Rigid-body Acceleration Examples

By Tom Irvine
Email: tomirvine@aol.com

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The purpose of this paper is to present typical rigid-body acceleration levels.

Human ability to withstand high acceleration levels depends on

1. Acceleration level
2. Duration
3. Orientation of the acceleration vector.

Note that 1 G = 10 m/sec^2 is used for some cases for simplified rounding purposes.

Table 1. Typical Acceleration Levels and Limits

Source	Acceleration (G)	Acceleration (m/sec^2)	Reference
Elevators, Recommended Limit	< 0.15	15	1
Boeing 747, Hard Landing, Vertical CG Acceleration, Trigger Level for Unscheduled Inspection	1.8*	18	2
Space Shuttle Re-entry	2	20	3
Space Shuttle Ascent	3	30	3
Apollo 17 Ascent	3.87	37.95	8
Top-Fuel Dragster, Horizontal	5.3	52	Appendix A
High-G Roller Coaster	3.5 to 6.3	35 to 63	7
Mercury-Atlas 6 Ascent	7.7	76	9
Typical Maximum Turn in an Aerobatic Plane or Fighter Jet	9 to 12	90 to 120	7

*Inertial acceleration where the vertical level is 1 G when the aircraft is stationary on the ground.

Table 1. Typical Acceleration Levels and Limits (cont)			
Source	Acceleration (G)	Acceleration (m/sec^2)	Reference
Fighter Aircraft Eject Seat	20	200	4
Football, Average Head Impact	40	400	5
Maximum for Human on a Rocket Sled	46.2	453	7
Automobile Airbag Trigger Level, also Chest Acceleration Limit	60	600	6
Football, Hardest Head Impact	130	1300	5

The levels in Table 2 are taken from Reference 4.

Table 2. Automotive Acceleration (G)				
Event	Typical car	Sports Car	F-1 Race Car	Large Truck
Starting	0.3–0.5	0.5–0.9	1.7	< 0.2
Braking	0.8–1.0	1.0–1.3	2	~ 0.6
Cornering	0.7–0.9	0.9–1.0	3	?

References

1. http://www.vibrationdata.com/Newsletters/May2005_NL.pdf
2. http://www.boeing.com/commercial/aeromagazine/aero_14/conditional_story.html#tab1
3. B. Bondar and R. Bondar, On the Shuttle Eight Days in Space, Greey de Pencier Books, Toronto, 1993.
4. http://physics.info/acceleration/
5. http://www.vibrationdata.com/Newsletters/December2005_NL.pdf
6. DEPARTMENT OF TRANSPORTATION**,** National Highway Traffic Safety Administration**,** 49 CFR Parts 552, 571, 585, and 595 [Docket No. NHTSA 99-6407; Notice 1] RIN 2127-AG70**,** Federal Motor Vehicle Safety Standards; Occupant Crash Protection.
7. http://en.wikipedia.org/wiki/G-force
8. Document No. D5-15560-12, Apollo/Saturn V Postflight Trajectory — AS-512, Saturn V Contract No. NAS 8-5608 , Schedule II, Part IX, Task Directive 290 (Part A), Tracking and Flight Reconstruction, G. T. Pinson, April 11, 1973, D. E. Chichester, Manager, Flight Technology, Boeing Company Space Division Launch Systems Branch.
9. http://en.wikipedia.org/wiki/Mercury-Atlas_6

APPENDIX A

This top-fuel dragster can accelerate from zero to 160 km/hr (100 mph) in 0.86 seconds, per Reference 7. This is a horizontal acceleration of 5.3 G.