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Pantex Plant

HE Friction Sensitivity

Oblique Impact Sensitivity of Explosives

The Skid Test

Half-Inch Gap Sensitivity Test

SANL 712-009

J. H. Van Velkinburgh

April, May, June 1970

ATOMIC ENERGY COMMISSION
UNITED STATES OF AMERICA

DEVELOPMENT DIVISION

DISCLAIMER

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The study of the friction sensitivity of HE and the mechanism of frictional initiation via an apparatus which subjects the explosive to shear while under a sustained normal loading force.

The use and study of a sensitivity test of large bare explosive charges to oblique impact; a condition resembling possible operational accidents.

The use of a sensitivity test to determine relative shock sensitivities of small diameter samples.

ABSTRACT

Oblique impact tests were performed on RX-04-DS and on the extrusion cast explosive RX-08-AZ. Partial reactions were observed on RX-04-DS at 5.0', 45° and at 1.25', 14°; no reactions were observed with RX-08-AZ in the severest of tests.

Vertical drop tests were performed on 6"-diameter hemispheres of LX-04-1. Results are tabulated.

A series of accelerometer instrumented oblique impact tests were performed to obtain normal and rotational acceleration versus time.

Half-inch gap test series were performed on RX-08-AZ.

No experimental work with the friction test apparatus was done this period.

DISCUSSION

The Skid Test

Two oblique impact tests were performed on the extrusion cast explosive RX-08-AZ. Tests were done from a drop height of 20 feet and impact angles of 14° and 45°. No reaction or evidence of cracking or mechanical failure was observed in either test.

A series of oblique impact tests were done on RX-04-DS (nominal density = 1.726 gm/cc, nominal composition 80.7% HMX/10% Al/9.3% Viton). Test results are tabulated below:

45° Impact Angle		14° Impact Angle	
3.5'	NR, NR, NR	1.25'	2, 1, NR, NR, NR
5.0'	3, NR, NR, NR		

Accelerometer instrumented vertical drop tests were conducted on 6" diameter hemispheres of LX-04-1. Results are tabulated in Table I and Fig. 1-4.

A series of accelerometer instrumented oblique impact tests were performed on 11"-diameter HE hemispheres to obtain normal and rotation acceleration versus time. Fastax high speed motion pictures were also taken to observe the final rotational velocity. The experimental arrangement is shown in Fig. 5. The two accelerometers are placed with their active axes normal to the equatorial surface and such that a line drawn through their centers is parallel to the direction of motion of the explosive billet. This arrangement makes possible a simple calculation to be done to obtain normal and rotational acceleration versus

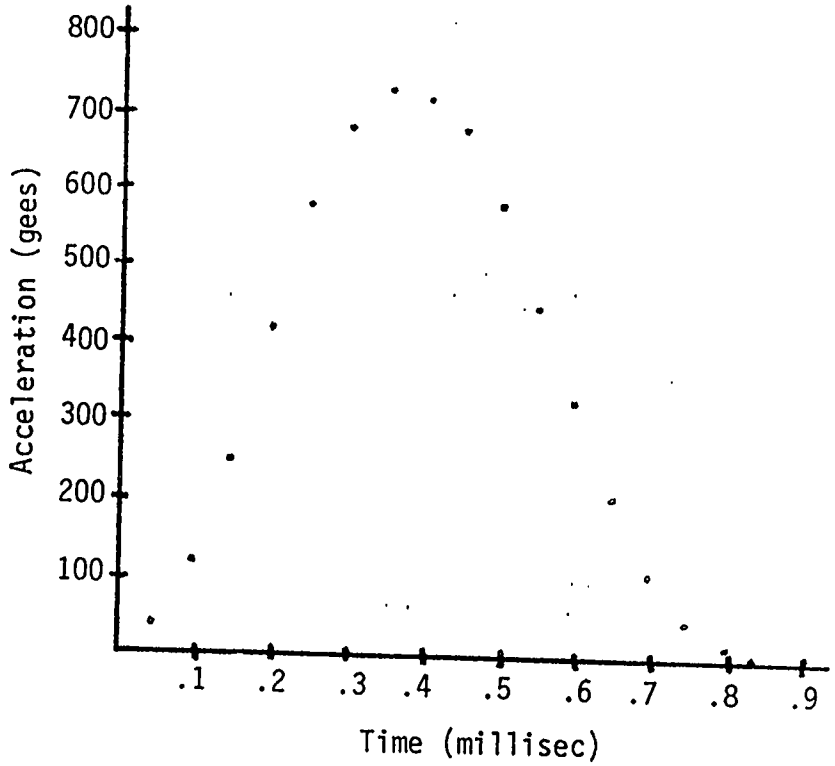
Table I

Vertical Drop Test Parameters of LX-04-1
6"-Diameter Hemispheres

Drop Height (feet)	Coefficient of Restitution		Impact Spot Diameter (inches)	Weight (pounds)
	Accelerometer	Faxtax		
½	0.69	0.50	0.52	3.80
1	0.69	0.50	0.60	3.80
2	0.70	0.46	0.71	3.82
4	0.63	0.42	0.83	3.80

Fig. 1

LX-04-1
6" Diameter Hemisphere
6-inch Vertical Drop



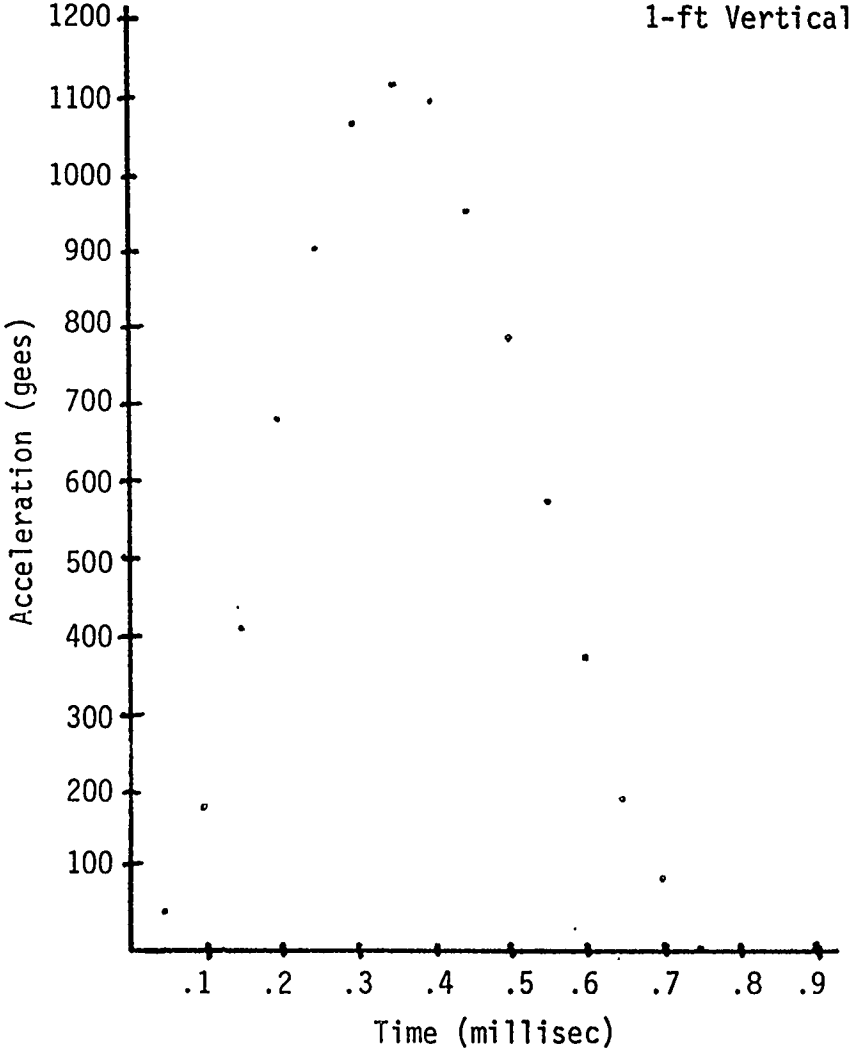
Time	Acceleration
.00	0
.05	40
.10	120
.15	250
.20	420
.25	580
.30	680
.35	730
.40	720
.45	680
.50	580
.55	450
.60	330
.65	210
.70	110
.75	50
.80	20
.83	0

Fig. 2

LX-04-1

6" Diameter Hemisphere

1-ft Vertical Drop



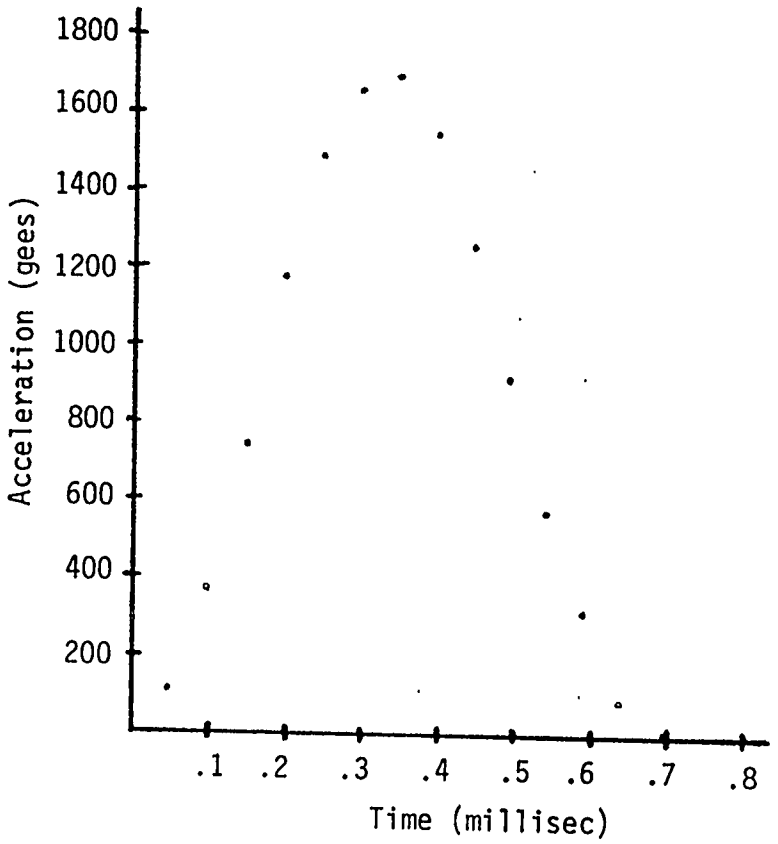
Time	Acceleration
.00	0
.05	50
.10	180
.15	410
.20	680
.25	900
.30	1060
.35	1110
.40	1080
.45	950
.50	780
.55	570
.60	370
.65	190
.70	90
.75	0

Fig. 3

LX-04-1

6" Diameter Hemisphere

2-ft Vertical Drop



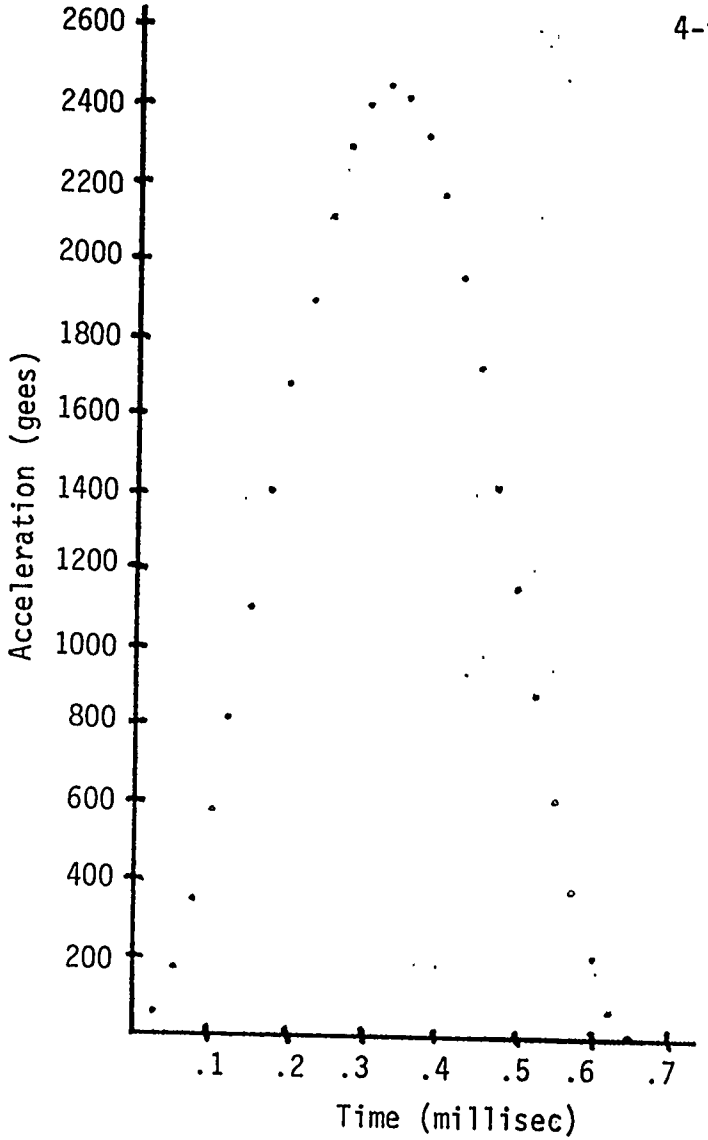
Time	Acceleration
.00	0
.05	120
.10	380
.15	750
.20	1180
.25	1490
.30	1660
.35	1690
.40	1550
.45	1260
.50	920
.55	580
.60	320
.65	100
.70	0

Fig. 4

LX-04-1

6" Diameter Hemisphere

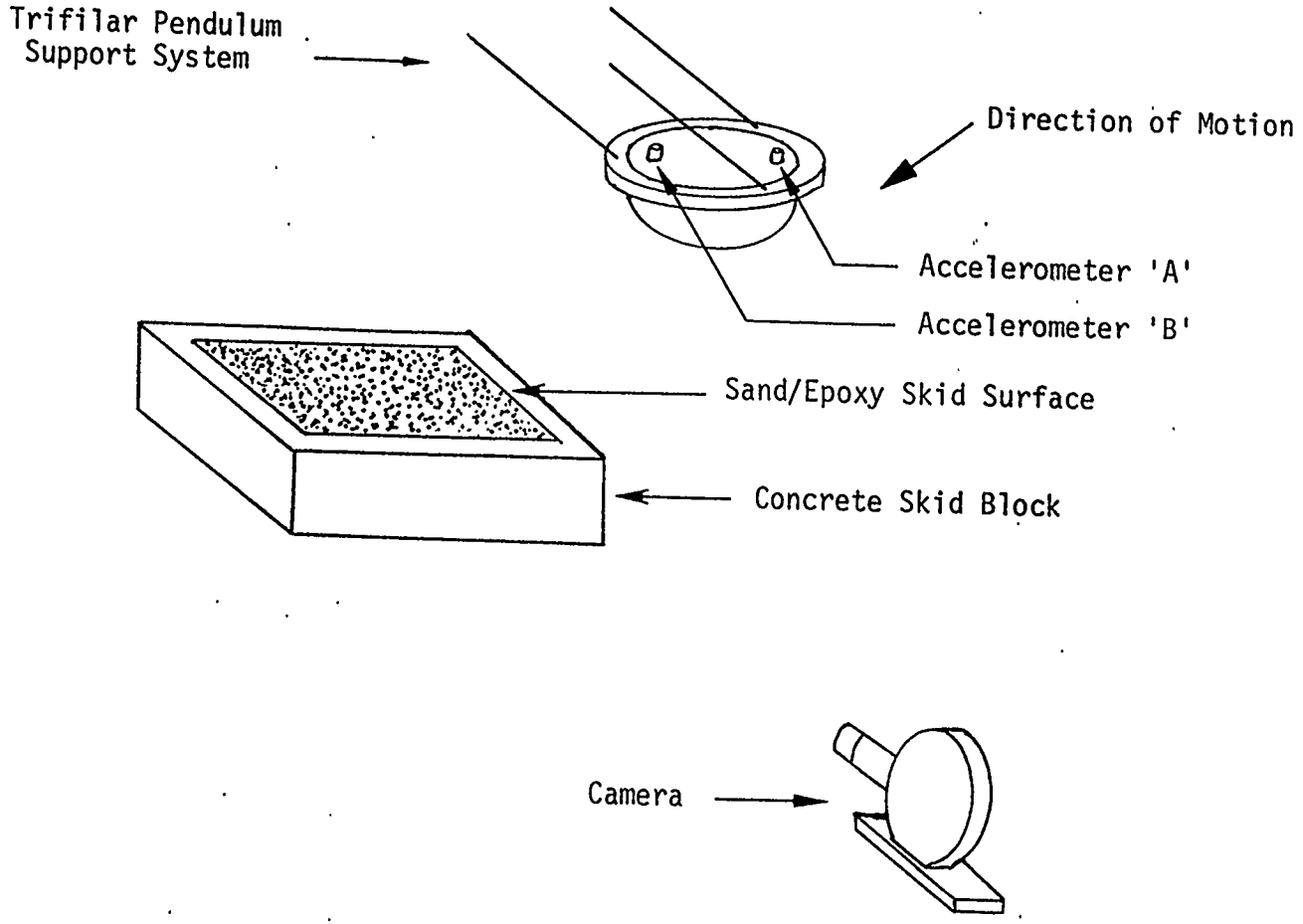
4-ft Vertical Drop



Time	Acceleration
.000	0
.025	60
.050	180
.075	350
.100	580
.125	820
.150	1100
.175	1410
.200	1680
.225	1900
.250	2110
.275	2290
.300	2410
.325	2450
.350	2420
.375	2320
.400	2170
.425	1960
.450	1730
.475	1420
.500	1170
.525	880
.550	610
.575	380
.600	210
.625	70
.650	0

Fig. 5

Instrumented Skid Test
Experimental Setup



time from the outputs of the two accelerometers. Normal acceleration is given by:

$$A_N = \frac{\text{accelerometer 'A' output + accelerometer 'B' output}}{2}$$

while rotational acceleration is given by:

$$A_R = \frac{\text{accelerometer 'A' output - accelerometer 'B' output}}{2}$$

The tests performed are listed in Table II. A sequence of tests to be done was determined by past experience with the explosives involved. This was done to expedite the work schedule and minimize destruction of accelerometers in case of explosive reaction. Final rotational velocities for the tests at 45° impact angle as measured from the Fastax films are listed in Table III. The final rotational velocity was also calculated by performing a numerical integration of the rotational acceleration-time trace. These values are listed in Table III. An attempt was made to obtain the coefficient of restitution (COR) from the Fastax films by measuring the rebound height of the center of mass of the explosive billet. By knowning the drop height, the COR can be calculated as the square root of the ratio of rebound height to drop height. These values are also given in Table III. Values for the tests at 14° impact angle are not given due to films not yet analyzed.

Normal and rotational accelerations as a function of time for the tests done are given in Figs. 6-59.

Table II

Accelerometer Instrumented Skid Tests Performed

45° Impact Angle

LX-04-1	3.5 feet (7)
	5.0 feet (9)
	7.1 feet (13)
LX-07-1	3.5 feet (10)
	3.5 feet (11)
LX-09-0	3.5 feet (14)
	3.5 feet (15)
PBX-9011	3.5 feet (1)
	5.0 feet (2)
	7.1 feet (3)
	10.0 feet (4)
	14.1 feet (5)
PBX-9404	3.5 feet (16)
	3.5 feet (17)
RX-04-DJ	3.5 feet (6)*
	5.0 feet (8)
	7.1 feet (12)

14° Impact Angle

LX-04-1	.88 feet (6)
	1.25 feet (8)
LX-07-1	.88 feet (9)
LX-09-0	.88 feet (11)
PBX-9011	.88 feet (1)
	1.25 feet (2)
	3.5 feet (3)
	7.1 feet (4)
	14.1 feet (10)*
PBX-9404	.88 feet (12)
RX-04-DJ	.88 feet (5)
	1.25 feet (7)

NOTE: Numbers following drop heights indicate order in which tests were to be done.

**test not done*

Table III

Final Rotational Velocities and Coefficient of REstitution as Measured from Fastax Film

Sequence Number	Material	Drop Height (feet)	Rotational Velocity (radians/sec)		Coefficient of Restitution
			Fastax	Accelerometer	
1	PBX 9011	3.5	26.57	29.75	Indeterminate
2	PBX 9011	5.0	33.37	35.71	.33
3	PBX 9011	7.1	41.30	46.09	.27-.28
4	PBX 9011	10.0	47.35	52.17	.29-.30
5	PBX 9011	14.1	**	58.64	
6	RX-04-DJ	3.5	*		
7	LX-04-1	3.5	23.72	25.92	.38
8	RX-04-DJ	5.0	27.11	28.76	.39-.40
9	LX-04-1	5.0	**	36.99	
10	LX-07-1	3.5	27.53	30.38	Indeterminate
11	LX-07-1	3.5	**	30.36	
12	RX-04-DJ	7.1	34.52	44.59	.32-.33
13	LX-04-1	7.1	37.18	42.47	.30
14	LX-09-0	3.5	25.46	29.05	Indeterminate
15	LX-09-0	3.5	26.42	31.22	.34-.35
16	PBX 9404	3.5	27.91	31.76	.33
17	PBX 9404	3.5	27.12	30.45	.31

**test not done*
***films to be analyzed*

Half-Inch Gap Sensitivity Test

A gap test series was performed on RX-08-AZ giving a $G_{50} \pm L_{95}$ of 48 ± 3 mils at a density of 1.823 gm/cc.

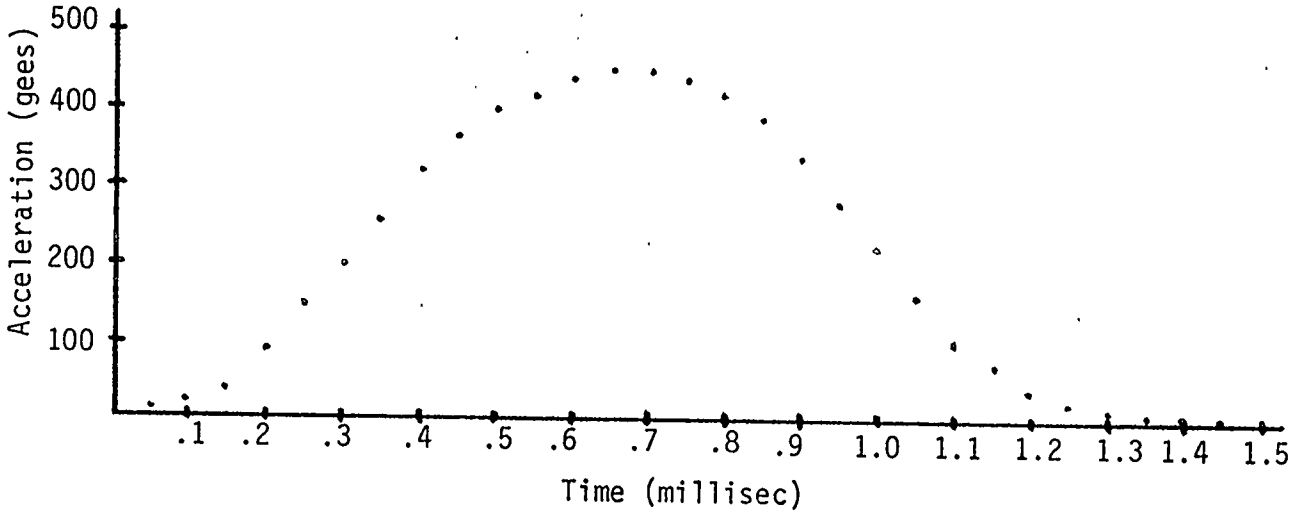
FUTURE WORK; COMMENTS; CONCLUSIONS

Fastax films of the instrumented skid tests at 14° impact angle will be analyzed shortly.

Several accelerometer instrumented vertical drop tests are planned for the future. Two each at a height of one foot on LX-07-1 and LX-09-0 and two each from heights of one and two feet on RX-04-DS. Accelerometer instrumented vertical drops and skid tests are planned on 24"-diameter (∿ 280 pounds) hemispheres of PBX-9404.

Fig. 6

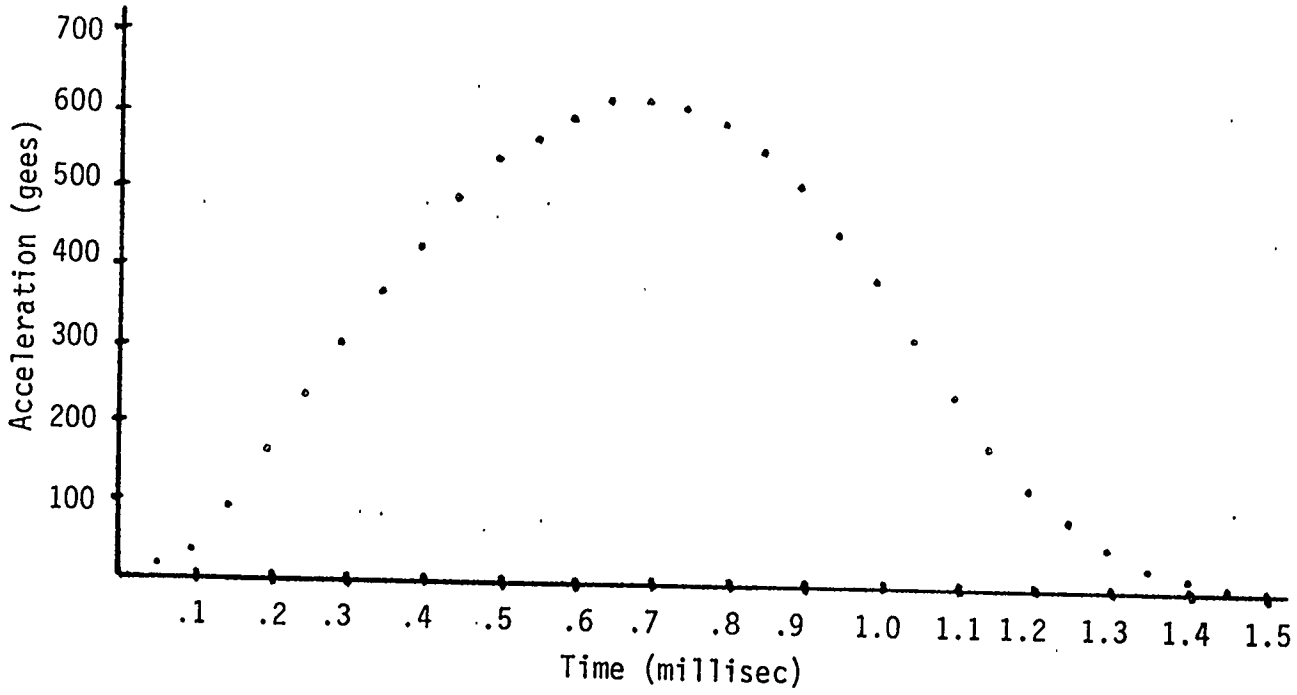
PBX-9011
3.5-ft., 45°
Rotational Acceleration



Time	Acceleration
.00	0
.05	10
.10	20
.15	45
.20	95
.25	150
.30	205
.35	260
.40	320
.45	370
.50	400
.55	420
.60	440
.65	450
.70	450
.75	440
.80	420
.85	390
.90	340
.95	280
1.00	225
1.05	160
1.10	115
1.15	70
1.20	40
1.25	25
1.30	15
1.35	10
1.40	0

Fig. 7

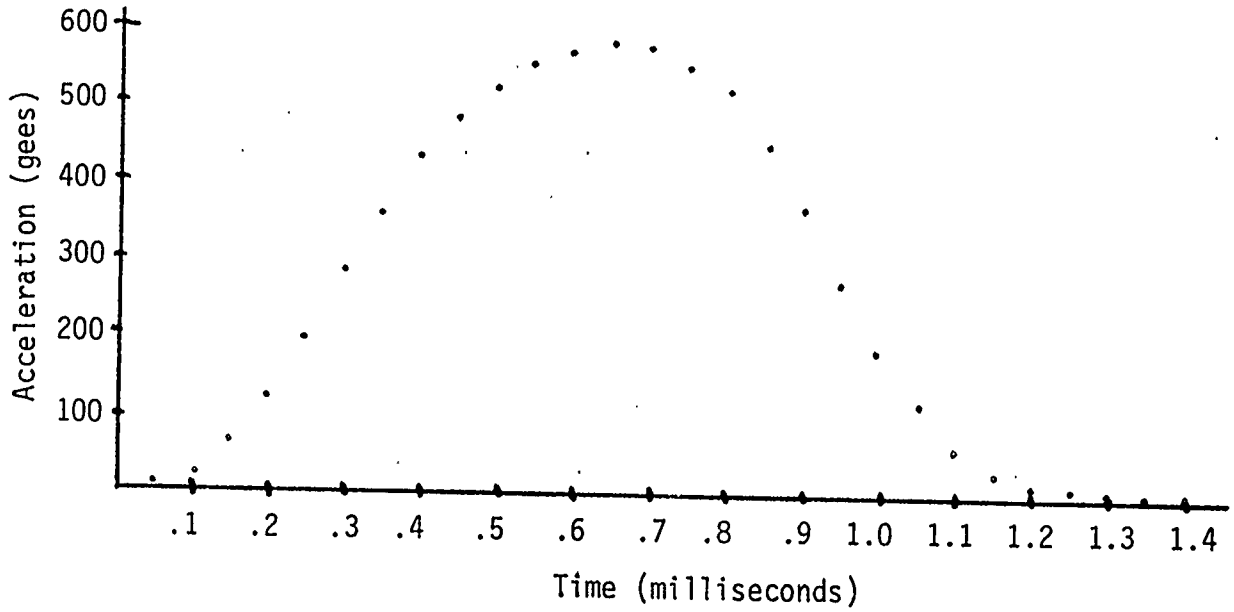
PBX-9011
3.5-ft., 45°
Normal Acceleration



Time	Acceleration
.00	0
.05	15
.10	40
.15	95
.20	165
.25	240
.30	305
.35	370
.40	430
.45	490
.50	540
.55	570
.60	600
.65	620
.70	620
.75	610
.80	590
.85	565
.90	520
.95	460
1.00	395
1.05	320
1.10	250
1.15	180
1.20	130
1.25	90
1.30	55
1.35	30
1.40	10
1.45	0

Fig. 8

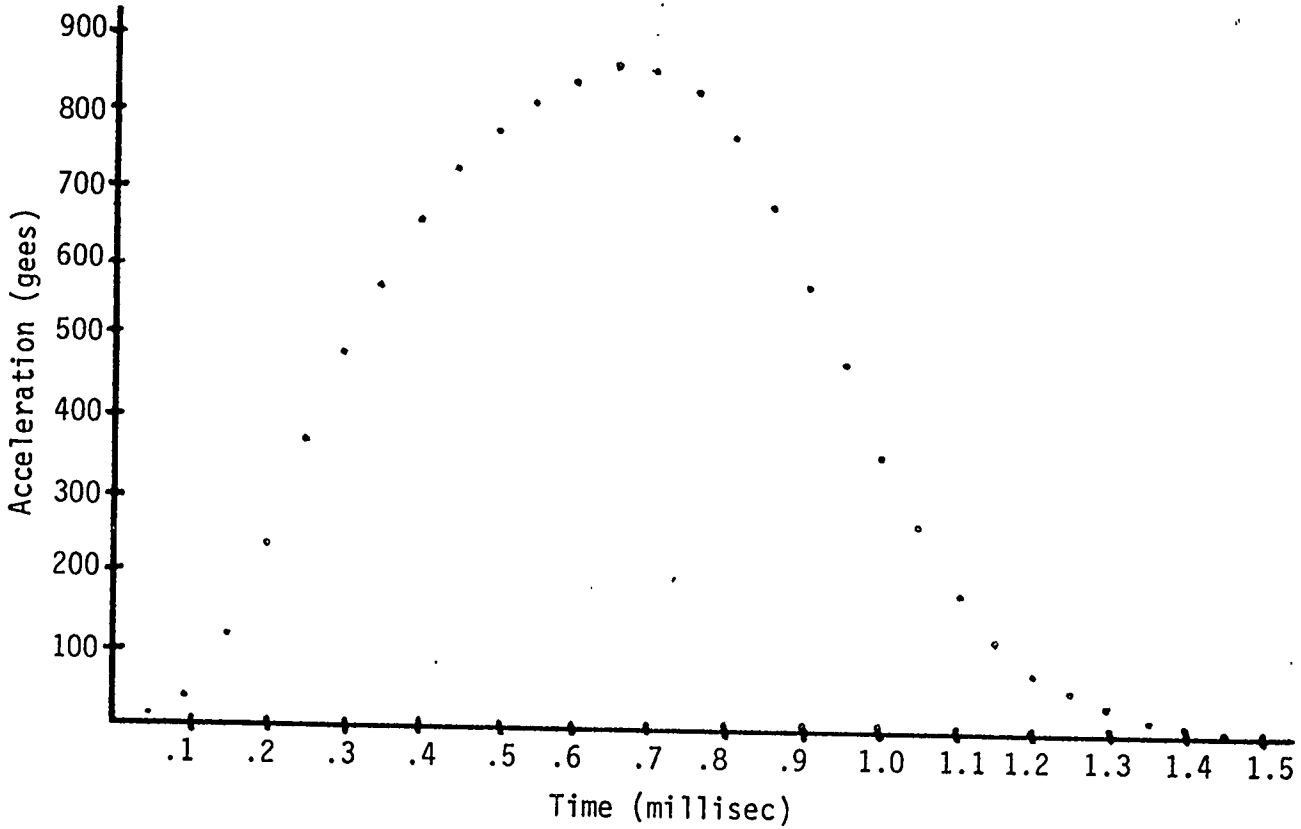
PBX-9011
5.0-ft., 45°
Rotational Acceleration



Time	Acceleration
.00	0
.05	5
.10	20
.15	70
.20	125
.25	200
.30	285
.35	360
.40	430
.45	485
.50	525
.55	550
.60	570
.65	580
.70	575
.75	550
.80	520
.85	450
.90	370
.95	280
1.00	190
1.05	120
1.10	70
1.15	35
1.20	20
1.25	10
1.30	5
1.35	0

Fig. 9

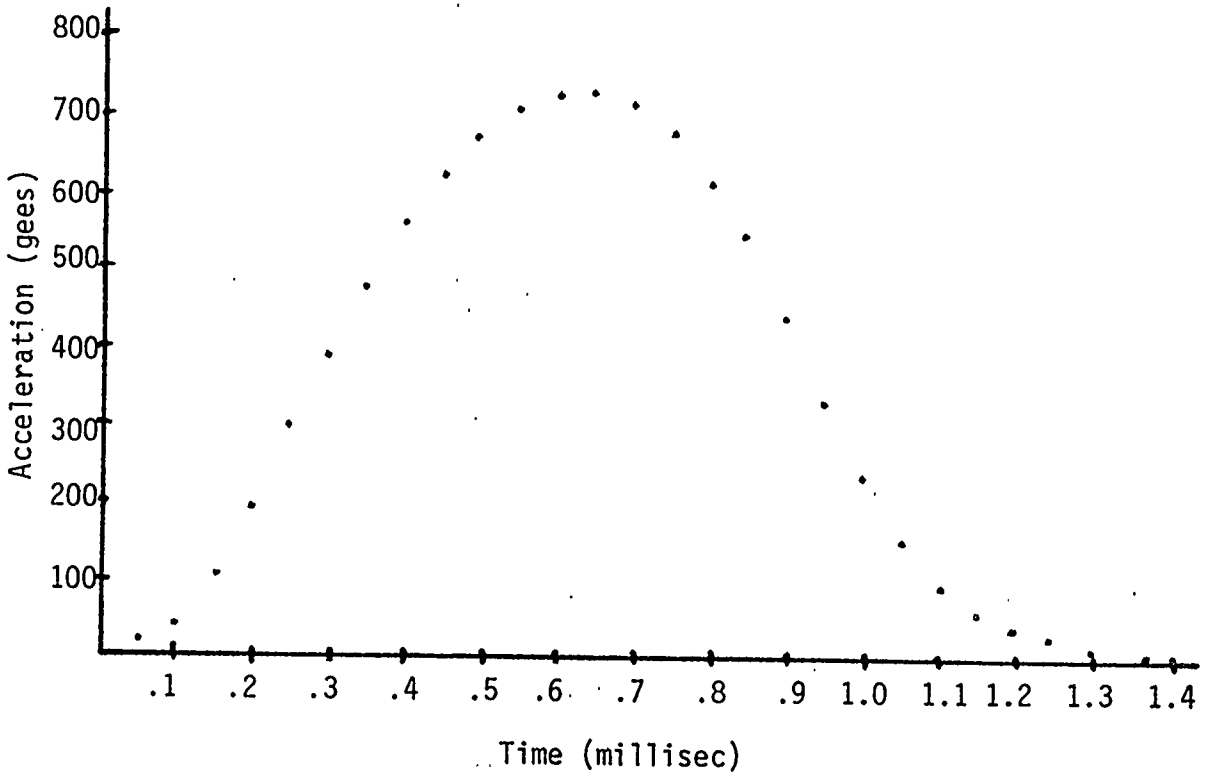
PBX-9011
5.0-ft., 45°
Normal Acceleration



Time	Acceleration
.00	0
.05	15
.10	40
.15	120
.20	235
.25	370
.30	480
.35	575
.40	655
.45	725
.50	775
.55	810
.60	840
.65	860
.70	855
.75	825
.80	770
.85	680
.90	580
.95	470
1.00	360
1.05	270
1.10	180
1.15	125
1.20	80
1.25	60
1.30	40
1.35	20
1.40	10
1.43	0

Fig. 10

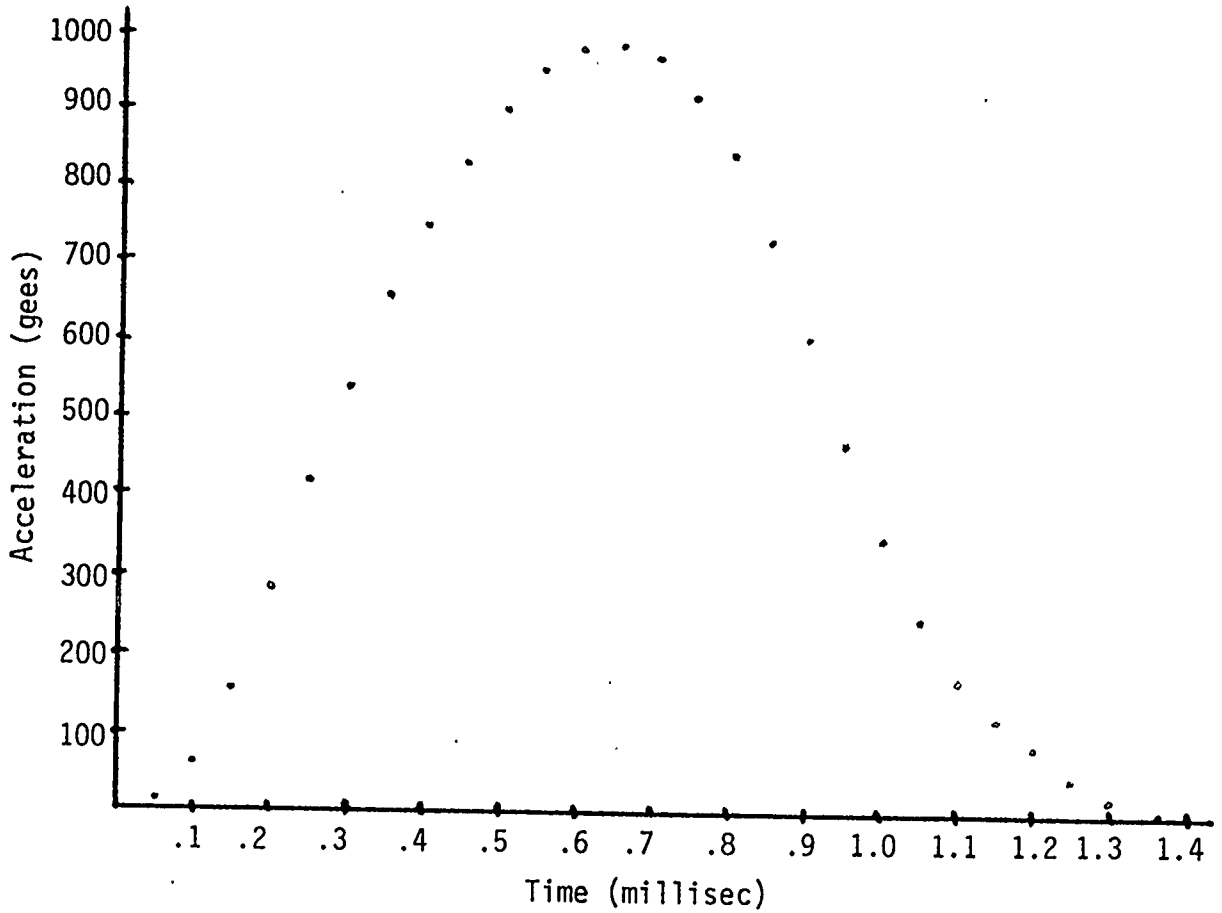
PBX-9011
7.1-ft., 45°
Rotational Acceleration



Time	Acceleration
.00	0
.05	10
.10	45
.15	110
.20	195
.25	300
.30	390
.35	480
.40	560
.45	620
.50	670
.55	705
.60	725
.65	730
.70	715
.75	680
.80	620
.85	550
.90	445
.95	335
1.00	240
1.05	160
1.10	100
1.15	65
1.20	50
1.25	30
1.30	20
1.37	0

Fig. 11

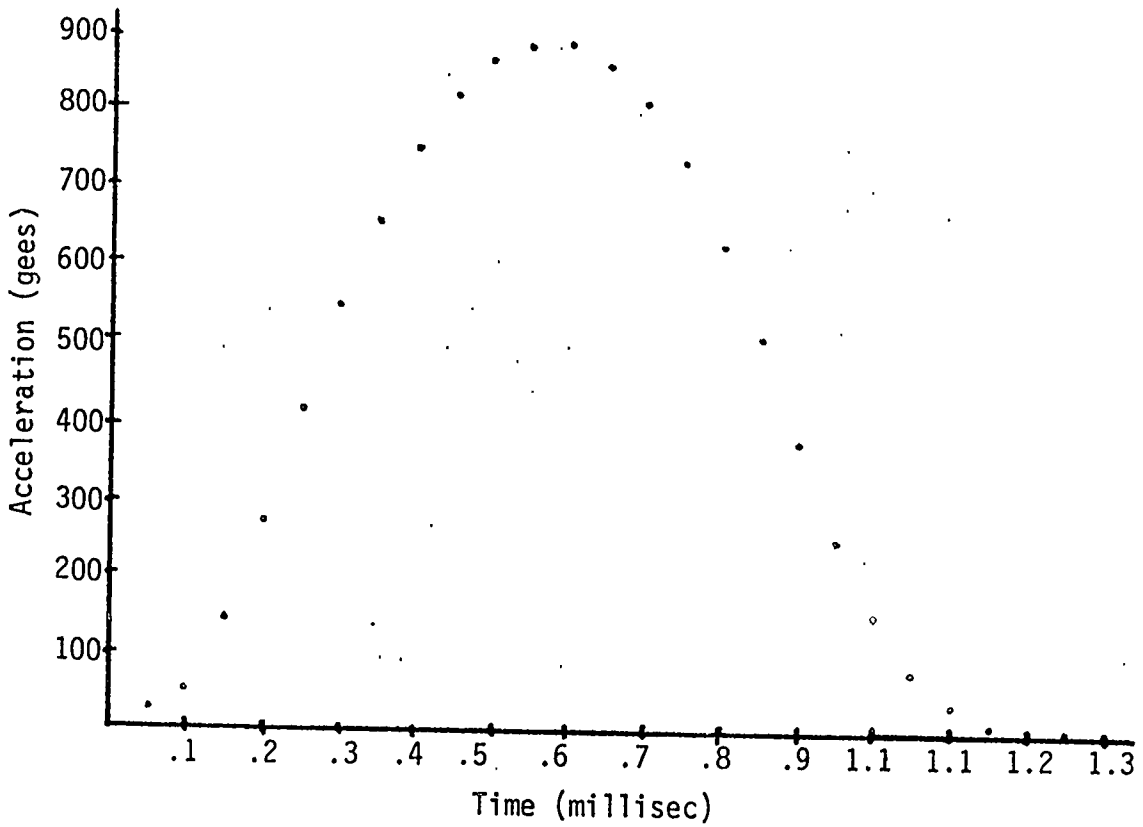
PBX-9011
7.1-ft., 45°
Normal Acceleration



Time	Acceleration
.00	0
.05	15
.10	65
.15	160
.20	285
.25	425
.30	545
.35	660
.40	745
.45	835
.50	910
.55	955
.60	980
.65	990
.70	975
.75	930
.80	850
.85	740
.90	615
.95	480
1.00	360
1.05	260
1.10	180
1.15	130
1.20	100
1.25	60
1.30	30
1.37	0

Fig. 12

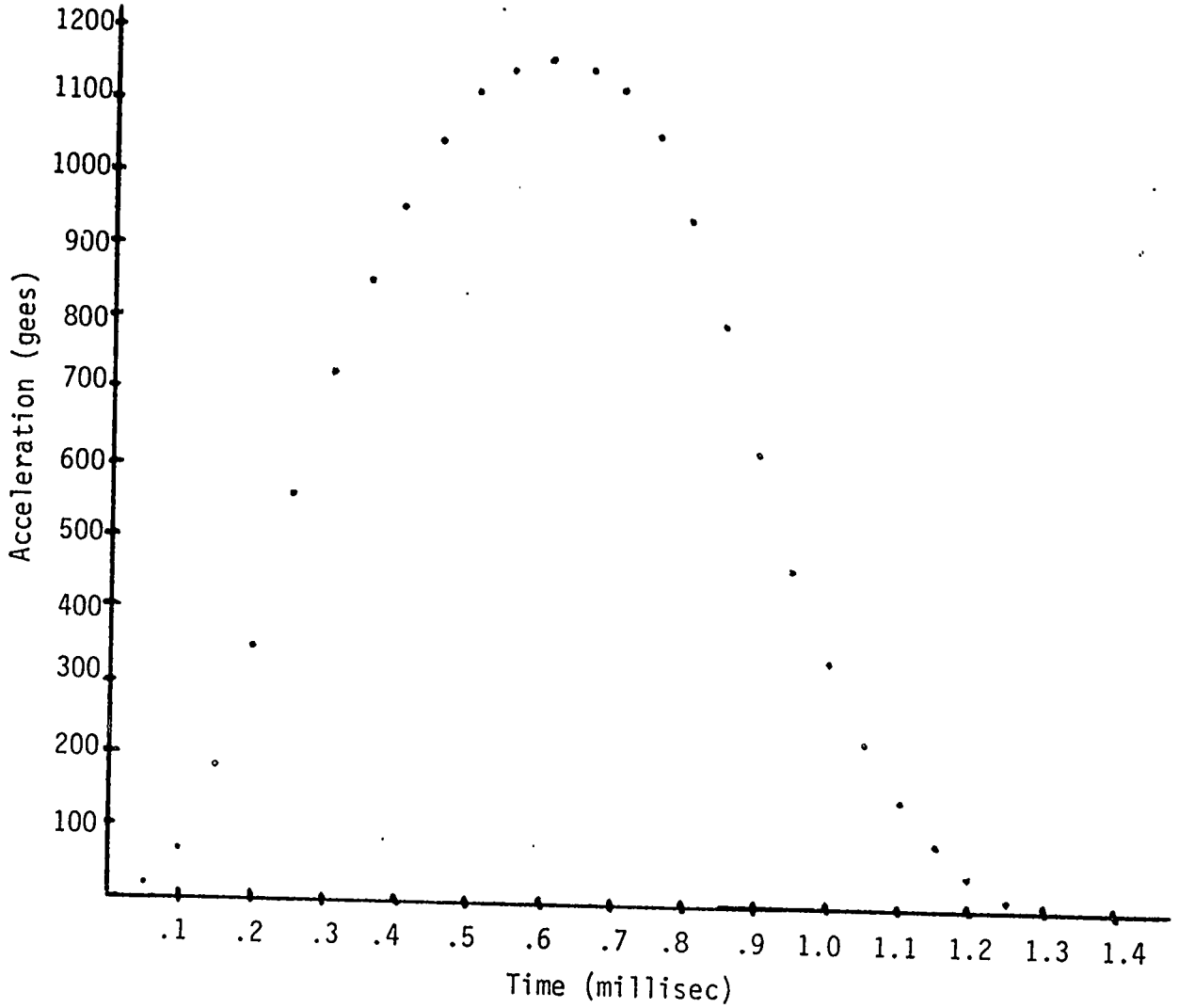
PBX-9011
10.0-ft., 45°
Rotational Acceleration



Time	Acceleration
.00	0
.05	10
.10	60
.15	150
.20	265
.25	415
.30	550
.35	660
.40	750
.45	825
.50	865
.55	885
.60	885
.65	860
.70	815
.75	740
.80	630
.85	510
.90	375
.95	250
1.00	160
1.05	85
1.10	45
1.15	15
1.20	5
1.25	0

Fig. 13

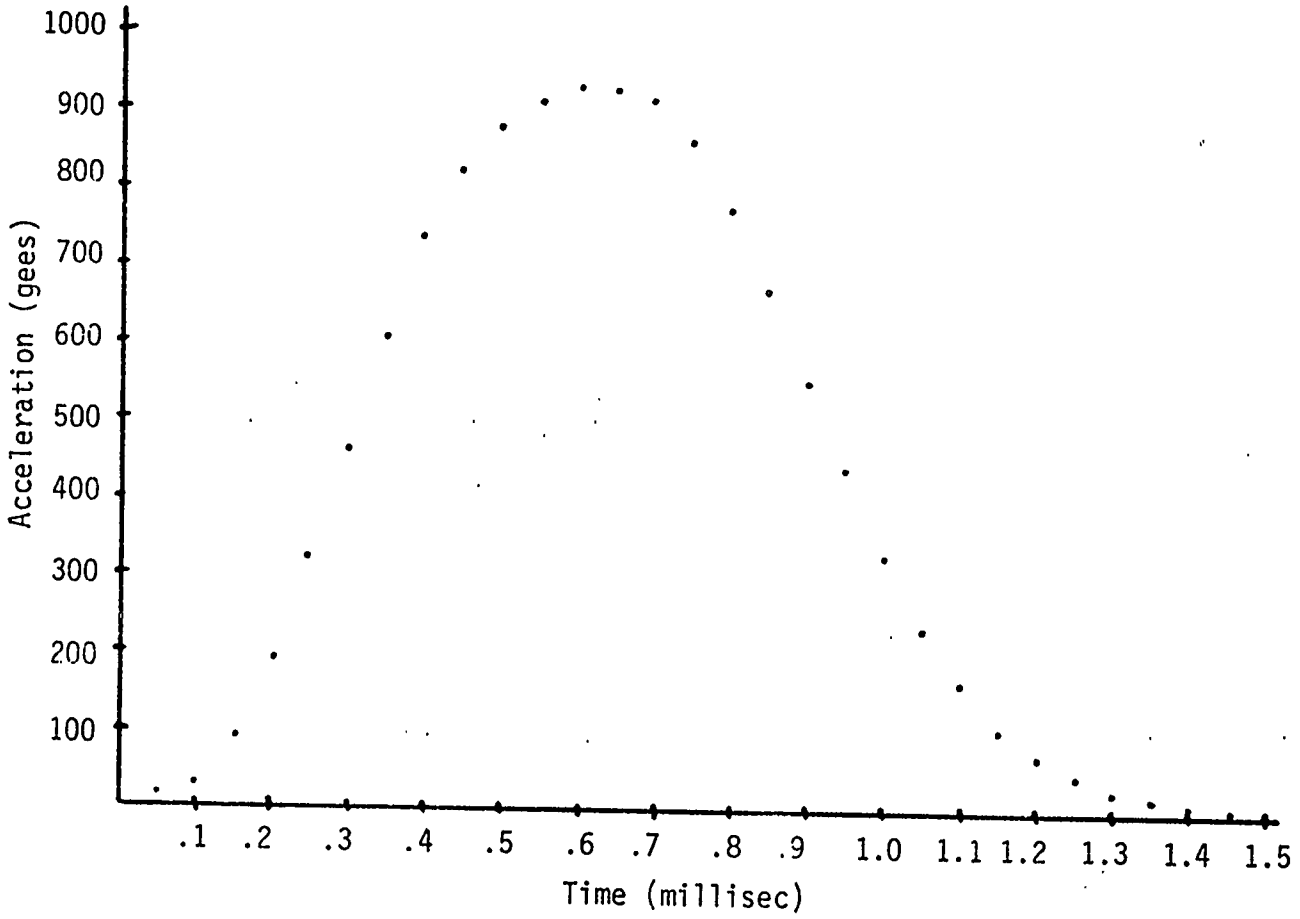
PBX-9011
10.0-ft., 45°
Normal Acceleration



Time	Acceleration
.00	0
.05	20
.10	70
.15	180
.20	345
.25	555
.30	720
.35	845
.40	950
.45	1040
.50	1105
.55	1135
.60	1145
.65	1140
.70	1115
.75	1050
.80	940
.85	795
.90	625
.95	470
1.00	340
1.05	235
1.10	155
1.15	90
1.20	45
1.25	10
1.30	0

Fig. 14

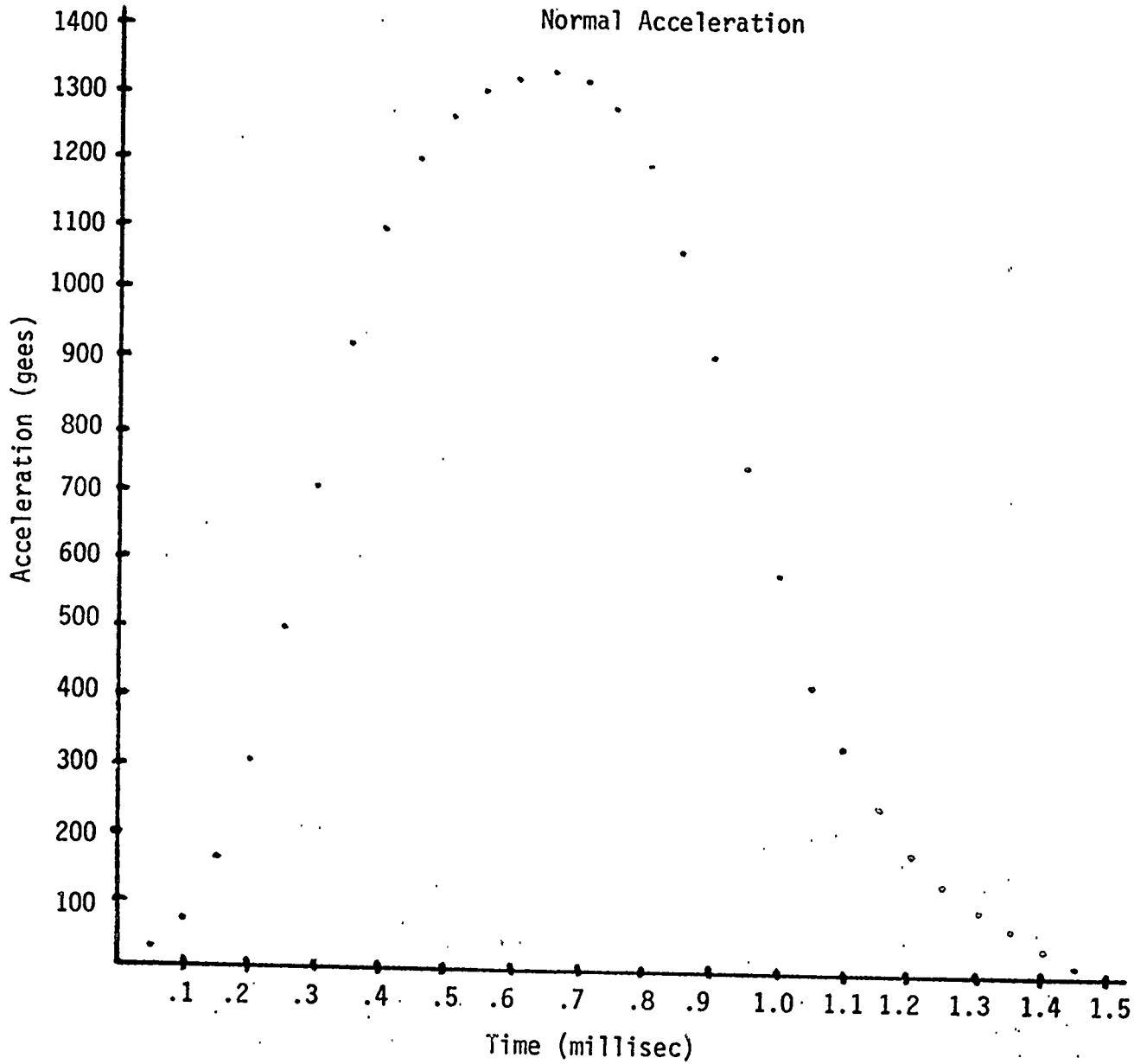
PBX-9011
14.1-ft., 45°
Rotational Acceleration



Time	Acceleration
.00	0
.05	10
.10	35
.15	95
.20	190
.25	325
.30	465
.35	605
.40	735
.45	820
.50	875
.55	905
.60	925
.65	925
.70	910
.75	860
.80	770
.85	670
.90	550
.95	440
1.00	330
1.05	235
1.10	165
1.15	110
1.20	75
1.25	50
1.30	30
1.35	20
1.40	15
1.45	10
1.50	0

Fig. 15

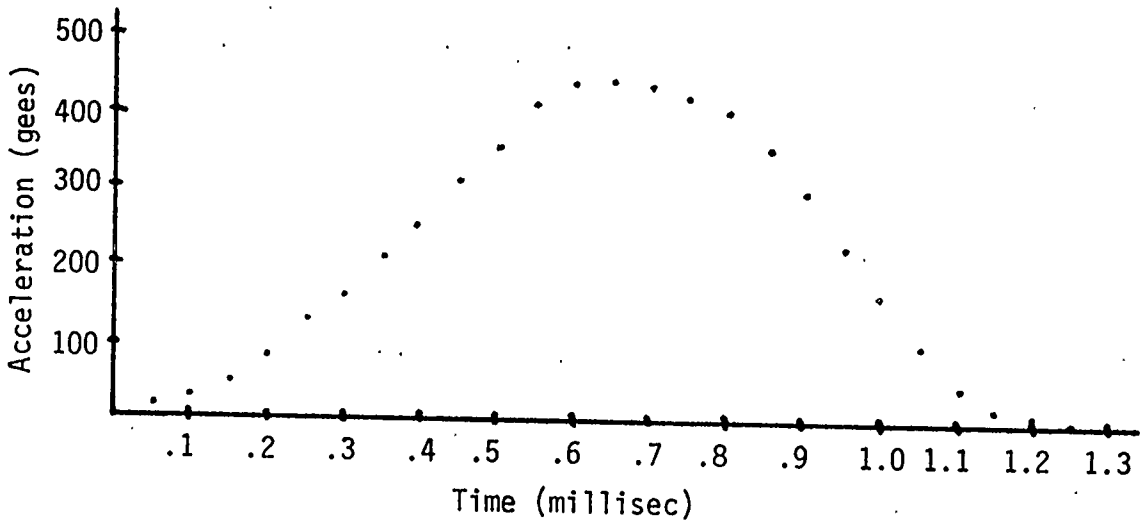
PBX-9011
14.1-ft., 45°
Normal Acceleration



Time	Acceleration
.00	0
.05	30
.10	75
.15	165
.20	310
.25	505
.30	715
.35	925
.40	1095
.45	1200
.50	1265
.55	1305
.60	1325
.65	1335
.70	1320
.75	1280
.80	1190
.85	1070
.90	910
.95	750
1.00	590
1.05	455
1.10	335
1.15	250
1.20	185
1.25	135
1.30	95
1.35	70
1.40	40
1.45	20
1.50	0

Fig. 16

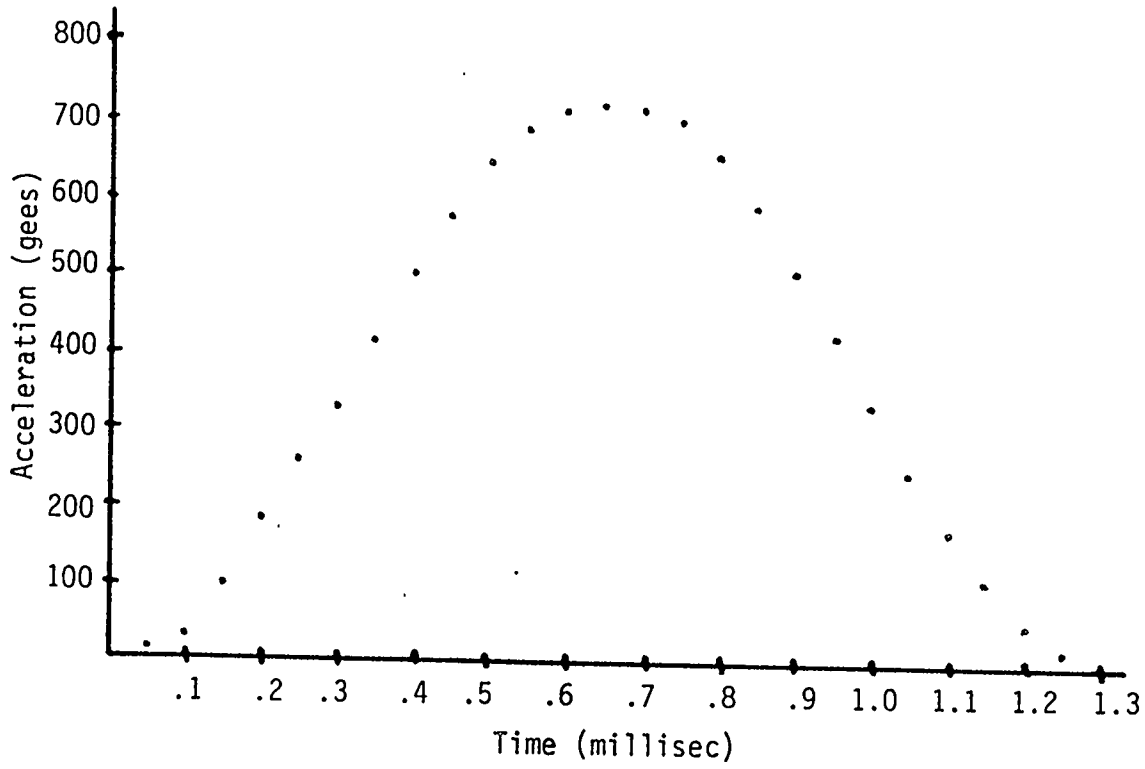
LX-04-1
3.5-ft., 45°
Rotational Acceleration



Time	Acceleration
.00	0
.05	5
.10	15
.15	50
.20	85
.25	125
.30	160
.35	210
.40	255
.45	310
.50	355
.55	415
.60	435
.65	445
.70	440
.75	425
.80	400
.85	355
.90	300
.95	230
1.00	170
1.05	105
1.10	50
1.15	20
1.20	10
1.25	0

Fig. 17

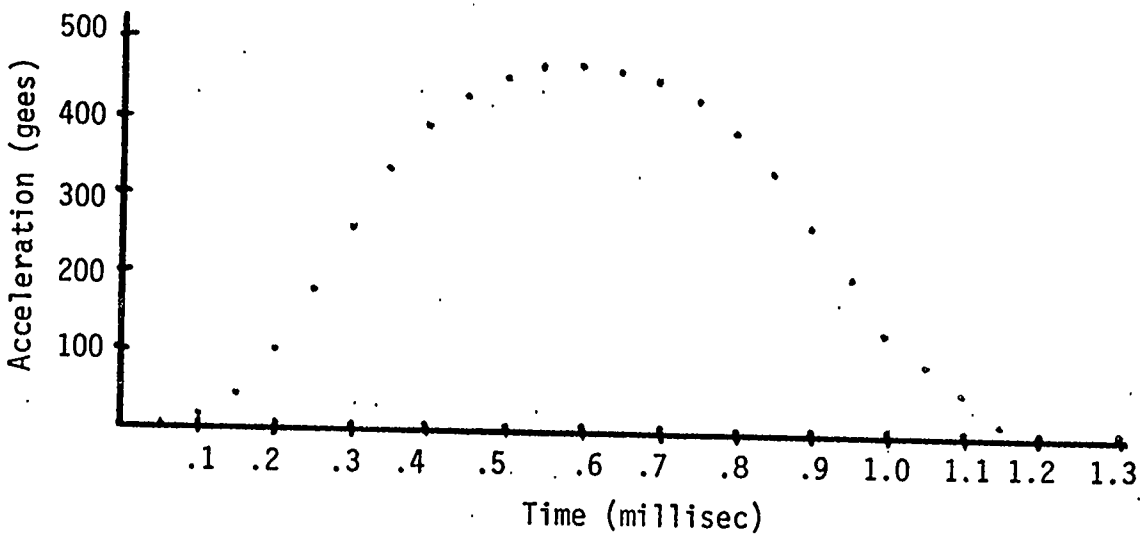
LX-04-1
3.5-ft., 45°
Normal Acceleration



Time	Acceleration
.00	0
.05	10
.10	35
.15	100
.20	185
.25	260
.30	330
.35	415
.40	495
.45	570
.50	640
.55	685
.60	705
.65	715
.70	710
.75	695
.80	650
.85	585
.90	510
.95	420
1.00	330
1.05	245
1.10	170
1.15	105
1.20	50
1.25	20
1.30	0

Fig. 18

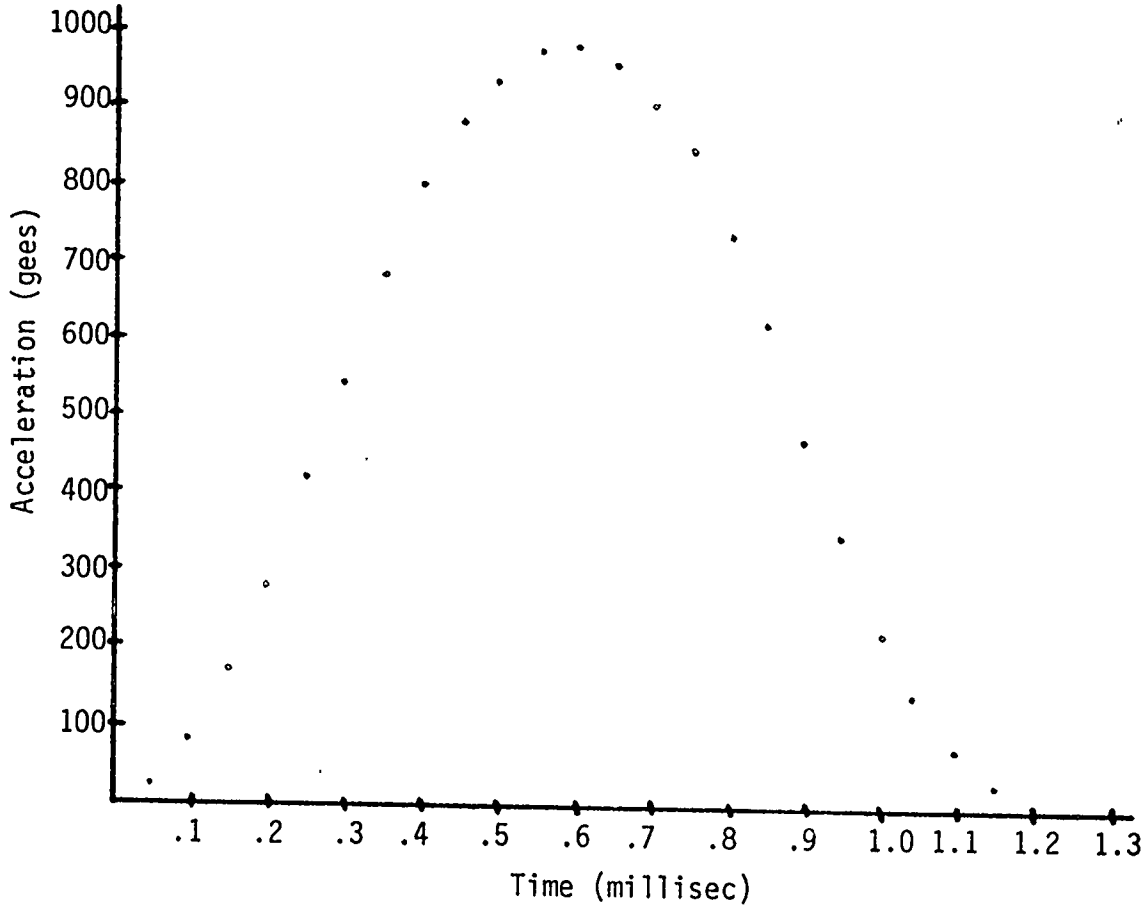
RX-04-DJ
5.0-ft., 45°
Rotational Acceleration



Time	Acceleration
.00	0
.05	0
.10	15
.15	50
.20	105
.25	185
.30	255
.35	335
.40	390
.45	430
.50	455
.55	470
.60	470
.65	465
.70	455
.75	430
.80	385
.85	335
.90	265
.95	205
1.00	135
1.05	95
1.10	60
1.15	20
1.20	0

Fig. 19

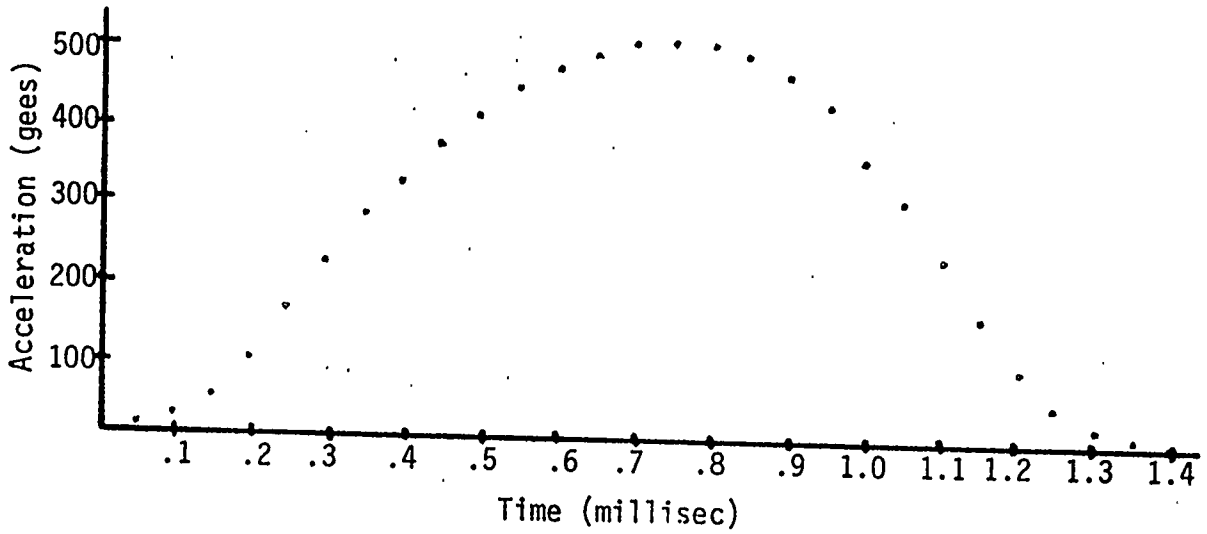
RX-04-DJ
5.0-ft., 45°
Normal Acceleration



Time	Acceleration
.00	0
.05	30
.10	85
.15	170
.20	285
.25	415
.30	545
.35	685
.40	790
.45	880
.50	945
.55	980
.60	980
.65	955
.70	915
.75	840
.80	735
.85	615
.90	475
.95	345
1.00	225
1.05	145
1.10	80
1.15	30
1.20	0

Fig. 20

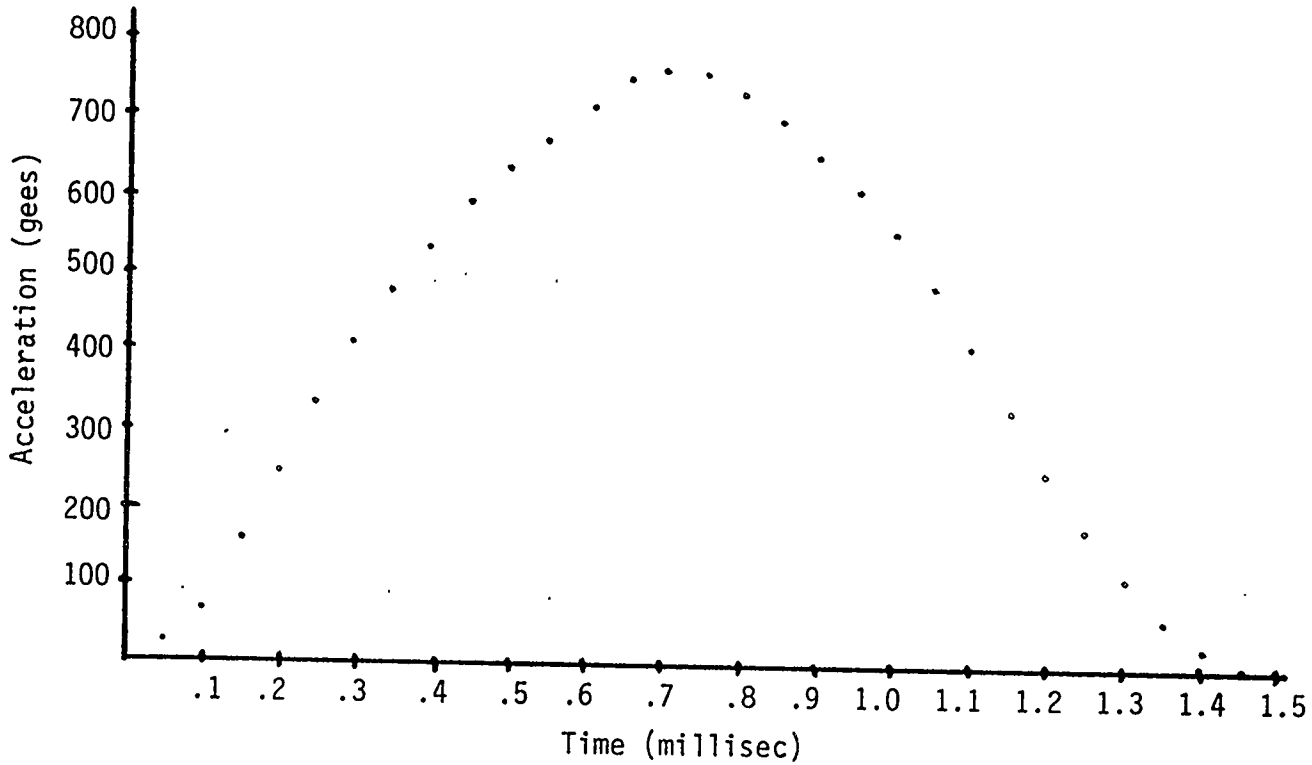
LX-04-1
5.0-ft., 45°
Rotational Acceleration



Time	Acceleration
.00	0
.05	5
.10	15
.15	55
.20	110
.25	170
.30	225
.35	290
.40	335
.45	375
.50	420
.55	455
.60	475
.65	495
.70	515
.75	520
.80	515
.85	500
.90	475
.95	435
1.00	370
1.05	315
1.10	240
1.15	170
1.20	100
1.25	55
1.30	25
1.35	5
1.40	0

Fig. 21

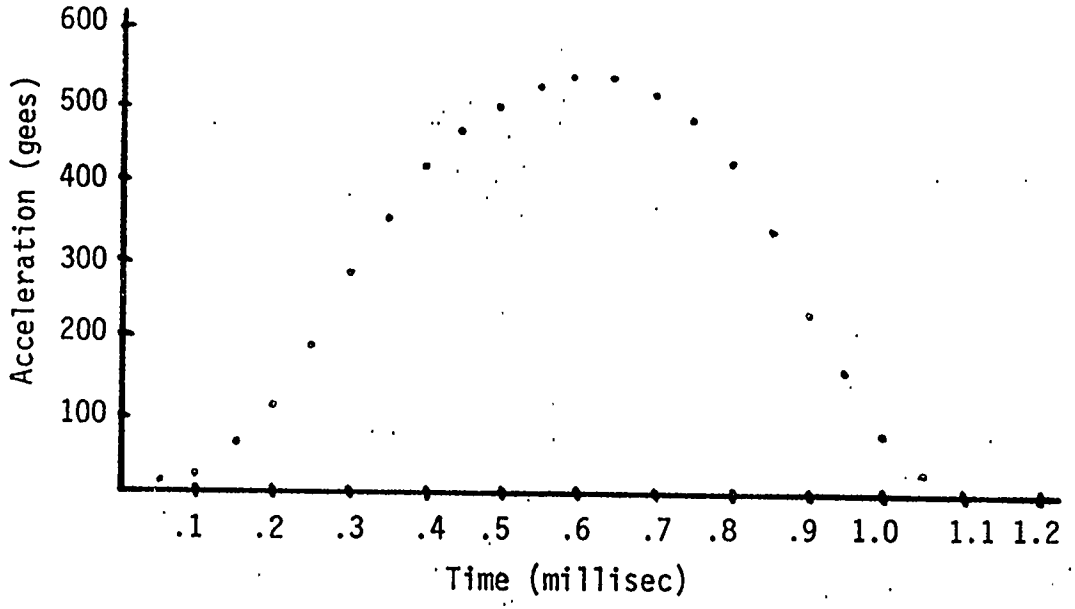
LX-04-1
5.0-ft., 45°
Normal Acceleration



Time	Acceleration
.00	0
.05	30
.10	70
.15	160
.20	250
.25	335
.30	410
.35	480
.40	535
.45	590
.50	635
.55	675
.60	715
.65	750
.70	760
.75	750
.80	730
.85	695
.90	660
.95	610
1.00	555
1.05	490
1.10	410
1.15	330
1.20	250
1.25	180
1.30	120
1.35	65
1.40	20
1.45	0

Fig. 22

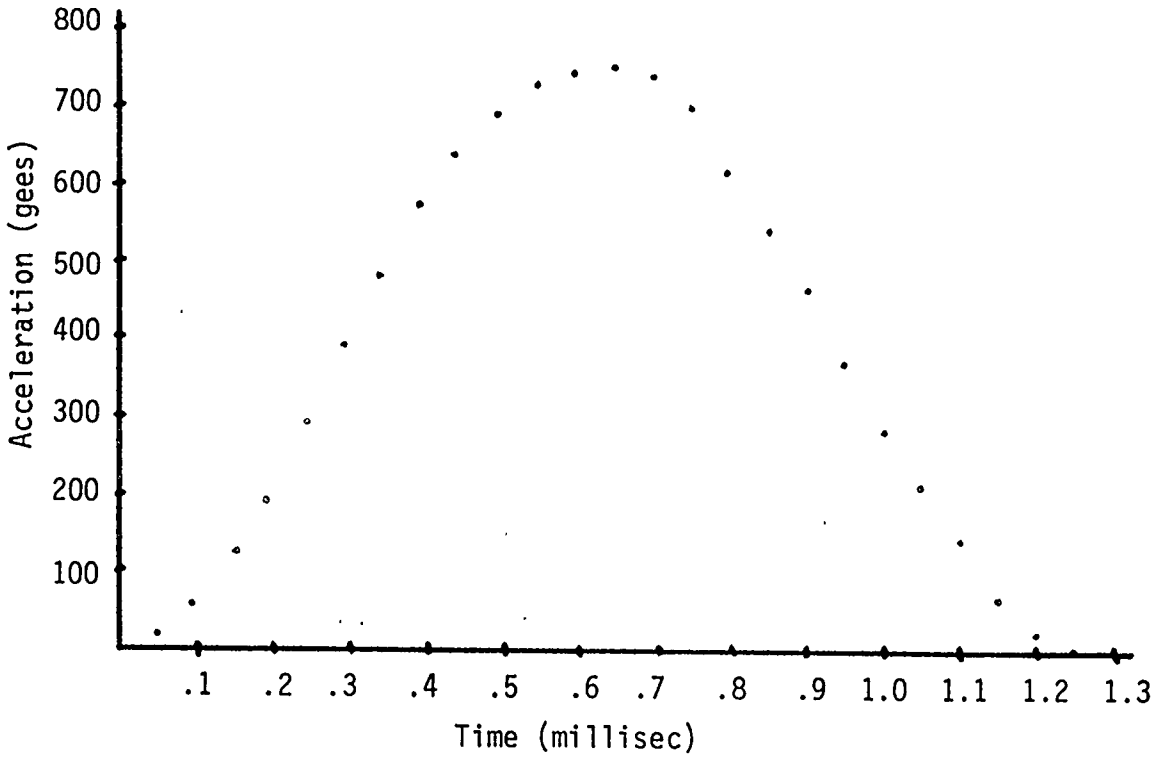
LX-07-1
3.5-ft., 45°
Rotational Acceleration



Time	Acceleration
.00	0
.05	5
.10	25
.15	65
.20	115
.25	190
.30	280
.35	350
.40	420
.45	470
.50	500
.55	525
.60	540
.65	540
.70	520
.75	485
.80	425
.85	340
.90	240
.95	155
1.00	75
1.05	30
1.10	0

Fig. 25

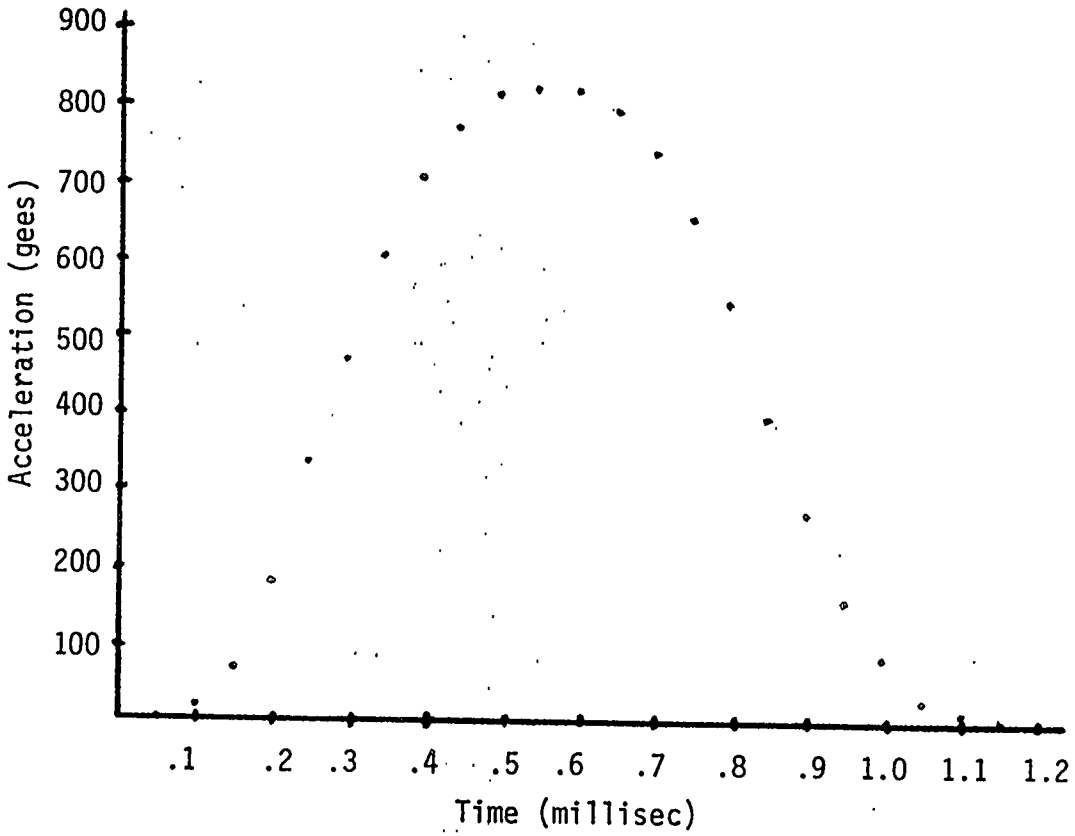
LX-07-1
3.5-ft., 45°
Normal Acceleration



Time	Acceleration
.00	0
.05	20
.10	60
.15	115
.20	190
.25	290
.30	395
.35	485
.40	570
.45	635
.50	690
.55	725
.60	745
.65	750
.70	735
.75	690
.80	620
.85	545
.90	465
.95	375
1.00	290
1.05	220
1.10	140
1.15	70
1.20	30
1.25	0

Fig. 26

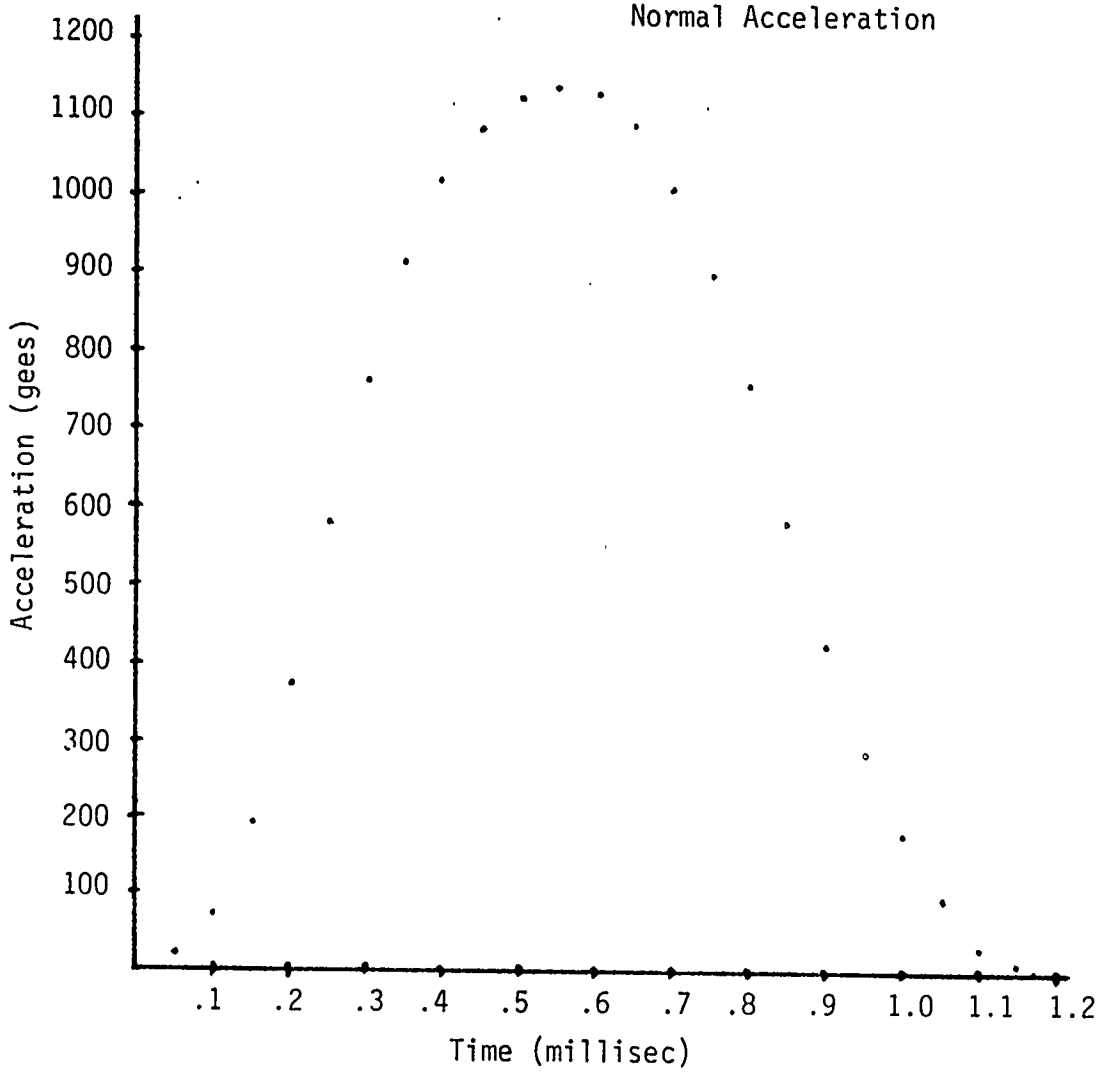
RX-04-DJ
7.1-ft., 45°
Rotational Acceleration



Time	Acceleration
.00	0
.05	0
.10	20
.15	75
.20	180
.25	335
.30	470
.35	600
.40	700
.45	765
.50	805
.55	815
.60	810
.65	790
.70	730
.75	650
.80	540
.85	395
.90	270
.95	160
1.00	85
1.05	35
1.10	10
1.15	0

Fig. 27

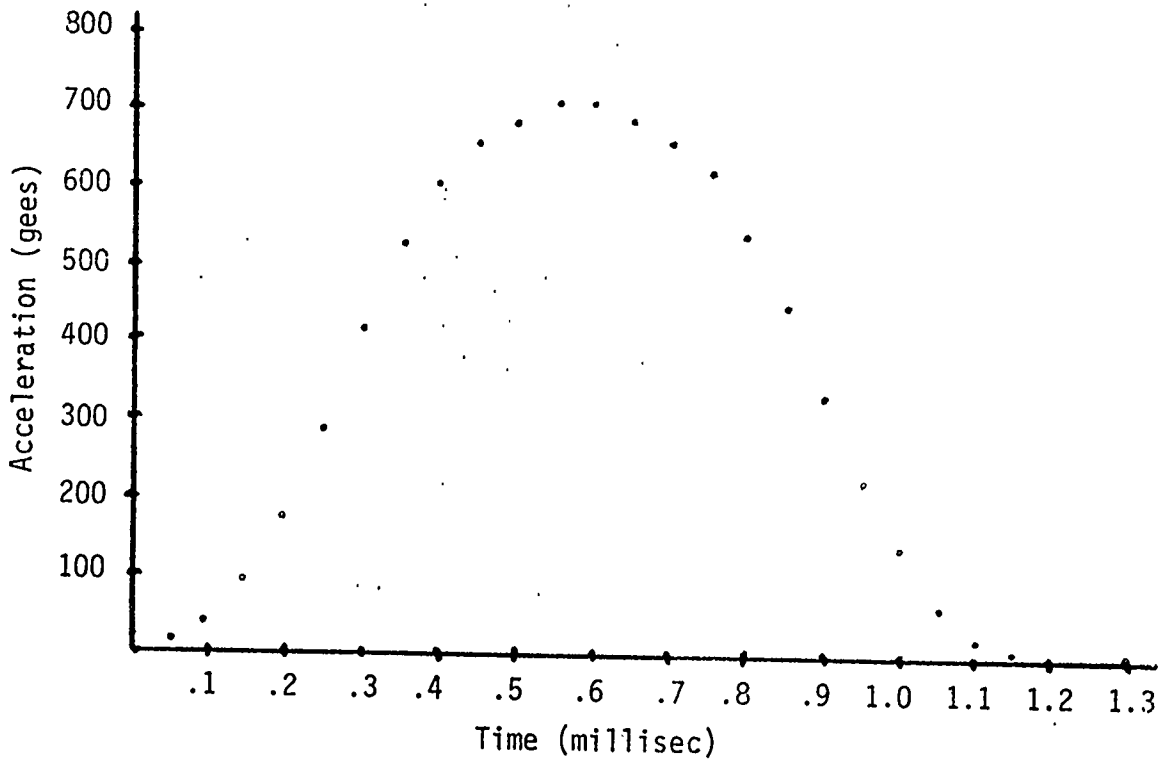
RX-04-DJ
7.1-ft., 45°
Normal Acceleration



Time	Acceleration
.00	0
.05	20
.10	80
.15	195
.20	370
.25	585
.30	760
.35	910
.40	1020
.45	1085
.50	1125
.55	1140
.60	1130
.65	1090
.70	1010
.75	900
.80	760
.85	585
.90	430
.95	290
1.00	185
1.05	100
1.10	40
1.15	5
1.18	0

Fig. 28

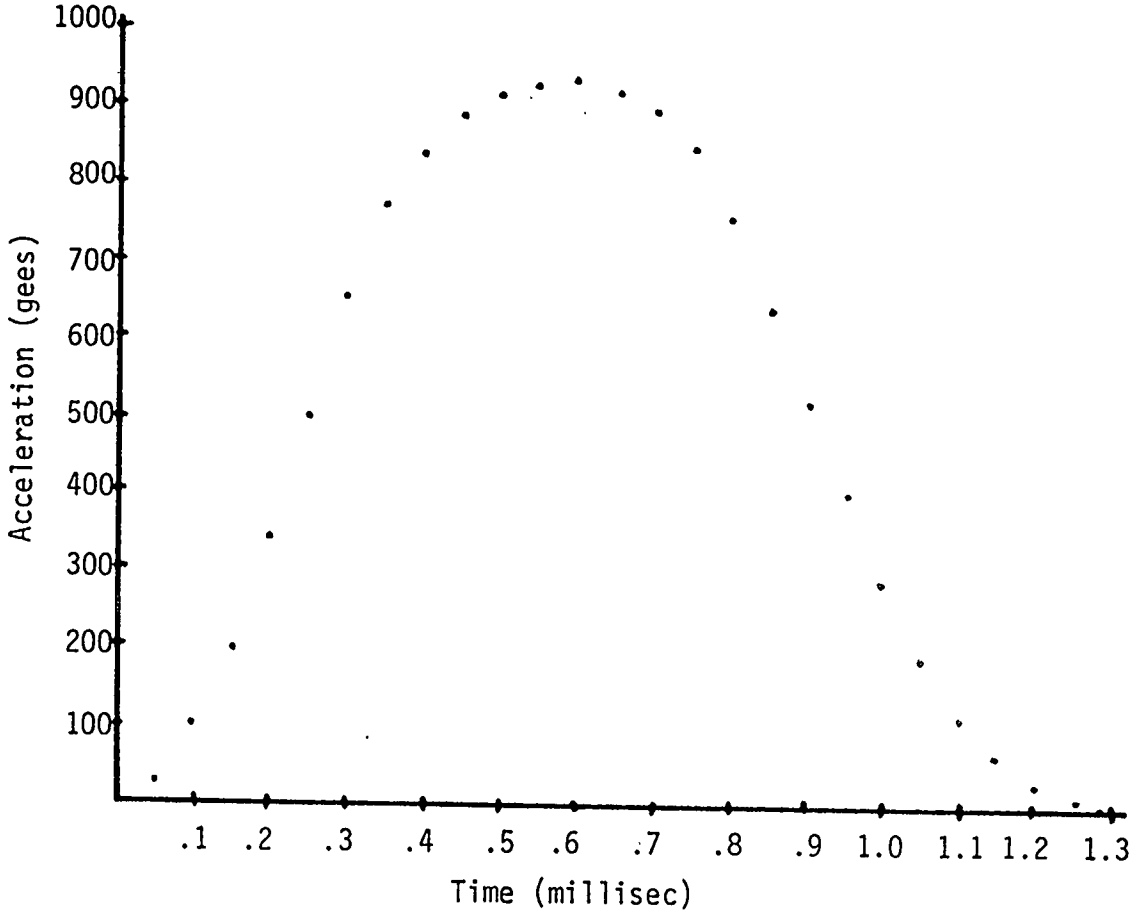
LX-04-1
7.1-ft., 45°
Rotational Acceleration



Time	Acceleration
.00	0
.05	10
.10	40
.15	95
.20	180
.25	290
.30	420
.35	530
.40	610
.45	665
.50	700
.55	715
.60	715
.65	695
.70	665
.75	630
.80	550
.85	455
.90	345
.95	235
1.00	145
1.05	75
1.10	25
1.15	10
1.20	0

Fig. 29

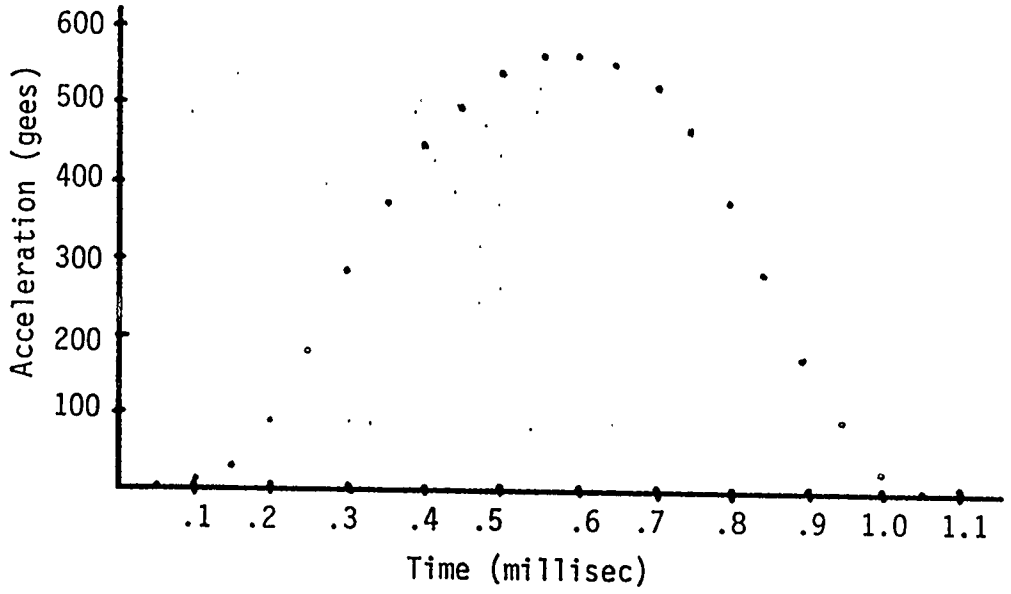
LX-04-1
7.1-ft., 45°
Normal Acceleration



Time	Acceleration
.00	0
.05	30
.10	100
.15	205
.20	340
.25	500
.30	650
.35	770
.40	840
.45	890
.50	920
.55	930
.60	935
.65	920
.70	895
.75	850
.80	760
.85	645
.90	525
.95	405
1.00	295
1.05	195
1.10	125
1.15	70
1.20	40
1.25	10
1.28	0

Fig. 30

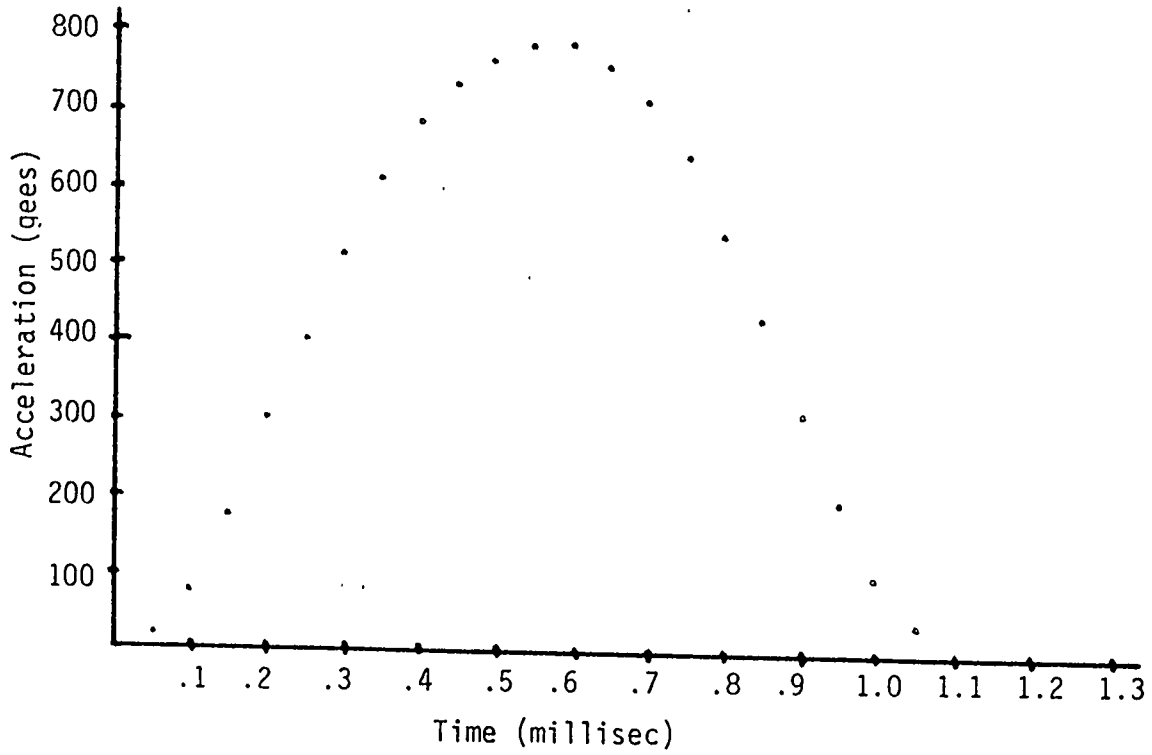
LX-09-0
3.5-ft., 45°
Rotational Acceleration



Time	Acceleration
.00	0
.05	0
.10	5
.15	25
.20	95
.25	180
.30	285
.35	370
.40	440
.45	490
.50	535
.55	560
.60	560
.65	545
.70	520
.75	460
.80	370
.85	280
.90	175
.95	95
1.00	30
1.05	0

Fig. 31

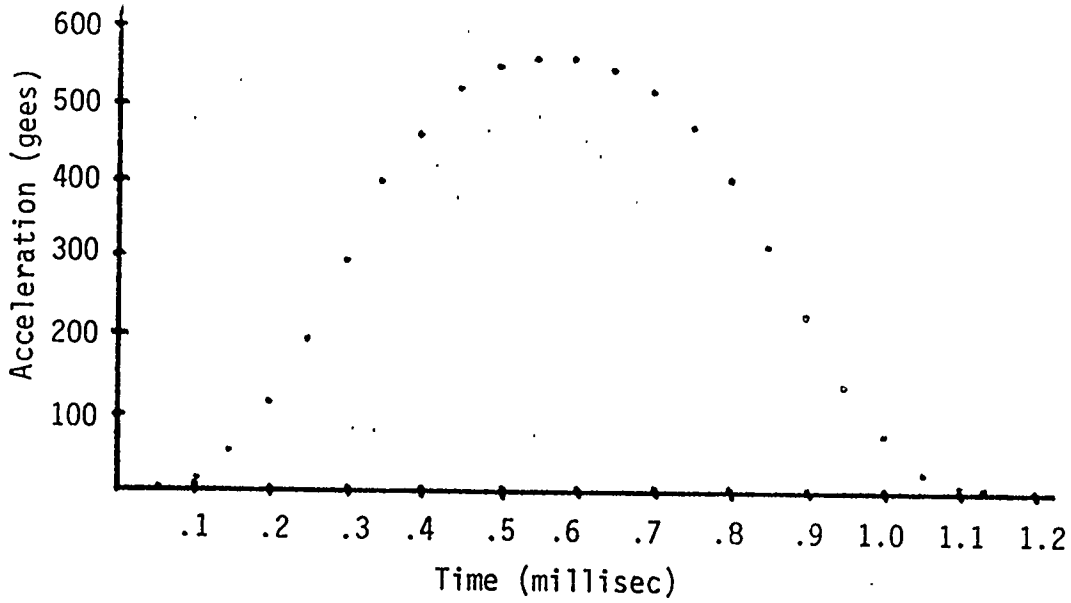
LX-09-0
3.5-ft., 45°
Normal Acceleration



Time	Acceleration
.00	0
.05	20
.10	75
.15	175
.20	295
.25	400
.30	515
.35	610
.40	680
.45	730
.50	760
.55	780
.60	780
.65	755
.70	710
.75	640
.80	540
.85	430
.90	305
.95	195
1.00	100
1.05	40
1.10	0

Fig. 32

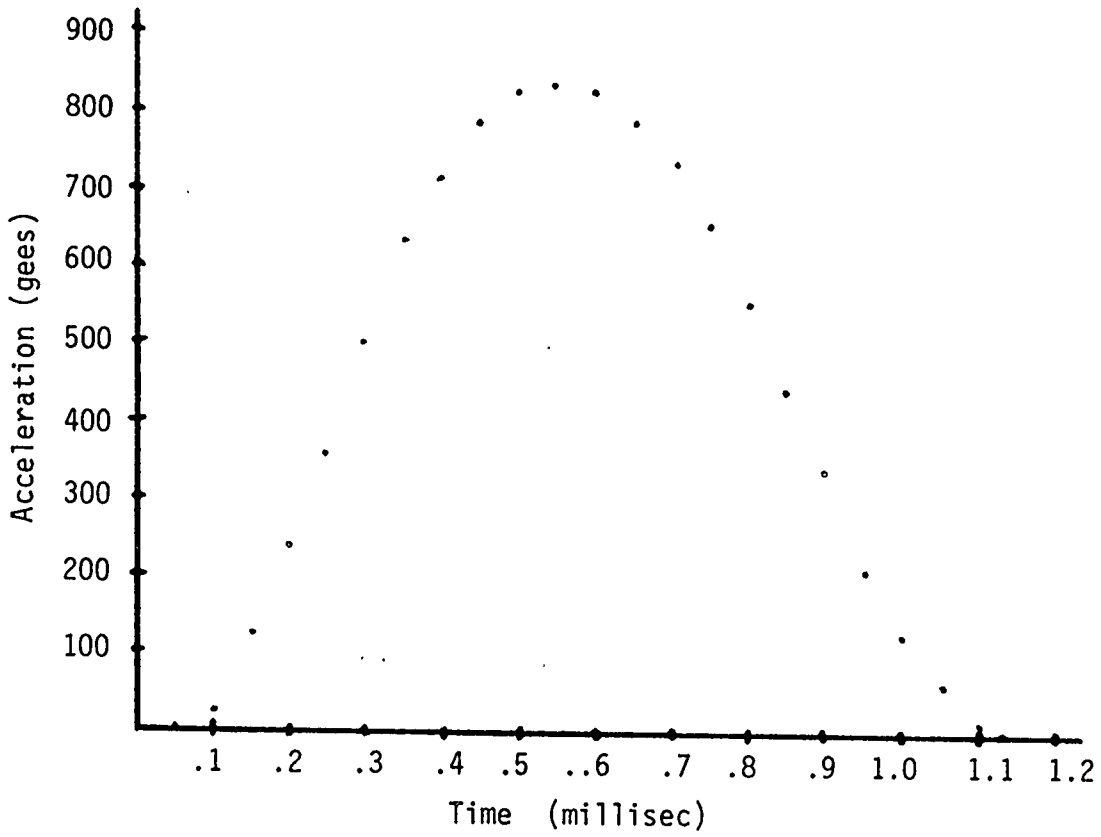
LX-09-0
3.5-ft., 45°
Rotational Acceleration



Time	Acceleration
.00	0
.05	0
.10	10
.15	60
.20	120
.25	200
.30	300
.35	400
.40	460
.45	515
.50	545
.55	555
.60	560
.65	545
.70	520
.75	470
.80	405
.85	320
.90	230
.95	140
1.00	75
1.05	35
1.10	5
1.13	0

Fig. 33

LX-09-0
3.5-ft., 45°
Normal Acceleration



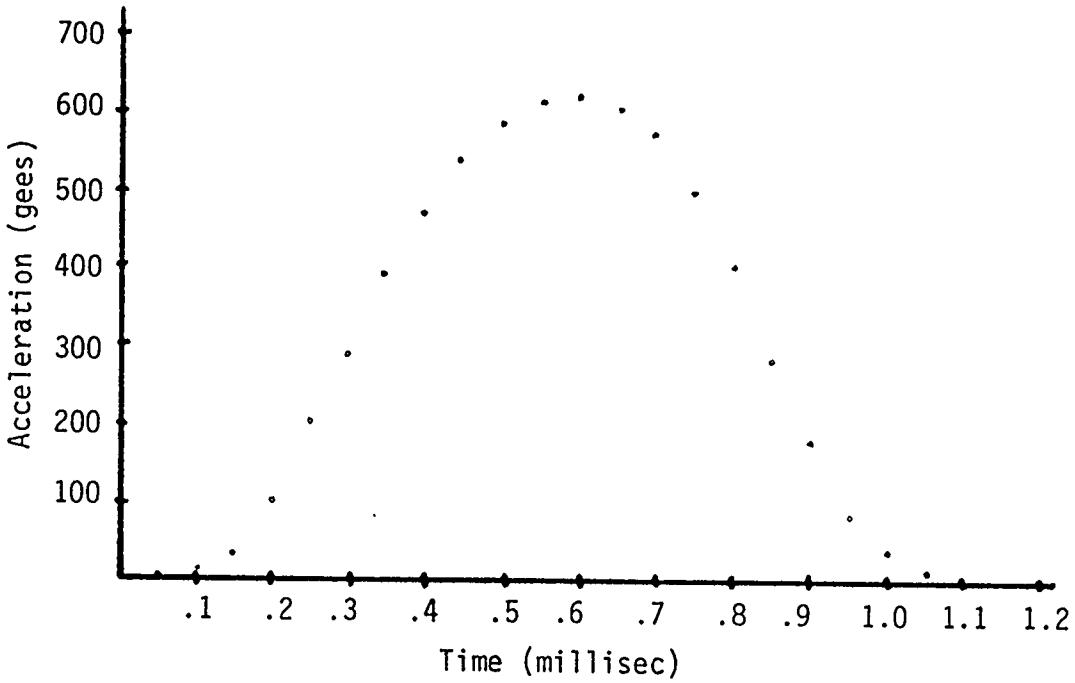
Time	Acceleration
.00	0
.05	0
.10	20
.15	130
.20	240
.25	360
.30	500
.35	630
.40	710
.45	785
.50	825
.55	835
.60	820
.65	785
.70	730
.75	650
.80	555
.85	440
.90	320
.95	210
1.00	125
1.05	65
1.10	15
1.13	0

Fig. 34

PBX-9404

3.5-ft., 45°

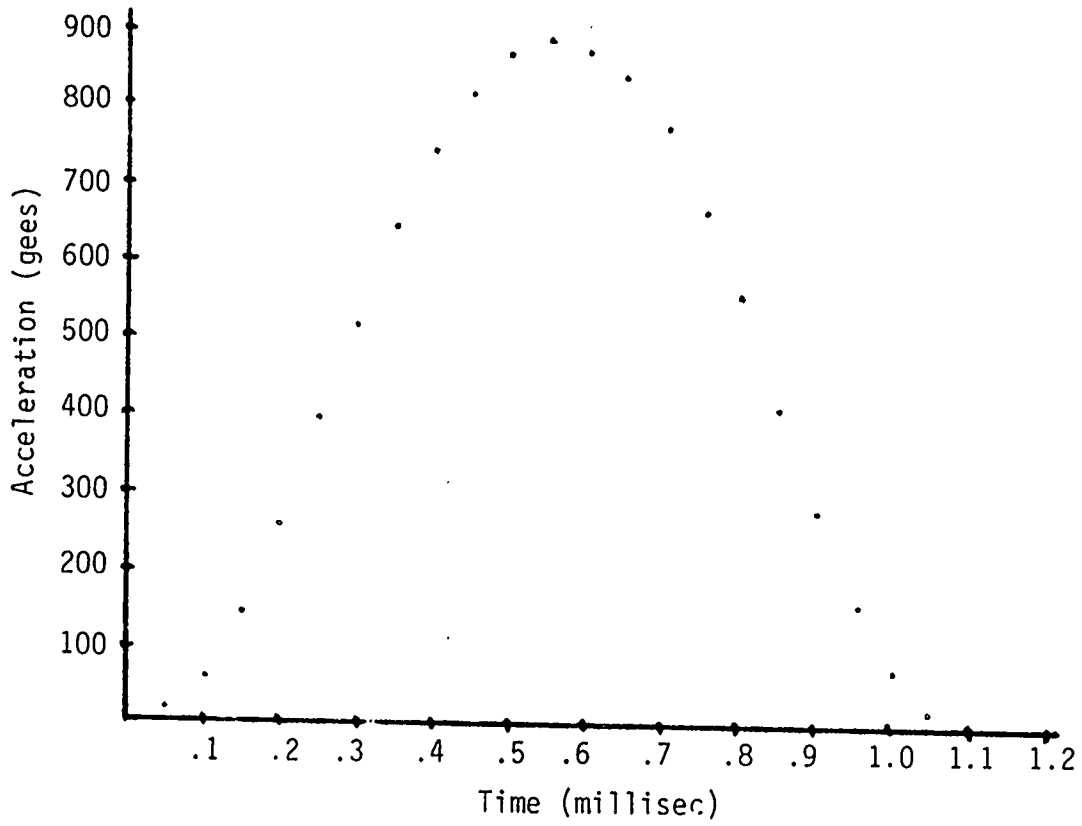
Rotational Acceleration



Time	Acceleration
.00	0
.05	0
.10	5
.15	35
.20	100
.25	200
.30	290
.35	400
.40	475
.45	540
.50	590
.55	615
.60	625
.65	610
.70	575
.75	500
.80	405
.85	285
.90	185
.95	90
1.00	40
1.05	15
1.10	0

Fig. 35

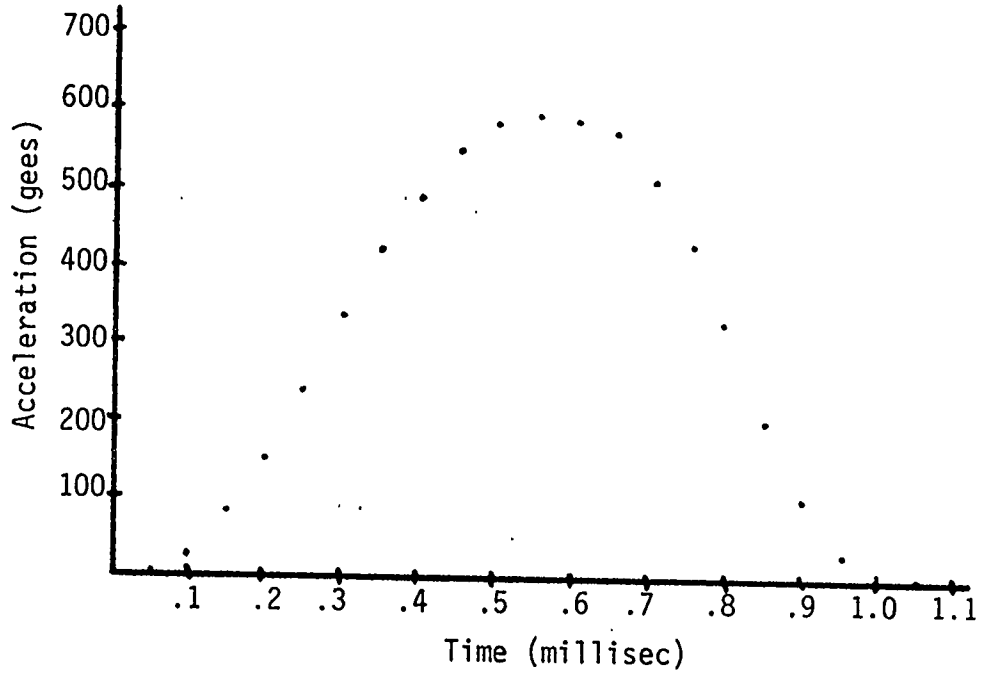
PBX-9404
3.5-ft., 45°
Normal Acceleration



Time	Acceleration
.00	0
.05	20
.10	65
.15	150
.20	260
.25	400
.30	520
.35	650
.40	745
.45	815
.50	865
.55	885
.60	875
.65	840
.70	775
.75	670
.80	555
.85	415
.90	285
.95	160
1.00	80
1.05	25
1.10	0

Fig. 36

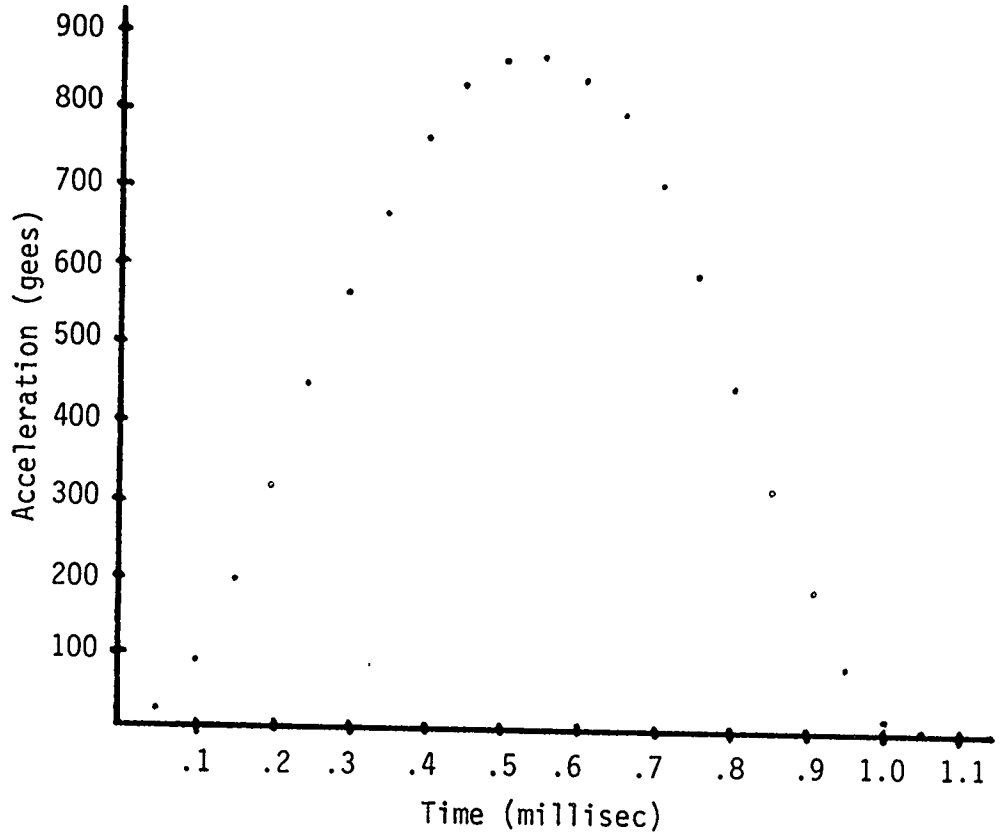
PBX-9404
3.5-ft., 45°
Rotational Acceleration



Time	Acceleration
.00	0
.05	5
.10	30
.15	85
.20	150
.25	240
.30	335
.35	420
.40	490
.45	550
.50	585
.55	600
.60	595
.65	575
.70	515
.75	435
.80	335
.85	210
.90	110
.95	40
1.00	5
1.05	0

Fig. 37

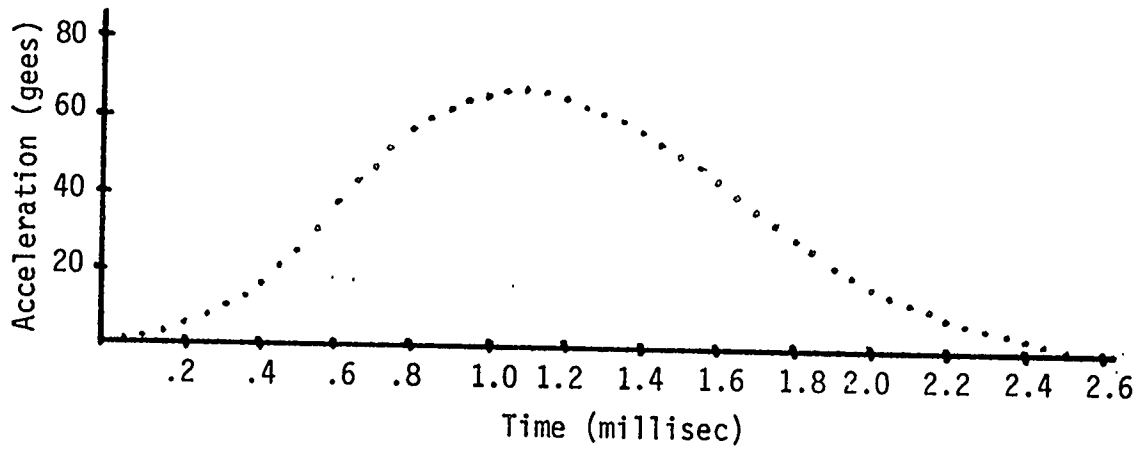
PBX-9404
3.5-ft., 45°
Normal Acceleration



Time	Acceleration
.00	0
.05	5
.10	30
.15	85
.20	150
.25	240
.30	335
.35	420
.40	490
.45	550
.50	585
.55	600
.60	595
.65	575
.70	515
.75	435
.80	335
.85	210
.90	110
.95	40
1.00	5
1.05	0

Fig. 38

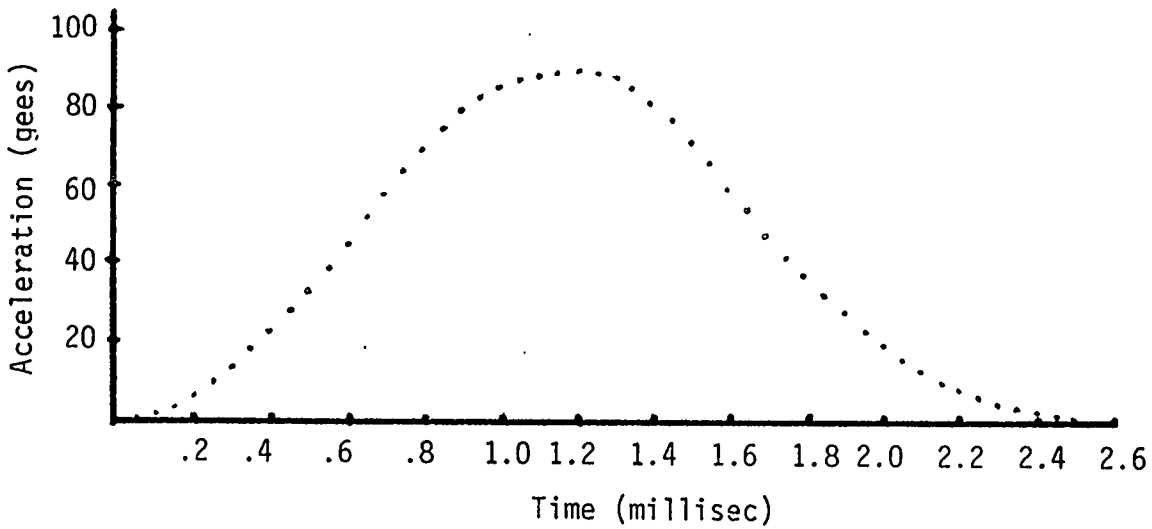
PBX-9011
.88-ft., 14°
Rotational Acceleration



Time	Acceleration
.00	0
.10	2
.20	5
.30	11
.40	19
.50	26
.60	38
.70	48
.80	57
.90	62
1.00	66
1.10	68
1.20	66
1.30	62
1.40	57
1.50	51
1.60	44
1.70	36
1.80	29
1 90	22
2.00	17
2.10	13
2.20	9
2.30	6
2.40	3
2.50	0

Fig. 39

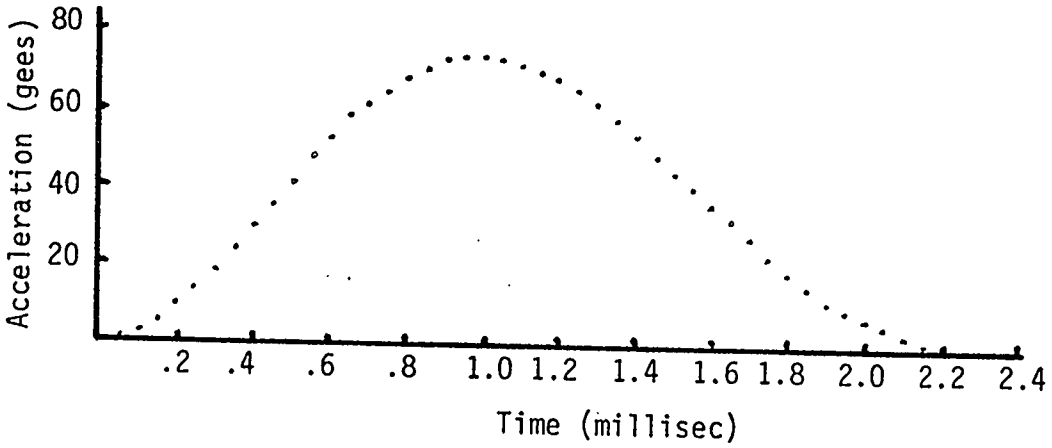
PBX-9011
.88-ft., 14°
Normal Acceleration



Time	Acceleration
.00	0
.10	2
.20	7
.30	14
.40	23
.50	33
.60	45
.70	58
.80	69
.90	79
1.00	85
1.10	88
1.20	90
1.30	88
1.40	81
1.50	72
1.60	60
1.70	48
1.80	37
1.90	28
2.00	20
2.10	13
2.20	9
2.30	6
2.40	3
2.50	0

Fig. 40

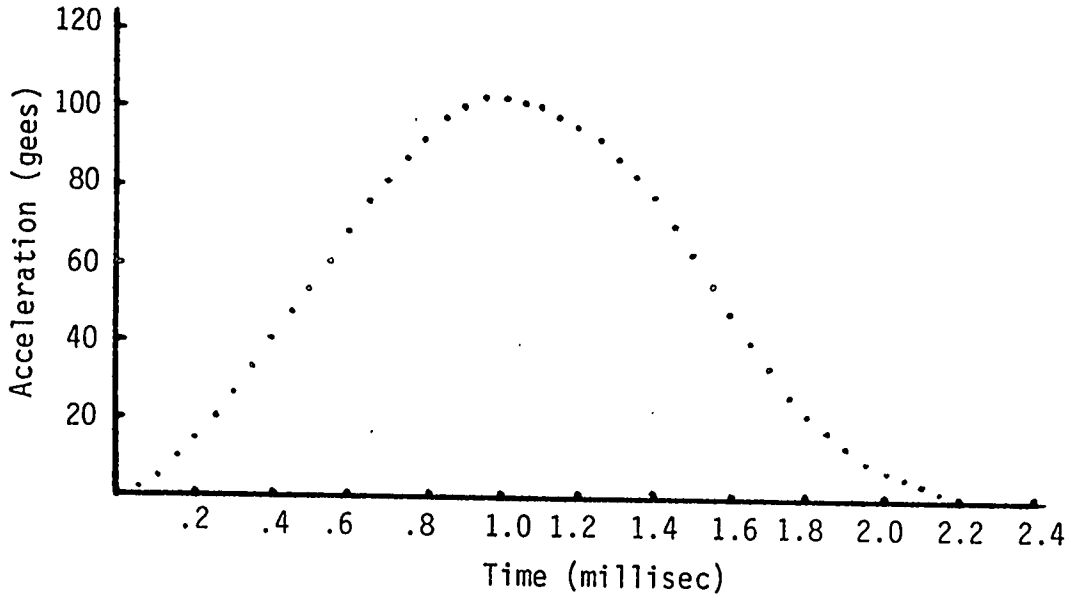
PBX-9011
1.25-ft., 14°
Rotational Acceleration



Time	Acceleration
.00	0
.10	3
.20	10
.30	19
.40	30
.50	41
.60	53
.70	61
.80	68
.90	73
1.00	74
1.10	72
1.20	69
1.30	62
1.40	54
1.50	45
1.60	37
1.70	28
1.80	19
1.90	13
2.00	8
2.10	4
2.20	0

Fig. 41

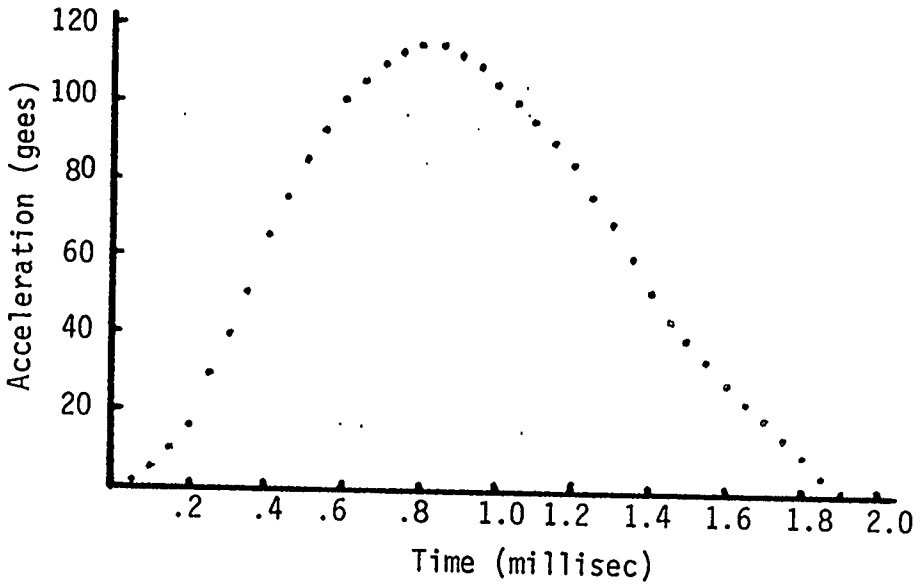
PBX-9011
1.25-ft., 14°
Normal Acceleration



Time	Acceleration
.00	0
.10	5
.20	15
.30	26
.40	40
.50	53
.60	68
.70	81
.80	92
.90	100
1.00	102
1.10	100
1.20	95
1.30	87
1.40	78
1.50	63
1.60	48
1.70	34
1.80	22
1.90	14
2.00	8
2.10	4
2.20	0

Fig. 42

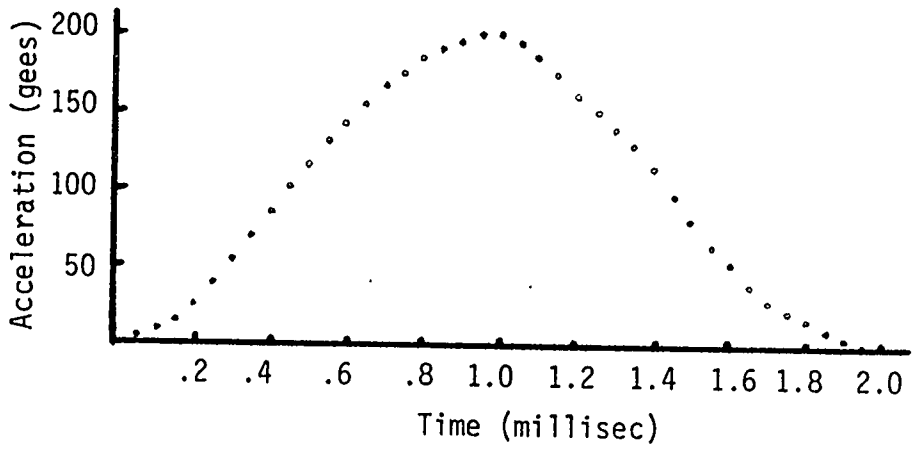
PBX-9011
3.5-ft., 14°
Rotational Acceleration



Time	Acceleration
.00	0
.10	5
.20	15
.30	40
.40	65
.50	85
.60	100
.70	110
.80	115
.90	110
1.00	105
1.10	95
1.20	85
1.30	70
1.40	50
1.50	40
1.60	30
1.70	20
1.80	10
1.90	0

Fig. 43

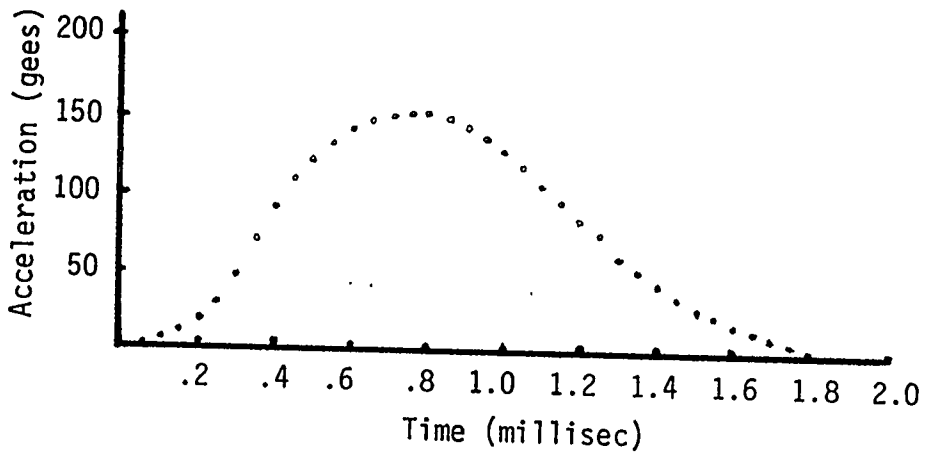
PBX-9011
3.5-ft., 14°
Normal Acceleration



Time	Acceleration
.00	0
.10	10
.20	25
.30	55
.40	85
.50	115
.60	140
.70	165
.80	185
.90	195
1.00	200
1.10	185
1.20	165
1.30	140
1.40	115
1.50	80
1.60	55
1.70	30
1.80	20
1.90	5
1.95	0

Fig. 44

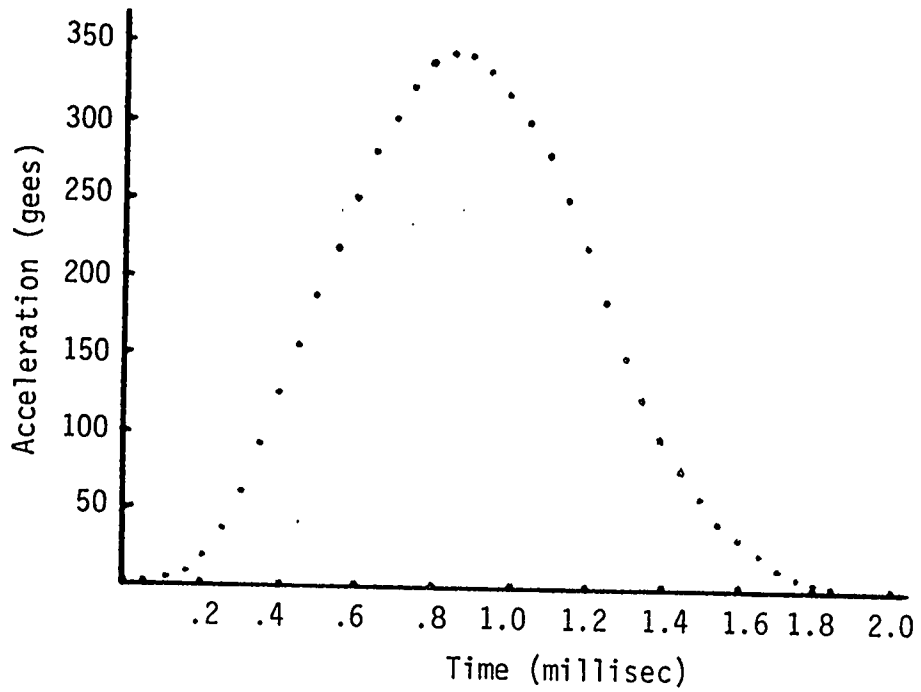
PBX-9011
7.1-ft., 14°
Rotational Acceleration



Time	Acceleration
.00	0
.10	4
.20	15
.30	48
.40	91
.50	123
.60	142
.70	149
.80	153
.90	145
1.00	129
1.10	106
1.20	86
1.30	63
1.40	45
1.50	29
1.60	20
1.70	10
1.80	0

Fig. 45

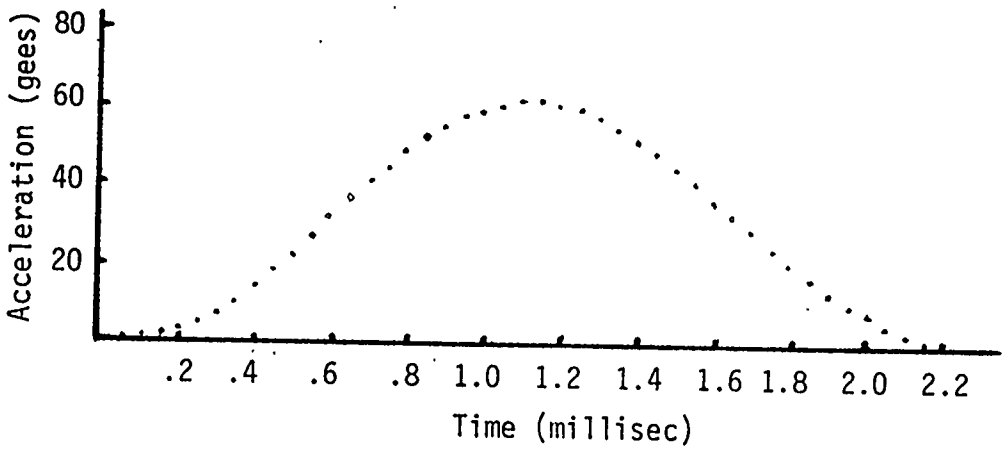
PBX-9011
7.1-ft., 14°
Normal Acceleration



Time	Acceleration
.00	0
.10	6
.20	20
.30	62
.40	124
.50	187
.60	248
.70	301
.80	337
.90	340
1.00	321
1.10	279
1.20	219
1.30	152
1.40	100
1.50	61
1.60	35
1.70	15
1.80	5
1.85	0

Fig. 46

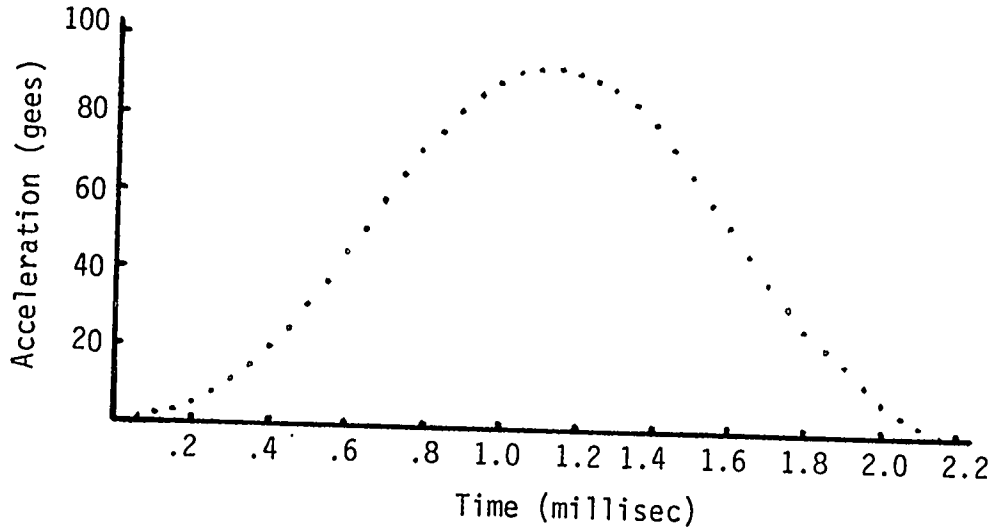
RX-04-DJ
.88-ft., 14°
Rotational Acceleration



Time	Acceleration
.00	0
.10	1
.20	3
.30	7
.40	14
.50	22
.60	32
.70	41
.80	49
.90	56
1.00	59
1.10	62
1.20	61
1.30	58
1.40	52
1.50	45
1.60	37
1.70	29
1.80	21
1.90	14
2.00	8
2.10	3
2.15	0

Fig. 47

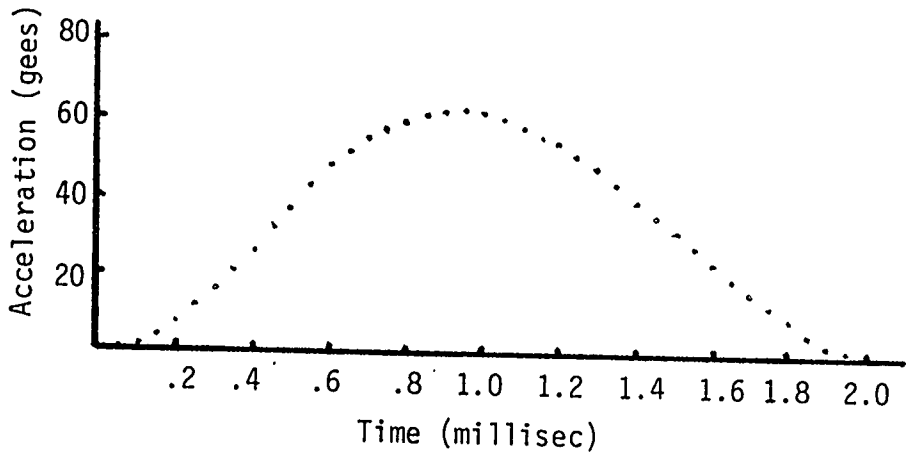
RX-04-DJ
.88-ft., 14°
Normal Acceleration



Time	Acceleration
.00	0
.10	2
.20	5
.30	11
.40	20
.50	31
.60	44
.70	58
.80	71
.90	82
1.00	89
1.10	93
1.20	92
1.30	88
1.40	79
1.50	66
1.60	53
1.70	39
1.80	27
1.90	18
2.00	9
2.10	3
2.15	0

Fig. 48

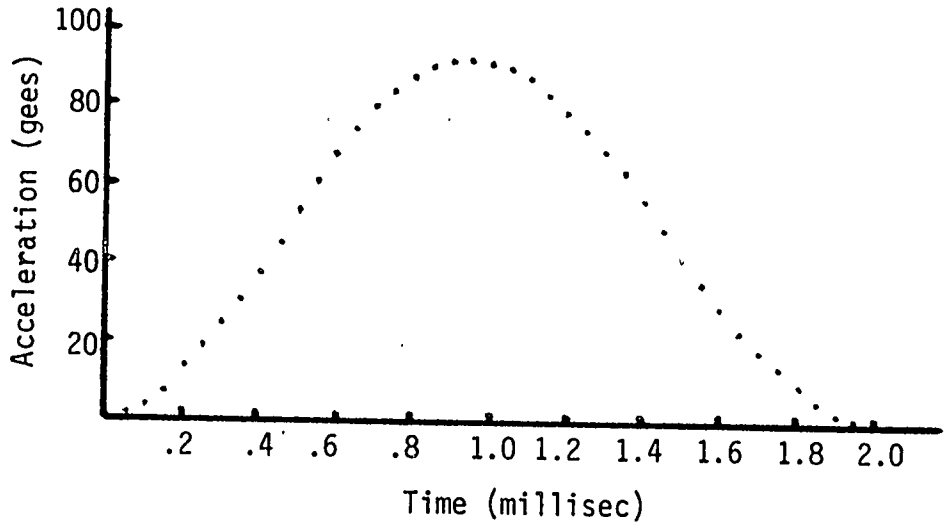
LX-04-1
.88-ft., 14°
Rotational Acceleration



Time	Acceleration
.00	0
.10	2
.20	8
.30	16
.40	26
.50	37
.60	48
.70	55
.80	59
.90	62
1.00	61
1.10	58
1.20	54
1.30	48
1.40	40
1.50	32
1.60	24
1.70	17
1.80	10
1.90	3
2.00	0

Fig. 49

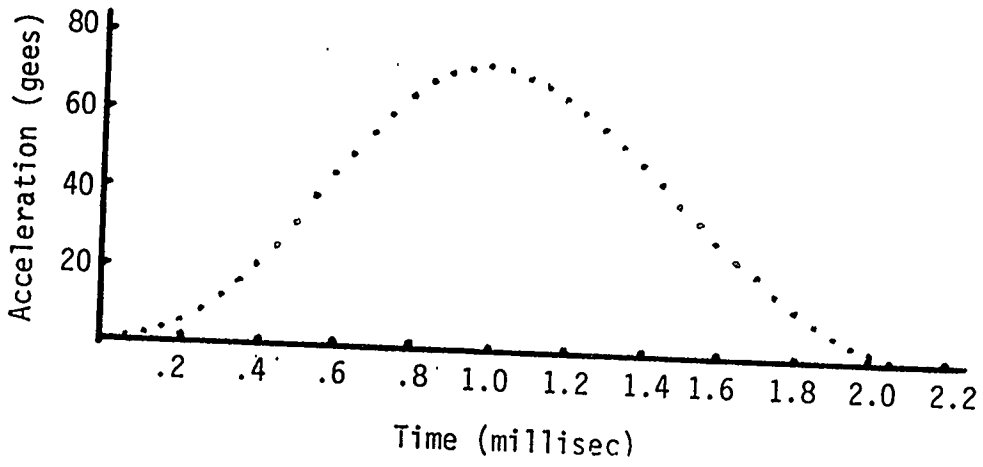
LX-04-1
.88-ft., 14°
Normal Acceleration



Time	Acceleration
.00	0
.10	3
.20	13
.30	24
.40	37
.50	53
.60	67
.70	80
.80	87
.90	92
1.00	91
1.10	87
1.20	79
1.30	69
1.40	56
1.50	42
1.60	29
1.70	19
1.80	10
1.90	3
2.00	0

Fig. 50

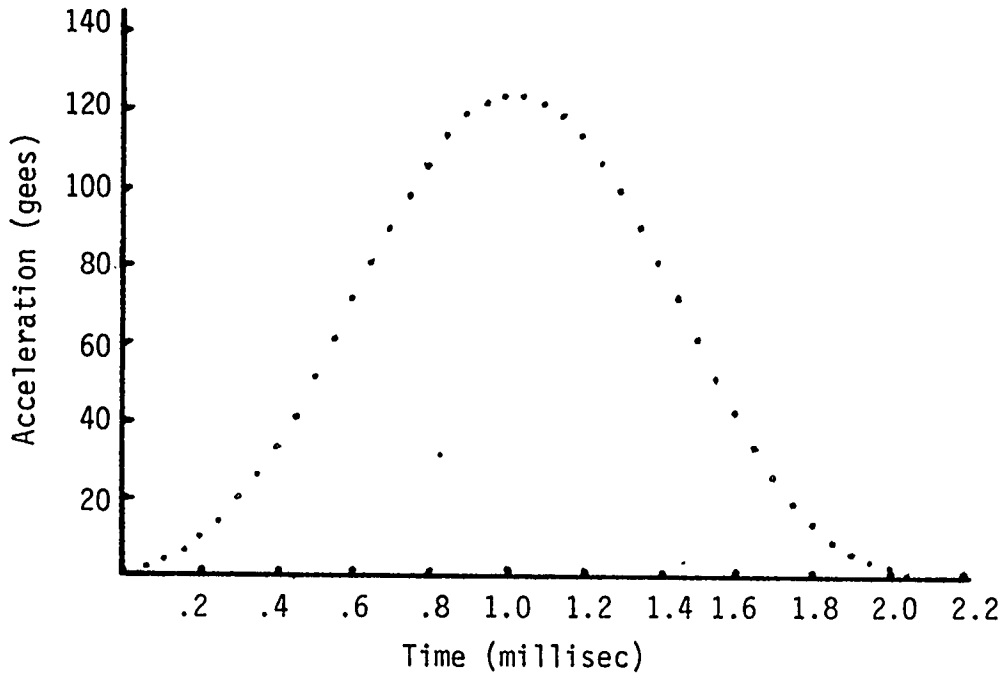
RX-04-DJ
1.25-ft., 14°
Rotational Acceleration



Time	Acceleration
.00	0
.10	2
.20	6
.30	12
.40	20
.50	31
.60	44
.70	55
.80	65
.90	71
1.00	73
1.10	70
1.20	66
1.30	58
1.40	49
1.50	39
1.60	29
1.70	21
1.80	13
1.90	6
2.00	2
2.05	0

Fig. 51

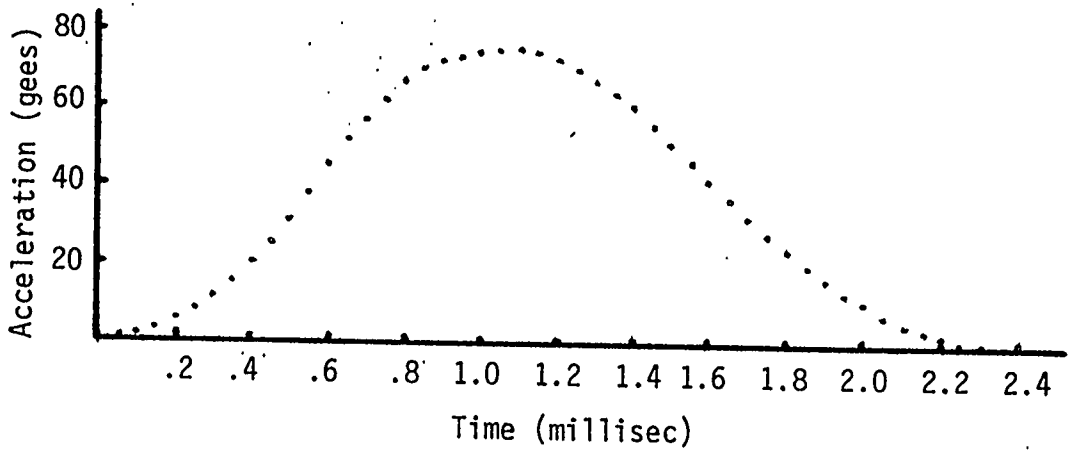
RX-04-DJ
1.25-ft., 14°
Normal Acceleration



Time	Acceleration
.00	0
.10	4
.20	10
.30	20
.40	33
.50	51
.60	71
.70	89
.80	105
.90	118
1.00	123
1.10	121
1.20	113
1.30	99
1.40	81
1.50	61
1.60	42
1.70	26
1.80	14
1.90	6
2.00	2
2.05	0

Fig. 52

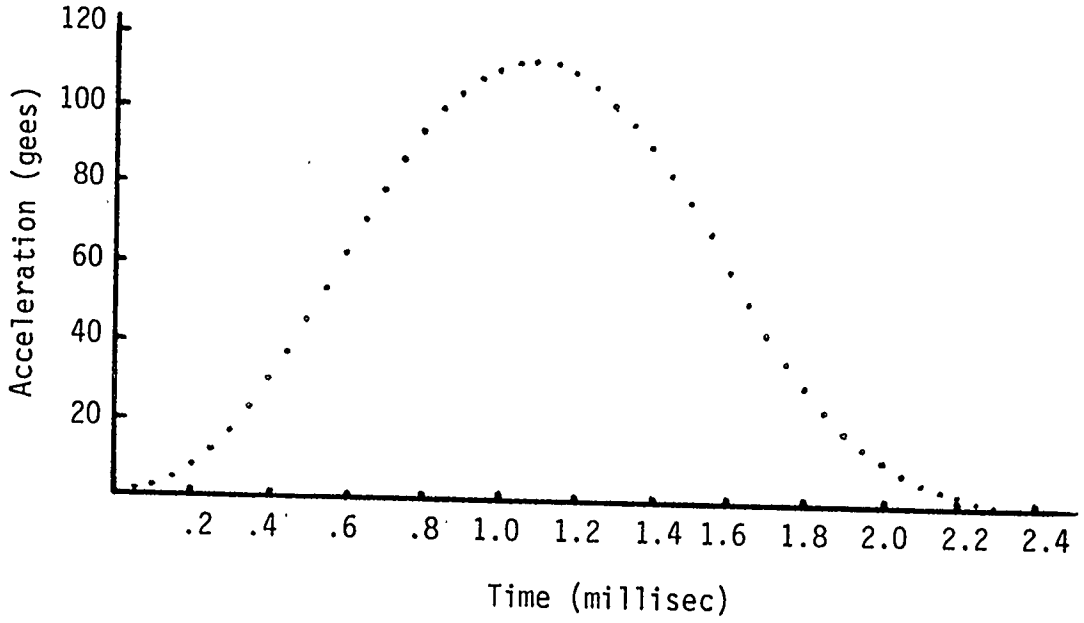
LX-04-1
1.25-ft., 14°
Rotational Acceleration



Time	Acceleration
.00	0
.10	2
.20	5
.30	11
.40	20
.50	31
.60	45
.70	57
.80	67
.90	72
1.00	74
1.10	76
1.20	73
1.30	67
1.40	61
1.50	52
1.60	42
1.70	33
1.80	24
1.90	17
2.00	11
2.10	6
2.20	3
2.30	0

Fig. 53

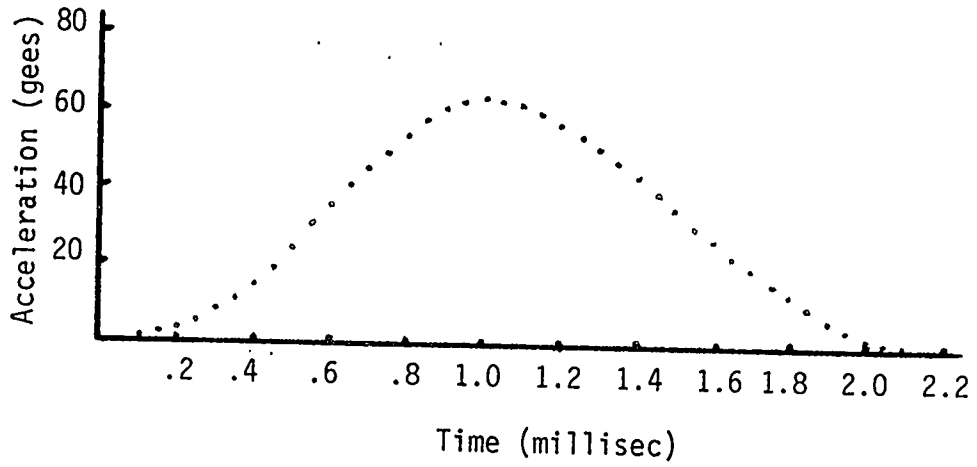
LX-04-1
1.25-ft., 14°
Normal Acceleration



Time	Acceleration
.00	0
.10	3
.20	8
.30	17
.40	30
.50	45
.60	62
.70	79
.80	94
.90	104
1.00	110
1.10	113
1.20	110
1.30	102
1.40	91
1.50	77
1.60	59
1.70	43
1.80	30
1.90	19
2.00	11
2.10	6
2.20	3
2.30	0

Fig. 54

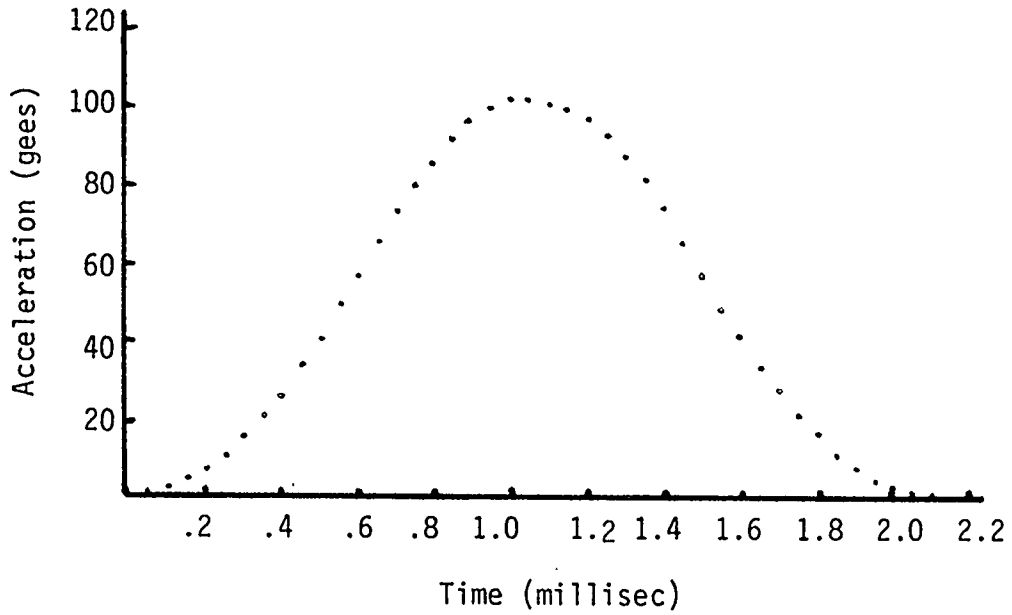
LX-07-1
.88-ft., 14°
Rotational Acceleration



Time	Acceleration
.00	0
.10	1
.20	3
.30	8
.40	14
.50	24
.60	35
.70	44
.80	53
.90	60
1.00	63
1.10	61
1.20	56
1.30	50
1.40	44
1.50	35
1.60	27
1.70	20
1.80	13
1.90	7
2.00	2
2.10	0

Fig. 55

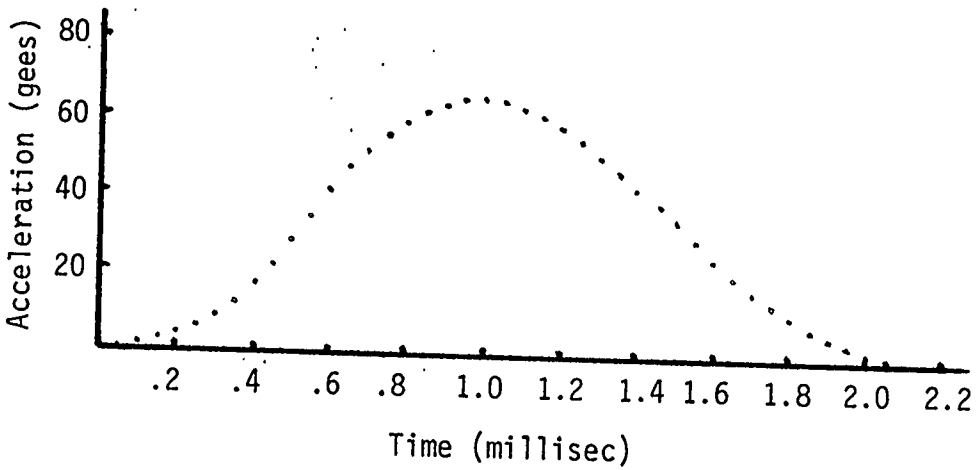
LX-07-1
.88-ft., 14°
Normal Acceleration



Time	Acceleration
.00	0
.10	2
.20	6
.30	15
.40	25
.50	40
.60	56
.70	73
.80	86
.90	96
1.00	102
1.10	101
1.20	98
1.30	87
1.40	74
1.50	57
1.60	41
1.70	28
1.80	16
1.90	7
2.00	2
2.10	0

Fig. 56

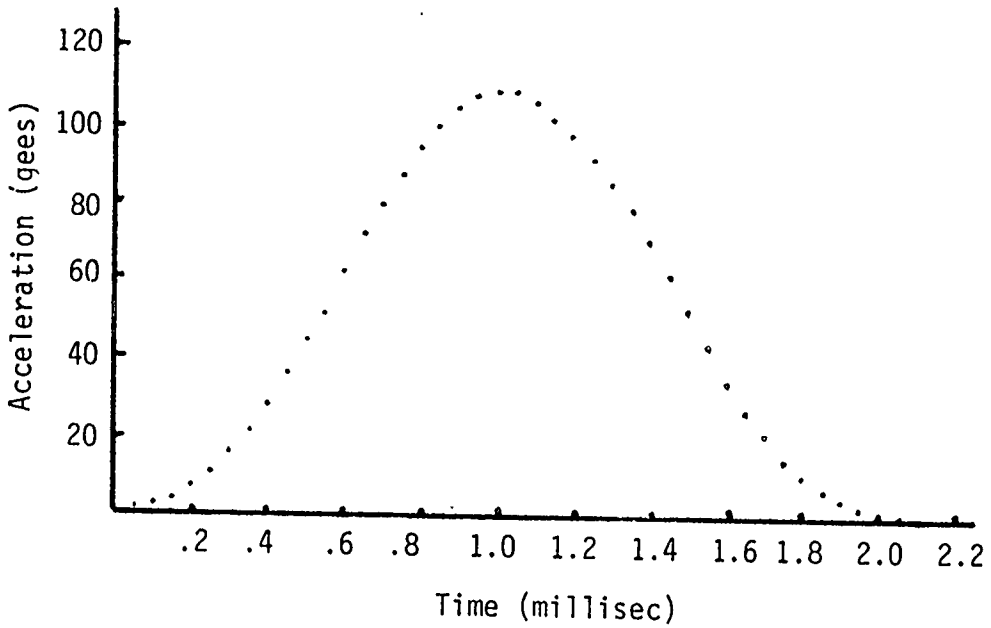
LX-09-0
.88-ft., 14°
Rotational Acceleration



Time	Acceleration
.00	0
.10	2
.20	4
.30	9
.40	17
.50	28
.60	41
.70	51
.80	58
.90	63
1.00	65
1.10	62
1.20	58
1.30	50
1.40	42
1.50	34
1.60	24
1.70	17
1.80	10
1.90	5
2.00	1
2.05	0

Fig. 57

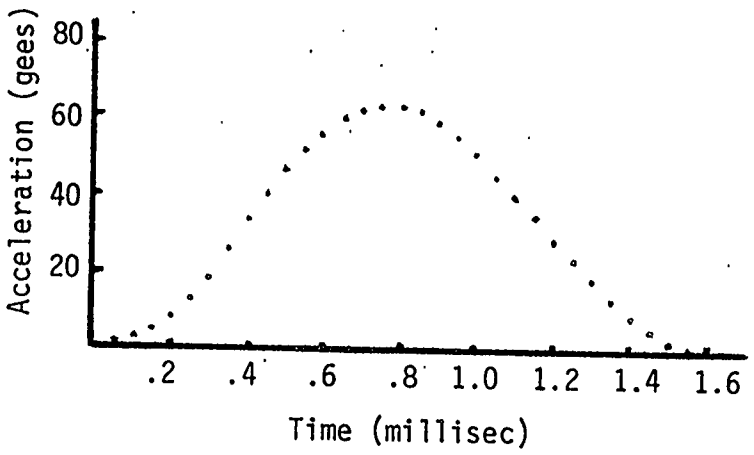
LX-09-0
.88-ft., 14°
Normal Acceleration



Time	Acceleration
.00	0
.10	3
.20	7
.30	16
.40	28
.50	44
.60	62
.70	79
.80	94
.90	104
1.00	109
1.10	106
1.20	98
1.30	86
1.40	71
1.50	53
1.60	34
1.70	21
1.80	11
1.90	5
2.00	1
2.05	0

Fig. 58

PBX-9404
.88-ft., 14°
Rotational Acceleration



Time	Acceleration
.00	0
.10	3
.20	8
.30	18
.40	33
.50	46
.60	55
.70	61
.80	63
.90	59
1.00	50
1.10	40
1.20	29
1.30	19
1.40	9
1.50	2
1.55	0