO=(-H-SQRT(H**2-4.*K))/2.
      IF(ABS(GONE).LT.ABS(GTWO))GO TO 1
      G=GTWO
      GO TO 2
    1 G=GONE
    2 P=B*SIN(PHI(1))+G*SIN(PHI(1)-ALPHR)+R*COS(PHI(1)-ALPHR)
      PSI=ASIN(P/C)
      IF(PSI.LT.0.)PSI=2.*PI-ABS(PSI)
      PSID=PSI*Z
C
C COMPUTE DPSI
C
      S=G+B*COS(ALPHR)+A*COS(PHI(1)-ALPHR)
      GDOT=PHI(2)*A*P/S
      Q=B*COS(PHI(1))+G*COS(PHI(1)-ALPHR)-R*SIN(PHI(1)-ALPHR)
      DPSI=(PHI(2)*Q+GDOT*SIN(PHI(1)-ALPHR))/(C*COS(PSI))
C
C TEST FOR CONTINATION OF COUPLED MOTION
C
      IF(T.EQ.TIME)GO TO 4
      IF(T.EQ. 0.)GO TO 4
      IF(.NOT.(G.LT. 0. .AND. ((ABS(DPSI).GT. ABS(DPSIP) .AND. PHI(2)
     1.GT. 0.) .OR. (ABS(DPSI).LT.ABS(DPSIP) .AND. PHI(2) .LT. 0.)).AND.
     2T.NE.0.))PRMT(5) = 1.
      IF(ABS(DPSI) .LT. 1.)PRMT(5) = 0.
C
C WRITE OUTPUT
C
    4 WRITE(6,3)T,PHID,PHI(2),G,GDOT,PSID,DPSI,PHITOT
    3 FORMAT(* *,5X,*T=*,F8.5,3X,*PHI=*,F8.3,3X,*PHIDOT=*,F8.3,3X,
     1*G=*,F9.4,3X,*GDOT=*,F8.3,3X,*PSID=*,F8.3,3X,*PSIDOT=*,F8.3,
     13X,*PHITOT =*,F8.3)
    5 DPSIP=DPSI
      TIME=T
```

```
                    RETURN
   55               END
```

```
      SUBROUTINE IMPACT(PHI,DPHI,PSI,DPSI)
      COMMON A,B,C,R,ALPHR,PI,TORK,COFR,IP,IS,EREST,LAMBDA,DELTA,
     1PHITOT,PHIPR
      REAL IP,IS,LAMBDA,K
      H=2.*(B*COS(ALPHR)+A*COS(PHI-ALPHR))
      K=A**2+B**2+R**2-C**2+2.*B*R*SIN(ALPHR)+2.*A*B*COS(PHI)-
     12.*A*R*SIN(PHI-ALPHR)
      GONE=(-H+SQRT(H**2-4.*K))/2.
      GTWO=(-H-SQRT(H**2-4.*K))/2.
      IF(ABS(GONE).LT.ABS(GTWO))GO TO 1
      G=GTWO
      GO TO 2
    1 G=GONE
    2 AONE=B*COS(ALPHR)+G
      DONE=C*COS(PHI-ALPHR-PSI)
      DPHIIN=DPHI
      DPSIIN=DPSI
      DPHIF=(IP*AONE*DPSIIN+IS*DONE*DPHIIN+IP*AONE*EREST/DONE*(DPSIIN
     1*DONE-DPHIIN*AONE))/(IP*AONE**2/DONE+IS*DONE)
      DPSIF=(DPHIF*AONE-EREST*(DPSIIN*DONE-DPHIIN*AONE))/DONE
      PHID=PHI*180./PI
      PSID=PSI*180./PI
      WRITE(6,3)
    3 FORMAT(*0*,5X,*IMPACT*)
      WRITE(6,5)PHID,DPHIF,PSID,DPSIF,PHITOT
    5 FORMAT(*0*,18X,*PHI=*,F8.3,3X,*DPHIF=*,F8.3,3X,*PSI=*,F8.3,3X,
     1*DPSIF=*,F8.3,3X,*PHITOT=*,F8.3)
      DPHI=DPHIF
      DPSI=DPSIF
    6 RETURN
      END
```

```
      SUBROUTINE FREE(TIME,PHI,DPHI,PSI,DPSI)
      REAL IP,IS,LAMBDA,K
      COMMON A,B,C,R,ALPHR,PI,TORK,COFR,IP,IS,EREST,LAMBDA,DELTA,
     1PHITOT,PHIPR
      T=TIME
      Z=PI/180.
C
C  RECORD INITIAL VALUES
C
      PHIIN=PHI
      DPHIIN=DPHI
      PSIIN=PSI
      DPSIIN = DPSI
      WRITE(6,5)
    5 FORMAT(*0*,5X,*FREE MOTION*)
C
C  STARWHEEL MOTION
C
    1 PHI=TORK/(2.*IS)*(T-TIME)*(T-TIME)+DPHIIN*(T-TIME)+PHIIN
      PHID=PHI/Z
      DELPHI=PHID-PHIPR
      PHITOT = PHITOT + DELPHI
      PHIPR = PHID
      DPHI=TORK/IS*(T-TIME)+DPHIIN
C
C  PALLET MOTION
C
      PSI = DPSIIN*(T-TIME) + PSIIN
      DPSI = DPSIIN
      PSID=PSI/Z
C
C  OUTPUT
C
      WRITE(6,2)T,PHID,DPHI,PSID,DPSI,PHITOT
    2 FORMAT(* *,5X,*T=*,F8.5,3X,*PHI=*,F8.3,3X,*PHDOT=*,F8.3,3X,
     1*PSI=*,F8.3,3X,*PSIDOT=*,F8.3,3X,*PHITOT =*,F8.3)
    9 IF(T.EQ.TIME)GO TO 3
C
C  CHECK FOR CONTINUED FREE MOTION
C
      F=A*SIN(PHI-ALPHR)-B*SIN(ALPHR)-C*SIN(PHI-ALPHR-PSI)-R
      GP=C*COS(PHI-ALPHR-PSI)-B*COS(ALPHR)-A*COS(PHI-ALPHR)
      IF(F.LE.0.)GO TO 4
C
C  CHECK FOR TOP OR BOTTOM ACTION
C
      IF(GP.LE.0.)GO TO 3
      PHID=PHI/Z
      IF(PHID.LE.150.)GO TO 6
      GO TO 7
    6 PHI=PHI+DELTA*Z
      PHIPR = PHI/Z
      PSI=PSI+2.*PI-LAMBDA*Z
```

```
      PSIIN = PSIIN + 2.*PI-LAMBDA*Z
      PHIIN = PHIIN + DELTA*7
      GO TO 3
    7 PHI=PHI-DELT'*Z*2.
      PHIPR = PHI/Z
      PSI=PSI-2.*PI+LAMBDA*Z
      PHIIN = PHIIN - DELTA*7*2.
      PSIIN = PSIIN -  2.*PI+LAMBDA*Z
C
C  INCREMENT TIME
C
    3 T=T+.00001
C
C  CONTINUE FREE MOTION
C
      GO TO 1
C
C  END OF FRFE MOTION
C
    4 TIME=T
      RETURN
      END
```

APPENDIX H

SOME GEOMETRIC RELATIONSHIP

DETERMINATION OF g_{MAX}

Figure H-1 shows the geometrical relationship between the pallet pin of radius r and the right hand escape-wheel tooth when the quantity g (equation (A12) in appendix A) reaches its maximum possible absolute value. The following relationship holds between the angles α and β:

$$\alpha = \beta - \frac{\delta}{2} \tag{H1}$$

where

$$\delta = \frac{360}{N} \tag{H2}$$

and N stands for the number of teeth on the escape-wheel.

The distance $\overline{ST}$ of the triangle OST is determined with the help of the sine law:

$$\overline{ST} = b\,\frac{\sin(\delta/2)}{\sin(\pi - \beta)} \tag{H3}$$

where b represents the escape-wheel radius.

Finally, g_{MAX} is obtained from:

$$g_{MAX} = \overline{ST} - \frac{r}{\tan\beta} \tag{H4}$$

To use g_{MAX} in connection with expressions derived in appendix A, it must be furnished with a minus sign to conform to the origin of the $\overline{n}_t - \overline{n}_n$ system.

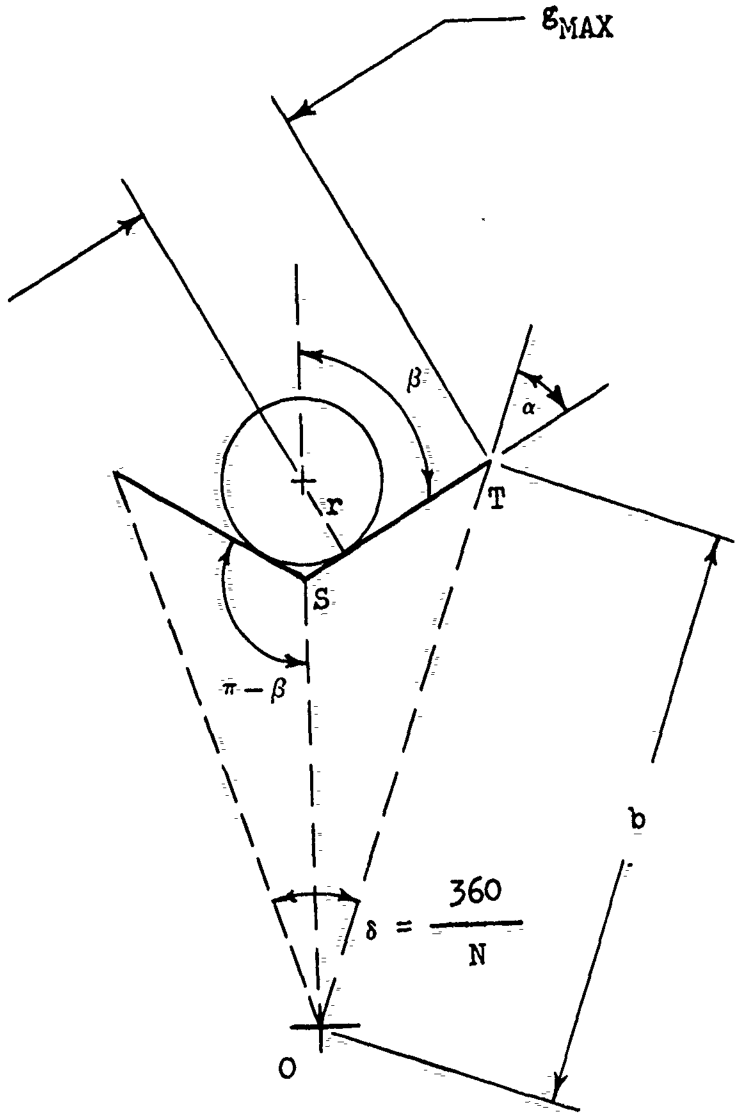

Figure H1. Configuration for g_{MAX}

DETERMINATION OF ESCAPE-WHEEL ANGLE φ_M CORRESPONDING TO $g = g_{MAX}$

The angle $\varphi = \varphi_M$, which corresponds to the maximum possible value of $g = g_{MAX}$, is obtained with the help of equation (A11) of appendix A:

$$g^2_{MAX} + g_{MAX}[2b\cos\alpha + 2a\cos(\varphi_M - \alpha)]$$
$$+ [a^2 + b^2 + r^2 - c^2 + 2br\sin\alpha + 2ab\cos\varphi_M - 2ar\sin(\varphi_M - \alpha)]$$
$$= 0 \tag{H5}$$

After the expansion of the trigonometric terms $\cos(\varphi_M - \alpha)$ and $\sin(\varphi_M - \alpha)$, the following expression results:

$$L\sin\varphi_M + M\cos\varphi_M + N = 0 \tag{H6}$$

where

$$L = 2a(g_{MAX}\sin\alpha - r\cos\alpha)$$

$$M = 2a(g_{MAX}\cos\alpha + b + r\sin\alpha)$$

$$N = g^2_{MAX} + a^2 + b^2 + r^2 - c^2 + 2b(g_{MAX}\cos\alpha + r\sin\alpha)$$

Equation (H5) may now be rewritten with the help of the following trigonometric identities:

$$\sin\varphi_M = \frac{2\tan\left(\frac{\varphi_M}{2}\right)}{1 + \tan^2\left(\frac{\varphi_M}{2}\right)} \tag{H7}$$

$$\cos\varphi_M = \frac{1 - \tan^2\left(\frac{\varphi_M}{2}\right)}{1 + \tan^2\left(\frac{\varphi_M}{2}\right)} \tag{H8}$$

This leads to:

$$(N - M)\tan^2\left(\frac{\varphi_M}{2}\right) + 2L\tan\left(\frac{\varphi_M}{2}\right) + (M + N) = 0 \qquad \text{(H9)}$$

This expression may now be solved for the angle φ_M using the solution for a quadratic equation. Accordingly,

$$\varphi_M = 2\tan^{-1}\left[\frac{-L \pm \sqrt{L^2 - N^2 + M^2}}{N - M}\right] \qquad \text{(H10)}$$

The two solutions correspond to top and bottom action.

DETERMINATION OF ESCAPE-WHEEL ANGLE φ CORRESPONDING TO $g = 0$

The angle $\varphi = \varphi_o$, which is associated with the instant when the pallet pin leaves the escape-wheel tooth during coupled motion, is obtained from equation (A11) with $g = 0$.

An expression similar to equation (H6) results:

$$L_o \sin\varphi_o + M_o \cos\varphi_o + N_o = 0 \qquad \text{(H11)}$$

where

$$L_o = -2ar\cos\alpha$$

$$M_o = 2a(b + r\sin\alpha)$$

$$N_o = a^2 + b^2 + r^2 - c^2 + 2br\sin\alpha$$

Equation (H11) is solved in the same manner as equation (H6).

This results in:

$$\varphi_o = 2\tan^{-1}\left[\frac{-L_o \pm \sqrt{L_o^2 - N_o^2 + M_o^2}}{N_o - M_o}\right] \qquad \text{(H12)}$$

Again, top and bottom action results are provided.

DISENGAGEMENT DISTANCE BETWEEN PALLET AND ESCAPE-WHEEL PIVOTS

Figure H-2 shows the disengagement configuration of the symmetrical pin pallet runaway escapement. The pallet angle ψ equals $\frac{\lambda}{2}$ when both pallet pins together are least advanced with respect to the escape-wheel. The center distance a is such that the escape-wheel radius b and the pallet pin radius r are collinear.

The disengagement center distance a_{dis} is determined with the help of the cosine law:

$$(b + r)^2 = a_{dis}^2 + c^2 - 2a_{dis}(c)\cos\left(\frac{\lambda}{2}\right) \tag{H13}$$

From the solution of the quadratic equation, one finds:

$$a_{dis} = (c)\cos\left(\frac{\lambda}{2}\right) + \sqrt{\left[(c)\cos\left(\frac{\lambda}{2}\right)\right]^2 - \left[c^2 - (b + r)^2\right]} \tag{H14}$$

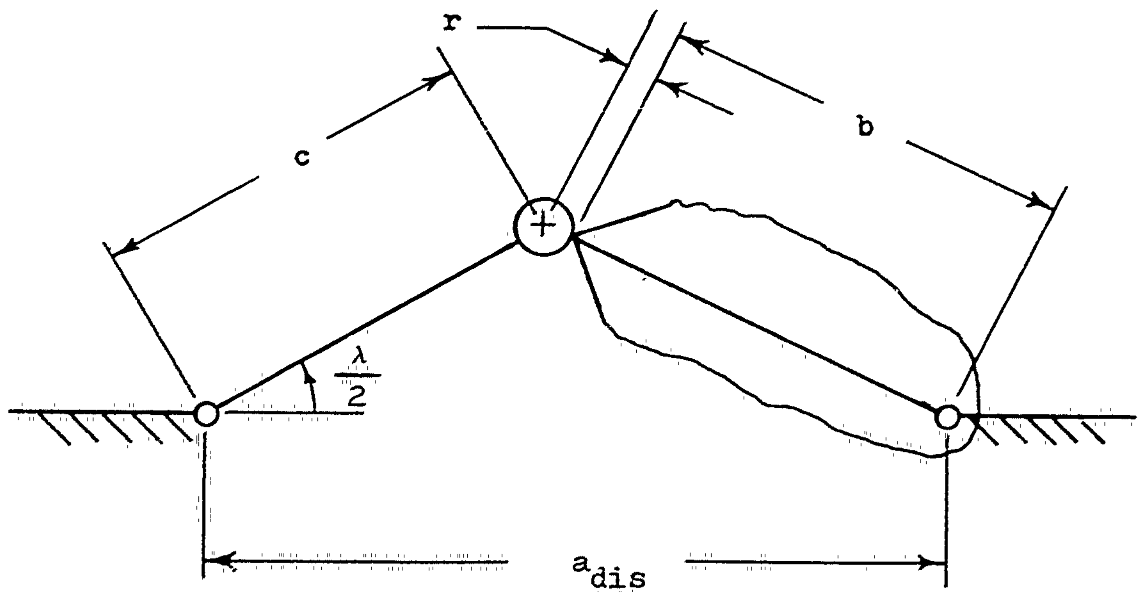

Figure H2. Disengagement condition

APPENDIX I

COMPUTER OUTPUT FOR STANDARD CONFIGURATION WITH $\mu = .3$ AND $\varepsilon = .25$

A= .19310 B= .15838 C= .09683 R= .01365 ALPHA= 40.0000

TORQUE= .17700E-01 COFR= .30000E+00 IPAL= .91000E-07 ISTAR= .17000E-07

EREST= .25 LAMBDA= 109.337 DELTA= 40.000

Appendix I
Std.Config.
$\mu = .3, c = .25$

Cycle No. 1

COUPLED MOTION

T=	PHI=	PHIDOT=	G=	GDOT=	PSID=	PSIDOT=	PHITOT =
0.00000	135.000	0.000	-.0457	0.000	42.412	0.000	-.000
.00000	135.000	.084	-.0457	.018	42.412	.108	.000
.00000	135.000	.151	-.0457	.032	42.412	.195	.000
.00000	135.000	.219	-.0457	.047	42.412	.281	.000
.00001	135.000	.286	-.0457	.061	42.412	.368	.000
.00001	135.000	.421	-.0457	.090	42.412	.542	.000
.00001	135.000	.556	-.0457	.119	42.412	.716	.000
.00002	135.000	.827	-.0457	.177	42.413	1.063	.000
.00002	135.001	1.097	-.0457	.235	42.413	1.410	.001
.00004	135.002	1.637	-.0457	.351	42.414	2.105	.002
.00005	135.003	2.177	-.0457	.467	42.416	2.800	.003
.00007	135.007	3.256	-.0456	.698	42.421	4.189	.007
.00010	135.012	4.335	-.0456	.930	42.428	5.579	.012
.00015	135.028	6.490	-.0456	1.392	42.448	8.357	.028
.00020	135.050	8.639	-.0455	1.854	42.476	11.134	.050
.00030	135.111	12.913	-.0453	2.774	42.556	16.686	.111
.00040	135.198	17.142	-.0449	3.688	42.667	22.232	.198
.00050	135.308	21.311	-.0445	4.594	42.811	27.771	.308
.00060	135.442	25.413	-.0440	5.491	42.986	33.300	.442
.00070	135.599	29.431	-.0434	6.376	43.192	38.819	.599
.00080	135.779	33.360	-.0427	7.250	43.430	44.326	.779
.00090	135.981	37.189	-.0420	8.109	43.700	49.819	.981
.00100	136.205	40.911	-.0411	8.954	44.001	55.298	1.205
.00110	136.449	44.522	-.0402	9.784	44.334	60.762	1.449
.00120	136.715	48.019	-.0392	10.597	44.697	66.211	1.715
.00130	136.999	51.397	-.0381	11.394	45.092	71.642	1.999
.00140	137.303	54.659	-.0369	12.173	45.519	77.058	2.303
.00150	137.626	57.804	-.0356	12.935	45.975	82.457	2.626
.00160	137.966	60.833	-.0343	13.680	46.463	87.840	2.966
.00170	138.322	63.759	-.0329	14.408	46.982	93.207	3.322
.00180	138.696	66.559	-.0314	15.118	47.531	98.559	3.696
.00190	139.085	69.261	-.0299	15.812	48.111	103.895	4.085
.00200	139.489	71.864	-.0282	16.489	48.722	109.220	4.489
.00210	139.908	74.372	-.0266	17.150	49.363	114.532	4.908
.00220	140.341	76.790	-.0248	17.794	50.034	119.832	5.341
.00230	140.788	79.125	-.0230	18.424	50.736	125.123	5.788
.00240	141.248	81.381	-.0211	19.038	51.468	130.405	6.248
.00250	141.721	83.564	-.0192	19.637	52.230	135.680	6.721
.00260	142.205	85.681	-.0172	20.221	53.023	140.950	7.205
.00270	142.702	87.740	-.0152	20.792	53.845	146.216	7.702
.00280	143.211	89.741	-.0131	21.349	54.698	151.480	8.211
.00290	143.731	91.692	-.0109	21.892	55.581	156.743	8.731
.00300	144.261	93.599	-.0087	22.421	56.494	162.008	9.261
.00310	144.803	95.463	-.0064	22.938	57.438	167.275	9.803
.00320	145.355	97.292	-.0041	23.441	58.411	172.547	10.355
.00330	145.918	99.099	-.0017	23.931	59.415	177.825	10.918

```
T= .00340  PHI= 186.491  PHIDOT= 100.859  G=   .0007  GDOT=  24.408  PSID=  60.449  PSIDOT= 183.111  PHITOT =  11.491

FREE MOTION
T= .00340  PHI= 186.491  PHDOT= 100.659  PSI= 311.112  PSIDOT= 183.111  PHITOT =  11.491
T= .00341  PHI= 186.551  PHDOT= 111.271  PSI= 311.217  PSIDOT= 183.111  PHITOT =  11.551
T= .00342  PHI= 186.618  PHDOT= 121.683  PSI= 311.322  PSIDOT= 183.111  PHITOT =  11.618
T= .00343  PHI= 186.691  PHDOT= 132.095  PSI= 311.427  PSIDOT= 183.111  PHITOT =  11.691
T= .00344  PHI= 186.770  PHDOT= 142.506  PSI= 311.532  PSIDOT= 183.111  PHITOT =  11.770
T= .00345  PHI= 186.854  PHDOT= 152.918  PSI= 311.637  PSIDOT= 183.111  PHITOT =  11.854
T= .00346  PHI= 186.945  PHDOT= 163.330  PSI= 311.742  PSIDOT= 183.111  PHITOT =  11.945
T= .00347  PHI= 187.041  PHDOT= 173.742  PSI= 311.846  PSIDOT= 183.111  PHITOT =  12.041
T= .00348  PHI= 187.144  PHDOT= 184.153  PSI= 311.951  PSIDOT= 183.111  PHITOT =  12.144
T= .00349  PHI= 187.252  PHDOT= 194.565  PSI= 312.056  PSIDOT= 183.111  PHITOT =  12.252
T= .00350  PHI= 187.367  PHDOT= 204.977  PSI= 312.161  PSIDOT= 183.111  PHITOT =  12.367
T= .00351  PHI= 187.487  PHDOT= 215.389  PSI= 312.266  PSIDOT= 183.111  PHITOT =  12.487
T= .00352  PHI= 187.614  PHDOT= 225.800  PSI= 312.371  PSIDOT= 183.111  PHITOT =  12.614
T= .00353  PHI= 187.746  PHDOT= 236.212  PSI= 312.476  PSIDOT= 183.111  PHITOT =  12.746
T= .00354  PHI= 187.884  PHDOT= 246.624  PSI= 312.581  PSIDOT= 183.111  PHITOT =  12.884
T= .00355  PHI= 188.029  PHDOT= 257.036  PSI= 312.686  PSIDOT= 183.111  PHITOT =  13.029
T= .00356  PHI= 188.179  PHDOT= 267.447  PSI= 312.791  PSIDOT= 183.111  PHITOT =  13.179

T= .00357  PHI= 188.335  PHDOT= 277.859  PSI= 312.896  PSIDOT= 183.111  PHITOT =  13.335
T= .00358  PHI= 188.497  PHDOT= 288.271  PSI= 313.001  PSIDOT= 183.111  PHITOT =  13.497
T= .00359  PHI= 188.665  PHDOT= 298.683  PSI= 313.105  PSIDOT= 183.111  PHITOT =  13.665
T= .00360  PHI= 188.840  PHDOT= 309.095  PSI= 313.210  PSIDOT= 183.111  PHITOT =  13.840
T= .00361  PHI= 189.020  PHDOT= 319.506  PSI= 313.315  PSIDOT= 183.111  PHITOT =  14.020
T= .00362  PHI= 189.206  PHDOT= 329.918  PSI= 313.420  PSIDOT= 183.111  PHITOT =  14.206
T= .00363  PHI= 189.398  PHDOT= 340.330  PSI= 313.525  PSIDOT= 183.111  PHITOT =  14.398
T= .00364  PHI= 189.596  PHDOT= 350.742  PSI= 313.630  PSIDOT= 183.111  PHITOT =  14.596
T= .00365  PHI= 189.800  PHDOT= 361.153  PSI= 313.735  PSIDOT= 183.111  PHITOT =  14.800
T= .00366  PHI= 190.010  PHDOT= 371.565  PSI= 313.840  PSIDOT= 183.111  PHITOT =  15.010
T= .00367  PHI= 190.225  PHDOT= 381.977  PSI= 313.945  PSIDOT= 183.111  PHITOT =  15.225
T= .00368  PHI= 190.447  PHDOT= 392.389  PSI= 314.050  PSIDOT= 183.111  PHITOT =  15.447
T= .00369  PHI= 190.675  PHDOT= 402.800  PSI= 314.155  PSIDOT= 183.111  PHITOT =  15.675
T= .00370  PHI= 190.909  PHDOT= 413.212  PSI= 314.260  PSIDOT= 183.111  PHITOT =  15.909
T= .00371  PHI= 191.149  PHDOT= 423.624  PSI= 314.364  PSIDOT= 183.111  PHITOT =  16.149
T= .00372  PHI= 191.394  PHDOT= 434.036  PSI= 314.469  PSIDOT= 183.111  PHITOT =  16.394
T= .00373  PHI= 191.646  PHDOT= 444.447  PSI= 314.574  PSIDOT= 183.111  PHITOT =  16.646
T= .00374  PHI= 191.904  PHDOT= 454.859  PSI= 314.679  PSIDOT= 183.111  PHITOT =  16.904
T= .00375  PHI= 192.167  PHDOT= 465.271  PSI= 314.784  PSIDOT= 183.111  PHITOT =  17.167
T= .00376  PHI= 192.437  PHDOT= 475.683  PSI= 314.889  PSIDOT= 183.111  PHITOT =  17.437
T= .00377  PHI= 192.712  PHDOT= 486.095  PSI= 314.994  PSIDOT= 183.111  PHITOT =  17.712
T= .00378  PHI= 192.994  PHDOT= 496.506  PSI= 315.099  PSIDOT= 183.111  PHITOT =  17.994
T= .00379  PHI= 193.281  PHDOT= 506.918  PSI= 315.204  PSIDOT= 183.111  PHITOT =  18.281
T= .00380  PHI= 193.575  PHDOT= 517.330  PSI= 315.309  PSIDOT= 183.111  PHITOT =  18.575
T= .00381  PHI= 193.874  PHDOT= 527.742  PSI= 315.414  PSIDOT= 183.111  PHITOT =  18.874
T= .00382  PHI= 194.179  PHDOT= 538.153  PSI= 315.518  PSIDOT= 183.111  PHITOT =  19.179
VP= -16.798   VS=  44.239

IMPACT

           PHI= 194.179  DPHIF=-214.794  PSI= 315.518  DPSIF=  26.138  PHITOT=  19.179
VP=  -2.398   VS= -17.657

FREE MOTION
T= .00382  PHI= 194.179  PHDOT=-214.794  PSI= 315.518  PSIDOT=  26.138  PHITOT =  19.179
T= .00383  PHI= 194.059  PHDOT=-204.382  PSI= 315.533  PSIDOT=  26.138  PHITOT =  19.059
VP=  -2.400   VS= -16.740

FREE MOTION
T= .00383  PHI= 194.059  PHDOT=-204.382  PSI= 315.533  PSIDOT=  26.138  PHITOT =  19.059
T= .00384  PHI= 193.945  PHDOT=-193.970  PSI= 315.546  PSIDOT=  26.138  PHITOT =  18.945
VP=  -2.402   VS= -15.832

FREE MOTION
T= .00384  PHI= 193.945  PHDOT=-193.970  PSI= 315.548  PSIDOT=  26.138  PHITOT =  18.945
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T= .00385	PHI= 193.837	PHIDOT=-183.559	PSI= 315.543	PSIDOT= 26.134	PHITOT = 18.837
T= .00386	PHI= 193.735	PHIDOT=-173.147	PSI= 315.578	PSIDOT= 26.133	PHITOT = 18.735
T= .00387	PHI= 193.639	PHIDOT=-162.735	PSI= 315.593	PSIDOT= 26.133	PHITOT = 18.639
T= .00388	PHI= 193.548	PHIDOT=-152.323	PSI= 315.608	PSIDOT= 26.133	PHITOT = 18.548
T= .00389	PHI= 193.464	PHIDOT=-141.912	PSI= 315.623	PSIDOT= 26.133	PHITOT = 18.464
T= .00390	PHI= 193.386	PHIDOT=-131.500	PSI= 315.638	PSIDOT= 26.133	PHITOT = 18.386
T= .00391	PHI= 193.313	PHIDOT=-121.088	PSI= 315.653	PSIDOT= 26.133	PHITOT = 18.313
T= .00392	PHI= 193.247	PHIDOT=-110.676	PSI= 315.668	PSIDOT= 26.133	PHITOT = 18.247
T= .00393	PHI= 193.187	PHIDOT=-100.265	PSI= 315.683	PSIDOT= 26.133	PHITOT = 18.187
T= .00394	PHI= 193.132	PHIDOT= -89.853	PSI= 315.698	PSIDOT= 26.133	PHITOT = 18.132
T= .00395	PHI= 193.084	PHIDOT= -79.441	PSI= 315.713	PSIDOT= 26.133	PHITOT = 18.084
T= .00396	PHI= 193.041	PHIDOT= -69.029	PSI= 315.728	PSIDOT= 26.133	PHITOT = 18.041
T= .00397	PHI= 193.004	PHIDOT= -58.617	PSI= 315.743	PSIDOT= 26.133	PHITOT = 18.004
T= .00398	PHI= 192.974	PHIDOT= -48.206	PSI= 315.758	PSIDOT= 26.133	PHITOT = 17.974
T= .00399	PHI= 192.949	PHIDOT= -37.794	PSI= 315.773	PSIDOT= 26.133	PHITOT = 17.949
T= .00400	PHI= 192.931	PHIDOT= -27.382	PSI= 315.788	PSIDOT= 26.133	PHITOT = 17.931
T= .00401	PHI= 192.918	PHIDOT= -16.970	PSI= 315.803	PSIDOT= 26.133	PHITOT = 17.918
T= .00402	PHI= 192.911	PHIDOT= -6.559	PSI= 315.818	PSIDOT= 26.133	PHITOT = 17.911
T= .00403	PHI= 192.910	PHIDOT= 3.853	PSI= 315.833	PSIDOT= 26.133	PHITOT = 17.910
T= .00404	PHI= 192.916	PHIDOT= 14.265	PSI= 315.848	PSIDOT= 26.133	PHITOT = 17.916
T= .00405	PHI= 192.927	PHIDOT= 24.677	PSI= 315.863	PSIDOT= 26.133	PHITOT = 17.927
T= .00406	PHI= 192.944	PHIDOT= 35.088	PSI= 315.878	PSIDOT= 26.133	PHITOT = 17.944
T= .00407	PHI= 192.967	PHIDOT= 45.500	PSI= 315.893	PSIDOT= 26.133	PHITOT = 17.967
T= .00408	PHI= 192.996	PHIDOT= 55.912	PSI= 315.908	PSIDOT= 26.133	PHITOT = 17.996
T= .00409	PHI= 193.031	PHIDOT= 66.324	PSI= 315.923	PSIDOT= 26.133	PHITOT = 18.031
T= .00410	PHI= 193.072	PHIDOT= 76.735	PSI= 315.938	PSIDOT= 26.133	PHITOT = 18.072
T= .00411	PHI= 193.119	PHIDOT= 87.147	PSI= 315.953	PSIDOT= 26.133	PHITOT = 18.119
T= .00412	PHI= 193.172	PHIDOT= 97.559	PSI= 315.968	PSIDOT= 26.133	PHITOT = 18.172
T= .00413	PHI= 193.231	PHIDOT= 107.971	PSI= 315.983	PSIDOT= 26.133	PHITOT = 18.231
T= .00414	PHI= 193.296	PHIDOT= 118.383	PSI= 315.998	PSIDOT= 26.133	PHITOT = 18.296
T= .00415	PHI= 193.366	PHIDOT= 128.794	PSI= 316.013	PSIDOT= 26.133	PHITOT = 18.366

VP= -2.416 VS= 10.328

IMPACT

PHI= 193.366 DPHIF= -312.360 PSI= 316.013 DPSIF= -8.130 PHITOT= 18.366

VP= .751 VS= -2.435

COUPLED MOTION

T= .00415	PHI= 193.366	PHIDOT= -32.369	G= -.0411	GDOT= -4.266	PSID= 316.007	PSIDOT= 26.343	PHITOT = 18.366
T= .00417	PHI= 193.328	PHIDOT= -22.673	G= -.0412	GDOT= -3.183	PSID= 316.046	PSIDOT= 19.642	PHITOT = 18.328
T= .00420	PHI= 193.301	PHIDOT= -14.955	G= -.0413	GDOT= -2.098	PSID= 316.063	PSIDOT= 12.942	PHITOT = 18.301
T= .00421	PHI= 193.292	PHIDOT= -11.033	G= -.0413	GDOT= -1.555	PSID= 316.071	PSIDOT= 9.592	PHITOT = 18.292
T= .00422	PHI= 193.286	PHIDOT= -7.213	G= -.0413	GDOT= -1.012	PSID= 316.077	PSIDOT= 6.262	PHITOT = 18.286
T= .00423	PHI= 193.283	PHIDOT= -5.281	G= -.0413	GDOT= -.741	PSID= 316.079	PSIDOT= 4.567	PHITOT = 18.283
T= .00424	PHI= 193.282	PHIDOT= -3.349	G= -.0413	GDOT= -.469	PSID= 316.080	PSIDOT= 2.892	PHITOT = 18.282
T= .00424	PHI= 193.281	PHIDOT= -2.374	G= -.0413	GDOT= -.333	PSID= 316.081	PSIDOT= 2.055	PHITOT = 18.281
T= .00424	PHI= 193.281	PHIDOT= -1.407	G= -.0413	GDOT= -.197	PSID= 316.081	PSIDOT= 1.217	PHITOT = 18.281
T= .00425	PHI= 193.281	PHIDOT= -.923	G= -.0413	GDOT= -.129	PSID= 316.081	PSIDOT= .798	PHITOT = 18.281
T= .00425	PHI= 193.281	PHIDOT= -.439	G= -.0413	GDOT= -.062	PSID= 316.081	PSIDOT= .380	PHITOT = 18.281
T= .00425	PHI= 193.281	PHIDOT= -.197	G= -.0413	GDOT= -.028	PSID= 316.081	PSIDOT= .170	PHITOT = 18.281
T= .00425	PHI= 193.281	PHIDOT= .025	G= -.0413	GDOT= .003	PSID= 316.081	PSIDOT= -.022	PHITOT = 18.281
T= .00425	PHI= 193.281	PHIDOT= .144	G= -.0413	GDOT= .020	PSID= 316.081	PSIDOT= -.125	PHITOT = 18.281
T= .00425	PHI= 193.281	PHIDOT= .265	G= -.0413	GDOT= .037	PSID= 316.081	PSIDOT= -.229	PHITOT = 18.281
T= .00425	PHI= 193.281	PHIDOT= .503	G= -.0413	GDOT= .070	PSID= 316.081	PSIDOT= -.435	PHITOT = 18.281
T= .00425	PHI= 193.281	PHIDOT= .741	G= -.0413	GDOT= .104	PSID= 316.081	PSIDOT= -.641	PHITOT = 18.281
T= .00425	PHI= 193.281	PHIDOT= .980	G= -.0413	GDOT= .137	PSID= 316.081	PSIDOT= -.847	PHITOT = 18.281
T= .00426	PHI= 193.281	PHIDOT= 1.219	G= -.0413	GDOT= .171	PSID= 316.081	PSIDOT= -1.054	PHITOT = 18.281
T= .00426	PHI= 193.281	PHIDOT= 1.696	G= -.0413	GDOT= .238	PSID= 316.081	PSIDOT= -1.467	PHITOT = 18.281
T= .00426	PHI= 193.282	PHIDOT= 2.174	G= -.0413	GDOT= .305	PSID= 316.080	PSIDOT= -1.880	PHITOT = 18.282
T= .00427	PHI= 193.283	PHIDOT= 3.129	G= -.0413	GDOT= .439	PSID= 316.079	PSIDOT= -2.706	PHITOT = 18.283
T= .00427	PHI= 193.284	PHIDOT= 4.084	G= -.0413	GDOT= .573	PSID= 316.078	PSIDOT= -3.532	PHITOT = 18.284
T= .00429	PHI= 193.287	PHIDOT= 5.993	G= -.0413	GDOT= .840	PSID= 316.075	PSIDOT= -5.183	PHITOT = 18.287

T=	.00430	PHI=	193.292	PHIDOT=	7.901	G=	-.0412	GDOT=	1.108	PSID=	316.071	PSIDOT=	-6.835	PHITOT =	18.292
T=	.00432	PHI=	193.306	PHIDOT=	11.712	G=	-.0413	GDOT=	1.643	PSID=	316.059	PSIDOT=	-10.137	PHITOT =	18.306
T=	.00435	PHI=	193.326	PHIDOT=	15.513	G=	-.0412	GDOT=	2.178	PSID=	316.042	PSIDOT=	-13.439	PHITOT =	18.326
T=	.00440	PHI=	193.361	PHIDOT=	23.072	G=	-.0411	GDOT=	3.244	PSID=	315.994	PSIDOT=	-20.037	PHITOT =	18.361
T=	.00445	PHI=	193.458	PHIDOT=	30.573	G=	-.0409	GDOT=	4.306	PSID=	315.927	PSIDOT=	-26.627	PHITOT =	18.458
T=	.00450	PHI=	193.556	PHIDOT=	37.973	G=	-.0407	GDOT=	5.363	PSID=	315.841	PSIDOT=	-33.206	PHITOT =	18.556
T=	.00455	PHI=	193.676	PHIDOT=	45.258	G=	-.0404	GDOT=	6.411	PSID=	315.737	PSIDOT=	-39.770	PHITOT =	18.676
T=	.00465	PHI=	193.976	PHIDOT=	59.394	G=	-.0396	GDOT=	8.481	PSID=	315.473	PSIDOT=	-52.845	PHITOT =	18.976
T=	.00475	PHI=	194.355	PHIDOT=	72.822	G=	-.0387	GDOT=	10.506	PSID=	315.131	PSIDOT=	-65.826	PHITOT =	19.355
T=	.00485	PHI=	194.809	PHIDOT=	85.390	G=	-.0375	GDOT=	12.476	PSID=	314.717	PSIDOT=	-78.685	PHITOT =	19.809
T=	.00495	PHI=	195.331	PHIDOT=	96.971	G=	-.0362	GDOT=	14.382	PSID=	314.230	PSIDOT=	-91.392	PHITOT =	20.331
T=	.00505	PHI=	195.918	PHIDOT=	107.454	G=	-.0347	GDOT=	16.216	PSID=	313.670	PSIDOT=	-103.916	PHITOT =	20.918
T=	.00515	PHI=	196.561	PHIDOT=	116.754	G=	-.0329	GDOT=	17.971	PSID=	313.040	PSIDOT=	-116.222	PHITOT =	21.561
T=	.00525	PHI=	197.253	PHIDOT=	124.804	G=	-.0311	GDOT=	19.642	PSID=	312.339	PSIDOT=	-128.276	PHITOT =	22.253
T=	.00535	PHI=	197.988	PHIDOT=	131.564	G=	-.0290	GDOT=	21.223	PSID=	311.570	PSIDOT=	-140.042	PHITOT =	22.988
T=	.00545	PHI=	198.758	PHIDOT=	137.014	G=	-.0268	GDOT=	22.710	PSID=	310.735	PSIDOT=	-151.482	PHITOT =	23.758
T=	.00555	PHI=	199.556	PHIDOT=	141.156	G=	-.0245	GDOT=	24.101	PSID=	309.835	PSIDOT=	-162.562	PHITOT =	24.556
T=	.00565	PHI=	200.373	PHIDOT=	144.013	G=	-.0220	GDOT=	25.392	PSID=	308.873	PSIDOT=	-173.248	PHITOT =	25.373
T=	.00575	PHI=	201.204	PHIDOT=	145.627	G=	-.0194	GDOT=	26.582	PSID=	307.851	PSIDOT=	-183.506	PHITOT =	26.204
T=	.00585	PHI=	202.040	PHIDOT=	146.056	G=	-.0167	GDOT=	27.671	PSID=	306.771	PSIDOT=	-193.307	PHITOT =	27.040
T=	.00595	PHI=	202.875	PHIDOT=	145.370	G=	-.0139	GDOT=	28.656	PSID=	305.637	PSIDOT=	-202.626	PHITOT =	27.875
T=	.00605	PHI=	203.704	PHIDOT=	143.654	G=	-.0110	GDOT=	29.540	PSID=	304.450	PSIDOT=	-211.440	PHITOT =	28.704
T=	.00615	PHI=	204.520	PHIDOT=	141.000	G=	-.0080	GDOT=	30.323	PSID=	303.215	PSIDOT=	-219.732	PHITOT =	29.520
T=	.00625	PHI=	205.318	PHIDOT=	137.505	G=	-.0049	GDOT=	31.006	PSID=	301.933	PSIDOT=	-227.487	PHITOT =	30.318
T=	.00635	PHI=	206.094	PHIDOT=	133.270	G=	-.0018	GDOT=	31.591	PSID=	300.609	PSIDOT=	-234.697	PHITOT =	31.094
T=	.00645	PHI=	206.844	PHIDOT=	128.397	G=	.0014	GDOT=	32.082	PSID=	299.245	PSIDOT=	-241.357	PHITOT =	31.844

FREE MOTION

T=	.00645	PHI=	126.844	PHDOT=	128.397	PSI=	48.582	PSIDOT=	-241.357	PHITOT =	31.844
T=	.00646	PHI=	126.920	PHDOT=	138.808	PSI=	48.444	PSIDOT=	-241.357	PHITOT =	31.920
T=	.00647	PHI=	127.003	PHDOT=	149.220	PSI=	48.305	PSIDOT=	-241.357	PHITOT =	32.003
T=	.00648	PHI=	127.091	PHDOT=	159.632	PSI=	48.167	PSIDOT=	-241.357	PHITOT =	32.091
T=	.00649	PHI=	127.186	PHDOT=	170.044	PSI=	48.029	PSIDOT=	-241.357	PHITOT =	32.186
T=	.00650	PHI=	127.286	PHDOT=	180.456	PSI=	47.890	PSIDOT=	-241.357	PHITOT =	32.286
T=	.00651	PHI=	127.393	PHDOT=	190.867	PSI=	47.752	PSIDOT=	-241.357	PHITOT =	32.393
T=	.00652	PHI=	127.505	PHDOT=	201.279	PSI=	47.614	PSIDOT=	-241.357	PHITOT =	32.505
T=	.00653	PHI=	127.623	PHDOT=	211.691	PSI=	47.476	PSIDOT=	-241.357	PHITOT =	32.623
T=	.00654	PHI=	127.747	PHDOT=	222.103	PSI=	47.337	PSIDOT=	-241.357	PHITOT =	32.747
T=	.00655	PHI=	127.878	PHDOT=	232.514	PSI=	47.199	PSIDOT=	-241.357	PHITOT =	32.878
T=	.00656	PHI=	128.014	PHDOT=	242.926	PSI=	47.061	PSIDOT=	-241.357	PHITOT =	33.014
T=	.00657	PHI=	128.156	PHDOT=	253.338	PSI=	46.922	PSIDOT=	-241.357	PHITOT =	33.156
T=	.00658	PHI=	128.304	PHDOT=	263.750	PSI=	46.784	PSIDOT=	-241.357	PHITOT =	33.304
T=	.00659	PHI=	128.458	PHDOT=	274.161	PSI=	46.646	PSIDOT=	-241.357	PHITOT =	33.458
T=	.00660	PHI=	128.618	PHDOT=	284.573	PSI=	46.507	PSIDOT=	-241.357	PHITOT =	33.618
T=	.00661	PHI=	128.784	PHDOT=	294.985	PSI=	46.369	PSIDOT=	-241.357	PHITOT =	33.784
T=	.00662	PHI=	128.956	PHDOT=	305.397	PSI=	46.231	PSIDOT=	-241.357	PHITOT =	33.956
T=	.00663	PHI=	129.134	PHDOT=	315.808	PSI=	46.093	PSIDOT=	-241.357	PHITOT =	34.134
T=	.00664	PHI=	129.318	PHDOT=	326.220	PSI=	45.954	PSIDOT=	-241.357	PHITOT =	34.318
T=	.00665	PHI=	129.508	PHDOT=	336.632	PSI=	45.816	PSIDOT=	-241.357	PHITOT =	34.508
T=	.00666	PHI=	129.704	PHDOT=	347.044	PSI=	45.678	PSIDOT=	-241.357	PHITOT =	34.704
T=	.00667	PHI=	129.906	PHDOT=	357.456	PSI=	45.539	PSIDOT=	-241.357	PHITOT =	34.906
T=	.00668	PHI=	130.114	PHDOT=	367.867	PSI=	45.401	PSIDOT=	-241.357	PHITOT =	35.114
T=	.00669	PHI=	130.327	PHDOT=	378.279	PSI=	45.263	PSIDOT=	-241.357	PHITOT =	35.327
T=	.00670	PHI=	130.547	PHDOT=	388.691	PSI=	45.125	PSIDOT=	-241.357	PHITOT =	35.547
T=	.00671	PHI=	130.773	PHDOT=	399.103	PSI=	44.986	PSIDOT=	-241.357	PHITOT =	35.773
T=	.00672	PHI=	131.004	PHDOT=	409.514	PSI=	44.848	PSIDOT=	-241.357	PHITOT =	36.004
T=	.00673	PHI=	131.242	PHDOT=	419.926	PSI=	44.710	PSIDOT=	-241.357	PHITOT =	36.242
T=	.00674	PHI=	131.486	PHDOT=	430.338	PSI=	44.571	PSIDOT=	-241.357	PHITOT =	36.486
T=	.00675	PHI=	131.735	PHDOT=	440.750	PSI=	44.433	PSIDOT=	-241.357	PHITOT =	36.735
T=	.00676	PHI=	131.991	PHDOT=	451.161	PSI=	44.295	PSIDOT=	-241.357	PHITOT =	36.991
T=	.00677	PHI=	132.252	PHDOT=	461.573	PSI=	44.157	PSIDOT=	-241.357	PHITOT =	37.252
T=	.00678	PHI=	132.520	PHDOT=	471.985	PSI=	44.018	PSIDOT=	-241.357	PHITOT =	37.520
T=	.00679	PHI=	132.793	PHDOT=	482.397	PSI=	43.880	PSIDOT=	-241.357	PHITOT =	37.793

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   T=  .00680   PHI= 133.072   PHDOT= 492.808   PSI=  43.742   PSIDOT=-241.357   PHITOT =  38.072
   T=  .00681   PHI= 133.358   PHDOT= 503.220   PSI=  43.603   PSIDOT=-241.357   PHITOT =  38.358
   T=  .00682   PHI= 133.649   PHDOT= 513.632   PSI=  43.465   PSIDOT=-241.357   PHITOT =  38.649
   T=  .00683   PHI= 133.946   PHDOT= 524.044   PSI=  43.327   PSIDOT=-241.357   PHITOT =  38.946
   T=  .00684   PHI= 134.250   PHDOT= 534.456   PSI=  43.189   PSIDOT=-241.357   PHITOT =  39.250
   T=  .00685   PHI= 134.559   PHDOT= 544.867   PSI=  43.050   PSIDOT=-241.357   PHITOT =  39.559
   T=  .00686   PHI= 134.874   PHDOT= 555.279   PSI=  42.912   PSIDOT=-241.357   PHITOT =  39.874
   T=  .00687   PHI= 135.195   PHDOT= 565.691   PSI=  42.774   PSIDOT=-241.357   PHITOT =  40.195
   T=  .00688   PHI= 135.522   PHDOT= 576.103   PSI=  42.635   PSIDOT=-241.357   PHITOT =  40.522
VP= -14.102   VS=  44.718

   IMPACT     Cycle No. 2

                PHI= 135.522   DPHIF=-280.455   PSI=  42.635   DPSIF=-120.910   PHITOT=  40.522
VP=  -7.064   VS= -21.769

   FREE MOTION
   T=  .00688   PHI= 135.522   PHDOT=-280.455   PSI=  42.635   PSIDOT=-120.910   PHITOT =  40.522
   T=  .00689   PHI= 135.365   PHDOT=-270.043   PSI=  42.566   PSIDOT=-120.910   PHITOT =  40.365
VP=  -7.079   VS= -20.800

   FREE MOTION
   T=  .00689   PHI= 135.365   PHDOT=-270.043   PSI=  42.566   PSIDOT=-120.910   PHITOT =  40.365
   T=  .00690   PHI= 135.213   PHDOT=-259.631   PSI=  42.497   PSIDOT=-120.910   PHITOT =  40.213
VP=  -7.092   VS= -19.850

   FREE MOTION
   T=  .00690   PHI= 135.213   PHDOT=-259.631   PSI=  42.497   PSIDOT=-120.910   PHITOT =  40.213
   T=  .00691   PHI= 135.067   PHDOT=-249.220   PSI=  42.428   PSIDOT=-120.910   PHITOT =  40.067
VP=  -7.105   VS= -18.918

   FREE MOTION
   T=  .00691   PHI= 135.067   PHDOT=-249.220   PSI=  42.428   PSIDOT=-120.910   PHITOT =  40.067
   T=  .00692   PHI= 134.927   PHDOT=-238.808   PSI=  42.358   PSIDOT=-120.910   PHITOT =  39.927
   T=  .00693   PHI= 134.793   PHDOT=-228.396   PSI=  42.289   PSIDOT=-120.910   PHITOT =  39.793
   T=  .00694   PHI= 134.665   PHDOT=-217.984   PSI=  42.220   PSIDOT=-120.910   PHITOT =  39.665
   T=  .00695   PHI= 134.544   PHDOT=-207.573   PSI=  42.151   PSIDOT=-120.910   PHITOT =  39.544
   T=  .00696   PHI= 134.428   PHDOT=-197.161   PSI=  42.081   PSIDOT=-120.910   PHITOT =  39.428
   T=  .00697   PHI= 134.318   PHDOT=-186.749   PSI=  42.012   PSIDOT=-120.910   PHITOT =  39.318

   T=  .00698   PHI= 134.214   PHDOT=-176.337   PSI=  41.943   PSIDOT=-120.910   PHITOT =  39.214
   T=  .00699   PHI= 134.116   PHDOT=-165.926   PSI=  41.873   PSIDOT=-120.910   PHITOT =  39.116
   T=  .00700   PHI= 134.023   PHDOT=-155.514   PSI=  41.804   PSIDOT=-120.910   PHITOT =  39.023
   T=  .00701   PHI= 133.937   PHDOT=-145.102   PSI=  41.735   PSIDOT=-120.910   PHITOT =  38.937
   T=  .00702   PHI= 133.857   PHDOT=-134.690   PSI=  41.666   PSIDOT=-120.910   PHITOT =  38.857
   T=  .00703   PHI= 133.783   PHDOT=-124.278   PSI=  41.596   PSIDOT=-120.910   PHITOT =  38.783
   T=  .00704   PHI= 133.715   PHDOT=-113.867   PSI=  41.527   PSIDOT=-120.910   PHITOT =  38.715
   T=  .00705   PHI= 133.653   PHDOT=-103.455   PSI=  41.458   PSIDOT=-120.910   PHITOT =  38.653
   T=  .00706   PHI= 133.596   PHDOT= -93.043   PSI=  41.388   PSIDOT=-120.910   PHITOT =  38.596
   T=  .00707   PHI= 133.546   PHDOT= -82.631   PSI=  41.319   PSIDOT=-120.910   PHITOT =  38.546
   T=  .00708   PHI= 133.502   PHDOT= -72.220   PSI=  41.250   PSIDOT=-120.910   PHITOT =  38.502
   T=  .00709   PHI= 133.463   PHDOT= -61.808   PSI=  41.181   PSIDOT=-120.910   PHITOT =  38.463
   T=  .00710   PHI= 133.431   PHDOT= -51.396   PSI=  41.111   PSIDOT=-120.910   PHITOT =  38.431
   T=  .00711   PHI= 133.404   PHDOT= -40.984   PSI=  41.042   PSIDOT=-120.910   PHITOT =  38.404
   T=  .00712   PHI= 133.384   PHDOT= -30.573   PSI=  40.973   PSIDOT=-120.910   PHITOT =  38.384
   T=  .00713   PHI= 133.369   PHDOT= -20.161   PSI=  40.904   PSIDOT=-120.910   PHITOT =  38.369
   T=  .00714   PHI= 133.361   PHDOT=  -9.749   PSI=  40.834   PSIDOT=-120.910   PHITOT =  38.361
   T=  .00715   PHI= 133.358   PHDOT=    .663   PSI=  40.765   PSIDOT=-120.910   PHITOT =  38.358
   T=  .00716   PHI= 133.361   PHDOT=  11.074   PSI=  40.696   PSIDOT=-120.910   PHITOT =  38.361
   T=  .00717   PHI= 133.371   PHDOT=  21.486   PSI=  40.626   PSIDOT=-120.910   PHITOT =  38.371
   T=  .00718   PHI= 133.386   PHDOT=  31.898   PSI=  40.557   PSIDOT=-120.910   PHITOT =  38.386
   T=  .00719   PHI= 133.407   PHDOT=  42.310   PSI=  40.488   PSIDOT=-120.910   PHITOT =  38.407
   T=  .00720   PHI= 133.435   PHDOT=  52.722   PSI=  40.419   PSIDOT=-120.910   PHITOT =  38.435
VP=  -7.043   VS=   3.684

   IMPACT
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 VP= -5.503   VS= -8.185  PHI= 133.435   DPHIF=-117.116   PSI=  40.419   DPSIF= -94.464   PHITOT=  38.435

      FREE MOTION
      T=  .00720   PHI= 133.435   PHDOT=-117.116   PSI=  40.419   PSIDOT= -94.464   PHITOT =  38.435
      T=  .00721   PHI= 133.370   PHDOT=-106.704   PSI=  40.366   PSIDOT= -94.464   PHITOT =  38.370
 VP= -5.504   VS= -7.432

      FREE MOTION
      T=  .00721   PHI= 133.370   PHDOT=-106.704   PSI=  40.364   PSIDOT= -94.464   PHITOT =  38.370
      T=  .00722   PHI= 133.312   PHDOT= -96.292   PSI=  40.310   PSIDOT= -94.464   PHITOT =  38.312
 VP= -5.505   VS= -6.687

      FREE MOTION
      T=  .00722   PHI= 133.312   PHDOT= -96.292   PSI=  40.310   PSIDOT= -94.464   PHITOT =  38.312
      T=  .00723   PHI= 133.260   PHDOT= -85.880   PSI=  40.256   PSIDOT= -94.464   PHITOT =  38.260
 VP= -5.506   VS= -5.947

      FREE MOTION
      T=  .00723   PHI= 133.260   PHDOT= -85.880   PSI=  40.256   PSIDOT= -94.464   PHITOT =  38.260
      T=  .00724   PHI= 133.214   PHDOT= -75.468   PSI=  40.202   PSIDOT= -94.464   PHITOT =  38.214
 VP= -5.503   VS= -5.214

      IMPACT

 VP= -5.461   VS= -5.533  PHI= 133.214   DPHIF= -80.092   PSI=  40.202   DPSIF= -93.736   PHITOT=  38.214

      COUPLED MOTION
      T=  .00724   PHI= 133.214   PHIDOT= -80.092   G=  -.0522   GDOT= -16.592   PSID=  40.204   PSIDOT= -94.974   PHITOT =  38.214
      T=  .00734   PHI= 132.830   PHIDOT= -53.464   G=  -.0536   GDOT= -10.990   PSID=  39.754   PSIDOT= -62.227   PHITOT =  37.830
      T=  .00744   PHI= 132.604   PHIDOT= -25.344   G=  -.0544   GDOT=  -5.186   PSID=  39.492   PSIDOT= -29.172   PHITOT =  37.604
      T=  .00746   PHI= 132.573   PHIDOT= -18.176   G=  -.0545   GDOT=  -3.715   PSID=  39.456   PSIDOT= -20.880   PHITOT =  37.573
      T=  .00749   PHI= 132.552   PHIDOT= -10.961   G=  -.0546   GDOT=  -2.240   PSID=  39.432   PSIDOT= -12.582   PHITOT =  37.552
      T=  .00750   PHI= 132.545   PHIDOT=  -7.344   G=  -.0546   GDOT=  -1.501   PSID=  39.424   PSIDOT=  -8.432   PHITOT =  37.545
      T=  .00751   PHI= 132.541   PHIDOT=  -3.731   G=  -.0547   GDOT=   -.762   PSID=  39.420   PSIDOT=  -4.281   PHITOT =  37.541
      T=  .00752   PHI= 132.540   PHIDOT=  -1.922   G=  -.0547   GDOT=   -.393   PSID=  39.419   PSIDOT=  -2.205   PHITOT =  37.540
      T=  .00753   PHI= 132.540   PHIDOT=   -.113   G=  -.0547   GDOT=   -.023   PSID=  39.418   PSIDOT=   -.129   PHITOT =  37.540
      T=  .00753   PHI= 132.540   PHIDOT=    .091   G=  -.0547   GDOT=    .019   PSID=  39.418   PSIDOT=    .105   PHITOT =  37.540
      T=  .00753   PHI= 132.540   PHIDOT=    .171   G=  -.0547   GDOT=    .035   PSID=  39.418   PSIDOT=    .196   PHITOT =  37.540
      T=  .00753   PHI= 132.540   PHIDOT=    .251   G=  -.0547   GDOT=    .051   PSID=  39.418   PSIDOT=    .288   PHITOT =  37.540
      T=  .00753   PHI= 132.540   PHIDOT=    .331   G=  -.0547   GDOT=    .068   PSID=  39.418   PSIDOT=    .379   PHITOT =  37.540
      T=  .00754   PHI= 132.540   PHIDOT=    .491   G=  -.0547   GDOT=    .100   PSID=  39.418   PSIDOT=    .562   PHITOT =  37.540
      T=  .00754   PHI= 132.540   PHIDOT=    .650   G=  -.0547   GDOT=    .133   PSID=  39.418   PSIDOT=    .745   PHITOT =  37.540
      T=  .00755   PHI= 132.541   PHIDOT=    .969   G=  -.0547   GDOT=    .198   PSID=  39.419   PSIDOT=   1.111   PHITOT =  37.541
      T=  .00755   PHI= 132.541   PHIDOT=   1.288   G=  -.0547   GDOT=    .263   PSID=  39.419   PSIDOT=   1.477   PHITOT =  37.541
      T=  .00756   PHI= 132.542   PHIDOT=   1.607   G=  -.0547   GDOT=    .328   PSID=  39.420   PSIDOT=   1.843   PHITOT =  37.542
      T=  .00756   PHI= 132.542   PHIDOT=   1.926   G=  -.0547   GDOT=    .393   PSID=  39.421   PSIDOT=   2.209   PHITOT =  37.542
      T=  .00758   PHI= 132.544   PHIDOT=   2.563   G=  -.0546   GDOT=    .524   PSID=  39.422   PSIDOT=   2.941   PHITOT =  37.544
      T=  .00759   PHI= 132.546   PHIDOT=   3.201   G=  -.0546   GDOT=    .654   PSID=  39.425   PSIDOT=   3.673   PHITOT =  37.546
      T=  .00761   PHI= 132.551   PHIDOT=   4.476   G=  -.0546   GDOT=    .915   PSID=  39.431   PSIDOT=   5.137   PHITOT =  37.551
      T=  .00764   PHI= 132.559   PHIDOT=   5.749   G=  -.0546   GDOT=   1.175   PSID=  39.439   PSIDOT=   6.601   PHITOT =  37.559
      T=  .00769   PHI= 132.579   PHIDOT=   8.284   G=  -.0545   GDOT=   1.695   PSID=  39.463   PSIDOT=   9.527   PHITOT =  37.579
      T=  .00774   PHI= 132.606   PHIDOT=  10.818   G=  -.0544   GDOT=   2.213   PSID=  39.494   PSIDOT=  12.453   PHITOT =  37.606
      T=  .00779   PHI= 132.641   PHIDOT=  13.335   G=  -.0543   GDOT=   2.730   PSID=  39.534   PSIDOT=  15.376   PHITOT =  37.641
      T=  .00784   PHI= 132.683   PHIDOT=  15.836   G=  -.0542   GDOT=   3.245   PSID=  39.582   PSIDOT=  18.297   PHITOT =  37.683
      T=  .00794   PHI= 132.787   PHIDOT=  20.777   G=  -.0538   GDOT=   4.267   PSID=  39.704   PSIDOT=  24.131   PHITOT =  37.787
      T=  .00804   PHI= 132.920   PHIDOT=  25.620   G=  -.0533   GDOT=   5.276   PSID=  39.859   PSIDOT=  29.952   PHITOT =  37.920
      T=  .00814   PHI= 133.081   PHIDOT=  30.347   G=  -.0527   GDOT=   6.270   PSID=  40.047   PSIDOT=  35.756   PHITOT =  38.081
      T=  .00824   PHI= 133.268   PHIDOT=  34.941   G=  -.0520   GDOT=   7.246   PSID=  40.268   PSIDOT=  41.540   PHITOT =  38.268
      T=  .00834   PHI= 133.481   PHIDOT=  39.387   G=  -.0513   GDOT=   8.203   PSID=  40.523   PSIDOT=  47.303   PHITOT =  38.481
      T=  .00844   PHI= 133.719   PHIDOT=  43.675   G=  -.0504   GDOT=   9.139   PSID=  40.810   PSIDOT=  53.043   PHITOT =  38.719
      T=  .00854   PHI= 133.981   PHIDOT=  47.798   G=  -.0494   GDOT=  10.053   PSID=  41.131   PSIDOT=  58.756   PHITOT =  38.981
      T=  .00864   PHI= 134.266   PHIDOT=  51.749   G=  -.0484   GDOT=  10.944   PSID=  41.484   PSIDOT=  64.442   PHITOT =  39.266
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T=	.00874	PHI=	134.574	PHIDOT=	55.527	G=	-.0473	GDOT=	11.811	PSID=	41.869	PSIDOT=	70.100	PHITOT =	39.574
T=	.00884	PHI=	134.902	PHIDOT=	59.132	G=	-.0460	GDOT=	12.654	PSID=	42.287	PSIDOT=	75.729	PHITOT =	39.902
T=	.00894	PHI=	135.251	PHIDOT=	62.565	G=	-.0447	GDOT=	13.472	PSID=	42.737	PSIDOT=	81.328	PHITOT =	40.251
T=	.00904	PHI=	135.619	PHIDOT=	65.831	G=	-.0433	GDOT=	14.267	PSID=	43.219	PSIDOT=	86.897	PHITOT =	40.619
T=	.00914	PHI=	136.005	PHIDOT=	68.934	G=	-.0419	GDOT=	15.038	PSID=	43.733	PSIDOT=	92.437	PHITOT =	41.005
T=	.00924	PHI=	136.409	PHIDOT=	71.883	G=	-.0403	GDOT=	15.786	PSID=	44.278	PSIDOT=	97.948	PHITOT =	41.409
T=	.00934	PHI=	136.829	PHIDOT=	74.685	G=	-.0387	GDOT=	16.512	PSID=	44.855	PSIDOT=	103.431	PHITOT =	41.829
T=	.00944	PHI=	137.264	PHIDOT=	77.348	G=	-.0370	GDOT=	17.216	PSID=	45.463	PSIDOT=	108.886	PHITOT =	42.264
T=	.00954	PHI=	137.715	PHIDOT=	79.881	G=	-.0353	GDOT=	17.899	PSID=	46.103	PSIDOT=	114.317	PHITOT =	42.715
T=	.00964	PHI=	138.179	PHIDOT=	82.294	G=	-.0335	GDOT=	18.562	PSID=	46.773	PSIDOT=	119.723	PHITOT =	43.179
T=	.00974	PHI=	138.657	PHIDOT=	84.595	G=	-.0316	GDOT=	19.206	PSID=	47.474	PSIDOT=	125.106	PHITOT =	43.657
T=	.00984	PHI=	139.148	PHIDOT=	86.795	G=	-.0296	GDOT=	19.831	PSID=	48.207	PSIDOT=	130.470	PHITOT =	44.148
T=	.00994	PHI=	139.652	PHIDOT=	88.902	G=	-.0276	GDOT=	20.438	PSID=	48.969	PSIDOT=	135.815	PHITOT =	44.652
T=	.01004	PHI=	140.167	PHIDOT=	90.924	G=	-.0255	GDOT=	21.029	PSID=	49.763	PSIDOT=	141.143	PHITOT =	45.167
T=	.01014	PHI=	140.694	PHIDOT=	92.874	G=	-.0234	GDOT=	21.603	PSID=	50.587	PSIDOT=	146.458	PHITOT =	45.694
T=	.01024	PHI=	141.231	PHIDOT=	94.754	G=	-.0212	GDOT=	22.162	PSID=	51.441	PSIDOT=	151.761	PHITOT =	46.231
T=	.01034	PHI=	141.779	PHIDOT=	96.575	G=	-.0190	GDOT=	22.706	PSID=	52.326	PSIDOT=	157.055	PHITOT =	46.779
T=	.01044	PHI=	142.338	PHIDOT=	98.343	G=	-.0167	GDOT=	23.235	PSID=	53.241	PSIDOT=	162.341	PHITOT =	47.338
T=	.01054	PHI=	142.906	PHIDOT=	100.065	G=	-.0143	GDOT=	23.750	PSID=	54.186	PSIDOT=	167.622	PHITOT =	47.906
T=	.01064	PHI=	143.484	PHIDOT=	101.747	G=	-.0119	GDOT=	24.252	PSID=	55.162	PSIDOT=	172.901	PHITOT =	48.484
T=	.01074	PHI=	144.072	PHIDOT=	103.394	G=	-.0095	GDOT=	24.740	PSID=	56.167	PSIDOT=	178.179	PHITOT =	49.072
T=	.01084	PHI=	144.669	PHIDOT=	105.013	G=	-.0070	GDOT=	25.214	PSID=	57.203	PSIDOT=	183.459	PHITOT =	49.669
T=	.01094	PHI=	145.275	PHIDOT=	106.607	G=	-.0044	GDOT=	25.676	PSID=	58.270	PSIDOT=	188.742	PHITOT =	50.275
T=	.01104	PHI=	145.891	PHIDOT=	108.181	G=	-.0018	GDOT=	26.124	PSID=	59.366	PSIDOT=	194.031	PHITOT =	50.891
T=	.01114	PHI=	146.515	PHIDOT=	109.739	G=	.0008	GDOT=	26.559	PSID=	60.493	PSIDOT=	199.328	PHITOT =	51.515

FREE MOTION

T=	.01114	PHI=	186.515	PHDOT=	109.739	PSI=	311.156	PSIDOT=	199.328	PHITOT =	51.515
T=	.01115	PHI=	186.581	PHDOT=	120.151	PSI=	311.270	PSIDOT=	199.328	PHITOT =	51.581
T=	.01116	PHI=	186.653	PHDOT=	130.563	PSI=	311.385	PSIDOT=	199.328	PHITOT =	51.653
T=	.01117	PHI=	186.730	PHDOT=	140.974	PSI=	311.499	PSIDOT=	199.328	PHITOT =	51.730
T=	.01118	PHI=	186.814	PHDOT=	151.386	PSI=	311.613	PSIDOT=	199.328	PHITOT =	51.814
T=	.01119	PHI=	186.904	PHDOT=	161.798	PSI=	311.727	PSIDOT=	199.328	PHITOT =	51.904
T=	.01120	PHI=	187.000	PHDOT=	172.210	PSI=	311.841	PSIDOT=	199.328	PHITOT =	52.000
T=	.01121	PHI=	187.101	PHDOT=	182.621	PSI=	311.956	PSIDOT=	199.328	PHITOT =	52.101
T=	.01122	PHI=	187.209	PHDOT=	193.033	PSI=	312.070	PSIDOT=	199.328	PHITOT =	52.209
T=	.01123	PHI=	187.322	PHDOT=	203.445	PSI=	312.184	PSIDOT=	199.328	PHITOT =	52.322
T=	.01124	PHI=	187.442	PHDOT=	213.857	PSI=	312.298	PSIDOT=	199.328	PHITOT =	52.442
T=	.01125	PHI=	187.568	PHDOT=	224.268	PSI=	312.412	PSIDOT=	199.328	PHITOT =	52.568
T=	.01126	PHI=	187.699	PHDOT=	234.680	PSI=	312.527	PSIDOT=	199.328	PHITOT =	52.699
T=	.01127	PHI=	187.836	PHDOT=	245.092	PSI=	312.641	PSIDOT=	199.328	PHITOT =	52.836
T=	.01128	PHI=	187.980	PHDOT=	255.504	PSI=	312.755	PSIDOT=	199.328	PHITOT =	52.980
T=	.01129	PHI=	188.129	PHDOT=	265.915	PSI=	312.869	PSIDOT=	199.328	PHITOT =	53.129
T=	.01130	PHI=	188.285	PHDOT=	276.327	PSI=	312.984	PSIDOT=	199.328	PHITOT =	53.285
T=	.01131	PHI=	188.446	PHDOT=	286.739	PSI=	313.098	PSIDOT=	199.328	PHITOT =	53.446
T=	.01132	PHI=	188.613	PHDOT=	297.151	PSI=	313.212	PSIDOT=	199.328	PHITOT =	53.613
T=	.01133	PHI=	188.786	PHDOT=	307.563	PSI=	313.326	PSIDOT=	199.328	PHITOT =	53.786
T=	.01134	PHI=	188.966	PHDOT=	317.974	PSI=	313.440	PSIDOT=	199.328	PHITOT =	53.966
T=	.01135	PHI=	189.151	PHDOT=	328.386	PSI=	313.555	PSIDOT=	199.328	PHITOT =	54.151
T=	.01136	PHI=	189.342	PHDOT=	338.798	PSI=	313.669	PSIDOT=	199.328	PHITOT =	54.342
T=	.01137	PHI=	189.539	PHDOT=	349.210	PSI=	313.783	PSIDOT=	199.328	PHITOT =	54.539
T=	.01138	PHI=	189.742	PHDOT=	359.621	PSI=	313.897	PSIDOT=	199.328	PHITOT =	54.742
T=	.01139	PHI=	189.951	PHDOT=	370.033	PSI=	314.011	PSIDOT=	199.328	PHITOT =	54.951
T=	.01140	PHI=	190.166	PHDOT=	380.445	PSI=	314.126	PSIDOT=	199.328	PHITOT =	55.166
T=	.01141	PHI=	190.387	PHDOT=	390.857	PSI=	314.240	PSIDOT=	199.328	PHITOT =	55.387
T=	.01142	PHI=	190.614	PHDOT=	401.268	PSI=	314.354	PSIDOT=	199.328	PHITOT =	55.614
T=	.01143	PHI=	190.847	PHDOT=	411.680	PSI=	314.468	PSIDOT=	199.328	PHITOT =	55.847
T=	.01144	PHI=	191.086	PHDOT=	422.092	PSI=	314.582	PSIDOT=	199.328	PHITOT =	56.086
T=	.01145	PHI=	191.331	PHDOT=	432.504	PSI=	314.697	PSIDOT=	199.328	PHITOT =	56.331
T=	.01146	PHI=	191.581	PHDOT=	442.915	PSI=	314.811	PSIDOT=	199.328	PHITOT =	56.581
T=	.01147	PHI=	191.838	PHDOT=	453.327	PSI=	314.925	PSIDOT=	199.328	PHITOT =	56.838
T=	.01148	PHI=	192.101	PHDOT=	463.739	PSI=	315.039	PSIDOT=	199.328	PHITOT =	57.101
T=	.01149	PHI=	192.370	PHDOT=	474.151	PSI=	315.153	PSIDOT=	199.328	PHITOT =	57.370
T=	.01150	PHI=	192.644	PHDOT=	484.563	PSI=	315.268	PSIDOT=	199.328	PHITOT =	57.644
T=	.01151	PHI=	192.925	PHDOT=	494.974	PSI=	315.382	PSIDOT=	199.328	PHITOT =	57.925
T=	.01152	PHI=	193.211	PHDOT=	505.386	PSI=	315.496	PSIDOT=	199.328	PHITOT =	58.211

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        T=  .01153   PHI= 193.504   PHDOT= 515.798   PSI= 315.610   PSIDOT= 199.328   PHITOT =  58.504
        T=  .01154   PHI= 193.802   PHDOT= 526.210   PSI= 315.724   PSIDOT= 199.328   PHITOT =  58.802
  VP= -18.348   VS=  42.763

        IMPACT

                     PHI= 193.802   DPHIF=-232.037   PSI= 315.724   DPSIF=  38.881   PHITOT=  58.802
  VP=  -3.579   VS= -18.857

        FREE MOTION
        T=  .01154   PHI= 193.802   PHDOT=-232.037   PSI= 315.724   PSIDOT=  38.881   PHITOT =  58.802
        T=  .01155   PHI= 193.672   PHDOT=-221.626   PSI= 315.747   PSIDOT=  38.881   PHITOT =  58.672
  VP=  -3.542   VS= -17.939

        FREE MOTION
        T=  .01155   PHI= 193.672   PHDOT=-221.626   PSI= 315.747   PSIDOT=  38.881   PHITOT =  58.672
        T=  .01156   PHI= 193.548   PHDOT=-211.214   PSI= 315.769   PSIDOT=  38.881   PHITOT =  58.548
        T=  .01157   PHI= 193.430   PHDOT=-200.802   PSI= 315.791   PSIDOT=  38.881   PHITOT =  58.430
        T=  .01158   PHI= 193.318   PHDOT=-190.390   PSI= 315.814   PSIDOT=  38.881   PHITOT =  58.318
        T=  .01159   PHI= 193.212   PHDOT=-179.979   PSI= 315.836   PSIDOT=  38.881   PHITOT =  58.212
        T=  .01160   PHI= 193.112   PHDOT=-169.567   PSI= 315.858   PSIDOT=  38.881   PHITOT =  58.112
        T=  .01161   PHI= 193.018   PHDOT=-159.155   PSI= 315.880   PSIDOT=  38.881   PHITOT =  58.018
        T=  .01162   PHI= 192.930   PHDOT=-148.743   PSI= 315.903   PSIDOT=  38.881   PHITOT =  57.930
        T=  .01163   PHI= 192.848   PHDOT=-138.332   PSI= 315.925   PSIDOT=  38.881   PHITOT =  57.848
        T=  .01164   PHI= 192.771   PHDOT=-127.920   PSI= 315.947   PSIDOT=  38.881   PHITOT =  57.771
        T=  .01165   PHI= 192.701   PHDOT=-117.508   PSI= 315.970   PSIDOT=  38.881   PHITOT =  57.701
        T=  .01166   PHI= 192.637   PHDOT=-107.096   PSI= 315.992   PSIDOT=  38.881   PHITOT =  57.637
        T=  .01167   PHI= 192.578   PHDOT= -96.685   PSI= 316.014   PSIDOT=  38.881   PHITOT =  57.578
        T=  .01168   PHI= 192.526   PHDOT= -86.273   PSI= 316.036   PSIDOT=  38.881   PHITOT =  57.526
        T=  .01169   PHI= 192.479   PHDOT= -75.861   PSI= 316.059   PSIDOT=  38.881   PHITOT =  57.479
        T=  .01170   PHI= 192.439   PHDOT= -65.449   PSI= 316.081   PSIDOT=  38.881   PHITOT =  57.439
        T=  .01171   PHI= 192.404   PHDOT= -55.037   PSI= 316.103   PSIDOT=  38.881   PHITOT =  57.404

        T=  .01172   PHI= 192.376   PHDOT= -44.626   PSI= 316.125   PSIDOT=  38.881   PHITOT =  57.376
        T=  .01173   PHI= 192.353   PHDOT= -34.214   PSI= 316.148   PSIDOT=  38.881   PHITOT =  57.353
        T=  .01174   PHI= 192.337   PHDOT= -23.802   PSI= 316.170   PSIDOT=  38.881   PHITOT =  57.337
        T=  .01175   PHI= 192.326   PHDOT= -13.390   PSI= 316.192   PSIDOT=  38.881   PHITOT =  57.326
        T=  .01176   PHI= 192.321   PHDOT=  -2.979   PSI= 316.215   PSIDOT=  38.881   PHITOT =  57.321
        T=  .01177   PHI= 192.323   PHDOT=   7.433   PSI= 316.237   PSIDOT=  38.881   PHITOT =  57.323
        T=  .01178   PHI= 192.330   PHDOT=  17.845   PSI= 316.259   PSIDOT=  38.881   PHITOT =  57.330
        T=  .01179   PHI= 192.343   PHDOT=  28.257   PSI= 316.281   PSIDOT=  38.881   PHITOT =  57.343
        T=  .01180   PHI= 192.362   PHDOT=  38.668   PSI= 316.304   PSIDOT=  38.881   PHITOT =  57.362
        T=  .01181   PHI= 192.387   PHDOT=  49.080   PSI= 316.326   PSIDOT=  38.881   PHITOT =  57.387
        T=  .01182   PHI= 192.418   PHDOT=  59.492   PSI= 316.348   PSIDOT=  38.881   PHITOT =  57.418
        T=  .01183   PHI= 192.455   PHDOT=  69.904   PSI= 316.371   PSIDOT=  38.881   PHITOT =  57.455
        T=  .01184   PHI= 192.498   PHDOT=  80.315   PSI= 316.393   PSIDOT=  38.881   PHITOT =  57.498
        T=  .01185   PHI= 192.547   PHDOT=  90.727   PSI= 316.415   PSIDOT=  38.881   PHITOT =  57.547
        T=  .01186   PHI= 192.602   PHDOT= 101.139   PSI= 316.437   PSIDOT=  38.881   PHITOT =  57.602
        T=  .01187   PHI= 192.663   PHDOT= 111.551   PSI= 316.460   PSIDOT=  38.881   PHITOT =  57.663
        T=  .01188   PHI= 192.730   PHDOT= 121.963   PSI= 316.482   PSIDOT=  38.881   PHITOT =  57.730
        T=  .01189   PHI= 192.803   PHDOT= 132.374   PSI= 316.504   PSIDOT=  38.881   PHITOT =  57.803
  VP=  -3.614   VS=  10.434

        IMPACT

                     PHI= 192.803   DPHIF= -44.468   PSI= 316.504   DPSIF=   -.073   PHITOT=  57.803

  VP=    .007   VS=  -3.505

        FREE MOTION
        T=  .01189   PHI= 192.803   PHDOT= -44.468   PSI= 316.504   PSIDOT=   -.073   PHITOT =  57.803
        T=  .01190   PHI= 192.781   PHDOT= -34.057   PSI= 316.504   PSIDOT=   -.073   PHITOT =  57.781
        T=  .01191   PHI= 192.764   PHDOT= -23.645   PSI= 316.504   PSIDOT=   -.073   PHITOT =  57.764
        T=  .01192   PHI= 192.754   PHDOT= -13.233   PSI= 316.504   PSIDOT=   -.073   PHITOT =  57.754
        T=  .01193   PHI= 192.749   PHDOT=  -2.821   PSI= 316.504   PSIDOT=   -.073   PHITOT =  57.749
        T=  .01194   PHI= 192.750   PHDOT=   7.590   PSI= 316.504   PSIDOT=   -.073   PHITOT =  57.750
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T=  .01195   PHI= 192.758   PHDOT=  18.002   PSI= 316.504   PSIDOT=   -.073   PHITOT =  57.758
T=  .01196   PHI= 192.771   PHDOT=  28.414   PSI= 316.504   PSIDOT=   -.073   PHITOT =  57.771
T=  .01197   PHI= 192.790   PHDOT=  38.826   PSI= 316.504   PSIDOT=   -.073   PHITOT =  57.790
  VP=   .007   VS=   3.059

IMPACT

             PHI= 192.790   DPHIF=     .393   PSI= 316.504   DPSIF=  -8.543   PHITOT=  57.790
  VP=   .794   VS=    .031

COUPLED MOTION
T=  .01197   PHI= 192.790   PHIDOT=     .393   G=   -.0425   GDOT=     .054   PSID= 316.501   PSIDOT=    -.333   PHITOT =  57.790
T=  .01207   PHI= 192.838   PHIDOT=   16.179   G=   -.0424   GDOT=    2.243   PSID= 316.461   PSIDOT=  -13.741   PHITOT =  57.838

T=  .01217   PHI= 192.975   PHIDOT=   31.763   G=   -.0421   GDOT=    4.419   PSID= 316.344   PSIDOT=  -27.127   PHITOT =  57.975
T=  .01227   PHI= 193.201   PHIDOT=   46.954   G=   -.0415   GDOT=    6.570   PSID= 316.150   PSIDOT=  -40.468   PHITOT =  58.201
T=  .01237   PHI= 193.512   PHIDOT=   61.570   G=   -.0408   GDOT=    8.685   PSID= 315.880   PSIDOT=  -53.742   PHITOT =  58.512
T=  .01247   PHI= 193.905   PHIDOT=   75.440   G=   -.0398   GDOT=   10.752   PSID= 315.534   PSIDOT=  -66.923   PHITOT =  58.905
T=  .01257   PHI= 194.375   PHIDOT=   88.410   G=   -.0386   GDOT=   12.762   PSID= 315.113   PSIDOT=  -79.984   PHITOT =  59.375
T=  .01267   PHI= 194.916   PHIDOT=  100.344   G=   -.0373   GDOT=   14.706   PSID= 314.618   PSIDOT=  -92.894   PHITOT =  59.916
T=  .01277   PHI= 195.523   PHIDOT=  111.135   G=   -.0357   GDOT=   16.575   PSID= 314.049   PSIDOT= -105.620   PHITOT =  60.523
T=  .01287   PHI= 196.187   PHIDOT=  120.687   G=   -.0339   GDOT=   18.343   PSID= 313.408   PSIDOT= -118.127   PHITOT =  61.187
T=  .01297   PHI= 196.903   PHIDOT=  128.935   G=   -.0320   GDOT=   20.063   PSID= 312.696   PSIDOT= -130.381   PHITOT =  61.903
T=  .01307   PHI= 197.662   PHIDOT=  135.834   G=   -.0299   GDOT=   21.670   PSID= 311.915   PSIDOT= -142.342   PHITOT =  62.662
T=  .01317   PHI= 198.457   PHIDOT=  141.373   G=   -.0277   GDOT=   23.181   PSID= 311.066   PSIDOT= -153.974   PHITOT =  63.457
T=  .01327   PHI= 199.280   PHIDOT=  145.548   G=   -.0253   GDOT=   24.593   PSID= 310.151   PSIDOT= -165.239   PHITOT =  64.280
T=  .01337   PHI= 200.122   PHIDOT=  148.389   G=   -.0228   GDOT=   25.902   PSID= 309.173   PSIDOT= -176.101   PHITOT =  65.122
T=  .01347   PHI= 200.978   PHIDOT=  149.939   G=   -.0201   GDOT=   27.107   PSID= 308.134   PSIDOT= -186.527   PHITOT =  65.978
T=  .01357   PHI= 201.838   PHIDOT=  150.262   G=   -.0174   GDOT=   28.207   PSID= 307.036   PSIDOT= -196.487   PHITOT =  66.838
T=  .01367   PHI= 202.697   PHIDOT=  149.432   G=   -.0145   GDOT=   29.202   PSID= 305.883   PSIDOT= -205.953   PHITOT =  67.697
T=  .01377   PHI= 203.549   PHIDOT=  147.540   G=   -.0115   GDOT=   30.093   PSID= 304.677   PSIDOT= -214.902   PHITOT =  68.549
T=  .01387   PHI= 204.386   PHIDOT=  144.682   G=   -.0085   GDOT=   30.880   PSID= 303.422   PSIDOT= -223.315   PHITOT =  69.386
T=  .01397   PHI= 205.205   PHIDOT=  140.961   G=   -.0053   GDOT=   31.565   PSID= 302.119   PSIDOT= -231.179   PHITOT =  70.205
T=  .01407   PHI= 206.000   PHIDOT=  136.483   G=   -.0022   GDOT=   32.151   PSID= 300.774   PSIDOT= -238.484   PHITOT =  71.000
T=  .01417   PHI= 206.768   PHIDOT=  131.355   G=    .0011   GDOT=   32.638   PSID= 299.388   PSIDOT= -245.226   PHITOT =  71.768

FREE MOTION
T=  .01417   PHI= 126.768   PHDOT= 131.355   PSI=  48.725   PSIDOT=-245.226   PHITOT =  71.768
T=  .01418   PHI= 126.846   PHDOT= 141.766   PSI=  48.584   PSIDOT=-245.226   PHITOT =  71.846
T=  .01419   PHI= 126.930   PHDOT= 152.178   PSI=  48.444   PSIDOT=-245.226   PHITOT =  71.930
T=  .01420   PHI= 127.020   PHDOT= 162.590   PSI=  48.303   PSIDOT=-245.226   PHITOT =  72.020
T=  .01421   PHI= 127.116   PHDOT= 173.002   PSI=  48.163   PSIDOT=-245.226   PHITOT =  72.116
T=  .01422   PHI= 127.218   PHDOT= 183.414   PSI=  48.022   PSIDOT=-245.226   PHITOT =  72.218
T=  .01423   PHI= 127.327   PHDOT= 193.825   PSI=  47.882   PSIDOT=-245.226   PHITOT =  72.327
T=  .01424   PHI= 127.441   PHDOT= 204.237   PSI=  47.741   PSIDOT=-245.226   PHITOT =  72.441
T=  .01425   PHI= 127.561   PHDOT= 214.649   PSI=  47.601   PSIDOT=-245.226   PHITOT =  72.561
T=  .01426   PHI= 127.687   PHDOT= 225.061   PSI=  47.460   PSIDOT=-245.226   PHITOT =  72.687
T=  .01427   PHI= 127.818   PHDOT= 235.472   PSI=  47.320   PSIDOT=-245.226   PHITOT =  72.818
T=  .01428   PHI= 127.956   PHDOT= 245.884   PSI=  47.179   PSIDOT=-245.226   PHITOT =  72.956
T=  .01429   PHI= 128.100   PHDOT= 256.296   PSI=  47.039   PSIDOT=-245.226   PHITOT =  73.100
T=  .01430   PHI= 128.250   PHDOT= 266.708   PSI=  46.898   PSIDOT=-245.226   PHITOT =  73.250
T=  .01431   PHI= 128.406   PHDOT= 277.119   PSI=  46.758   PSIDOT=-245.226   PHITOT =  73.406
T=  .01432   PHI= 128.568   PHDOT= 287.531   PSI=  46.617   PSIDOT=-245.226   PHITOT =  73.568
T=  .01433   PHI= 128.735   PHDOT= 297.943   PSI=  46.476   PSIDOT=-245.226   PHITOT =  73.735
T=  .01434   PHI= 128.909   PHDOT= 308.355   PSI=  46.336   PSIDOT=-245.226   PHITOT =  73.909
T=  .01435   PHI= 129.089   PHDOT= 318.766   PSI=  46.195   PSIDOT=-245.226   PHITOT =  74.089
T=  .01436   PHI= 129.274   PHDOT= 329.178   PSI=  46.055   PSIDOT=-245.226   PHITOT =  74.274
T=  .01437   PHI= 129.466   PHDOT= 339.590   PSI=  45.914   PSIDOT=-245.226   PHITOT =  74.466
T=  .01438   PHI= 129.663   PHDOT= 350.002   PSI=  45.774   PSIDOT=-245.226   PHITOT =  74.663
T=  .01439   PHI= 129.867   PHDOT= 360.414   PSI=  45.633   PSIDOT=-245.226   PHITOT =  74.867
T=  .01440   PHI= 130.076   PHDOT= 370.825   PSI=  45.493   PSIDOT=-245.226   PHITOT =  75.076
T=  .01441   PHI= 130.292   PHDOT= 381.237   PSI=  45.352   PSIDOT=-245.226   PHITOT =  75.292

T=  .01442   PHI= 130.513   PHDOT= 391.649   PSI=  45.212   PSIDOT=-245.226   PHITOT =  75.513

T=  .01443   PHI= 130.741   PHDOT= 402.061   PSI=  45.071   PSIDOT=-245.226   PHITOT =  75.741
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T= .01444  PHI= 130.974  PHDOT= 412.472  PSI= 44.931  PSIDOT=-245.226  PHITOT = 75.974
T= .01445  PHI= 131.213  PHDOT= 422.884  PSI= 44.790  PSIDOT=-245.226  PHITOT = 76.213
T= .01446  PHI= 131.459  PHDOT= 433.296  PSI= 44.650  PSIDOT=-245.226  PHITOT = 76.459
T= .01447  PHI= 131.710  PHDOT= 443.708  PSI= 44.509  PSIDOT=-245.226  PHITOT = 76.710
T= .01448  PHI= 131.967  PHDOT= 454.119  PSI= 44.369  PSIDOT=-245.226  PHITOT = 76.967
T= .01449  PHI= 132.230  PHDOT= 464.531  PSI= 44.228  PSIDOT=-245.226  PHITOT = 77.230
T= .01450  PHI= 132.499  PHDOT= 474.943  PSI= 44.088  PSIDOT=-245.226  PHITOT = 77.499
T= .01451  PHI= 132.774  PHDOT= 485.355  PSI= 43.947  PSIDOT=-245.226  PHITOT = 77.774
T= .01452  PHI= 133.056  PHDOT= 495.766  PSI= 43.807  PSIDOT=-245.226  PHITOT = 78.056
T= .01453  PHI= 133.343  PHDOT= 506.178  PSI= 43.666  PSIDOT=-245.226  PHITOT = 78.343
T= .01454  PHI= 133.636  PHDOT= 516.590  PSI= 43.526  PSIDOT=-245.226  PHITOT = 78.636
T= .01455  PHI= 133.935  PHDOT= 527.002  PSI= 43.385  PSIDOT=-245.226  PHITOT = 78.935
T= .01456  PHI= 134.239  PHDOT= 537.414  PSI= 43.245  PSIDOT=-245.226  PHITOT = 79.239
T= .01457  PHI= 134.550  PHDOT= 547.825  PSI= 43.104  PSIDOT=-245.226  PHITOT = 79.550
T= .01458  PHI= 134.867  PHDOT= 558.237  PSI= 42.964  PSIDOT=-245.226  PHITOT = 79.867
T= .01459  PHI= 135.190  PHDOT= 568.649  PSI= 42.823  PSIDOT=-245.226  PHITOT = 80.190
T= .01460  PHI= 135.519  PHDOT= 579.061  PSI= 42.683  PSIDOT=-245.226  PHITOT = 80.519
VP= -14.344  VS= 44.940

IMPACT      Cycle No. 3

           PHI= 135.519  DPHIF=-284.190  PSI= 42.683  DPSIF=-123.677  PHITOT= 80.519
VP= -7.234  VS= -22.056

FREE MOTION
T= .01460  PHI= 135.519  PHDOT=-284.190  PSI= 42.683  PSIDOT=-123.677  PHITOT = 80.519
T= .01461  PHI= 135.359  PHDOT=-273.779  PSI= 42.612  PSIDOT=-123.677  PHITOT = 80.359
VP= -7.249  VS= -21.063

FREE MOTION
T= .01461  PHI= 135.359  PHDOT=-273.779  PSI= 42.612  PSIDOT=-123.677  PHITOT = 80.359
T= .01462  PHI= 135.205  PHDOT=-263.367  PSI= 42.541  PSIDOT=-123.677  PHITOT = 80.205
VP= -7.263  VS= -20.128

FREE MOTION
T= .01462  PHI= 135.205  PHDOT=-263.367  PSI= 42.541  PSIDOT=-123.677  PHITOT = 80.205
T= .01463  PHI= 135.057  PHDOT=-252.955  PSI= 42.470  PSIDOT=-123.677  PHITOT = 80.057
VP= -7.276  VS= -19.192

FREE MOTION
T= .01463  PHI= 135.057  PHDOT=-252.955  PSI= 42.470  PSIDOT=-123.677  PHITOT = 80.057
T= .01464  PHI= 134.915  PHDOT=-242.543  PSI= 42.399  PSIDOT=-123.677  PHITOT = 79.915
T= .01465  PHI= 134.779  PHDOT=-232.131  PSI= 42.329  PSIDOT=-123.677  PHITOT = 79.779
T= .01466  PHI= 134.649  PHDOT=-221.720  PSI= 42.258  PSIDOT=-123.677  PHITOT = 79.649
T= .01467  PHI= 134.525  PHDOT=-211.308  PSI= 42.187  PSIDOT=-123.677  PHITOT = 79.525
T= .01468  PHI= 134.407  PHDOT=-200.896  PSI= 42.116  PSIDOT=-123.677  PHITOT = 79.407
T= .01469  PHI= 134.295  PHDOT=-190.484  PSI= 42.045  PSIDOT=-123.677  PHITOT = 79.295
T= .01470  PHI= 134.189  PHDOT=-180.073  PSI= 41.974  PSIDOT=-123.677  PHITOT = 79.189
T= .01471  PHI= 134.089  PHDOT=-169.661  PSI= 41.903  PSIDOT=-123.677  PHITOT = 79.089
T= .01472  PHI= 133.994  PHDOT=-159.249  PSI= 41.833  PSIDOT=-123.677  PHITOT = 78.994
T= .01473  PHI= 133.906  PHDOT=-148.837  PSI= 41.762  PSIDOT=-123.677  PHITOT = 78.906
T= .01474  PHI= 133.824  PHDOT=-138.426  PSI= 41.691  PSIDOT=-123.677  PHITOT = 78.824
T= .01475  PHI= 133.748  PHDOT=-128.014  PSI= 41.620  PSIDOT=-123.677  PHITOT = 78.748
T= .01476  PHI= 133.677  PHDOT=-117.602  PSI= 41.549  PSIDOT=-123.677  PHITOT = 78.677
T= .01477  PHI= 133.613  PHDOT=-107.190  PSI= 41.478  PSIDOT=-123.677  PHITOT = 78.613
T= .01478  PHI= 133.554  PHDOT= -96.779  PSI= 41.407  PSIDOT=-123.677  PHITOT = 78.554
T= .01479  PHI= 133.502  PHDOT= -86.367  PSI= 41.337  PSIDOT=-123.677  PHITOT = 78.502
T= .01480  PHI= 133.455  PHDOT= -75.955  PSI= 41.266  PSIDOT=-123.677  PHITOT = 78.455
T= .01481  PHI= 133.415  PHDOT= -65.543  PSI= 41.195  PSIDOT=-123.677  PHITOT = 78.415
T= .01482  PHI= 133.380  PHDOT= -55.131  PSI= 41.124  PSIDOT=-123.677  PHITOT = 78.380
T= .01483  PHI= 133.352  PHDOT= -44.720  PSI= 41.053  PSIDOT=-123.677  PHITOT = 78.352
T= .01484  PHI= 133.329  PHDOT= -34.308  PSI= 40.982  PSIDOT=-123.677  PHITOT = 78.329
T= .01485  PHI= 133.312  PHDOT= -23.896  PSI= 40.911  PSIDOT=-123.677  PHITOT = 78.312
T= .01486  PHI= 133.302  PHDOT= -13.484  PSI= 40.840  PSIDOT=-123.677  PHITOT = 78.302
T= .01487  PHI= 133.297  PHDOT=  -3.073  PSI= 40.770  PSIDOT=-123.677  PHITOT = 78.297
T= .01488  PHI= 133.298  PHDOT=   7.339  PSI= 40.699  PSIDOT=-123.677  PHITOT = 78.298
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T=  .05256   PHI= 202.414   PHIDOT= 152.345   G=  -.0156   GDOT=  29.371   PSID= 306.270   PSIDOT=-206.292   PHITOT = 267.414
T=  .05266   PHI= 203.282   PHIDOT= 150.537   G=  -.0125   GDOT=  30.286   PSID= 305.061   PSIDOT=-215.431   PHITOT = 268.282
T=  .05276   PHI= 204.137   PHIDOT= 147.725   G=  -.0094   GDOT=  31.096   PSID= 303.802   PSIDOT=-224.029   PHITOT = 269.137
T=  .05286   PHI= 204.973   PHIDOT= 144.015   G=  -.0062   GDOT=  31.802   PSID= 302.495   PSIDOT=-232.072   PHITOT = 269.973
T=  .05296   PHI= 205.786   PHIDOT= 139.514   G=  -.0030   GDOT=  32.407   PSID= 301.144   PSIDOT=-239.549   PHITOT = 270.786
T=  .05306   PHI= 206.571   PHIDOT= 134.332   G=   .0002   GDOT=  32.912   PSID= 299.751   PSIDOT=-246.454   PHITOT = 271.571

FREE MOTION
T=  .05306   PHI= 126.571   PHDOT= 134.339   PSI=  49.088   PSIDOT=-246.454   PHITOT = 271.571
T=  .05307   PHI= 126.651   PHDOT= 144.751   PSI=  48.947   PSIDOT=-246.454   PHITOT = 271.651
T=  .05308   PHI= 126.737   PHDOT= 155.163   PSI=  48.806   PSIDOT=-246.454   PHITOT = 271.737
T=  .05309   PHI= 126.829   PHDOT= 165.574   PSI=  48.665   PSIDOT=-246.454   PHITOT = 271.829
T=  .05310   PHI= 126.927   PHDOT= 175.986   PSI=  48.524   PSIDOT=-246.454   PHITOT = 271.927
T=  .05311   PHI= 127.030   PHDOT= 155.398   PSI=  48.382   PSIDOT=-246.454   PHITOT = 272.030

T=  .05312   PHI= 127.140   PHDOT= 196.810   PSI=  48.241   PSIDOT=-246.454   PHITOT = 272.140
T=  .05313   PHI= 127.256   PHDOT= 207.221   PSI=  48.100   PSIDOT=-246.454   PHITOT = 272.256
T=  .05314   PHI= 127.378   PHDOT= 217.633   PSI=  47.959   PSIDOT=-246.454   PHITOT = 272.378
T=  .05315   PHI= 127.505   PHDOT= 228.045   PSI=  47.818   PSIDOT=-246.454   PHITOT = 272.505
T=  .05316   PHI= 127.639   PHDOT= 238.457   PSI=  47.676   PSIDOT=-246.454   PHITOT = 272.639
T=  .05317   PHI= 127.779   PHDOT= 248.868   PSI=  47.535   PSIDOT=-246.454   PHITOT = 272.779
T=  .05318   PHI= 127.924   PHDOT= 259.280   PSI=  47.394   PSIDOT=-246.454   PHITOT = 272.924
T=  .05319   PHI= 128.076   PHDOT= 269.692   PSI=  47.253   PSIDOT=-246.454   PHITOT = 273.076
T=  .05320   PHI= 128.233   PHDOT= 280.104   PSI=  47.112   PSIDOT=-246.454   PHITOT = 273.233
T=  .05321   PHI= 128.397   PHDOT= 290.515   PSI=  46.970   PSIDOT=-246.454   PHITOT = 273.397
T=  .05322   PHI= 128.566   PHDOT= 300.927   PSI=  46.829   PSIDOT=-246.454   PHITOT = 273.566
T=  .05323   PHI= 128.741   PHDOT= 311.339   PSI=  46.688   PSIDOT=-246.454   PHITOT = 273.741
T=  .05324   PHI= 128.923   PHDOT= 321.751   PSI=  46.547   PSIDOT=-246.454   PHITOT = 273.923
T=  .05325   PHI= 129.110   PHDOT= 332.163   PSI=  46.406   PSIDOT=-246.454   PHITOT = 274.110     End of Cycle No. 7
T=  .05326   PHI= 129.303   PHDOT= 342.574   PSI=  46.264   PSIDOT=-246.454   PHITOT = 274.303
T=  .05327   PHI= 129.503   PHDOT= 352.986   PSI=  46.123   PSIDOT=-246.454   PHITOT = 274.503
T=  .05328   PHI= 129.708   PHDOT= 363.398   PSI=  45.982   PSIDOT=-246.454   PHITOT = 274.708
T=  .05329   PHI= 129.919   PHDOT= 373.810   PSI=  45.841   PSIDOT=-246.454   PHITOT = 274.919
T=  .05330   PHI= 130.136   PHDOT= 384.221   PSI=  45.699   PSIDOT=-246.454   PHITOT = 275.136
T=  .05331   PHI= 130.359   PHDOT= 394.633   PSI=  45.558   PSIDOT=-246.454   PHITOT = 275.359
T=  .05332   PHI= 130.588   PHDOT= 405.045   PSI=  45.417   PSIDOT=-246.454   PHITOT = 275.588
T=  .05333   PHI= 130.824   PHDOT= 415.457   PSI=  45.276   PSIDOT=-246.454   PHITOT = 275.824
T=  .05334   PHI= 131.065   PHDOT= 425.868   PSI=  45.135   PSIDOT=-246.454   PHITOT = 276.065
T=  .05335   PHI= 131.312   PHDOT= 436.280   PSI=  44.993   PSIDOT=-246.454   PHITOT = 276.312

T=  .05336   PHI= 131.565   PHDOT= 446.692   PSI=  44.852   PSIDOT=-246.454   PHITOT = 276.565
T=  .05337   PHI= 131.823   PHDOT= 457.104   PSI=  44.711   PSIDOT=-246.454   PHITOT = 276.823
T=  .05338   PHI= 132.088   PHDOT= 467.515   PSI=  44.570   PSIDOT=-246.454   PHITOT = 277.088
T=  .05339   PHI= 132.359   PHDOT= 477.927   PSI=  44.429   PSIDOT=-246.454   PHITOT = 277.359
T=  .05340   PHI= 132.636   PHDOT= 488.339   PSI=  44.287   PSIDOT=-246.454   PHITOT = 277.636
T=  .05341   PHI= 132.919   PHDOT= 498.751   PSI=  44.146   PSIDOT=-246.454   PHITOT = 277.919
T=  .05342   PHI= 133.208   PHDOT= 509.163   PSI=  44.005   PSIDOT=-246.454   PHITOT = 278.208
T=  .05343   PHI= 133.502   PHDOT= 519.574   PSI=  43.864   PSIDOT=-246.454   PHITOT = 278.502
T=  .05344   PHI= 133.803   PHDOT= 529.986   PSI=  43.723   PSIDOT=-246.454   PHITOT = 278.803
T=  .05345   PHI= 134.110   PHDOT= 540.398   PSI=  43.581   PSIDOT=-246.454   PHITOT = 279.110
T=  .05346   PHI= 134.422   PHDOT= 550.810   PSI=  43.440   PSIDOT=-246.454   PHITOT = 279.422
T=  .05347   PHI= 134.741   PHDOT= 561.221   PSI=  43.299   PSIDOT=-246.454   PHITOT = 279.741
T=  .05348   PHI= 135.065   PHDOT= 571.633   PSI=  43.158   PSIDOT=-246.454   PHITOT = 280.065
T=  .05349   PHI= 135.396   PHDOT= 582.045   PSI=  43.017   PSIDOT=-246.454   PHITOT = 280.396
T=  .05350   PHI= 135.732   PHDOT= 592.457   PSI=  42.875   PSIDOT=-246.454   PHITOT = 280.732
VP= -14.409   VS=  46.458
                 Cycle No. 8
IMPACT

             PHI= 135.732   DPHIF=-286.525   PSI=  42.875   DPSIF=-124.023   PHITOT= 280.732
VP=  -7.251   VS= -22.468

FREE MOTION
T=  .05350   PHI= 135.732   PHDOT=-286.525   PSI=  42.875   PSIDOT=-124.023   PHITOT = 280.732
T=  .05351   PHI= 135.571   PHDOT=-276.113   PSI=  42.804   PSIDOT=-124.023   PHITOT = 280.571
VP=  -7.266   VS= -21.483
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         FREE MOTION
         T=  .05351   PHI= 135.571   PHDOT=-276.113   PSI=  42.804   PSIDOT=-124.023   PHITOT = 280.571
         T=  .05352   PHI= 135.416   PHDOT=-265.701   PSI=  42.733   PSIDOT=-124.023   PHITOT = 280.416
   VP=   -7.280   VS= -20.517

         FREE MOTION
         T=  .05352   PHI= 135.416   PHDOT=-265.701   PSI=  42.733   PSIDOT=-124.023   PHITOT = 280.416
         T=  .05353   PHI= 135.267   PHDOT=-255.289   PSI=  42.662   PSIDOT=-124.023   PHITOT = 280.267
   VP=   -7.293   VS= -19.570

         FREE MOTION
         T=  .05353   PHI= 135.267   PHDOT=-255.289   PSI=  42.662   PSIDOT=-124.023   PHITOT = 280.267
         T=  .05354   PHI= 135.123   PHDOT=-244.878   PSI=  42.591   PSIDOT=-124.023   PHITOT = 280.123
         T=  .05355   PHI= 134.986   PHDOT=-234.466   PSI=  42.520   PSIDOT=-124.023   PHITOT = 279.986
         T=  .05356   PHI= 134.855   PHDOT=-224.054   PSI=  42.449   PSIDOT=-124.023   PHITOT = 279.855
         T=  .05357   PHI= 134.729   PHDOT=-213.642   PSI=  42.378   PSIDOT=-124.023   PHITOT = 279.729
         T=  .05358   PHI= 134.610   PHDOT=-203.231   PSI=  42.307   PSIDOT=-124.023   PHITOT = 279.610
         T=  .05359   PHI= 134.496   PHDOT=-192.819   PSI=  42.236   PSIDOT=-124.023   PHITOT = 279.496
         T=  .05360   PHI= 134.389   PHDOT=-182.407   PSI=  42.165   PSIDOT=-124.023   PHITOT = 279.389
         T=  .05361   PHI= 134.287   PHDOT=-171.995   PSI=  42.094   PSIDOT=-124.023   PHITOT = 279.287
         T=  .05362   PHI= 134.192   PHDOT=-161.583   PSI=  42.023   PSIDOT=-124.023   PHITOT = 279.192
         T=  .05363   PHI= 134.102   PHDOT=-151.172   PSI=  41.952   PSIDOT=-124.023   PHITOT = 279.102
         T=  .05364   PHI= 134.019   PHDOT=-140.760   PSI=  41.880   PSIDOT=-124.023   PHITOT = 279.019
         T=  .05365   PHI= 133.941   PHDOT=-130.348   PSI=  41.809   PSIDOT=-124.023   PHITOT = 278.941
         T=  .05366   PHI= 133.869   PHDOT=-119.936   PSI=  41.738   PSIDOT=-124.023   PHITOT = 278.869
         T=  .05367   PHI= 133.803   PHDOT=-109.525   PSI=  41.667   PSIDOT=-124.023   PHITOT = 278.803
         T=  .05368   PHI= 133.744   PHDOT= -99.113   PSI=  41.596   PSIDOT=-124.023   PHITOT = 278.744
         T=  .05369   PHI= 133.690   PHDOT= -88.701   PSI=  41.525   PSIDOT=-124.023   PHITOT = 278.690
         T=  .05370   PHI= 133.642   PHDOT= -78.289   PSI=  41.454   PSIDOT=-124.023   PHITOT = 278.642
         T=  .05371   PHI= 133.600   PHDOT= -67.878   PSI=  41.383   PSIDOT=-124.023   PHITOT = 278.600
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         T=  .05373   PHI= 133.534   PHDOT= -47.054   PSI=  41.241   PSIDOT=-124.023   PHITOT = 278.534
         T=  .05374   PHI= 133.510   PHDOT= -36.642   PSI=  41.170   PSIDOT=-124.023   PHITOT = 278.510
         T=  .05375   PHI= 133.492   PHDOT= -26.231   PSI=  41.099   PSIDOT=-124.023   PHITOT = 278.492
         T=  .05376   PHI= 133.480   PHDOT= -15.819   PSI=  41.028   PSIDOT=-124.023   PHITOT = 278.480
         T=  .05377   PHI= 133.474   PHDOT=  -5.407   PSI=  40.957   PSIDOT=-124.023   PHITOT = 278.474
         T=  .05378   PHI= 133.474   PHDOT=   5.005   PSI=  40.886   PSIDOT=-124.023   PHITOT = 278.474
         T=  .05379   PHI= 133.480   PHDOT=  15.417   PSI=  40.815   PSIDOT=-124.023   PHITOT = 278.480
         T=  .05380   PHI= 133.492   PHDOT=  25.828   PSI=  40.744   PSIDOT=-124.023   PHITOT = 278.492
         T=  .05381   PHI= 133.509   PHDOT=  36.240   PSI=  40.672   PSIDOT=-124.023   PHITOT = 278.509
         T=  .05382   PHI= 133.533   PHDOT=  46.652   PSI=  40.601   PSIDOT=-124.023   PHITOT = 278.533
         T=  .05383   PHI= 133.563   PHDOT=  57.064   PSI=  40.530   PSIDOT=-124.023   PHITOT = 278.563
   VP=   -7.222   VS=   4.015

         IMPACT
                      PHI= 133.563   DPHIF=-119.929   PSI=  40.530   DPSIF= -96.656   PHITOT= 278.563
   VP=   -5.628   VS=  -8.437

         FREE MOTION
         T=  .05383   PHI= 133.563   PHDOT=-119.929   PSI=  40.530   PSIDOT= -96.656   PHITOT = 278.563
         T=  .05384   PHI= 133.497   PHDOT=-109.517   PSI=  40.475   PSIDOT= -96.656   PHITOT = 278.497
   VP=   -5.630   VS=  -7.679

         FREE MOTION
         T=  .05384   PHI= 133.497   PHDOT=-109.517   PSI=  40.475   PSIDOT= -96.656   PHITOT = 278.497
         T=  .05385   PHI= 133.437   PHDOT= -99.105   PSI=  40.420   PSIDOT= -96.656   PHITOT = 278.437
   VP=   -5.630   VS=  -6.927

         FREE MOTION
         T=  .05385   PHI= 133.437   PHDOT= -99.105   PSI=  40.420   PSIDOT= -96.656   PHITOT = 278.437
         T=  .05386   PHI= 133.384   PHDOT= -88.694   PSI=  40.364   PSIDOT= -96.656   PHITOT = 278.384
   VP=   -5.630   VS=  -6.182
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FREE MOTION

T= .05386 PHI= 133.384 PHDOT= -88.694 PSI= 40.364 PSIDOT= -96.656 PHITOT = 278.384

T= .05387 PHI= 133.336 PHDOT= -78.282 PSI= 40.309 PSIDOT= -96.656 PHITOT = 278.336

VP= -5.629 VS= -5.443

IMPACT

PHI= 133.336 DPHIF= -81.242 PSI= 40.309 DPSIF= -96.193 PHITOT= 278.336

VP= -5.602 VS= -5.649

COUPLED MOTION

T	PHI	PHIDOT	G	GDOT	PSID	PSIDOT	PHITOT
.05387	133.336	-81.242	-.0518	-16.872	40.349	-94.901	278.336
.05397	132.945	-54.985	-.0532	-11.329	39.887	-64.357	277.945
.05407	132.709	-27.221	-.0541	-5.591	39.612	-31.493	277.709
.05409	132.675	-20.127	-.0542	-4.124	39.573	-23.247	277.675
.05412	132.651	-12.997	-.0543	-2.662	39.546	-14.994	277.651
.05413	132.643	-9.422	-.0543	-1.929	39.537	-10.866	277.643
.05414	132.638	-5.843	-.0543	-1.196	39.530	-6.737	277.638
.05415	132.636	-4.053	-.0543	-.830	39.528	-4.672	277.636
.05416	132.635	-2.262	-.0543	-.463	39.527	-2.607	277.635
.05416	132.634	-1.366	-.0543	-.280	39.526	-1.575	277.634
.05416	132.634	-.471	-.0543	-.096	39.526	-.542	277.634
.05416	132.634	-.247	-.0543	-.050	39.526	-.284	277.634
.05417	132.634	-.023	-.0543	-.005	39.526	-.026	277.634
.05417	132.634	.028	-.0543	.006	39.526	.032	277.634
.05417	132.634	.048	-.0543	.010	39.526	.055	277.634
.05417	132.634	.067	-.0543	.014	39.526	.078	277.634
.05417	132.634	.087	-.0543	.018	39.526	.101	277.634
.05417	132.634	.127	-.0543	.026	39.526	.146	277.634
.05417	132.634	.166	-.0543	.034	39.526	.192	277.634
.05417	132.634	.206	-.0543	.042	39.526	.238	277.634
.05417	132.634	.246	-.0543	.050	39.526	.283	277.634
.05417	132.634	.325	-.0543	.067	39.526	.374	277.634
.05417	132.634	.404	-.0543	.083	39.526	.466	277.634
.05417	132.634	.483	-.0543	.099	39.526	.557	277.634
.05418	132.634	.562	-.0543	.115	39.526	.648	277.634
.05418	132.634	.721	-.0543	.148	39.527	.831	277.634
.05418	132.635	.879	-.0543	.180	39.527	1.014	277.635
.05419	132.635	1.196	-.0543	.245	39.527	1.379	277.635
.05419	132.635	1.513	-.0543	.310	39.528	1.744	277.635
.05421	132.637	2.146	-.0543	.439	39.529	2.474	277.637
.05422	132.638	2.779	-.0543	.569	39.531	3.206	277.638
.05424	132.643	4.045	-.0543	.828	39.537	4.665	277.643
.05427	132.650	5.310	-.0543	1.087	39.545	6.125	277.650
.05432	132.669	7.834	-.0542	1.605	39.566	9.045	277.669
.05437	132.695	10.349	-.0541	2.121	39.596	11.964	277.695
.05442	[illegible].728	12.853	-.0540	2.636	39.635	14.881	277.728
.05447	132.769	15.336	-.0538	3.148	39.682	17.796	277.769
.05457	132.871	20.252	-.0535	4.166	39.800	23.618	277.871
.05467	133.000	25.073	-.0530	5.172	39.952	29.426	278.000
.05477	133.158	29.781	-.0524	6.163	40.138	35.219	278.158
.05487	133.341	34.350	-.0518	7.136	40.356	40.993	278.341
.05497	133.551	38.795	-.0510	8.091	40.607	46.746	278.551
.05507	133.786	43.076	-.0502	9.026	40.892	52.476	278.786
.05517	134.044	47.193	-.0492	9.938	41.209	58.181	279.044
.05527	134.326	51.144	-.0482	10.828	41.558	63.859	279.326
.05537	134.630	54.923	-.0470	11.694	41.940	69.510	279.630
.05547	134.955	58.532	-.0458	12.537	42.355	75.132	279.955
.05557	135.301	61.971	-.0445	13.356	42.801	80.725	280.301
.05567	135.665	65.245	-.0432	14.151	43.280	86.289	280.665
.05577	136.048	68.359	-.0417	14.923	43.790	91.823	281.048
.05587	136.448	71.319	-.0402	15.672	44.332	97.330	281.448
.05597	136.865	74.133	-.0386	16.399	44.905	102.809	281.865
.05607	137.297	76.803	-.0369	17.105	45.510	108.261	282.297
.05617	137.745	79.354	-.0352	17.789	46.146	113.688	282.745

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T	PHI	PHIDOT	G	GDOT	PSID	PSIDOT	PHITOT
.05627	138.206	81.783	-.0333	18.454	46.813	119.092	283.206
.05637	138.692	84.098	-.0315	19.099	47.510	124.473	283.682
.05647	139.170	86.312	-.0295	19.726	48.239	129.835	284.170
.05657	139.671	88.434	-.0275	20.335	48.998	135.178	284.671
.05667	140.183	90.471	-.0255	20.927	49.768	140.506	285.183
.05677	140.707	92.432	-.0233	21.504	50.608	145.819	285.707
.05687	141.242	94.325	-.0212	22.066	51.459	151.121	286.242
.05697	141.788	96.158	-.0189	22.610	52.340	156.414	286.788
.05707	142.344	97.938	-.0166	23.141	53.251	161.700	287.344
.05717	142.910	99.672	-.0143	23.658	54.193	166.980	287.910
.05727	143.486	101.364	-.0119	24.161	55.165	172.258	288.486
.05737	144.072	103.022	-.0095	24.651	56.167	177.536	289.072
.05747	144.667	104.650	-.0070	25.127	57.199	182.815	289.667
.05757	145.271	106.254	-.0044	25.590	58.262	188.098	290.271
.05767	145.884	107.836	-.0019	26.040	59.355	193.387	290.884
.05777	146.506	109.402	.0008	26.477	60.478	198.683	291.506

FREE MOTION

T	PHI	PHDOT	PSI	PSIDOT	PHITOT
.05777	186.506	109.402	311.141	198.683	291.506
.05778	186.572	119.814	311.255	198.683	291.572
.05779	186.644	130.226	311.368	198.683	291.644
.05780	186.721	140.638	311.482	198.683	291.721
.05781	186.805	151.049	311.596	198.683	291.805
.05782	186.894	161.461	311.710	198.683	291.894
.05783	186.990	171.873	311.824	198.683	291.990
.05784	187.091	182.285	311.938	198.683	292.091
.05785	187.199	192.696	312.051	198.683	292.199
.05786	187.312	203.108	312.165	198.683	292.312
.05787	187.432	213.520	312.279	198.683	292.432
.05788	187.557	223.932	312.393	198.683	292.557
.05789	187.688	234.343	312.507	198.683	292.688
.05790	187.825	244.755	312.621	198.683	292.825
.05791	187.969	255.167	312.734	198.683	292.969
.05792	188.118	265.579	312.848	198.683	293.118
.05793	188.273	275.990	312.962	198.683	293.273
.05794	188.434	286.402	313.076	198.683	293.434
.05795	188.601	296.814	313.190	198.683	293.601
.05796	188.774	307.226	313.304	198.683	293.774
.05797	188.953	317.638	313.417	198.683	293.953
.05798	189.138	328.049	313.531	198.683	294.138
.05799	189.329	338.461	313.645	198.683	294.329
.05800	189.526	348.873	313.759	198.683	294.526
.05801	189.729	359.285	313.873	198.683	294.729
.05802	189.938	369.696	313.987	198.683	294.938
.05803	190.153	380.108	314.101	198.683	295.153
.05804	190.373	390.520	314.214	198.683	295.373
.05805	190.600	400.932	314.328	198.683	295.600
.05806	190.833	411.343	314.442	198.683	295.833
.05807	191.071	421.755	314.556	198.683	296.071
.05808	191.316	432.167	314.670	198.683	296.316
.05809	191.567	442.579	314.784	198.683	296.567
.05810	191.823	452.990	314.897	198.683	296.823
.05811	192.086	463.402	315.011	198.683	297.086
.05812	192.354	473.814	315.125	198.683	297.354
.05813	192.629	484.226	315.239	198.683	297.629
.05814	192.909	494.638	315.353	198.683	297.909
.05815	193.196	505.049	315.467	198.683	298.196
.05816	193.488	515.461	315.580	198.683	298.488
.05817	193.766	525.873	315.694	198.683	298.786

VP= -18.287 VS= 42.715

IMPACT

PHI= 193.786 DPHIF=-231.270 PSI= 315.694 DPSIF= 38.403 PHITOT= 298.786

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VP=  -3.535   VS= -18.785

FREE MOTION
T=  .05817   PHI= 193.746   PHDOT=-231.270   PSI= 315.694   PSIDOT=  38.403   PHITOT = 298.786
T=  .05818   PHI= 193.657   PHDOT=-220.859   PSI= 315.716   PSIDOT=  38.403   PHITOT = 298.657
T=  .05819   PHI= 193.533   PHDOT=-210.447   PSI= 315.738   PSIDOT=  38.403   PHITOT = 298.533
T=  .05820   PHI= 193.416   PHDOT=-200.035   PSI= 315.760   PSIDOT=  38.403   PHITOT = 298.416
T=  .05821   PHI= 193.304   PHDOT=-189.623   PSI= 315.782   PSIDOT=  38.403   PHITOT = 298.304
T=  .05822   PHI= 193.198   PHDOT=-179.211   PSI= 315.804   PSIDOT=  38.403   PHITOT = 298.198
T=  .05823   PHI= 193.099   PHDOT=-168.800   PSI= 315.826   PSIDOT=  38.403   PHITOT = 298.099
T=  .05824   PHI= 193.005   PHDOT=-158.388   PSI= 315.848   PSIDOT=  38.403   PHITOT = 298.005
T=  .05825   PHI= 192.917   PHDOT=-147.976   PSI= 315.870   PSIDOT=  38.403   PHITOT = 297.917
T=  .05826   PHI= 192.835   PHDOT=-137.564   PSI= 315.892   PSIDOT=  38.403   PHITOT = 297.835
T=  .05827   PHI= 192.759   PHDOT=-127.153   PSI= 315.914   PSIDOT=  38.403   PHITOT = 297.759
T=  .05828   PHI= 192.690   PHDOT=-116.741   PSI= 315.936   PSIDOT=  38.403   PHITOT = 297.690
T=  .05829   PHI= 192.626   PHDOT=-106.329   PSI= 315.958   PSIDOT=  38.403   PHITOT = 297.626
T=  .05830   PHI= 192.568   PHDOT= -95.917   PSI= 315.980   PSIDOT=  38.403   PHITOT = 297.568
T=  .05831   PHI= 192.516   PHDOT= -85.506   PSI= 316.002   PSIDOT=  38.403   PHITOT = 297.516
T=  .05832   PHI= 192.470   PHDOT= -75.094   PSI= 316.024   PSIDOT=  38.403   PHITOT = 297.470
T=  .05833   PHI= 192.430   PHDOT= -64.682   PSI= 316.046   PSIDOT=  38.403   PHITOT = 297.430
T=  .05834   PHI= 192.396   PHDOT= -54.270   PSI= 316.068   PSIDOT=  38.403   PHITOT = 297.396
T=  .05835   PHI= 192.367   PHDOT= -43.859   PSI= 316.090   PSIDOT=  38.403   PHITOT = 297.367
T=  .05836   PHI= 192.345   PHDOT= -33.447   PSI= 316.112   PSIDOT=  38.403   PHITOT = 297.345
T=  .05837   PHI= 192.329   PHDOT= -23.035   PSI= 316.134   PSIDOT=  38.403   PHITOT = 297.329
T=  .05838   PHI= 192.319   PHDOT= -12.623   PSI= 316.156   PSIDOT=  38.403   PHITOT = 297.319
T=  .05839   PHI= 192.315   PHDOT=  -2.211   PSI= 316.178   PSIDOT=  38.403   PHITOT = 297.315
T=  .05840   PHI= 192.316   PHDOT=   8.200   PSI= 316.200   PSIDOT=  38.403   PHITOT = 297.316
T=  .05841   PHI= 192.324   PHDOT=  18.612   PSI= 316.222   PSIDOT=  38.403   PHITOT = 297.324
T=  .05842   PHI= 192.338   PHDOT=  29.024   PSI= 316.244   PSIDOT=  38.403   PHITOT = 297.338
T=  .05843   PHI= 192.357   PHDOT=  39.436   PSI= 316.266   PSIDOT=  38.403   PHITOT = 297.357
T=  .05844   PHI= 192.383   PHDOT=  49.847   PSI= 316.288   PSIDOT=  38.403   PHITOT = 297.383
T=  .05845   PHI= 192.414   PHDOT=  60.259   PSI= 316.310   PSIDOT=  38.403   PHITOT = 297.414
T=  .05846   PHI= 192.452   PHDOT=  70.671   PSI= 316.332   PSIDOT=  38.403   PHITOT = 297.452
T=  .05847   PHI= 192.495   PHDOT=  81.083   PSI= 316.354   PSIDOT=  38.403   PHITOT = 297.495
T=  .05848   PHI= 192.545   PHDOT=  91.494   PSI= 316.376   PSIDOT=  38.403   PHITOT = 297.545
T=  .05849   PHI= 192.600   PHDOT= 101.906   PSI= 316.398   PSIDOT=  38.403   PHITOT = 297.600
T=  .05850   PHI= 192.662   PHDOT= 112.318   PSI= 316.420   PSIDOT=  38.403   PHITOT = 297.662
T=  .05851   PHI= 192.729   PHDOT= 122.730   PSI= 316.442   PSIDOT=  38.403   PHITOT = 297.729
T=  .05852   PHI= 192.802   PHDOT= 133.141   PSI= 316.464   PSIDOT=  38.403   PHITOT = 297.802
T=  .05853   PHI= 192.882   PHDOT= 143.553   PSI= 316.486   PSIDOT=  38.403   PHITOT = 297.882
VP=  -3.567   VS=  11.342

IMPACT

              PHI= 192.882   DPHIF= -43.916   PSI= 316.486   DPSIF=  -2.773   PHITOT= 297.882
VP=   .258   VS=  -3.470

FREE MOTION
T=  .05853   PHI= 192.882   PHDOT= -43.916   PSI= 316.486   PSIDOT=  -2.773   PHITOT = 297.882
T=  .05854   PHI= 192.859   PHDOT= -33.504   PSI= 316.485   PSIDOT=  -2.773   PHITOT = 297.859
VP=   .258   VS=  -2.645

FREE MOTION
T=  .05854   PHI= 192.859   PHDOT= -33.504   PSI= 316.485   PSIDOT=  -2.773   PHITOT = 297.859
T=  .05855   PHI= 192.843   PHDOT= -23.092   PSI= 316.483   PSIDOT=  -2.773   PHITOT = 297.843
VP=   .258   VS=  -1.822

FREE MOTION
T=  .05855   PHI= 192.843   PHDOT= -23.092   PSI= 316.483   PSIDOT=  -2.773   PHITOT = 297.843
T=  .05856   PHI= 192.833   PHDOT= -12.681   PSI= 316.482   PSIDOT=  -2.773   PHITOT = 297.833
VP=   .258   VS=  -1.000

FREE MOTION
T=  .05856   PHI= 192.833   PHDOT= -12.681   PSI= 316.482   PSIDOT=  -2.773   PHITOT = 297.833
T=  .05857   PHI= 192.829   PHDOT=  -2.269   PSI= 316.480   PSIDOT=  -2.773   PHITOT = 297.829
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VP=   .258   VS=  -.179

FREE MOTION
T=  .05857   PHI= 192.829   PHDOT=  -2.269   PSI= 316.480   PSIDOT=  -2.773   PHITOT = 297.829
T=  .05858   PHI= 192.830   PHDOT=   8.143   PSI= 316.478   PSIDOT=  -2.773   PHITOT = 297.830
VP=   .258   VS=   .662

IMPACT
             PHI= 192.830   DPHIF=   3.302   PSI= 316.478   DPSIF=  -3.838   PHITOT= 297.830
VP=   .357   VS=   .260

COUPLED MOTION
T=  .05858   PHI= 192.830   PHIDOT=   3.302   G=  -.0424   GDOT=    .458   PSID= 316.467   PSIDOT=   -2.803   PHITOT = 297.830
T=  .05868   PHI= 192.894   PHIDOT=  19.023   G=  -.0423   GDOT=   2.641   PSID= 316.412   PSIDOT=  -14.193   PHITOT = 297.894
T=  .05878   PHI= 193.048   PHIDOT=  34.559   G=  -.0419   GDOT=   4.810   PSID= 316.261   PSIDOT=  -29.557   PHITOT = 298.048
T=  .05888   PHI= 193.289   PHIDOT=  49.567   G=  -.0413   GDOT=   6.951   PSID= 316.074   PSIDOT=  -42.873   PHITOT = 298.289
T=  .05898   PHI= 193.615   PHIDOT=  64.020   G=  -.0405   GDOT=   9.055   PSID= 315.790   PSIDOT=  -56.116   PHITOT = 298.615
T=  .05908   PHI= 194.021   PHIDOT=  77.706   G=  -.0395   GDOT=  11.109   PSID= 315.431   PSIDOT=  -69.262   PHITOT = 299.021
T=  .05918   PHI= 194.503   PHIDOT=  90.459   G=  -.0383   GDOT=  13.104   PSID= 314.997   PSIDOT=  -82.281   PHITOT = 299.503
T=  .05928   PHI= 195.056   PHIDOT= 102.163   G=  -.0369   GDOT=  15.032   PSID= 314.488   PSIDOT=  -95.144   PHITOT = 300.056
T=  .05938   PHI= 195.672   PHIDOT= 112.704   G=  -.0353   GDOT=  16.886   PSID= 313.907   PSIDOT= -107.815   PHITOT = 300.672
T=  .05948   PHI= 196.345   PHIDOT= 122.002   G=  -.0335   GDOT=  18.653   PSID= 313.253   PSIDOT= -120.264   PHITOT = 301.345
T=  .05958   PHI= 197.067   PHIDOT= 129.989   G=  -.0316   GDOT=  20.334   PSID= 312.529   PSIDOT= -132.451   PHITOT = 302.067
T=  .05968   PHI= 197.832   PHIDOT= 136.629   G=  -.0295   GDOT=  21.922   PSID= 311.736   PSIDOT= -144.339   PHITOT = 302.832
T=  .05978   PHI= 198.630   PHIDOT= 141.904   G=  -.0272   GDOT=  23.413   PSID= 310.876   PSIDOT= -155.891   PHITOT = 303.630
T=  .05988   PHI= 199.455   PHIDOT= 145.831   G=  -.0248   GDOT=  24.804   PSID= 309.951   PSIDOT= -167.070   PHITOT = 304.455
T=  .05998   PHI= 200.299   PHIDOT= 148.431   G=  -.0222   GDOT=  26.093   PSID= 308.962   PSIDOT= -177.840   PHITOT = 305.299
T=  .06008   PHI= 201.154   PHIDOT= 149.755   G=  -.0196   GDOT=  27.277   PSID= 307.914   PSIDOT= -188.170   PHITOT = 306.154
T=  .06018   PHI= 202.013   PHIDOT= 149.867   G=  -.0168   GDOT=  28.357   PSID= 306.807   PSIDOT= -198.028   PHITOT = 307.013
T=  .06028   PHI= 202.869   PHIDOT= 148.844   G=  -.0139   GDOT=  29.333   PSID= 305.645   PSIDOT= -207.388   PHITOT = 307.869
T=  .06038   PHI= 203.716   PHIDOT= 146.782   G=  -.0109   GDOT=  30.204   PSID= 304.431   PSIDOT= -216.229   PHITOT = 308.716
T=  .06048   PHI= 204.549   PHIDOT= 143.772   G=  -.0079   GDOT=  30.971   PSID= 303.168   PSIDOT= -224.531   PHITOT = 309.549
T=  .06058   PHI= 205.362   PHIDOT= 139.921   G=  -.0047   GDOT=  31.638   PSID= 301.860   PSIDOT= -232.285   PHITOT = 310.362
T=  .06068   PHI= 206.151   PHIDOT= 135.334   G=  -.0015   GDOT=  32.205   PSID= 300.508   PSIDOT= -239.480   PHITOT = 311.151
T=  .06078   PHI= 206.912   PHIDOT= 130.118   G=   .0017   GDOT=  32.675   PSID= 299.116   PSIDOT= -246.111   PHITOT = 311.912

FREE MOTION
T=  .06078   PHI= 126.912   PHDOT= 170.118   PSI=  48.453   PSIDOT=-246.111   PHITOT = 311.912
T=  .06079   PHI= 126.989   PHDOT= 140.529   PSI=  48.312   PSIDOT=-246.111   PHITOT = 311.989

T=  .06080   PHI= 127.073   PHDOT= 150.941   PSI=  48.171   PSIDOT=-246.111   PHITOT = 312.073
T=  .06081   PHI= 127.162   PHDOT= 161.353   PSI=  48.030   PSIDOT=-246.111   PHITOT = 312.162
T=  .06082   PHI= 127.258   PHDOT= 171.765   PSI=  47.889   PSIDOT=-246.111   PHITOT = 312.256
T=  .06083   PHI= 127.359   PHDOT= 182.177   PSI=  47.748   PSIDOT=-246.111   PHITOT = 312.359
T=  .06084   PHI= 127.467   PHDOT= 192.588   PSI=  47.607   PSIDOT=-246.111   PHITOT = 312.467
T=  .06085   PHI= 127.580   PHDOT= 203.000   PSI=  47.466   PSIDOT=-246.111   PHITOT = 312.580
T=  .06086   PHI= 127.699   PHDOT= 213.412   PSI=  47.325   PSIDOT=-246.111   PHITOT = 312.699
T=  .06087   PHI= 127.824   PHDOT= 223.824   PSI=  47.184   PSIDOT=-246.111   PHITOT = 312.824
T=  .06088   PHI= 127.956   PHDOT= 234.235   PSI=  47.043   PSIDOT=-246.111   PHITOT = 312.956
T=  .06089   PHI= 128.093   PHDOT= 244.647   PSI=  46.902   PSIDOT=-246.111   PHITOT = 313.093
T=  .06090   PHI= 128.236   PHDOT= 255.059   PSI=  46.761   PSIDOT=-246.111   PHITOT = 313.236
T=  .06091   PHI= 128.385   PHDOT= 265.471   PSI=  46.620   PSIDOT=-246.111   PHITOT = 313.385
T=  .06092   PHI= 128.540   PHDOT= 275.882   PSI=  46.479   PSIDOT=-246.111   PHITOT = 313.540
T=  .06093   PHI= 128.701   PHDOT= 286.294   PSI=  46.338   PSIDOT=-246.111   PHITOT = 313.701
T=  .06094   PHI= 128.868   PHDOT= 296.706   PSI=  46.197   PSIDOT=-246.111   PHITOT = 313.868
T=  .06095   PHI= 129.041   PHDOT= 307.118   PSI=  46.056   PSIDOT=-246.111   PHITOT = 314.041
T=  .06096   PHI= 129.220   PHDOT= 317.529   PSI=  45.915   PSIDOT=-246.111   PHITOT = 314.220
T=  .06097   PHI= 129.405   PHDOT= 327.941   PSI=  45.774   PSIDOT=-246.111   PHITOT = 314.405
T=  .06098   PHI= 129.596   PHDOT= 338.353   PSI=  45.633   PSIDOT=-246.111   PHITOT = 314.596
T=  .06099   PHI= 129.793   PHDOT= 348.765   PSI=  45.492   PSIDOT=-246.111   PHITOT = 314.793
T=  .06100   PHI= 129.996   PHDOT= 359.177   PSI=  45.351   PSIDOT=-246.111   PHITOT = 314.996
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T=  .06101   PHI= 130.204   PHDOT= 369.588   PSI=  45.210   PSIDOT=-246.111   PHITOT = 315.204
T=  .06102   PHI= 130.419   PHDOT= 380.000   PSI=  45.069   PSIDOT=-246.111   PHITOT = 315.419
T=  .06103   PHI= 130.640   PHDOT= 390.412   PSI=  44.928   PSIDOT=-246.111   PHITOT = 315.640

T=  .06104   PHI= 130.867   PHDOT= 400.824   PSI=  44.787   PSIDOT=-246.111   PHITOT = 315.867
T=  .06105   PHI= 131.099   PHDOT= 411.235   PSI=  44.646   PSIDOT=-246.111   PHITOT = 316.099
T=  .06106   PHI= 131.338   PHDOT= 421.647   PSI=  44.505   PSIDOT=-246.111   PHITOT = 316.338
T=  .06107   PHI= 131.582   PHDOT= 432.059   PSI=  44.364   PSIDOT=-246.111   PHITOT = 316.582
T=  .06108   PHI= 131.833   PHDOT= 442.471   PSI=  44.223   PSIDOT=-246.111   PHITOT = 316.833
T=  .06109   PHI= 132.089   PHDOT= 452.882   PSI=  44.082   PSIDOT=-246.111   PHITOT = 317.089
T=  .06110   PHI= 132.352   PHDOT= 463.294   PSI=  43.941   PSIDOT=-246.111   PHITOT = 317.352
T=  .06111   PHI= 132.620   PHDOT= 473.706   PSI=  43.800   PSIDOT=-246.111   PHITOT = 317.620
T=  .06112   PHI= 132.895   PHDOT= 484.118   PSI=  43.659   PSIDOT=-246.111   PHITOT = 317.895
T=  .06113   PHI= 133.175   PHDOT= 494.529   PSI=  43.518   PSIDOT=-246.111   PHITOT = 318.175
T=  .06114   PHI= 133.461   PHDOT= 504.941   PSI=  43.377   PSIDOT=-246.111   PHITOT = 318.461
T=  .06115   PHI= 133.754   PHDOT= 515.353   PSI=  43.236   PSIDOT=-246.111   PHITOT = 318.754
T=  .06116   PHI= 134.052   PHDOT= 525.765   PSI=  43.095   PSIDOT=-246.111   PHITOT = 319.052
T=  .06117   PHI= 134.356   PHDOT= 536.177   PSI=  42.954   PSIDOT=-246.111   PHITOT = 319.356
T=  .06118   PHI= 134.666   PHDOT= 546.588   PSI=  42.813   PSIDOT=-246.111   PHITOT = 319.666
T=  .06119   PHI= 134.983   PHDOT= 557.000   PSI=  42.672   PSIDOT=-246.111   PHITOT = 319.983
T=  .06120   PHI= 135.305   PHDOT= 567.412   PSI=  42.531   PSIDOT=-246.111   PHITOT = 320.305
VP= -14.417   VS=  43.578

IMPACT

              PHI= 135.305   DPHIF=-283.971   PSI=  42.531   DPSIF=-124.799   PHITOT= 320.305
VP=  -7.311   VS= -21.809

FREE MOTION
T=  .06120   PHI= 135.305   PHDOT=-283.971   PSI=  42.531   PSIDOT=-124.799   PHITOT = 320.305
T=  .06121   PHI= 135.145   PHDOT=-273.559   PSI=  42.459   PSIDOT=-124.799   PHITOT = 320.145
VP=  -7.325   VS= -20.845

FREE MOTION
T=  .06121   PHI= 135.145   PHDOT=-273.559   PSI=  42.459   PSIDOT=-124.799   PHITOT = 320.145
T=  .06122   PHI= 134.991   PHDOT=-263.147   PSI=  42.388   PSIDOT=-124.799   PHITOT = 319.991
VP=  -7.339   VS= -19.901

FREE MOTION
T=  .06122   PHI= 134.991   PHDOT=-263.147   PSI=  42.388   PSIDOT=-124.799   PHITOT = 319.991
T=  .06123   PHI= 134.843   PHDOT=-252.735   PSI=  42.316   PSIDOT=-124.799   PHITOT = 319.843
T=  .06124   PHI= 134.702   PHDOT=-242.323   PSI=  42.245   PSIDOT=-124.799   PHITOT = 319.702
T=  .06125   PHI= 134.566   PHDOT=-231.912   PSI=  42.173   PSIDOT=-124.799   PHITOT = 319.566
T=  .06126   PHI= 134.436   PHDOT=-221.500   PSI=  42.102   PSIDOT=-124.799   PHITOT = 319.436
T=  .06127   PHI= 134.312   PHDOT=-211.088   PSI=  42.030   PSIDOT=-124.799   PHITOT = 319.312
T=  .06128   PHI= 134.194   PHDOT=-200.676   PSI=  41.959   PSIDOT=-124.799   PHITOT = 319.194
T=  .06129   PHI= 134.082   PHDOT=-190.265   PSI=  41.887   PSIDOT=-124.799   PHITOT = 319.082
T=  .06130   PHI= 133.976   PHDOT=-179.853   PSI=  41.816   PSIDOT=-124.799   PHITOT = 318.976
T=  .06131   PHI= 133.876   PHDOT=-169.441   PSI=  41.744   PSIDOT=-124.799   PHITOT = 318.876
T=  .06132   PHI= 133.782   PHDOT=-159.029   PSI=  41.673   PSIDOT=-124.799   PHITOT = 318.782
T=  .06133   PHI= 133.694   PHDOT=-148.618   PSI=  41.601   PSIDOT=-124.799   PHITOT = 318.694
T=  .06134   PHI= 133.611   PHDOT=-138.206   PSI=  41.530   PSIDOT=-124.799   PHITOT = 318.611
T=  .06135   PHI= 133.535   PHDOT=-127.794   PSI=  41.458   PSIDOT=-124.799   PHITOT = 318.535
T=  .06136   PHI= 133.465   PHDOT=-117.382   PSI=  41.387   PSIDOT=-124.799   PHITOT = 318.465
T=  .06137   PHI= 133.401   PHDOT=-106.971   PSI=  41.315   PSIDOT=-124.799   PHITOT = 318.401
T=  .06138   PHI= 133.342   PHDOT= -96.559   PSI=  41.244   PSIDOT=-124.799   PHITOT = 318.342
T=  .06139   PHI= 133.290   PHDOT= -86.147   PSI=  41.172   PSIDOT=-124.799   PHITOT = 318.290
T=  .06140   PHI= 133.244   PHDOT= -75.735   PSI=  41.101   PSIDOT=-124.799   PHITOT = 318.244
T=  .06141   PHI= 133.203   PHDOT= -65.323   PSI=  41.029   PSIDOT=-124.799   PHITOT = 318.203
T=  .06142   PHI= 133.169   PHDOT= -54.912   PSI=  40.958   PSIDOT=-124.799   PHITOT = 318.169
T=  .06143   PHI= 133.140   PHDOT= -44.500   PSI=  40.886   PSIDOT=-124.799   PHITOT = 318.140
T=  .06144   PHI= 133.118   PHDOT= -34.088   PSI=  40.815   PSIDOT=-124.799   PHITOT = 318.118
T=  .06145   PHI= 133.101   PHDOT= -23.676   PSI=  40.743   PSIDOT=-124.799   PHITOT = 318.101
T=  .06146   PHI= 133.091   PHDOT= -13.265   PSI=  40.672   PSIDOT=-124.799   PHITOT = 318.091
T=  .06147   PHI= 133.086   PHDOT=  -2.853   PSI=  40.600   PSIDOT=-124.799   PHITOT = 318.086
T=  .06148   PHI= 133.087   PHDOT=   7.559   PSI=  40.529   PSIDOT=-124.799   PHITOT = 318.087
```

```
T=  .06149   PHI= 133.095   PHDOT=  17.971   PSI=  40.457   PSIDOT=-124.799   PHITOT = 318.095
T=  .06150   PHI= 133.108   PHDOT=  28.382   PSI=  40.386   PSIDOT=-124.799   PHITOT = 318.108
T=  .06151   PHI= 133.127   PHDOT=  38.794   PSI=  40.314   PSIDOT=-124.799   PHITOT = 318.127
T=  .06152   PHI= 133.152   PHDOT=  49.206   PSI=  40.243   PSIDOT=-124.799   PHITOT = 318.152
T=  .06153   PHI= 133.184   PHDOT=  59.618   PSI=  40.171   PSIDOT=-124.799   PHITOT = 318.184
T=  .06154   PHI= 133.221   PHDOT=  70.029   PSI=  40.100   PSIDOT=-124.799   PHITOT = 318.221
VP= -7.252   VS=  4.840

IMPACT
             PHI= 133.221   DPHIF=-123.159   PSI=  40.100   DPSIF= -94.453   PHITOT= 318.221
VP= -5.489   VS= -8.517

FREE MOTION
T=  .06154   PHI= 133.221   PHDOT=-123.159   PSI=  40.100   PSIDOT= -94.453   PHITOT = 318.221
T=  .06155   PHI= 133.153   PHDOT=-112.747   PSI=  40.046   PSIDOT= -94.453   PHITOT = 318.153
VP= -5.490   VS= -7.765

FREE MOTION
T=  .06155   PHI= 133.153   PHDOT=-112.747   PSI=  40.046   PSIDOT= -94.453   PHITOT = 318.153
T=  .06156   PHI= 133.092   PHDOT=-102.336   PSI=  39.992   PSIDOT= -94.453   PHITOT = 318.092
VP= -5.491   VS= -7.025

FREE MOTION
T=  .06156   PHI= 133.092   PHDOT=-102.336   PSI=  39.992   PSIDOT= -94.453   PHITOT = 318.092
T=  .06157   PHI= 133.036   PHDOT= -91.924   PSI=  39.937   PSIDOT= -94.453   PHITOT = 318.036
VP= -5.492   VS= -6.292

FREE MOTION
T=  .06157   PHI= 133.036   PHDOT= -91.924   PSI=  39.937   PSIDOT= -94.453   PHITOT = 318.036
T=  .06158   PHI= 132.986   PHDOT= -81.512   PSI=  39.883   PSIDOT= -94.453   PHITOT = 317.986
VP= -5.491   VS= -5.564

FREE MOTION
T=  .06158   PHI= 132.986   PHDOT= -81.512   PSI=  39.883   PSIDOT= -94.453   PHITOT = 317.986
T=  .06159   PHI= 132.943   PHDOT= -71.100   PSI=  39.829   PSIDOT= -94.453   PHITOT = 317.943
VP= -5.490   VS= -4.842

IMPACT
             PHI= 132.943   DPHIF= -81.556   PSI=  39.829   DPSIF= -92.786   PHITOT= 317.943
VP= -5.393   VS= -5.555
```

APPENDIX J

COMPUTER OUTPUT FOR STANDARD CONFIGURATION
WITH $\mu = .3$ AND $\varepsilon = 0$

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

A= .19310 B= .15838 C= .09683 R= .01365 ALPHA= 40.0000

TORQUE= .17700E-01 COFR= .30000E+00 IPAL= .91000E-07 ISTAR= .17000E-07

Appendix J

Std.Config.
$\mu = .3,\ \varepsilon = 0$

EREST= 0.00 LAMBDA= 109.337 DELTA= 40.000

Cycle No. 1

COUPLED MOTION

T=	PHI=	PHIDOT=	G=	GDOT=	PSI=	PSIDOT=	PHITOT =
0.00000	135.000	0.000	-.0457	0.000	42.412	0.000	-.000
.00000	135.000	.044	-.0457	.018	42.412	.105	.000
.00000	135.030	.151	-.0457	.032	42.412	.195	.000
.00000	135.000	.219	-.0457	.047	42.412	.281	.000
.00001	135.000	.284	-.0457	.041	42.412	.368	.000
.00001	135.000	.421	-.0457	.090	42.412	.542	.000
.00001	135.000	.556	-.0457	.119	42.412	.716	.000
.00002	135.000	.827	-.0457	.177	42.413	1.063	.000
.00002	135.001	1.097	-.0457	.235	42.413	1.410	.001
.00004	135.002	1.637	-.0457	.351	42.414	2.105	.002
.00005	135.003	2.177	-.0457	.447	42.416	2.800	.003
.00007	135.007	3.254	-.0456	.698	42.421	4.189	.007
.00010	135.012	4.335	-.0456	.930	42.428	5.579	.012
.00015	135.028	6.490	-.0456	1.392	42.448	8.357	.028
.00020	135.050	8.639	-.0455	1.854	42.476	11.134	.050
.00030	135.111	12.913	-.0453	2.774	42.556	16.686	.111
.00040	135.198	17.142	-.0449	3.688	42.667	22.232	.198
.00050	135.308	21.313	-.0445	4.594	42.811	27.771	.308
.00060	135.442	25.413	-.0440	5.491	42.986	33.300	.442
.00070	135.599	29.433	-.0434	6.376	43.192	38.819	.599
.00080	135.779	33.360	-.0427	7.250	43.430	44.326	.779
.00090	135.981	37.180	-.0420	8.109	43.700	49.819	.981
.00100	136.205	40.911	-.0411	8.954	44.001	55.298	1.205
.00110	136.449	44.522	-.0402	9.784	44.334	60.762	1.449
.00120	136.715	48.018	-.0392	10.597	44.697	66.211	1.715
.00130	136.999	51.397	-.0381	11.394	45.092	71.642	1.999
.00140	137.303	54.659	-.0369	12.173	45.518	77.058	2.303
.00150	137.626	57.804	-.0356	12.935	45.975	82.457	2.626
.00160	137.966	60.833	-.0343	13.680	46.463	87.840	2.966
.00170	138.322	63.750	-.0329	14.408	46.982	93.207	3.322
.00180	138.696	66.558	-.0314	15.118	47.531	98.559	3.696
.00190	139.085	69.261	-.0299	15.812	48.111	103.896	4.085
.00200	139.489	71.864	-.0282	16.489	48.722	109.220	4.489
.00210	139.908	74.372	-.0266	17.150	49.363	114.532	4.908
.00220	140.341	76.790	-.0248	17.794	50.034	119.832	5.341
.00230	140.788	79.125	-.0230	18.424	50.736	125.123	5.788
.00240	141.248	81.381	-.0211	19.038	51.468	130.405	6.248
.00250	141.721	83.564	-.0192	19.637	52.230	135.680	6.721
.00260	142.205	85.683	-.0172	20.221	53.023	140.950	7.205
.00270	142.702	87.740	-.0152	20.792	53.845	146.216	7.702
.00280	143.211	89.741	-.0131	21.349	54.698	151.480	8.211
.00290	143.731	91.692	-.0109	21.892	55.581	156.743	8.731
.00300	144.261	93.598	-.0087	22.421	56.494	162.008	9.261
.00310	144.803	95.463	-.0064	22.938	57.438	167.275	9.803
.00320	145.355	97.292	-.0041	23.441	58.411	172.547	10.355
.00330	145.918	99.090	-.0017	23.931	59.415	177.825	10.918
.00340	146.491	100.859	.0007	24.408	60.449	183.111	11.491

FREE MOTION

```
T=  .00340   PHI= 186.491   PHDOT= 100.859   PSI= 311.112   PSIDOT= 183.111   PHITOT =  11.491
T=  .00341   PHI= 186.551   PHDOT= 111.271   PSI= 311.217   PSIDOT= 183.111   PHITOT =  11.551
T=  .00342   PHI= 186.618   PHDOT= 121.653   PSI= 311.322   PSIDOT= 183.111   PHITOT =  11.618
T=  .00343   PHI= 186.691   PHDOT= 132.095   PSI= 311.427   PSIDOT= 183.111   PHITOT =  11.691
T=  .00344   PHI= 186.773   PHDOT= 142.506   PSI= 311.532   PSIDOT= 183.111   PHITOT =  11.773
T=  .00345   PHI= 186.854   PHDOT= 152.918   PSI= 311.637   PSIDOT= 183.111   PHITOT =  11.854
T=  .00346   PHI= 186.945   PHDOT= 163.330   PSI= 311.742   PSIDOT= 183.111   PHITOT =  11.945
T=  .00347   PHI= 187.041   PHDOT= 173.742   PSI= 311.846   PSIDOT= 183.111   PHITOT =  12.041
T=  .00348   PHI= 187.144   PHDOT= 184.153   PSI= 311.951   PSIDOT= 183.111   PHITOT =  12.144
T=  .00349   PHI= 187.252   PHDOT= 194.565   PSI= 312.056   PSIDOT= 183.111   PHITOT =  12.252
T=  .00350   PHI= 187.367   PHDOT= 204.977   PSI= 312.161   PSIDOT= 183.111   PHITOT =  12.367
T=  .00351   PHI= 187.487   PHDOT= 215.389   PSI= 312.266   PSIDOT= 183.111   PHITOT =  12.487
T=  .00352   PHI= 187.614   PHDOT= 225.800   PSI= 312.371   PSIDOT= 183.111   PHITOT =  12.614
T=  .00353   PHI= 187.746   PHDOT= 236.212   PSI= 312.476   PSIDOT= 183.111   PHITOT =  12.746
T=  .00354   PHI= 187.884   PHDOT= 246.624   PSI= 312.581   PSIDOT= 183.111   PHITOT =  12.884
T=  .00355   PHI= 188.029   PHDOT= 257.036   PSI= 312.686   PSIDOT= 183.111   PHITOT =  13.029
T=  .00356   PHI= 188.179   PHDOT= 267.447   PSI= 312.791   PSIDOT= 183.111   PHITOT =  13.179
T=  .00357   PHI= 188.335   PHDOT= 277.859   PSI= 312.896   PSIDOT= 183.111   PHITOT =  13.335
T=  .00358   PHI= 188.497   PHDOT= 288.271   PSI= 313.001   PSIDOT= 183.111   PHITOT =  13.497
T=  .00359   PHI= 188.665   PHDOT= 298.683   PSI= 313.105   PSIDOT= 183.111   PHITOT =  13.665
T=  .00360   PHI= 188.840   PHDOT= 309.095   PSI= 313.210   PSIDOT= 183.111   PHITOT =  13.840
T=  .00361   PHI= 189.020   PHDOT= 319.506   PSI= 313.315   PSIDOT= 183.111   PHITOT =  14.020
T=  .00362   PHI= 189.205   PHDOT= 329.918   PSI= 313.420   PSIDOT= 183.111   PHITOT =  14.205
T=  .00363   PHI= 189.398   PHDOT= 340.330   PSI= 313.525   PSIDOT= 183.111   PHITOT =  14.398
T=  .00364   PHI= 189.596   PHDOT= 350.742   PSI= 313.630   PSIDOT= 183.111   PHITOT =  14.596
T=  .00365   PHI= 189.800   PHDOT= 361.153   PSI= 313.735   PSIDOT= 183.111   PHITOT =  14.800
T=  .00366   PHI= 190.010   PHDOT= 371.565   PSI= 313.840   PSIDOT= 183.111   PHITOT =  15.010
T=  .00367   PHI= 190.225   PHDOT= 381.977   PSI= 313.945   PSIDOT= 183.111   PHITOT =  15.225
T=  .00368   PHI= 190.447   PHDOT= 392.389   PSI= 314.050   PSIDOT= 183.111   PHITOT =  15.447
T=  .00369   PHI= 190.675   PHDOT= 402.800   PSI= 314.155   PSIDOT= 183.111   PHITOT =  15.675
T=  .00370   PHI= 190.909   PHDOT= 413.212   PSI= 314.260   PSIDOT= 183.111   PHITOT =  15.909
T=  .00371   PHI= 191.149   PHDOT= 423.624   PSI= 314.364   PSIDOT= 183.111   PHITOT =  16.149
T=  .00372   PHI= 191.394   PHDOT= 434.036   PSI= 314.469   PSIDOT= 183.111   PHITOT =  16.394
T=  .00373   PHI= 191.646   PHDOT= 444.447   PSI= 314.574   PSIDOT= 183.111   PHITOT =  16.646
T=  .00374   PHI= 191.904   PHDOT= 454.859   PSI= 314.679   PSIDOT= 183.111   PHITOT =  16.904
T=  .00375   PHI= 192.167   PHDOT= 465.271   PSI= 314.784   PSIDOT= 183.111   PHITOT =  17.167
T=  .00376   PHI= 192.437   PHDOT= 475.683   PSI= 314.889   PSIDOT= 183.111   PHITOT =  17.437
T=  .00377   PHI= 192.712   PHDOT= 486.095   PSI= 314.994   PSIDOT= 183.111   PHITOT =  17.712
T=  .00378   PHI= 192.994   PHDOT= 496.506   PSI= 315.099   PSIDOT= 183.111   PHITOT =  17.994
T=  .00379   PHI= 193.281   PHDOT= 506.918   PSI= 315.204   PSIDOT= 183.111   PHITOT =  18.281
T=  .00380   PHI= 193.575   PHDOT= 517.330   PSI= 315.309   PSIDOT= 183.111   PHITOT =  18.575
T=  .00381   PHI= 193.874   PHDOT= 527.742   PSI= 315.414   PSIDOT= 183.111   PHITOT =  18.874
T=  .00382   PHI= 194.179   PHDOT= 538.153   PSI= 315.518   PSIDOT= 183.111   PHITOT =  19.179
VP= -16.798   VS=  44.239

     IMPACT

                PHI= 194.179   DPHIF= -64.204   PSI= 315.518   DPSIF=  57.532   PHITOT=  19.179
VP=  -5.278   VS=  -5.278

     COUPLED MOTION
T=  .00382   PHI= 194.179   PHIDOT= -64.204   G=  -.0391   GDOT=  -9.219   PSID= 315.289   PSIDOT=  57.611   PHITOT =  19.179
T=  .00392   PHI= 193.894   PHIDOT= -35.093   G=  -.0398   GDOT=  -5.000   PSID= 315.544   PSIDOT=  31.119   PHITOT =  18.894
T=  .00402   PHI= 193.779   PHIDOT=  -5.240   G=  -.0401   GDOT=   -.744   PSID= 315.646   PSIDOT=   4.624   PHITOT =  18.779
T=  .00403   PHI= 193.777   PHIDOT=  -3.363   G=  -.0401   GDOT=   -.478   PSID= 315.647   PSIDOT=   2.968   PHITOT =  18.777
T=  .00403   PHI= 193.776   PHIDOT=  -1.487   G=  -.0401   GDOT=   -.211   PSID= 315.648   PSIDOT=   1.312   PHITOT =  18.776
T=  .00403   PHI= 193.776   PHIDOT=  -1.018   G=  -.0401   GDOT=   -.145   PSID= 315.648   PSIDOT=    .898   PHITOT =  18.776
T=  .00404   PHI= 193.776   PHIDOT=   -.549   G=  -.0401   GDOT=   -.078   PSID= 315.648   PSIDOT=    .484   PHITOT =  18.776
T=  .00404   PHI= 193.776   PHIDOT=   -.314   G=  -.0401   GDOT=   -.045   PSID= 315.648   PSIDOT=    .277   PHITOT =  18.776
T=  .00404   PHI= 193.776   PHIDOT=   -.080   G=  -.0401   GDOT=   -.011   PSID= 315.648   PSIDOT=    .070   PHITOT =  18.776
T=  .00404   PHI= 193.776   PHIDOT=    .055   G=  -.0401   GDOT=    .008   PSID= 315.648   PSIDOT=   -.049   PHITOT =  18.776
T=  .00404   PHI= 193.776   PHIDOT=    .171   G=  -.0401   GDOT=    .024   PSID= 315.648   PSIDOT=   -.151   PHITOT =  18.776
T=  .00404   PHI= 193.776   PHIDOT=    .286   G=  -.0401   GDOT=    .041   PSID= 315.648   PSIDOT=   -.252   PHITOT =  18.776
T=  .00404   PHI= 193.776   PHIDOT=    .401   G=  -.0401   GDOT=    .057   PSID= 315.648   PSIDOT=   -.354   PHITOT =  18.776
T=  .00404   PHI= 193.776   PHIDOT=    .516   G=  -.0401   GDOT=    .073   PSID= 315.648   PSIDOT=   -.456   PHITOT =  18.776
T=  .00404   PHI= 193.776   PHIDOT=    .631   G=  -.0401   GDOT=    .090   PSID= 315.648   PSIDOT=   -.557   PHITOT =  18.776
```

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T=  .00404   PHI= 193.776   PHIDOT=    .862   G=  -.0401   GDOT=    .122   PSID= 315.648   PSIDOT=   -.760   PHITOT =  18.776
T=  .00404   PHI= 193.776   PHIDOT=   1.092   G=  -.0401   GDOT=    .155   PSID= 315.648   PSIDOT=   -.964   PHITOT =  18.776
T=  .00405   PHI= 193.776   PHIDOT=   1.553   G=  -.0401   GDOT=    .221   PSID= 315.648   PSIDOT=  -1.370   PHITOT =  18.776
T=  .00405   PHI= 193.777   PHIDOT=   2.014   G=  -.0401   GDOT=    .286   PSID= 315.648   PSIDOT=  -1.777   PHITOT =  18.777
T=  .00405   PHI= 193.777   PHIDOT=   2.474   G=  -.0401   GDOT=    .351   PSID= 315.647   PSIDOT=  -2.184   PHITOT =  18.777
T=  .00406   PHI= 193.778   PHIDOT=   2.935   G=  -.0401   GDOT=    .417   PSID= 315.647   PSIDOT=  -2.590   PHITOT =  18.778
T=  .00406   PHI= 193.779   PHIDOT=   3.856   G=  -.0401   GDOT=    .548   PSID= 315.646   PSIDOT=  -3.403   PHITOT =  18.779
T=  .00407   PHI= 193.780   PHIDOT=   4.778   G=  -.0401   GDOT=    .679   PSID= 315.644   PSIDOT=  -4.216   PHITOT =  18.780
T=  .00408   PHI= 193.785   PHIDOT=   6.619   G=  -.0401   GDOT=    .940   PSID= 315.641   PSIDOT=  -5.843   PHITOT =  18.785
T=  .00409   PHI= 193.790   PHIDOT=   8.459   G=  -.0401   GDOT=   1.202   PSID= 315.636   PSIDOT=  -7.469   PHITOT =  18.790
T=  .00411   PHI= 193.797   PHIDOT=  10.298   G=  -.0401   GDOT=   1.463   PSID= 315.630   PSIDOT=  -9.094   PHITOT =  18.797
T=  .00412   PHI= 193.805   PHIDOT=  12.135   G=  -.0401   GDOT=   1.725   PSID= 315.623   PSIDOT= -10.720   PHITOT =  18.805
T=  .00414   PHI= 193.825   PHIDOT=  15.901   G=  -.0400   GDOT=   2.247   PSID= 315.605   PSIDOT= -13.970   PHITOT =  18.825
T=  .00417   PHI= 193.850   PHIDOT=  19.455   G=  -.0399   GDOT=   2.769   PSID= 315.583   PSIDOT= -17.219   PHITOT =  18.850
T=  .00419   PHI= 193.880   PHIDOT=  23.094   G=  -.0399   GDOT=   3.249   PSID= 315.556   PSIDOT= -20.465   PHITOT =  18.880
T=  .00422   PHI= 193.916   PHIDOT=  26.716   G=  -.0398   GDOT=   3.809   PSID= 315.524   PSIDOT= -23.711   PHITOT =  18.916
T=  .00427   PHI= 194.003   PHIDOT=  33.894   G=  -.0396   GDOT=   4.844   PSID= 315.447   PSIDOT= -30.192   PHITOT =  19.003
T=  .00432   PHI= 194.110   PHIDOT=  40.976   G=  -.0393   GDOT=   5.872   PSID= 315.351   PSIDOT= -36.660   PHITOT =  19.110
T=  .00437   PHI= 194.238   PHIDOT=  47.929   G=  -.0390   GDOT=   6.893   PSID= 315.237   PSIDOT= -43.112   PHITOT =  19.238
T=  .00442   PHI= 194.385   PHIDOT=  54.741   G=  -.0386   GDOT=   7.906   PSID= 315.104   PSIDOT= -49.545   PHITOT =  19.385
T=  .00452   PHI= 194.736   PHIDOT=  67.863   G=  -.0377   GDOT=   9.895   PSID= 314.784   PSIDOT= -62.339   PHITOT =  19.736
T=  .00462   PHI= 195.161   PHIDOT=  80.164   G=  -.0366   GDOT=  11.834   PSID= 314.390   PSIDOT= -75.016   PHITOT =  20.161
T=  .00472   PHI= 195.653   PHIDOT=  91.591   G=  -.0353   GDOT=  13.713   PSID= 313.925   PSIDOT= -87.546   PHITOT =  20.653
T=  .00482   PHI= 196.208   PHIDOT= 101.968   G=  -.0339   GDOT=  15.524   PSID= 313.387   PSIDOT= -99.899   PHITOT =  21.208
T=  .00492   PHI= 196.820   PHIDOT= 111.227   G=  -.0322   GDOT=  17.241   PSID= 312.780   PSIDOT=-112.063   PHITOT =  21.820
T=  .00502   PHI= 197.481   PHIDOT= 119.303   G=  -.0304   GDOT=  18.917   PSID= 312.104   PSIDOT=-123.943   PHITOT =  22.481
T=  .00512   PHI= 198.186   PHIDOT= 126.144   G=  -.0285   GDOT=  20.488   PSID= 311.360   PSIDOT=-135.564   PHITOT =  23.186
T=  .00522   PHI= 198.924   PHIDOT= 131.740   G=  -.0263   GDOT=  21.968   PSID= 310.551   PSIDOT=-146.872   PHITOT =  23.924
T=  .00532   PHI= 199.692   PHIDOT= 136.076   G=  -.0241   GDOT=  23.355   PSID= 309.678   PSIDOT=-157.832   PHITOT =  24.692
T=  .00542   PHI= 200.481   PHIDOT= 139.172   G=  -.0217   GDOT=  24.646   PSID= 308.743   PSIDOT=-168.411   PHITOT =  25.481
T=  .00552   PHI= 201.284   PHIDOT= 141.066   G=  -.0191   GDOT=  25.839   PSID= 307.749   PSIDOT=-178.578   PHITOT =  26.284
T=  .00562   PHI= 202.095   PHIDOT= 141.801   G=  -.0165   GDOT=  26.933   PSID= 306.698   PSIDOT=-188.304   PHITOT =  27.095
T=  .00572   PHI= 202.907   PHIDOT= 141.450   G=  -.0138   GDOT=  27.927   PSID= 305.592   PSIDOT=-197.562   PHITOT =  27.907
T=  .00582   PHI= 203.714   PHIDOT= 140.084   G=  -.0109   GDOT=  28.822   PSID= 304.435   PSIDOT=-206.332   PHITOT =  28.714
T=  .00592   PHI= 204.511   PHIDOT= 137.796   G=  -.0080   GDOT=  29.618   PSID= 303.229   PSIDOT=-214.595   PHITOT =  29.511
T=  .00602   PHI= 205.291   PHIDOT= 134.667   G=  -.0050   GDOT=  30.317   PSID= 301.977   PSIDOT=-222.337   PHITOT =  30.291
T=  .00612   PHI= 206.052   PHIDOT= 130.800   G=  -.0019   GDOT=  30.920   PSID= 300.682   PSIDOT=-229.549   PHITOT =  31.052
T=  .00622   PHI= 206.789   PHIDOT= 126.289   G=   .0012   GDOT=  31.429   PSID= 299.347   PSIDOT=-236.225   PHITOT =  31.789

FREE MOTION
T=  .00622   PHI= 126.789   PHDOT= 126.289   PSI=  48.684   PSIDOT=-236.225   PHITOT =  31.789
T=  .00623   PHI= 126.864   PHDOT= 136.700   PSI=  48.549   PSIDOT=-236.225   PHITOT =  31.864
T=  .00624   PHI= 126.946   PHDOT= 147.112   PSI=  48.414   PSIDOT=-236.225   PHITOT =  31.946
T=  .00625   PHI= 127.033   PHDOT= 157.524   PSI=  48.278   PSIDOT=-236.225   PHITOT =  32.033
T=  .00626   PHI= 127.126   PHDOT= 167.936   PSI=  48.143   PSIDOT=-236.225   PHITOT =  32.126
T=  .00627   PHI= 127.225   PHDOT= 178.347   PSI=  48.008   PSIDOT=-236.225   PHITOT =  32.225
T=  .00628   PHI= 127.331   PHDOT= 188.759   PSI=  47.872   PSIDOT=-236.225   PHITOT =  32.331
T=  .00629   PHI= 127.442   PHDOT= 199.171   PSI=  47.737   PSIDOT=-236.225   PHITOT =  32.442
T=  .00630   PHI= 127.559   PHDOT= 209.583   PSI=  47.602   PSIDOT=-236.225   PHITOT =  32.559
T=  .00631   PHI= 127.682   PHDOT= 219.994   PSI=  47.466   PSIDOT=-236.225   PHITOT =  32.682
T=  .00632   PHI= 127.811   PHDOT= 230.406   PSI=  47.331   PSIDOT=-236.225   PHITOT =  32.811
T=  .00633   PHI= 127.946   PHDOT= 240.818   PSI=  47.196   PSIDOT=-236.225   PHITOT =  32.946
T=  .00634   PHI= 128.087   PHDOT= 251.230   PSI=  47.060   PSIDOT=-236.225   PHITOT =  33.087
T=  .00635   PHI= 128.234   PHDOT= 261.642   PSI=  46.925   PSIDOT=-236.225   PHITOT =  33.234
T=  .00636   PHI= 128.387   PHDOT= 272.053   PSI=  46.790   PSIDOT=-236.225   PHITOT =  33.387
T=  .00637   PHI= 128.546   PHDOT= 282.465   PSI=  46.654   PSIDOT=-236.225   PHITOT =  33.546
T=  .00638   PHI= 128.710   PHDOT= 292.877   PSI=  46.519   PSIDOT=-236.225   PHITOT =  33.710
T=  .00639   PHI= 128.881   PHDOT= 303.289   PSI=  46.383   PSIDOT=-236.225   PHITOT =  33.881
T=  .00640   PHI= 129.058   PHDOT= 313.700   PSI=  46.248   PSIDOT=-236.225   PHITOT =  34.058
T=  .00641   PHI= 129.241   PHDOT= 324.112   PSI=  46.112   PSIDOT=-236.225   PHITOT =  34.241
T=  .00642   PHI= 129.429   PHDOT= 334.524   PSI=  45.977   PSIDOT=-236.225   PHITOT =  34.429
T=  .00643   PHI= 129.624   PHDOT= 344.936   PSI=  45.842   PSIDOT=-236.225   PHITOT =  34.624
T=  .00644   PHI= 129.825   PHDOT= 355.347   PSI=  45.707   PSIDOT=-236.225   PHITOT =  34.825
T=  .00645   PHI= 130.031   PHDOT= 365.759   PSI=  45.571   PSIDOT=-236.225   PHITOT =  35.031
T=  .00646   PHI= 130.244   PHDOT= 376.171   PSI=  45.436   PSIDOT=-236.225   PHITOT =  35.244
T=  .00647   PHI= 130.462   PHDOT= 386.583   PSI=  45.301   PSIDOT=-236.225   PHITOT =  35.462
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T=  .00648   PHI= 130.687   PHDOT= 395.994   PSI=  45.165   PSIDOT=-236.225   PHITOT =  35.687
T=  .00649   PHI= 130.917   PHDOT= 407.406   PSI=  45.030   PSIDOT=-236.225   PHITOT =  35.917
T=  .00650   PHI= 131.154   PHDOT= 417.818   PSI=  44.895   PSIDOT=-236.225   PHITOT =  36.154
T=  .00651   PHI= 131.396   PHDOT= 428.230   PSI=  44.759   PSIDOT=-236.225   PHITOT =  36.396
T=  .00652   PHI= 131.644   PHDOT= 438.642   PSI=  44.624   PSIDOT=-236.225   PHITOT =  36.644
T=  .00653   PHI= 131.899   PHDOT= 449.053   PSI=  44.489   PSIDOT=-236.225   PHITOT =  36.899
T=  .00654   PHI= 132.159   PHDOT= 459.465   PSI=  44.353   PSIDOT=-236.225   PHITOT =  37.159
T=  .00655   PHI= 132.425   PHDOT= 469.877   PSI=  44.218   PSIDOT=-236.225   PHITOT =  37.425
T=  .00656   PHI= 132.697   PHDOT= 480.289   PSI=  44.083   PSIDOT=-236.225   PHITOT =  37.697
T=  .00657   PHI= 132.975   PHDOT= 490.700   PSI=  43.947   PSIDOT=-236.225   PHITOT =  37.975
T=  .00658   PHI= 133.260   PHDOT= 501.112   PSI=  43.812   PSIDOT=-236.225   PHITOT =  38.260
T=  .00659   PHI= 133.550   PHDOT= 511.524   PSI=  43.677   PSIDOT=-236.225   PHITOT =  38.550
T=  .00660   PHI= 133.846   PHDOT= 521.936   PSI=  43.541   PSIDOT=-236.225   PHITOT =  38.846
T=  .00661   PHI= 134.148   PHDOT= 532.347   PSI=  43.406   PSIDOT=-236.225   PHITOT =  39.148
T=  .00662   PHI= 134.456   PHDOT= 542.759   PSI=  43.271   PSIDOT=-236.225   PHITOT =  39.456
T=  .00663   PHI= 134.770   PHDOT= 553.171   PSI=  43.135   PSIDOT=-236.225   PHITOT =  39.770
T=  .00664   PHI= 135.090   PHDOT= 563.583   PSI=  43.000   PSIDOT=-236.225   PHITOT =  40.090
T=  .00665   PHI= 135.416   PHDOT= 573.994   PSI=  42.864   PSIDOT=-236.225   PHITOT =  40.416
VP= -13.908   VS=  44.323
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IMPACT   <u>Cycle No. 2</u>

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             PHI= 135.416   DPHIF=-106.237   PSI=  42.864   DPSIF=-139.331   PHITOT=  40.416
VP=  -8.204   VS=  -8.204

COUPLED MOTION
T=  .00665   PHI= 135.416   PHIDOT=-106.237   G=  -.0441   GDOT= -22.943   PSID=  42.951   PSIDOT=-139.056   PHITOT =  40.416
T=  .00675   PHI= 134.865   PHIDOT= -85.713   G=  -.0462   GDOT= -18.329   PSID=  42.239   PSIDOT=-109.593   PHITOT =  39.865
T=  .00685   PHI= 134.437   PHIDOT= -63.431   G=  -.0478   GDOT= -13.457   PSID=  41.697   PSIDOT= -79.594   PHITOT =  39.437
T=  .00695   PHI= 134.141   PHIDOT= -39.743   G=  -.0489   GDOT=  -8.385   PSID=  41.327   PSIDOT= -49.211   PHITOT =  39.141
T=  .00705   PHI= 133.983   PHIDOT= -15.126   G=  -.0494   GDOT=  -3.182   PSID=  41.133   PSIDOT= -18.596   PHITOT =  38.983
T=  .00707   PHI= 133.966   PHIDOT=  -8.892   G=  -.0495   GDOT=  -1.870   PSID=  41.112   PSIDOT= -10.923   PHITOT =  38.966
T=  .00710   PHI= 133.958   PHIDOT=  -2.644   G=  -.0495   GDOT=   -.556   PSID=  41.102   PSIDOT=  -3.746   PHITOT =  38.958
T=  .00710   PHI= 133.957   PHIDOT=  -1.862   G=  -.0495   GDOT=   -.392   PSID=  41.101   PSIDOT=  -2.287   PHITOT =  38.957
T=  .00711   PHI= 133.957   PHIDOT=  -1.081   G=  -.0495   GDOT=   -.227   PSID=  41.101   PSIDOT=  -1.327   PHITOT =  38.957
T=  .00711   PHI= 133.957   PHIDOT=   -.690   G=  -.0495   GDOT=   -.145   PSID=  41.101   PSIDOT=   -.847   PHITOT =  38.957
T=  .00711   PHI= 133.957   PHIDOT=   -.299   G=  -.0495   GDOT=   -.063   PSID=  41.101   PSIDOT=   -.368   PHITOT =  38.957
T=  .00711   PHI= 133.957   PHIDOT=   -.104   G=  -.0495   GDOT=   -.022   PSID=  41.101   PSIDOT=   -.128   PHITOT =  38.957
T=  .00711   PHI= 133.957   PHIDOT=    .065   G=  -.0495   GDOT=    .014   PSID=  41.101   PSIDOT=    .080   PHITOT =  38.957
T=  .00711   PHI= 133.957   PHIDOT=    .101   G=  -.0495   GDOT=    .021   PSID=  41.101   PSIDOT=    .124   PHITOT =  38.957
T=  .00711   PHI= 133.957   PHIDOT=    .137   G=  -.0495   GDOT=    .029   PSID=  41.101   PSIDOT=    .168   PHITOT =  38.957
T=  .00711   PHI= 133.957   PHIDOT=    .209   G=  -.0495   GDOT=    .044   PSID=  41.101   PSIDOT=    .257   PHITOT =  38.957
T=  .00712   PHI= 133.957   PHIDOT=    .281   G=  -.0495   GDOT=    .059   PSID=  41.101   PSIDOT=    .346   PHITOT =  38.957
T=  .00712   PHI= 133.957   PHIDOT=    .354   G=  -.0495   GDOT=    .074   PSID=  41.101   PSIDOT=    .434   PHITOT =  38.957
T=  .00712   PHI= 133.957   PHIDOT=    .424   G=  -.0495   GDOT=    .089   PSID=  41.101   PSIDOT=    .523   PHITOT =  38.957
T=  .00712   PHI= 133.957   PHIDOT=    .570   G=  -.0495   GDOT=    .120   PSID=  41.101   PSIDOT=    .700   PHITOT =  38.957
T=  .00712   PHI= 133.957   PHIDOT=    .714   G=  -.0495   GDOT=    .150   PSID=  41.101   PSIDOT=    .877   PHITOT =  38.957
T=  .00713   PHI= 133.957   PHIDOT=   1.003   G=  -.0495   GDOT=    .211   PSID=  41.102   PSIDOT=   1.231   PHITOT =  38.957
T=  .00714   PHI= 133.958   PHIDOT=   1.291   G=  -.0495   GDOT=    .272   PSID=  41.102   PSIDOT=   1.586   PHITOT =  38.958
T=  .00714   PHI= 133.958   PHIDOT=   1.580   G=  -.0495   GDOT=    .332   PSID=  41.103   PSIDOT=   1.940   PHITOT =  38.958
T=  .00715   PHI= 133.959   PHIDOT=   1.862   G=  -.0495   GDOT=    .393   PSID=  41.104   PSIDOT=   2.295   PHITOT =  38.959
T=  .00716   PHI= 133.961   PHIDOT=   2.444   G=  -.0495   GDOT=    .514   PSID=  41.105   PSIDOT=   3.003   PHITOT =  38.961
T=  .00717   PHI= 133.962   PHIDOT=   3.022   G=  -.0495   GDOT=    .635   PSID=  41.108   PSIDOT=   3.712   PHITOT =  38.962
T=  .00719   PHI= 133.965   PHIDOT=   3.599   G=  -.0495   GDOT=    .757   PSID=  41.111   PSIDOT=   4.421   PHITOT =  38.965
T=  .00720   PHI= 133.968   PHIDOT=   4.175   G=  -.0495   GDOT=    .878   PSID=  41.114   PSIDOT=   5.130   PHITOT =  38.968
T=  .00722   PHI= 133.974   PHIDOT=   5.327   G=  -.0495   GDOT=   1.120   PSID=  41.123   PSIDOT=   6.547   PHITOT =  38.974
T=  .00725   PHI= 133.983   PHIDOT=   6.478   G=  -.0494   GDOT=   1.363   PSID=  41.133   PSIDOT=   7.964   PHITOT =  38.983
T=  .00730   PHI= 134.005   PHIDOT=   8.774   G=  -.0494   GDOT=   1.846   PSID=  41.160   PSIDOT=  10.797   PHITOT =  39.005
T=  .00735   PHI= 134.033   PHIDOT=  11.061   G=  -.0493   GDOT=   2.329   PSID=  41.195   PSIDOT=  13.630   PHITOT =  39.033
T=  .00740   PHI= 134.068   PHIDOT=  13.337   G=  -.0491   GDOT=   2.810   PSID=  41.238   PSIDOT=  16.460   PHITOT =  39.068
T=  .00745   PHI= 134.110   PHIDOT=  15.600   G=  -.0490   GDOT=   3.289   PSID=  41.289   PSIDOT=  19.289   PHITOT =  39.110
T=  .00755   PHI= 134.212   PHIDOT=  20.074   G=  -.0486   GDOT=   4.242   PSID=  41.416   PSIDOT=  24.941   PHITOT =  39.212
T=  .00765   PHI= 134.340   PHIDOT=  24.478   G=  -.0481   GDOT=   5.184   PSID=  41.575   PSIDOT=  30.582   PHITOT =  39.340
T=  .00775   PHI= 134.492   PHIDOT=  28.787   G=  -.0476   GDOT=   6.114   PSID=  41.766   PSIDOT=  36.210   PHITOT =  39.492
T=  .00785   PHI= 134.669   PHIDOT=  32.991   G=  -.0469   GDOT=   7.030   PSID=  41.990   PSIDOT=  41.824   PHITOT =  39.669
T=  .00795   PHI= 134.870   PHIDOT=  37.081   G=  -.0462   GDOT=   7.930   PSID=  42.245   PSIDOT=  47.422   PHITOT =  39.870
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T=  .00805  PHI= 135.094  PHIDOT=  41.047  G=  -.0453  GDOT=  8.816  PSID= 42.533  PSIDOT=  53.002  PHITOT =  40.094
T=  .00815  PHI= 135.340  PHIDOT=  44.886  G=  -.0444  GDOT=  9.680  PSID= 42.853  PSIDOT=  58.565  PHITOT =  40.340
T=  .00825  PHI= 135.603  PHIDOT=  48.585  G=  -.0434  GDOT= 10.528  PSID= 43.204  PSIDOT=  64.106  PHITOT =  40.608
T=  .00835  PHI= 135.897  PHIDOT=  52.159  G=  -.0423  GDOT= 11.356  PSID= 43.587  PSIDOT=  69.625  PHITOT =  40.897
T=  .00845  PHI= 136.205  PHIDOT=  55.577  G=  -.0411  GDOT= 12.165  PSID= 44.002  PSIDOT=  75.124  PHITOT =  41.205
T=  .00855  PHI= 136.533  PHIDOT=  58.864  G=  -.0399  GDOT= 12.954  PSID= 44.448  PSIDOT=  80.602  PHITOT =  41.533
T=  .00865  PHI= 136.880  PHIDOT=  62.029  G=  -.0385  GDOT= 13.723  PSID= 44.926  PSIDOT=  86.058  PHITOT =  41.880
T=  .00875  PHI= 137.244  PHIDOT=  65.042  G=  -.0371  GDOT= 14.472  PSID= 45.436  PSIDOT=  91.493  PHITOT =  42.244
T=  .00885  PHI= 137.625  PHIDOT=  67.934  G=  -.0356  GDOT= 15.203  PSID= 45.974  PSIDOT=  96.908  PHITOT =  42.625
T=  .00895  PHI= 138.022  PHIDOT=  70.702  G=  -.0341  GDOT= 15.914  PSID= 46.545  PSIDOT= 102.303  PHITOT =  43.022
T=  .00905  PHI= 138.435  PHIDOT=  73.365  G=  -.0326  GDOT= 16.606  PSID= 47.146  PSIDOT= 107.679  PHITOT =  43.435
T=  .00915  PHI= 138.862  PHIDOT=  75.911  G=  -.0308  GDOT= 17.280  PSID= 47.779  PSIDOT= 113.037  PHITOT =  43.862
T=  .00925  PHI= 139.304  PHID T=  78.354  G=  -.0290  GDOT= 17.937  PSID= 48.442  PSIDOT= 118.379  PHITOT =  44.304
T=  .00935  PHI= 139.760  PHIDOT=  80.701  G=  -.0272  GDOT= 18.577  PSID= 49.135  PSIDOT= 123.705  PHITOT =  44.760
T=  .00945  PHI= 140.229  PHIDOT=  82.950  G=  -.0253  GDOT= 19.200  PSID= 49.859  PSIDOT= 129.019  PHITOT =  45.229
T=  .00955  PHI= 140.711  PHIDOT=  85.136  G=  -.0233  GDOT= 19.807  PSID= 50.613  PSIDOT= 134.321  PHITOT =  45.711
T=  .00965  PHI= 141.204  PHIDOT=  87.235  G=  -.0213  GDOT= 20.398  PSID= 51.398  PSIDOT= 139.612  PHITOT =  46.204
T=  .00975  PHI= 141.710  PHIDOT=  89.267  G=  -.0192  GDOT= 20.974  PSID= 52.213  PSIDOT= 144.896  PHITOT =  46.710
T=  .00985  PHI= 142.227  PHIDOT=  91.238  G=  -.0171  GDOT= 21.536  PSID= 53.059  PSIDOT= 150.173  PHITOT =  47.227
T=  .00995  PHI= 142.755  PHIDOT=  93.152  G=  -.0149  GDOT= 22.084  PSID= 53.934  PSIDOT= 155.446  PHITOT =  47.755
T=  .01005  PHI= 143.295  PHIDOT=  95.017  G=  -.0127  GDOT= 22.617  PSID= 54.840  PSIDOT= 160.716  PHITOT =  48.295
T=  .01015  PHI= 143.844  PHIDOT=  96.837  G=  -.0104  GDOT= 23.137  PSID= 55.776  PSIDOT= 165.986  PHITOT =  48.844
T=  .01025  PHI= 144.404  PHIDOT=  98.618  G=  -.0081  GDOT= 23.644  PSID= 56.742  PSIDOT= 171.257  PHITOT =  49.404
T=  .01035  PHI= 144.974  PHIDOT= 100.365  G=  -.0057  GDOT= 24.137  PSID= 57.739  PSIDOT= 176.531  PHITOT =  49.974
T=  .01045  PHI= 145.554  PHIDOT= 102.083  G=  -.0032  GDOT= 24.617  PSID= 58.765  PSIDOT= 181.810  PHITOT =  50.554
T=  .01055  PHI= 146.144  PHIDOT= 103.774  G=  -.0008  GDOT= 25.084  PSID= 59.822  PSIDOT= 187.096  PHITOT =  51.144
T=  .01065  PHI= 146.743  PHIDOT= 105.444  G=   .0018  GDOT= 25.537  PSID= 60.909  PSIDOT= 192.390  PHITOT =  51.743

FREE MOTION
T=  .01065  PHI= 186.743  PHDOT= 105.444  PSI= 311.572  PSIDOT= 192.390  PHITOT =  51.743
T=  .01066  PHI= 186.807  PHDOT= 115.856  PSI= 311.682  PSIDOT= 192.390  PHITOT =  51.807
T=  .01067  PHI= 186.876  PHDOT= 126.268  PSI= 311.792  PSIDOT= 192.390  PHITOT =  51.876
T=  .01068  PHI= 186.951  PHDOT= 136.680  PSI= 311.903  PSIDOT= 192.390  PHITOT =  51.951
T=  .01069  PHI= 187.033  PHDOT= 147.092  PSI= 312.013  PSIDOT= 192.390  PHITOT =  52.033
T=  .01070  PHI= 187.120  PHDOT= 157.503  PSI= 312.123  PSIDOT= 192.390  PHITOT =  52.120
T=  .01071  PHI= 187.213  PHDOT= 167.915  PSI= 312.233  PSIDOT= 192.390  PHITOT =  52.213
T=  .01072  PHI= 187.312  PHDOT= 178.327  PSI= 312.343  PSIDOT= 192.390  PHITOT =  52.312
T=  .01073  PHI= 187.418  PHDOT= 188.739  PSI= 312.454  PSIDOT= 192.390  PHITOT =  52.418
T=  .01074  PHI= 187.529  PHDOT= 199.150  PSI= 312.564  PSIDOT= 192.390  PHITOT =  52.529
T=  .01075  PHI= 187.646  PHDOT= 209.562  PSI= 312.674  PSIDOT= 192.390  PHITOT =  52.646
T=  .01076  PHI= 187.769  PHDOT= 219.974  PSI= 312.784  PSIDOT= 192.390  PHITOT =  52.769
T=  .01077  PHI= 187.898  PHDOT= 230.386  PSI= 312.895  PSIDOT= 192.390  PHITOT =  52.898
T=  .01078  PHI= 188.033  PHDOT= 240.797  PSI= 313.005  PSIDOT= 192.390  PHITOT =  53.033
T=  .01079  PHI= 188.174  PHDOT= 251.209  PSI= 313.115  PSIDOT= 192.390  PHITOT =  53.174
T=  .01080  PHI= 188.321  PHDOT= 261.621  PSI= 313.225  PSIDOT= 192.390  PHITOT =  53.321
T=  .01081  PHI= 188.474  PHDOT= 272.033  PSI= 313.336  PSIDOT= 192.390  PHITOT =  53.474
T=  .01082  PHI= 188.632  PHDOT= 282.444  PSI= 313.446  PSIDOT= 192.390  PHITOT =  53.632
T=  .01083  PHI= 188.797  PHDOT= 292.856  PSI= 313.556  PSIDOT= 192.390  PHITOT =  53.797
T=  .01084  PHI= 188.968  PHDOT= 303.268  PSI= 313.666  PSIDOT= 192.390  PHITOT =  53.968
T=  .01085  PHI= 189.145  PHDOT= 313.680  PSI= 313.776  PSIDOT= 192.390  PHITOT =  54.145
T=  .01086  PHI= 189.327  PHDOT= 324.092  PSI= 313.887  PSIDOT= 192.390  PHITOT =  54.327
T=  .01087  PHI= 189.516  PHDOT= 334.503  PSI= 313.997  PSIDOT= 192.390  PHITOT =  54.516
T=  .01088  PHI= 189.711  PHDOT= 344.915  PSI= 314.107  PSIDOT= 192.390  PHITOT =  54.711
T=  .01089  PHI= 189.911  PHDOT= 355.327  PSI= 314.217  PSIDOT= 192.390  PHITOT =  54.911
T=  .01090  PHI= 190.118  PHDOT= 365.739  PSI= 314.328  PSIDOT= 192.390  PHITOT =  55.118
T=  .01091  PHI= 190.330  PHDOT= 376.150  PSI= 314.438  PSIDOT= 192.390  PHITOT =  55.330
T=  .01092  PHI= 190.549  PHDOT= 386.562  PSI= 314.548  PSIDOT= 192.390  PHITOT =  55.549
T=  .01093  PHI= 190.773  PHDOT= 396.974  PSI= 314.658  PSIDOT= 192.390  PHITOT =  55.773
T=  .01094  PHI= 191.004  PHDOT= 407.386  PSI= 314.769  PSIDOT= 192.390  PHITOT =  56.004
T=  .01095  PHI= 191.240  PHDOT= 417.797  PSI= 314.879  PSIDOT= 192.390  PHITOT =  56.240
T=  .01096  PHI= 191.483  PHDOT= 428.209  PSI= 314.989  PSIDOT= 192.390  PHITOT =  56.483
T=  .01097  PHI= 191.731  PHDOT= 438.621  PSI= 315.099  PSIDOT= 192.390  PHITOT =  56.731
T=  .01098  PHI= 191.985  PHDOT= 449.033  PSI= 315.209  PSIDOT= 192.390  PHITOT =  56.985
T=  .01099  PHI= 192.245  PHDOT= 459.444  PSI= 315.320  PSIDOT= 192.390  PHITOT =  57.245
T=  .01100  PHI= 192.512  PHDOT= 469.856  PSI= 315.430  PSIDOT= 192.390  PHITOT =  57.512
T=  .01101  PHI= 192.784  PHDOT= 480.268  PSI= 315.540  PSIDOT= 192.390  PHITOT =  57.784
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T= .01102	PHI= 193.062	PHDOT= 490.680	PSI= 315.650	PSIDOT= 192.390	PHITOT = 58.052
T= .01103	PHI= 193.346	PHDOT= 501.092	PSI= 315.761	PSIDOT= 192.390	PHITOT = 58.346
T= .01104	PHI= 193.636	PHDOT= 511.503	PSI= 315.871	PSIDOT= 192.390	PHITOT = 58.636

VP= -17.741 VS= 41.358

IMPACT

PHI= 193.636 DPHIF= -76.532 PSI= 315.871 DPSIF= 67.106 PHITOT= 58.636

VP= -6.188 VS= -6.188

COUPLED MOTION

T= .01104	PHI= 193.636	PHIDOT= -76.532	G= -.0405	GDOT= -10.831	PSID= 315.771	PSIDOT= 67.144	PHITOT = 58.636
T= .01114	PHI= 193.243	PHIDOT= -46.502	G= -.0413	GDOT= -6.521	PSID= 316.079	PSIDOT= 40.212	PHITOT = 58.243
T= .01124	PHI= 193.105	PHIDOT= -15.478	G= -.0418	GDOT= -2.140	PSID= 316.232	PSIDOT= 13.288	PHITOT = 58.105
T= .01125	PHI= 193.096	PHIDOT= -11.562	G= -.0418	GDOT= -1.614	PSID= 316.240	PSIDOT= 9.923	PHITOT = [illegible]
T= .01126	PHI= 193.089	PHIDOT= -7.643	G= -.0418	GDOT= -1.046	PSID= 316.246	PSIDOT= 6.558	PHITOT = 58.089
T= .01127	PHI= 193.086	PHIDOT= -5.683	G= -.0418	GDOT= -.793	PSID= 316.248	PSIDOT= 4.825	PHITOT = 58.086
T= .01128	PHI= 193.085	PHIDOT= -3.722	G= -.0418	GDOT= -.519	PSID= 316.250	PSIDOT= 3.193	PHITOT = 58.085
T= .01128	PHI= 193.084	PHIDOT= -2.741	G= -.0418	GDOT= -.382	PSID= 316.250	PSIDOT= 2.351	PHITOT = 58.084
T= .01128	PHI= 193.084	PHIDOT= -1.760	G= -.0418	GDOT= -.246	PSID= 316.251	PSIDOT= 1.510	PHITOT = 58.084
T= .01129	PHI= 193.084	PHIDOT= -1.270	G= -.0418	GDOT= -.177	PSID= 316.251	PSIDOT= 1.089	PHITOT = 58.084
T= .01129	PHI= 193.083	PHIDOT= -.780	G= -.0418	GDOT= -.109	PSID= 316.251	PSIDOT= .669	PHITOT = 58.083
T= .01129	PHI= 193.083	PHIDOT= -.534	G= -.0418	GDOT= -.075	PSID= 316.251	PSIDOT= .458	PHITOT = 58.083
T= .01129	PHI= 193.083	PHIDOT= -.289	G= -.0418	GDOT= -.040	PSID= 316.251	PSIDOT= .248	PHITOT = 58.083
T= .01129	PHI= 193.083	PHIDOT= -.167	G= -.0418	GDOT= -.023	PSID= 316.251	PSIDOT= .143	PHITOT = 58.083
T= .01129	PHI= 193.083	PHIDOT= -.044	G= -.0418	GDOT= -.006	PSID= 316.251	PSIDOT= .038	PHITOT = 58.083
T= .01129	PHI= 193.083	PHIDOT= .062	G= -.0418	GDOT= .009	PSID= 316.251	PSIDOT= -.053	PHITOT = 58.083
T= .01129	PHI= 193.083	PHIDOT= .123	G= -.0418	GDOT= .017	PSID= 316.251	PSIDOT= -.105	PHITOT = 58.083
T= .01129	PHI= 193.083	PHIDOT= .183	G= -.0418	GDOT= .026	PSID= 316.251	PSIDOT= -.157	PHITOT = 58.083
T= .01129	PHI= 193.083	PHIDOT= .244	G= -.0418	GDOT= .034	PSID= 316.251	PSIDOT= -.209	PHITOT = 58.083
T= .01129	PHI= 193.083	PHIDOT= .306	G= -.0418	GDOT= .042	PSID= 316.251	PSIDOT= -.261	PHITOT = 58.083
T= .01129	PHI= 193.083	PHIDOT= .365	G= -.0418	GDOT= .051	PSID= 316.251	PSIDOT= -.313	PHITOT = 58.083
T= .01129	PHI= 193.083	PHIDOT= .484	G= -.0418	GDOT= .068	PSID= 316.251	PSIDOT= -.417	PHITOT = 58.083
T= .01129	PHI= 193.083	PHIDOT= .607	G= -.0418	GDOT= .085	PSID= 316.251	PSIDOT= -.521	PHITOT = 58.083
T= .01129	PHI= 193.084	PHIDOT= .849	G= -.0418	GDOT= .118	PSID= 316.251	PSIDOT= -.728	PHITOT = 58.084
T= .01130	PHI= 193.084	PHIDOT= 1.091	G= -.0418	GDOT= .152	PSID= 316.251	PSIDOT= -.936	PHITOT = 58.084
T= .01130	PHI= 193.084	PHIDOT= 1.574	G= -.0418	GDOT= .220	PSID= 316.251	PSIDOT= -1.352	PHITOT = 58.084
T= .01130	PHI= 193.084	PHIDOT= 2.060	G= -.0418	GDOT= .287	PSID= 316.250	PSIDOT= -1.767	PHITOT = 58.084
T= .01131	PHI= 193.085	PHIDOT= 3.028	G= -.0418	GDOT= .422	PSID= 316.249	PSIDOT= -2.598	PHITOT = 58.085
T= .01131	PHI= 193.086	PHIDOT= 3.997	G= -.0418	GDOT= .558	PSID= 316.248	PSIDOT= -3.429	PHITOT = 58.086
T= .01133	PHI= 193.090	PHIDOT= 5.933	G= -.0418	GDOT= .828	PSID= 316.245	PSIDOT= -5.090	PHITOT = 58.090
T= .01134	PHI= 193.095	PHIDOT= 7.868	G= -.0418	GDOT= 1.098	PSID= 316.241	PSIDOT= -6.752	PHITOT = 58.095
T= .01136	PHI= 193.109	PHIDOT= 11.733	G= -.0418	GDOT= 1.638	PSID= 316.229	PSIDOT= -10.074	PHITOT = 58.109
T= .01139	PHI= 193.128	PHIDOT= 15.588	G= -.0417	GDOT= 2.177	PSID= 316.212	PSIDOT= -13.396	PHITOT = 58.128
T= .01141	PHI= 193.154	PHIDOT= 19.432	G= -.0417	GDOT= 2.716	PSID= 316.191	PSIDOT= -16.716	PHITOT = 58.154
T= .01144	PHI= 193.184	PHIDOT= 23.261	G= -.0416	GDOT= 3.253	PSID= 316.164	PSIDOT= -20.034	PHITOT = 58.184
T= .01149	PHI= 193.262	PHIDOT= 30.862	G= -.0414	GDOT= 4.325	PSID= 316.097	PSIDOT= -26.666	PHITOT = 58.262
T= .01154	PHI= 193.361	PHIDOT= 38.369	G= -.0411	GDOT= 5.391	PSID= 316.012	PSIDOT= -33.283	PHITOT = 58.361
T= .01159	PHI= 193.481	PHIDOT= 45.754	G= -.0409	GDOT= 6.449	PSID= 315.907	PSIDOT= -39.889	PHITOT = 58.481
T= .01164	PHI= 193.623	PHIDOT= 53.005	G= -.0405	GDOT= 7.498	PSID= 315.783	PSIDOT= -46.477	PHITOT = 58.623
T= .01174	PHI= 193.967	PHIDOT= 67.000	G= -.0397	GDOT= 9.545	PSID= 315.479	PSIDOT= -59.590	PHITOT = 58.967
T= .01184	PHI= 194.389	PHIDOT= 80.196	G= -.0386	GDOT= 11.581	PSID= 315.100	PSIDOT= -72.596	PHITOT = 59.389
T= .01194	PHI= 194.884	PHIDOT= 92.450	G= -.0373	GDOT= 13.536	PSID= 314.648	PSIDOT= -85.467	PHITOT = 59.884
T= .01204	PHI= 195.446	PHIDOT= 103.641	G= -.0359	GDOT= 15.423	PSID= 314.121	PSIDOT= -98.170	PHITOT = 60.446
T= .01214	PHI= 196.070	PHIDOT= 113.670	G= -.0343	GDOT= 17.233	PSID= 313.523	PSIDOT=-110.674	PHITOT = 61.070
T= .01224	PHI= 196.747	PHIDOT= 122.458	G= -.0324	GDOT= 18.960	PSID= 312.854	PSIDOT=-122.963	PHITOT = 61.747
T= .01234	PHI= 197.470	PHIDOT= 129.952	G= -.0305	GDOT= 20.599	PSID= 312.115	PSIDOT=-134.960	PHITOT = 62.470
T= .01244	PHI= 198.233	PHIDOT= 136.120	G= -.0283	GDOT= 22.145	PSID= 311.308	PSIDOT=-146.630	PHITOT = 63.233
T= .01254	PHI= 199.028	PHIDOT= 140.955	G= -.0260	GDOT= 23.595	PSID= 310.435	PSIDOT=-157.975	PHITOT = 64.028
T= .01264	PHI= 199.846	PHIDOT= 144.471	G= -.0236	GDOT= 24.945	PSID= 309.498	PSIDOT=-168.940	PHITOT = 64.846
T= .01274	PHI= 200.681	PHIDOT= 146.700	G= -.0211	GDOT= 26.194	PSID= 308.500	PSIDOT=-179.490	PHITOT = 65.681
T= .01284	PHI= 201.525	PHIDOT= 147.694	G= -.0184	GDOT= 27.340	PSID= 307.442	PSIDOT=-189.595	PHITOT = 66.525
T= .01294	PHI= 202.371	PHIDOT= 147.520	G= -.0156	GDOT= 28.382	PSID= 306.328	PSIDOT=-199.226	PHITOT = 67.371
T= .01304	PHI= 203.213	PHIDOT= 146.258	G= -.0127	GDOT= 29.322	PSID= 305.160	PSIDOT=-208.358	PHITOT = 68.213
T= .01314	PHI= 204.045	PHIDOT= 143.994	G= -.0097	GDOT= 30.158	PSID= 303.942	PSIDOT=-216.971	PHITOT = 69.045
T= .01324	PHI= 204.861	PHIDOT= 140.837	G= -.0067	GDOT= 30.894	PSID= 302.675	PSIDOT=-225.049	PHITOT = 69.861

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T=  .01334   PHI= 205.657   PHIDOT= 136.871   G=   -.0036   GDOT=  31.529   PSID= 301.354   PSIDOT=-232.581   PHITOT =  70.657
T=  .01344   PHI= 206.429   PHIDOT= 132.212   G=   -.0004   GDOT=  32.047   PSID= 300.011   PSIDOT=-239.559   PHITOT =  71.429
T=  .01354   PHI= 207.171   PHIDOT= 126.961   G=    .0029   GDOT=  32.511   PSID= 298.620   PSIDOT=-245.981   PHITOT =  72.171

FREE MOTION
T=  .01354   PHI= 127.171   PHDOT= 126.961   PSI=  47.957   PSIDOT=-245.981   PHITOT =  72.171
T=  .01355   PHI= 127.247   PHDOT= 137.372   PSI=  47.816   PSIDOT=-245.981   PHITOT =  72.247
T=  .01356   PHI= 127.329   PHDOT= 147.784   PSI=  47.675   PSIDOT=-245.981   PHITOT =  72.329
T=  .01357   PHI= 127.416   PHDOT= 158.196   PSI=  47.534   PSIDOT=-245.981   PHITOT =  72.416
T=  .01358   PHI= 127.510   PHDOT= 168.608   PSI=  47.393   PSIDOT=-245.981   PHITOT =  72.510
T=  .01359   PHI= 127.610   PHDOT= 179.019   PSI=  47.252   PSIDOT=-245.981   PHITOT =  72.610
T=  .01360   PHI= 127.715   PHDOT= 189.431   PSI=  47.111   PSIDOT=-245.981   PHITOT =  72.715
T=  .01361   PHI= 127.827   PHDOT= 199.843   PSI=  46.970   PSIDOT=-245.981   PHITOT =  72.827
T=  .01362   PHI= 127.944   PHDOT= 210.255   PSI=  46.829   PSIDOT=-245.981   PHITOT =  72.944
T=  .01363   PHI= 128.068   PHDOT= 220.667   PSI=  46.688   PSIDOT=-245.981   PHITOT =  73.068
T=  .01364   PHI= 128.197   PHDOT= 231.078   PSI=  46.547   PSIDOT=-245.981   PHITOT =  73.197
T=  .01365   PHI= 128.332   PHDOT= 241.490   PSI=  46.407   PSIDOT=-245.981   PHITOT =  73.332
T=  .01366   PHI= 128.474   PHDOT= 251.902   PSI=  46.266   PSIDOT=-245.981   PHITOT =  73.474
T=  .01367   PHI= 128.621   PHDOT= 262.314   PSI=  46.125   PSIDOT=-245.981   PHITOT =  73.621
T=  .01368   PHI= 128.774   PHDOT= 272.725   PSI=  45.984   PSIDOT=-245.981   PHITOT =  73.774
T=  .01369   PHI= 128.934   PHDOT= 283.137   PSI=  45.843   PSIDOT=-245.981   PHITOT =  73.934
T=  .01370   PHI= 129.099   PHDOT= 293.549   PSI=  45.702   PSIDOT=-245.981   PHITOT =  74.099
T=  .01371   PHI= 129.270   PHDOT= 303.961   PSI=  45.561   PSIDOT=-245.981   PHITOT =  74.270
T=  .01372   PHI= 129.447   PHDOT= 314.372   PSI=  45.420   PSIDOT=-245.981   PHITOT =  74.447
T=  .01373   PHI= 129.630   PHDOT= 324.784   PSI=  45.279   PSIDOT=-245.981   PHITOT =  74.630
T=  .01374   PHI= 129.819   PHDOT= 335.196   PSI=  45.138   PSIDOT=-245.981   PHITOT =  74.819
T=  .01375   PHI= 130.014   PHDOT= 345.608   PSI=  44.997   PSIDOT=-245.981   PHITOT =  75.014
T=  .01376   PHI= 130.215   PHDOT= 356.019   PSI=  44.856   PSIDOT=-245.981   PHITOT =  75.215
T=  .01377   PHI= 130.422   PHDOT= 366.431   PSI=  44.715   PSIDOT=-245.981   PHITOT =  75.422
T=  .01378   PHI= 130.635   PHDOT= 376.843   PSI=  44.574   PSIDOT=-245.981   PHITOT =  75.635
T=  .01379   PHI= 130.854   PHDOT= 387.255   PSI=  44.433   PSIDOT=-245.981   PHITOT =  75.854
T=  .01380   PHI= 131.079   PHDOT= 397.667   PSI=  44.292   PSIDOT=-245.981   PHITOT =  76.079
T=  .01381   PHI= 131.310   PHDOT= 408.078   PSI=  44.152   PSIDOT=-245.981   PHITOT =  76.310
T=  .01382   PHI= 131.547   PHDOT= 418.490   PSI=  44.011   PSIDOT=-245.981   PHITOT =  76.547
T=  .01383   PHI= 131.789   PHDOT= 428.902   PSI=  43.870   PSIDOT=-245.981   PHITOT =  76.789
T=  .01384   PHI= 132.038   PHDOT= 439.314   PSI=  43.729   PSIDOT=-245.981   PHITOT =  77.038
T=  .01385   PHI= 132.293   PHDOT= 449.725   PSI=  43.588   PSIDOT=-245.981   PHITOT =  77.293
T=  .01386   PHI= 132.553   PHDOT= 460.137   PSI=  43.447   PSIDOT=-245.981   PHITOT =  77.553
T=  .01387   PHI= 132.820   PHDOT= 470.549   PSI=  43.306   PSIDOT=-245.981   PHITOT =  77.820
T=  .01388   PHI= 133.093   PHDOT= 480.961   PSI=  43.165   PSIDOT=-245.981   PHITOT =  78.093
T=  .01389   PHI= 133.371   PHDOT= 491.372   PSI=  43.024   PSIDOT=-245.981   PHITOT =  78.371
T=  .01390   PHI= 133.656   PHDOT= 501.784   PSI=  42.883   PSIDOT=-245.981   PHITOT =  78.656
T=  .01391   PHI= 133.946   PHDOT= 512.196   PSI=  42.742   PSIDOT=-245.981   PHITOT =  78.946
T=  .01392   PHI= 134.243   PHDOT= 522.608   PSI=  42.601   PSIDOT=-245.981   PHITOT =  79.243
T=  .01393   PHI= 134.545   PHDOT= 533.019   PSI=  42.460   PSIDOT=-245.981   PHITOT =  79.545
T=  .01394   PHI= 134.853   PHDOT= 543.431   PSI=  42.319   PSIDOT=-245.981   PHITOT =  79.853
T=  .01395   PHI= 135.168   PHDOT= 553.843   PSI=  42.178   PSIDOT=-245.981   PHITOT =  80.168
VP= -14.338   VS=  42.251

IMPACT     Cycle No. 3

             PHI= 135.168   DPHIF=-115.001   PSI=  42.178   DPSIF=-150.511   PHITOT=  80.168
VP=  -8.773   VS=  -8.773

COUPLED MOTION
T=  .01395   PHI= 135.168   PHIDOT=-115.001   G=   -.0450   GDOT= -24.727   PSID=  42.629   PSIDOT=-149.963   PHITOT =  80.168
T=  .01405   PHI= 134.567   PHIDOT= -94.240   G=   -.0473   GDOT= -20.043   PSID=  41.861   PSIDOT=-118.939   PHITOT =  79.567
T=  .01415   PHI= 134.092   PHIDOT= -71.470   G=   -.0490   GDOT= -15.066   PSID=  41.267   PSIDOT= -88.311   PHITOT =  79.092
T=  .01425   PHI= 133.751   PHIDOT= -47.064   G=   -.0503   GDOT=  -9.855   PSID=  40.850   PSIDOT= -57.244   PHITOT =  78.751
T=  .01435   PHI= 133.555   PHIDOT= -21.492   G=   -.0510   GDOT=  -4.443   PSID=  40.611   PSIDOT= -25.991   PHITOT =  78.555
T=  .01437   PHI= 133.528   PHIDOT= -14.987   G=   -.0511   GDOT=  -3.124   PSID=  40.580   PSIDOT= -15.040   PHITOT =  78.528
T=  .01440   PHI= 133.512   PHIDOT=  -8.459   G=   -.0512   GDOT=  -1.763   PSID=  40.560   PSIDOT= -10.174   PHITOT =  78.512
T=  .01441   PHI= 133.507   PHIDOT=  -5.189   G=   -.0512   GDOT=  -1.041   PSID=  40.554   PSIDOT=  -6.239   PHITOT =  78.507
T=  .01442   PHI= 133.504   PHIDOT=  -1.917   G=   -.0512   GDOT=   -.399   PSID=  40.551   PSIDOT=  -2.304   PHITOT =  78.504
T=  .01443   PHI= 133.504   PHIDOT=  -1.098   G=   -.0512   GDOT=   -.229   PSID=  40.551   PSIDOT=  -1.321   PHITOT =  78.504
T=  .01443   PHI= 133.504   PHIDOT=   -.280   G=   -.0512   GDOT=   -.058   PSID=  40.550   PSIDOT=   -.337   PHITOT =  78.504
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    T=  .05027   PHI= 134.310   PHDOT= 544.586   PSI=  43.632   PSIDOT=-235.663   PHITOT = 279.310
    T=  .05028   PHI= 134.625   PHDOT= 554.998   PSI=  43.497   PSIDOT=-235.663   PHITOT = 279.625
    T=  .05029   PHI= 134.946   PHDOT= 565.410   PSI=  43.362   PSIDOT=-235.663   PHITOT = 279.946
    T=  .05030   PHI= 135.273   PHDOT= 575.822   PSI=  43.227   PSIDOT=-235.663   PHITOT = 280.273
    T=  .05031   PHI= 135.606   PHDOT= 586.233   PSI=  43.092   PSIDOT=-235.663   PHITOT = 280.606
VP= -13.887   VS=  45.689

    IMPACT      Cycle No. 8

                 PHI= 135.606   DPHIF=-104.424   PSI=  43.092   DPSIF=-139.107   PHITOT= 280.606
VP=  -8.138   VS=  -8.138

    COUPLED MOTION
    T=  .05031   PHI= 135.606   PHIDOT=-104.424   G=  -.0434   GDOT= -22.676   PSID=  43.201   PSIDOT=-137.765   PHITOT = 280.606
    T=  .05041   PHI= 135.064   PHIDOT= -84.235   G=  -.0454   GDOT= -18.078   PSID=  42.495   PSIDOT=-108.631   PHITOT = 280.064
    T=  .05051   PHI= 134.644   PHIDOT= -62.364   G=  -.0470   GDOT= -13.282   PSID=  41.957   PSIDOT= -78.973   PHITOT = 279.644
    T=  .05061   PHI= 134.352   PHIDOT= -39.150   G=  -.0481   GDOT=  -8.293   PSID=  41.591   PSIDOT= -48.941   PHITOT = 279.352
    T=  .05071   PHI= 134.197   PHIDOT= -15.047   G=  -.0487   GDOT=  -3.178   PSID=  41.397   PSIDOT= -18.479   PHITOT = 279.197
    T=  .05073   PHI= 134.179   PHIDOT=  -8.944   G=  -.0487   GDOT=  -1.888   PSID=  41.376   PSIDOT= -11.094   PHITOT = 279.179
    T=  .05076   PHI= 134.171   PHIDOT=  -2.828   G=  -.0487   GDOT=   -.597   PSID=  41.365   PSIDOT=  -3.506   PHITOT = 279.171
    T=  .05076   PHI= 134.171   PHIDOT=  -2.063   G=  -.0487   GDOT=   -.435   PSID=  41.365   PSIDOT=  -2.558   PHITOT = 279.171
    T=  .05077   PHI= 134.170   PHIDOT=  -1.298   G=  -.0487   GDOT=   -.274   PSID=  41.364   PSIDOT=  -1.609   PHITOT = 279.170
    T=  .05077   PHI= 134.170   PHIDOT=   -.915   G=  -.0487   GDOT=   -.193   PSID=  41.364   PSIDOT=  -1.135   PHITOT = 279.170
    T=  .05077   PHI= 134.170   PHIDOT=   -.533   G=  -.0487   GDOT=   -.112   PSID=  41.364   PSIDOT=   -.660   PHITOT = 279.170
    T=  .05077   PHI= 134.170   PHIDOT=   -.150   G=  -.0487   GDOT=   -.032   PSID=  41.364   PSIDOT=   -.186   PHITOT = 279.170
    T=  .05077   PHI= 134.170   PHIDOT=    .150   G=  -.0487   GDOT=    .032   PSID=  41.364   PSIDOT=    .186   PHITOT = 279.170
    T=  .05077   PHI= 134.170   PHIDOT=    .221   G=  -.0487   GDOT=    .047   PSID=  41.364   PSIDOT=    .274   PHITOT = 279.170
    T=  .05078   PHI= 134.170   PHIDOT=    .292   G=  -.0487   GDOT=    .062   PSID=  41.364   PSIDOT=    .363   PHITOT = 279.170
    T=  .05078   PHI= 134.170   PHIDOT=    .364   G=  -.0487   GDOT=    .077   PSID=  41.364   PSIDOT=    .451   PHITOT = 279.170
    T=  .05078   PHI= 134.170   PHIDOT=    .435   G=  -.0487   GDOT=    .092   PSID=  41.364   PSIDOT=    .539   PHITOT = 279.170
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    T=  .05079   PHI= 134.171   PHIDOT=   1.004   G=  -.0487   GDOT=    .212   PSID=  41.365   PSIDOT=   1.245   PHITOT = 279.171
    T=  .05080   PHI= 134.171   PHIDOT=   1.288   G=  -.0487   GDOT=    .272   PSID=  41.365   PSIDOT=   1.598   PHITOT = 279.171
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    T=  .05082   PHI= 134.174   PHIDOT=   2.426   G=  -.0487   GDOT=    .512   PSID=  41.369   PSIDOT=   3.009   PHITOT = 279.174
    T=  .05083   PHI= 134.176   PHIDOT=   2.995   G=  -.0487   GDOT=    .632   PSID=  41.371   PSIDOT=   3.715   PHITOT = 279.176
    T=  .05085   PHI= 134.178   PHIDOT=   3.564   G=  -.0487   GDOT=    .752   PSID=  41.374   PSIDOT=   4.420   PHITOT = 279.178
    T=  .05086   PHI= 134.181   PHIDOT=   4.132   G=  -.0487   GDOT=    .872   PSID=  41.377   PSIDOT=   5.126   PHITOT = 279.181
    T=  .05088   PHI= 134.188   PHIDOT=   5.268   G=  -.0487   GDOT=   1.112   PSID=  41.386   PSIDOT=   6.537   PHITOT = 279.188
    T=  .05091   PHI= 134.196   PHIDOT=   6.403   G=  -.0487   GDOT=   1.352   PSID=  41.396   PSIDOT=   7.948   PHITOT = 279.196
    T=  .05096   PHI= 134.217   PHIDOT=   8.667   G=  -.0486   GDOT=   1.831   PSID=  41.423   PSIDOT=  10.769   PHITOT = 279.217
    T=  .05101   PHI= 134.246   PHIDOT=  10.923   G=  -.0485   GDOT=   2.309   PSID=  41.458   PSIDOT=  13.589   PHITOT = 279.246
    T=  .05106   PHI= 134.280   PHIDOT=  13.160   G=  -.0483   GDOT=   2.785   PSID=  41.501   PSIDOT=  16.408   PHITOT = 279.280
    T=  .05111   PHI= 134.321   PHIDOT=  15.401   G=  -.0482   GDOT=   3.260   PSID=  41.552   PSIDOT=  19.225   PHITOT = 279.321
    T=  .05121   PHI= 134.422   PHIDOT=  19.812   G=  -.0478   GDOT=   4.206   PSID=  41.678   PSIDOT=  24.853   PHITOT = 279.422
    T=  .05131   PHI= 134.548   PHIDOT=  24.156   G=  -.0474   GDOT=   5.137   PSID=  41.836   PSIDOT=  30.471   PHITOT = 279.548
    T=  .05141   PHI= 134.699   PHIDOT=  28.420   G=  -.0468   GDOT=   6.059   PSID=  42.027   PSIDOT=  36.077   PHITOT = 279.699
    T=  .05151   PHI= 134.873   PHIDOT=  32.577   G=  -.0461   GDOT=   6.967   PSID=  42.250   PSIDOT=  41.669   PHITOT = 279.873
    T=  .05161   PHI= 135.072   PHIDOT=  36.623   G=  -.0454   GDOT=   7.861   PSID=  42.505   PSIDOT=  47.245   PHITOT = 280.072
    T=  .05171   PHI= 135.293   PHIDOT=  40.551   G=  -.0446   GDOT=   8.738   PSID=  42.791   PSIDOT=  52.805   PHITOT = 280.293
    T=  .05181   PHI= 135.536   PHIDOT=  44.353   G=  -.0437   GDOT=   9.599   PSID=  43.110   PSIDOT=  58.347   PHITOT = 280.536
    T=  .05191   PHI= 135.801   PHIDOT=  48.024   G=  -.0427   GDOT=  10.441   PSID=  43.460   PSIDOT=  63.870   PHITOT = 280.801
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    T=  .05211   PHI= 136.392   PHIDOT=  54.973   G=  -.0404   GDOT=  12.069   PSID=  44.255   PSIDOT=  74.856   PHITOT = 281.392
    T=  .05221   PHI= 136.716   PHIDOT=  58.244   G=  -.0392   GDOT=  12.855   PSID=  44.699   PSIDOT=  80.318   PHITOT = 281.716
    T=  .05231   PHI= 137.059   PHIDOT=  61.380   G=  -.0378   GDOT=  13.621   PSID=  45.175   PSIDOT=  85.761   PHITOT = 282.059
    T=  .05241   PHI= 137.419   PHIDOT=  64.403   G=  -.0364   GDOT=  14.368   PSID=  45.682   PSIDOT=  91.183   PHITOT = 282.419
    T=  .05251   PHI= 137.796   PHIDOT=  67.293   G=  -.0350   GDOT=  15.096   PSID=  46.220   PSIDOT=  96.586   PHITOT = 282.796
    T=  .05261   PHI= 138.190   PHIDOT=  70.065   G=  -.0334   GDOT=  15.806   PSID=  46.789   PSIDOT= 101.970   PHITOT = 283.190
    T=  .05271   PHI= 138.599   PHIDOT=  72.723   G=  -.0318   GDOT=  16.497   PSID=  47.388   PSIDOT= 107.336   PHITOT = 283.599
    T=  .05281   PHI= 139.023   PHIDOT=  75.273   G=  -.0301   GDOT=  17.171   PSID=  48.019   PSIDOT= 112.686   PHITOT = 284.023
    T=  .05291   PHI= 139.462   PHIDOT=  77.723   G=  -.0284   GDOT=  17.827   PSID=  48.680   PSIDOT= 118.020   PHITOT = 284.462
    T=  .05301   PHI= 139.914   PHIDOT=  80.078   G=  -.0265   GDOT=  18.467   PSID=  49.371   PSIDOT= 123.340   PHITOT = 284.914
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 T=  .05351   PHI= 142.364   PHIDOT=  90.675   G=   -.0166   GDOT=  21.428   PSID=  53.286   PSIDOT= 149.786   PHITOT = 287.364
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 T=  .05411   PHI= 145.673   PHIDOT= 101.608   G=   -.0027   GDOT=  24.515   PSID=  58.977   PSIDOT= 181.417   PHITOT = 290.673
 T=  .05421   PHI= 146.260   PHIDOT= 103.316   G=   -.0003   GDOT=  24.983   PSID=  60.031   PSIDOT= 186.703   PHITOT = 291.260
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 FREE MOTION
 T=  .05431   PHI= 186.857   PHDOT= 104.998   PSI= 311.779   PSIDOT= 191.998   PHITOT = 291.857
 T=  .05432   PHI= 186.920   PHDOT= 115.410   PSI= 311.889   PSIDOT= 191.998   PHITOT = 291.920
 T=  .05433   PHI= 186.989   PHDOT= 125.821   PSI= 311.999   PSIDOT= 191.998   PHITOT = 291.989
 T=  .05434   PHI= 187.064   PHDOT= 136.233   PSI= 312.109   PSIDOT= 191.998   PHITOT = 292.064
 T=  .05435   PHI= 187.145   PHDOT= 146.645   PSI= 312.219   PSIDOT= 191.998   PHITOT = 292.145
 T=  .05436   PHI= 187.232   PHDOT= 157.057   PSI= 312.329   PSIDOT= 191.998   PHITOT = 292.232
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 T=  .05438   PHI= 187.424   PHDOT= 177.880   PSI= 312.549   PSIDOT= 191.998   PHITOT = 292.424
 T=  .05439   PHI= 187.529   PHDOT= 188.292   PSI= 312.659   PSIDOT= 191.998   PHITOT = 292.529
 T=  .05440   PHI= 187.640   PHDOT= 198.704   PSI= 312.769   PSIDOT= 191.998   PHITOT = 292.640
 T=  .05441   PHI= 187.757   PHDOT= 209.116   PSI= 312.879   PSIDOT= 191.998   PHITOT = 292.757
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 T=  .05443   PHI= 188.008   PHDOT= 229.939   PSI= 313.099   PSIDOT= 191.998   PHITOT = 293.008
 T=  .05444   PHI= 188.143   PHDOT= 240.351   PSI= 313.209   PSIDOT= 191.998   PHITOT = 293.143
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 T=  .05446   PHI= 188.430   PHDOT= 261.174   PSI= 313.429   PSIDOT= 191.998   PHITOT = 293.430
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 T=  .05451   PHI= 189.253   PHDOT= 313.233   PSI= 313.979   PSIDOT= 191.998   PHITOT = 294.253
 T=  .05452   PHI= 189.435   PHDOT= 323.645   PSI= 314.089   PSIDOT= 191.998   PHITOT = 294.435
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 T=  .05460   PHI= 191.110   PHDOT= 406.939   PSI= 314.969   PSIDOT= 191.998   PHITOT = 296.110
 T=  .05461   PHI= 191.346   PHDOT= 417.351   PSI= 315.079   PSIDOT= 191.998   PHITOT = 296.346
 T=  .05462   PHI= 191.588   PHDOT= 427.763   PSI= 315.189   PSIDOT= 191.998   PHITOT = 296.588
 T=  .05463   PHI= 191.836   PHDOT= 438.174   PSI= 315.299   PSIDOT= 191.998   PHITOT = 296.836
 T=  .05464   PHI= 192.090   PHDOT= 448.586   PSI= 315.409   PSIDOT= 191.998   PHITOT = 297.090
 T=  .05465   PHI= 192.350   PHDOT= 458.998   PSI= 315.519   PSIDOT= 191.998   PHITOT = 297.350
 T=  .05466   PHI= 192.616   PHDOT= 469.410   PSI= 315.629   PSIDOT= 191.998   PHITOT = 297.616
 T=  .05467   PHI= 192.888   PHDOT= 479.821   PSI= 315.739   PSIDOT= 191.998   PHITOT = 297.888
 T=  .05468   PHI= 193.166   PHDOT= 490.233   PSI= 315.849   PSIDOT= 191.998   PHITOT = 298.166
 T=  .05469   PHI= 193.450   PHDOT= 500.645   PSI= 315.959   PSIDOT= 191.998   PHITOT = 298.450
VP= -17.732   VS=  40.250

 IMPACT

              PHI= 193.450   DPHIF= -77.927   PSI= 315.959   DPSIF=  67.838   PHITOT= 298.450
VP=  -6.265   VS=  -6.265

 COUPLED MOTION
 T=  .05469   PHI= 193.450   PHIDOT= -77.927   G=   -.0409   GDOT= -10.974   PSID= 315.934   PSIDOT=  67.847   PHITOT = 298.450
 T=  .05479   PHI= 193.090   PHIDOT= -47.541   G=   -.0418   GDOT=  -6.633   PSID= 316.265   PSIDOT=  40.790   PHITOT = 298.090
 T=  .05489   PHI= 192.907   PHIDOT= -16.134   G=   -.0423   GDOT=  -2.241   PSID= 316.402   PSIDOT=  13.743   PHITOT = 297.907
 T=  .05491   PHI= 192.890   PHIDOT=  -8.204   G=   -.0423   GDOT=  -1.139   PSID= 316.417   PSIDOT=   6.982   PHITOT = 297.890
 T=  .05494   PHI= 192.884   PHIDOT=   -.261   G=   -.0423   GDOT=   -.016   PSID= 316.422   PSIDOT=    .222   PHITOT = 297.884
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.05494	192.884	.366	-.0423	.051	316.422	-.312	297.884
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.05495	192.884	1.594	-.0423	.221	316.421	-1.357	297.884
.05495	192.884	1.840	-.0423	.255	316.421	-1.566	297.884
.05496	192.885	2.331	-.0423	.324	316.421	-1.983	297.885
.05496	192.885	2.822	-.0423	.392	316.420	-2.401	297.885
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.05496	192.886	3.804	-.0423	.528	316.419	-3.237	297.886
.05497	192.888	4.786	-.0423	.664	316.418	-4.073	297.888
.05498	192.890	5.768	-.0423	.801	316.417	-4.909	297.890
.05498	192.892	6.749	-.0423	.937	316.415	-5.745	297.892
.05499	192.894	7.730	-.0423	1.073	316.412	-6.580	297.894
.05500	192.901	9.691	-.0423	1.346	316.407	-8.252	297.901
.05501	192.908	11.650	-.0423	1.618	316.401	-9.923	297.908
.05503	192.917	13.607	-.0422	1.890	316.393	-11.594	297.917
.05504	192.928	15.561	-.0422	2.162	316.384	-13.264	297.928
.05506	192.953	19.460	-.0421	2.706	316.363	-16.605	297.953
.05509	192.984	23.344	-.0421	3.248	316.336	-19.943	297.984
.05514	193.061	31.054	-.0419	4.330	316.270	-26.614	298.062
.05519	193.161	38.669	-.0416	5.405	316.184	-33.274	298.161
.05524	193.283	46.164	-.0413	6.473	316.079	-39.920	298.283
.05529	193.426	53.518	-.0410	7.532	315.955	-46.549	298.426
.05539	193.773	67.714	-.0401	9.618	315.651	-59.745	298.773
.05549	194.200	81.101	-.0391	11.651	315.271	-72.836	299.200
.05559	194.701	93.530	-.0378	13.624	314.814	-85.791	299.701
.05569	195.270	104.878	-.0363	15.527	314.288	-98.580	300.270
.05579	195.900	115.043	-.0347	17.352	313.687	-111.170	300.900
.05589	196.586	123.948	-.0329	19.093	313.015	-123.525	301.586
.05599	197.318	131.534	-.0309	20.745	312.272	-135.609	302.318
.05609	198.090	137.777	-.0287	22.303	311.461	-147.384	303.090
.05619	198.895	142.662	-.0264	23.766	310.584	-158.812	303.895
.05629	199.723	146.204	-.0240	25.124	309.642	-169.859	304.723
.05639	200.567	148.443	-.0214	26.381	308.638	-180.488	305.567
.05649	201.421	149.424	-.0187	27.535	307.575	-190.668	306.421
.05659	202.277	149.222	-.0159	28.584	306.454	-200.370	307.277
.05669	203.129	147.914	-.0130	29.529	305.280	-209.570	308.129
.05679	203.970	145.593	-.0100	30.370	304.054	-218.245	308.970
.05689	204.796	142.359	-.0069	31.108	302.780	-226.380	309.796
.05699	205.600	138.315	-.0038	31.746	301.461	-233.964	310.600
.05709	206.379	133.564	-.0006	32.285	300.100	-240.989	311.379
.05719	207.130	128.220	.0027	32.729	298.700	-247.452	312.130

FREE MOTION

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.05719	127.1[illegible]	128.220	48.037	-247.452	312.130
.05720	127.206	138.631	47.895	-247.452	312.206
.05721	127.289	149.043	47.754	-247.452	312.289
.05722	127.377	159.455	47.612	-247.452	312.377
.05723	127.471	169.867	47.470	-247.452	312.471
.05724	127.572	180.278	47.328	-247.452	312.572
.05725	127.678	190.690	47.187	-247.452	312.678
.05726	127.790	201.102	47.045	-247.452	312.790
.05727	127.908	211.514	46.903	-247.452	312.908
.05728	128.032	221.925	46.761	-247.452	313.032
.05729	128.163	232.337	46.619	-247.452	313.163

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T=  .05732   PHI= 128.589   PHDOT= 263.573   PSI=  46.194   PSIDOT=-247.452   PHITOT = 313.589
T=  .05733   PHI= 128.743   PHDOT= 273.984   PSI=  46.052   PSIDOT=-247.452   PHITOT = 313.743
T=  .05734   PHI= 128.903   PHDOT= 284.396   PSI=  45.911   PSIDOT=-247.452   PHITOT = 313.903
T=  .05735   PHI= 129.069   PHDOT= 294.808   PSI=  45.769   PSIDOT=-247.452   PHITOT = 314.069
T=  .05736   PHI= 129.241   PHDOT= 305.220   PSI=  45.627   PSIDOT=-247.452   PHITOT = 314.241
T=  .05737   PHI= 129.418   PHDOT= 315.631   PSI=  45.485   PSIDOT=-247.452   PHITOT = 314.418
T=  .05738   PHI= 129.602   PHDOT= 326.043   PSI=  45.343   PSIDOT=-247.452   PHITOT = 314.602
T=  .05739   PHI= 129.792   PHDOT= 336.455   PSI=  45.202   PSIDOT=-247.452   PHITOT = 314.792
T=  .05740   PHI= 129.988   PHDOT= 346.867   PSI=  45.060   PSIDOT=-247.452   PHITOT = 314.988
T=  .05741   PHI= 130.190   PHDOT= 357.278   PSI=  44.918   PSIDOT=-247.452   PHITOT = 315.190
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VP= -14.443    VS=  42.322

     IMPACT

               PHI= 135.156   DPHIF=-115.965   PSI=  42.224   DPSIF=-151.480   PHITOT= 320.156
VP=  -8.841    VS=  -8.841
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