Space Travel Made Easy

The following system was designed to provide players of science fiction role-playing games with a way of determining spacecraft travel times between destinations in the solar system. While it's intended to be realistic it does assume that all trips are straight line journeys from point A to point B. No provisions have been made for orbital mechanics, transfer orbits, or relative velocities, since this would add a level of complexity beyond what is necessary for gameplay at this point.

Ready, Set, Burn!

Once the distance to the destination in kilometers has been determined there are two ways of making the journey through space: coasting or constant acceleration.

Coasting involves firing the engines to accelerate the ship up to speed, shutting them down and allowing the ship to glide along for the bulk of the journey, and firing them again to decelerate the ship so it arrives at rest at it's destination. It has the advantage of being very fuel efficient, but suffers from being relatively slow. Coasting is normally used when speed isn't a high priority or the ship lacks the fuel capacity for a constant acceleration trip.

A constant acceleration trip fires the engines for the entire journey. The ship accelerates at a steady rate till it reaches the halfway point of the distance to the destination, flips over, and then decelerates till it arrives at rest at the destination. It's by far the faster of the two methods, but it gobbles up fuel at a prodigious rate. For that reason it's only used when speed is an absolute priority.

Coasting

Calculating the travel time for a coasting trip requires that the distance to the destination, acceleration of the ship in Gs, and burn hours available to the ship be determined. The trip is then broken up into three parts: boost, glide, and braking.

In the boost phase the ship fires it's engines to accelerate up to a pre-determined speed. Consult Chart 1 or 1.5 and cross reference acceleration in Gs with the length of the burn to determine the ship's speed in thousands of kilometers per hour at the end of the burn. Chart 2 shows how much distance the ship will cover while accelerating up to it's final velocity.

Thanks to the wonderfully elegant laws of physics you can calculate the details of the braking phase at the same time you're detailing the boost phase. The braking maneuver decelerates the ship by the same amount it accelerated during boost, so it requires exactly the same amount of time, fuel and distance. Simply double the amount of fuel used during the boost to account for what's used during braking and you'll have the total amount of fuel required for the trip. The distance covered during boost, the number from Chart 2 or 2.5, is also the distance covered during braking. The same principle goes for time: doubling the time spent boosting will give you the total time for both the boost and braking phases.

Once you've subtracted the distance used up during boost and braking from the total trip distance you're left with the distance that has to be covered during the glide phase. Divide that amount by the ship's speed in kilometers per hour, determined during the boost phase above, to get the number of hours the ship will spend in glide. Total that up with the time required for boost and braking and you'll have the total trip time.

Example: The "Bent Arrow" is a light transport capable of 2G acceleration and loaded with enough fuel for 20 hours of full burn. It's carrying cargo to a mining asteroid 100,000,000 kilometers away.

The pilot decides to fire a full 2G burn for 6 hours during the boost phase. The boost will take 6 hours, give the ship a post-burn speed of 1,524,000 kilometers per hour (determined by cross referencing the ships acceleration and burn time on Chart 1),

and cover 1,143,000 kilometers (determined by cross referencing the same factors on Chart 2).

Since we know that the braking phase must be equal to the boost phase we can just double the figures for time and distance to account for both. Boost and braking will take a total of 12 hours and cover 2,286,000 kilometers.

The only thing left is determining how long the ship will have to coast. We subtract the 2,286,000 kilometers covered during boost and braking from the total distance of 100,000,000 to discover we need to cover 97,714,000 kilometers during the glide phase. Dividing that distance by our post-burn speed of 1,524,000 kilometers per hour tells us the glide phase will take 64 hours.

The "Bent Arrow" will make the 100,000,000 kilometer trip in 76 hours. The boost phase will take 6 hours and cover 1,143,000 kilometers. The glide phase will take 64 hours and cover 97,714,000 kilometers. The braking phase will take 6 hours and cover 1,143,000 kilometers.

Constant Acceleration

Calculating the travel time for a constant acceleration trip requires that the distance to the destination, acceleration of the ship in Gs, and burn hours available to the ship be determined.

Cross-reference the ship's acceleration with the approximate distance to be traveled on Chart 3 or 3.5 to determine the trip's length in hours. The referee should, if necessary, adjust this figure based on the actual distance involved. The rows above and below the one actually used can provide a good guide for fudging the final time.

Example: The "Streak" is a high-speed courier capable of 6Gs acceleration and loaded with enough fuel for 30 hours of full burn. It's been hired to carry a load of vaccine for the Examplium virus to an asteroid 150,000,000 kilometers away.

Since the ship can do 6G we'll need to use Chart 3.5. Looking at the column of distances we can see that 150,000,000 kilometers isn't listed. We use 100,000,000 kilometers and cross-reference it with the 6G column to find the trip will take 23.93 hours. Since the next highest distance of 200,000,000 kilometers would take 33.84 hours the referee decides to average the two to fudge the travel time and rules it will take 29 hours.

Equations

Players in search of more realism can use the equations the charts are based on and do the math themselves. T = time in seconds, D = distance in meters, A = acceleration in meters/second/second. One G is equivalent to 9.8 m/s/s of acceleration. Multiply hours by 3600 to convert to seconds. Multiply kilometers by 1000 to convert to meters.

The distance covered during the boost phase of coasting, and the braking phase as well, can be determined with D = A*T^2/8. Post-burn speed is equal to T*A.

The travel time for a constant acceleration trip can be determined with T = 2*(sqrt D/A).

Chart 1 (Post-burn speeds for accelerations up to 5G)

The first column gives burn time in increments of half an hour. Move left till you arrive at the column equal to your ship's acceleration to determine speed in thousands of kilometers per hour at the end of the burn. Consult Chart 1.5 for accelerations from 5.5 to 10 Gs.

Burn time	.5G	1G	1.5G	2G	2.5G	3G	3.5G	4G	4.5G	5G
0.5	32	64	95	127	159	191	222	254	286	318
1	64	127	191	254	318	381	445	508	572	635
1.5	95	191	286	381	476	572	667	762	857	953
2	127	254	381	508	635	762	889	1016	1143	1270
2.5	159	318	476	635	794	953	1111	1270	1429	1588
3	191	381	572	762	953	1143	1334	1524	1715	1905
3.5	222	445	667	889	1111	1334	1556	1778	2000	2223
4	254	508	762	1016	1270	1524	1778	2032	2286	2540
4.5	286	572	857	1143	1429	1715	2000	2286	2572	2858
5	318	635	953	1270	1588	1905	2223	2540	2858	3175
5.5	349	699	1048	1397	1746	2096	2445	2794	3143	3493
6	381	762	1143	1524	1905	2286	2667	3048	3429	3810
6.5	413	826	1238	1651	2064	2477	2889	3302	3715	4128
7	445	889	1334	1778	2223	2667	3112	3556	4001	4445
7.5	476	953	1429	1905	2381	2858	3334	3810	4287	4763
8	508	1016	1524	2032	2540	3048	3556	4064	4572	5080
8.5	540	1080	1619	2159	2699	3239	3778	4318	4858	5398
9	572	1143	1715	2286	2858	3429	4001	4572	5144	5715
9.5	603	1207	1810	2413	3016	3620	4223	4826	5430	6033
10	635	1270	1905	2540	3175	3810	4445	5080	5715	6350
10.5	667	1334	2000	2667	3334	4001	4668	5334	6001	6668
11	699	1397	2096	2794	3493	4191	4890	5588	6287	6985
11.5	730	1461	2191	2921	3651	4382	5112	5842	6573	7303
12	762	1524	2286	3048	3810	4572	5334	6096	6858	7620
12.5	794	1588	2381	3175	3969	4763	5557	6350	7144	7938
13	826	1651	2477	3302	4128	4953	5779	6604	7430	8256
13.5	857	1715	2572	3429	4287	5144	6001	6858	7716	8573
14	889	1778	2667	3556	4445	5334	6223	7112	8002	8891
14.5	921	1842	2762	3683	4604	5525	6446	7366	8287	9208
15	953	1905	2858	3810	4763	5715	6668	7620	8573	9526
15.5	984	1969	2953	3937	4922	5906	6890	7874	8859	9843
16	1016	2032	3048	4064	5080	6096	7112	8129	9145	10161
16.5	1048	2096	3143	4191	5239	6287	7335	8383	9430	10478
17	1080	2159	3239	4318	5398	6477	7557	8637	9716	10796
17.5	1111	2223	3334	4445	5557	6668	7779	8891	10002	11113
18	1143	2286	3429	4572	5715	6858	8002	9145	10288	11431
18.5	1175	2350	3524	4699	5874	7049	8224	9399	10573	11748
19	1207	2413	3620	4826	6033	7239	8446	9653	10859	12066
19.5	1238	2477	3715	4953	6192	7430	8668	9907	11145	12383
20	1270	2540	3810	5080	6350	7620	8891	10161	11431	12701

Chart 1.5 (Post-burn speeds for accelerations from 5.5 to 10G)

The first column gives burn time in increments of half an hour. Move left till you arrive at the column equal to your ship's acceleration to determine speed in thousands of kilometers per hour at the end of the burn.

Burn Time	5.5G	6G	6.5G	7G	7.5G	8G	8.5G	9G	9.5G	10G
0.5	349	381	413	445	476	508	540	572	603	635
1	699	762	826	889	953	1016	1080	1143	1207	1270
1.5	1048	1143	1238	1334	1429	1524	1619	1715	1810	1905
2	1397	1524	1651	1778	1905	2032	2159	2286	2413	2540
2.5	1746	1905	2064	2223	2381	2540	2699	2858	3016	3175
3	2096	2286	2477	2667	2858	3048	3239	3429	3620	3810
3.5	2445	2667	2889	3112	3334	3556	3778	4001	4223	4445
4	2794	3048	3302	3556	3810	4064	4318	4572	4826	5080
4.5	3143	3429	3715	4001	4287	4572	4858	5144	5430	5715
5	3493	3810	4128	4445	4763	5080	5398	5715	6033	6350
5.5	3842	4191	4541	4890	5239	5588	5938	6287	6636	6985
6	4191	4572	4953	5334	5715	6096	6477	6858	7239	7620
6.5	4541	4953	5366	5779	6192	6604	7017	7430	7843	8256

7	4890	5334	5779	6223	6668	7112	7557	8002	8446	8891
7.5	5239	5715	6192	6668	7144	7620	8097	8573	9049	9526
8	5588	6096	6604	7112	7620	8129	8637	9145	9653	10161
8.5	5938	6477	7017	7557	8097	8637	9176	9716	10256	10796
9	6287	6858	7430	8002	8573	9145	9716	10288	10859	11431
9.5	6636	7239	7843	8446	9049	9653	10256	10859	11462	12066
10	6985	7620	8256	8891	9526	10161	10796	11431	12066	12701
10.5	7335	8002	8668	9335	10002	10669	11335	12002	12669	13336
11	7684	8383	9081	9780	10478	11177	11875	12574	13272	13971
11.5	8033	8764	9494	10224	10954	11685	12415	13145	13876	14606
12	8383	9145	9907	10669	11431	12193	12955	13717	14479	15241
12.5	8732	9526	10319	11113	11907	12701	13495	14288	15082	15876
13	9081	9907	10732	11558	12383	13209	14034	14860	15685	16511
13.5	9430	10288	11145	12002	12860	13717	14574	15431	16289	17146
14	9780	10669	11558	12447	13336	14225	15114	16003	16892	17781
14.5	10129	11050	11971	12891	13812	14733	15654	16575	17495	18416
15	10478	11431	12383	13336	14288	15241	16194	17146	18099	19051
15.5	10827	11812	12796	13780	14765	15749	16733	17718	18702	19686
16	11177	12193	13209	14225	15241	16257	17273	18289	19305	20321
16.5	11526	12574	13622	14669	15717	16765	17813	18861	19909	20956
17	11875	12955	14034	15114	16194	17273	18353	19432	20512	21591
17.5	12225	13336	14447	15558	16670	17781	18892	20004	21115	22226
18	12574	13717	14860	16003	17146	18289	19432	20575	21718	22861
18.5	12923	14098	15273	16448	17622	18797	19972	21147	22322	23496
19	13272	14479	15685	16892	18099	19305	20512	21718	22925	24132
19.5	13622	14860	16098	17337	18575	19813	21052	22290	23528	24767
20	13971	15241	16511	17781	19051	20321	21591	22861	24132	25402

Chart 2 (Not inserted at this time)
Chart 2.5 (Not inserted at this time)

Chart 3 (Travel times for accelerations up to 5G)

This chart details the time needed for a constant acceleration trip (accelerate to midpoint, flip, decelerate to destination) by ships capable of up to 5Gs acceleration. The first column gives trip distance in kilometers. Move left till you arrive at the column equal to your ship's acceleration to determine how many hours the journey will take.

Kilometers	.5G	1G	1.5G	2G	2.5G	3G	3.5G	4G	4.5G	5G
1000	0.25	0.18	0.14	0.13	0.11	0.10	0.09	0.09	0.08	0.08
5000	0.56	0.40	0.32	0.28	0.25	0.23	0.21	0.20	0.19	0.18
10000	0.79	0.56	0.46	0.40	0.35	0.32	0.30	0.28	0.26	0.25
50000	1.77	1.25	1.02	0.89	0.79	0.72	0.67	0.63	0.59	0.56
100000	2.51	1.77	1.45	1.25	1.12	1.02	0.95	0.89	0.84	0.79
200000	3.55	2.51	2.05	1.77	1.59	1.45	1.34	1.25	1.18	1.12
300000	4.35	3.07	2.51	2.17	1.94	1.77	1.64	1.54	1.45	1.37
400000	5.02	3.55	2.90	2.51	2.24	2.05	1.90	1.77	1.67	1.59
500000	5.61	3.97	3.24	2.81	2.51	2.29	2.12	1.98	1.87	1.77
600000	6.15	4.35	3.55	3.07	2.75	2.51	2.32	2.17	2.05	1.94
700000	6.64	4.70	3.83	3.32	2.97	2.71	2.51	2.35	2.21	2.10
800000	7.10	5.02	4.10	3.55	3.17	2.90	2.68	2.51	2.37	2.24
900000	7.53	5.32	4.35	3.76	3.37	3.07	2.85	2.66	2.51	2.38
1000000	7.94	5.61	4.58	3.97	3.55	3.24	3.00	2.81	2.65	2.51
2000000	11.22	7.94	6.48	5.61	5.02	4.58	4.24	3.97	3.74	3.55
3000000	13.75	9.72	7.94	6.87	6.15	5.61	5.20	4.86	4.58	4.35
4000000	15.87	11.22	9.16	7.94	7.10	6.48	6.00	5.61	5.29	5.02
5000000	17.75	12.55	10.25	8.87	7.94	7.25	6.71	6.27	5.92	5.61
6000000	19.44	13.75	11.22	9.72	8.69	7.94	7.35	6.87	6.48	6.15
7000000	21.00	14.85	12.12	10.50	9.39	8.57	7.94	7.42	7.00	6.64
8000000	22.45	15.87	12.96	11.22	10.04	9.16	8.48	7.94	7.48	7.10
9000000	23.81	16.84	13.75	11.90	10.65	9.72	9.00	8.42	7.94	7.53
10000000	25.10	17.75	14.49	12.55	11.22	10.25	9.49	8.87	8.37	7.94
20000000	35.49	25.10	20.49	17.75	15.87	14.49	13.42	12.55	11.83	11.22
30000000	43.47	30.74	25.10	21.74	19.44	17.75	16.43	15.37	14.49	13.75
40000000	50.19	35.49	28.98	25.10	22.45	20.49	18.97	17.75	16.73	15.87
50000000	56.12	39.68	32.40	28.06	25.10	22.91	21.21	19.84	18.71	17.75
60000000	61.48	43.47	35.49	30.74	27.49	25.10	23.24	21.74	20.49	19.44
70000000	66.40	46.95	38.34	33.20	29.70	27.11	25.10	23.48	22.13	21.00
80000000	70.99	50.19	40.98	35.49	31.75	28.98	26.83	25.10	23.66	22.45
90000000	75.29	53.24	43.47	37.65	33.67	30.74	28.46	26.62	25.10	23.81
100000000	79.37	56.12	45.82	39.68	35.49	32.40	30.00	28.06	26.46	25.10
200000000	112.24	79.37	64.80	56.12	50.19	45.82	42.42	39.68	37.41	35.49
300000000	137.46	97.20	79.37	68.73	61.48	56.12	51.96	48.60	45.82	43.47

400000000	158.73	112.24	91.64	79.37	70.99	64.80	59.99	56.12	52.91	50.19	
500000000	177.47	125.49	102.46	88.73	79.37	72.45	67.08	62.74	59.16	56.12	
600000000	194.40	137.46	112.24	97.20	86.94	79.37	73.48	68.73	64.80	61.48	
700000000	209.98	148.48	121.23	104.99	93.91	85.72	79.37	74.24	69.99	66.40	
800000000	224.48	158.73	129.60	112.24	100.39	91.64	84.84	79.37	74.83	70.99	
900000000	238.10	168.36	137.46	119.05	106.48	97.20	89.99	84.18	79.37	75.29	
1000000000	250.97	177.47	144.90	125.49	112.24	102.46	94.86	88.73	83.66	79.37	
2000000000	354.93	250.97	204.92	177.47	158.73	144.90	134.15	125.49	118.31	112.24	
3000000000	434.70	307.38	250.97	217.35	194.40	177.47	164.30	153.69	144.90	137.46	
4000000000	501.95	354.93	289.80	250.97	224.48	204.92	189.72	177.47	167.32	158.73	
5000000000	561.20	396.83	324.01	280.60	250.97	229.11	212.11	198.41	187.07	177.47	
6000000000	614.76	434.70	354.93	307.38	274.93	250.97	232.36	217.35	204.92	194.40	
7000000000	664.02	469.53	383.37	332.01	296.96	271.08	250.97	234.77	221.34	209.98	
8000000000	709.86	501.95	409.84	354.93	317.46	289.80	268.30	250.97	236.62	224.48	
9000000000	752.92	532.40	434.70	376.46	336.72	307.38	284.58	266.20	250.97	238.10	
10000000000		793.65	561.20	458.21	396.83	354.93	324.01	299.97	280.60	264.55	250.97

Chart 3.5 (Travel times for accelerations from 5.5 to 10G)

This chart details the time needed for a constant acceleration trip (accelerate to midpoint, flip, decelerate to destination) by ships capable of up to 10Gs acceleration. The first column gives trip distance in kilometers. Move left till you arrive at the column equal to your ship's acceleration to determine how many hours the journey will take.

Kilometers	5.5G	6G	6.5G	7G	7.5G	8G	8.5G	9G	9.5G	10G	
1000	0.08	0.07	0.07	0.07	0.06	0.06	0.06	0.06	0.06	0.06	
5000	0.17	0.16	0.16	0.15	0.14	0.14	0.14	0.13	0.13	0.13	
10000	0.24	0.23	0.22	0.21	0.20	0.20	0.19	0.19	0.18	0.18	
50000	0.54	0.51	0.49	0.47	0.46	0.44	0.43	0.42	0.41	0.40	
100000	0.76	0.72	0.70	0.67	0.65	0.63	0.61	0.59	0.58	0.56	
200000	1.07	1.02	0.98	0.95	0.92	0.89	0.86	0.84	0.81	0.79	
300000	1.31	1.25	1.21	1.16	1.12	1.09	1.05	1.02	1.00	0.97	
400000	1.51	1.45	1.39	1.34	1.30	1.25	1.22	1.18	1.15	1.12	
500000	1.69	1.62	1.56	1.50	1.45	1.40	1.36	1.32	1.29	1.25	
600000	1.85	1.77	1.71	1.64	1.59	1.54	1.49	1.45	1.41	1.37	
700000	2.00	1.92	1.84	1.77	1.71	1.66	1.61	1.57	1.52	1.48	
800000	2.14	2.05	1.97	1.90	1.83	1.77	1.72	1.67	1.63	1.59	
900000	2.27	2.17	2.09	2.01	1.94	1.88	1.83	1.77	1.73	1.68	
1000000	2.39	2.29	2.20	2.12	2.05	1.98	1.92	1.87	1.82	1.77	
2000000	3.38	3.24	3.11	3.00	2.90	2.81	2.72	2.65	2.57	2.51	
3000000	4.14	3.97	3.81	3.67	3.55	3.44	3.33	3.24	3.15	3.07	
4000000	4.79	4.58	4.40	4.24	4.10	3.97	3.85	3.74	3.64	3.55	
5000000	5.35	5.12	4.92	4.74	4.58	4.44	4.30	4.18	4.07	3.97	
6000000	5.86	5.61	5.39	5.20	5.02	4.86	4.71	4.58	4.46	4.35	
7000000	6.33	6.06	5.82	5.61	5.42	5.25	5.09	4.95	4.82	4.70	
8000000	6.77	6.48	6.23	6.00	5.80	5.61	5.44	5.29	5.15	5.02	
9000000	7.18	6.87	6.60	6.36	6.15	5.95	5.77	5.61	5.46	5.32	
10000000	7.57	7.25	6.96	6.71	6.48	6.27	6.09	5.92	5.76	5.61	
20000000	10.70	10.25	9.84	9.49	9.16	8.87	8.61	8.37	8.14	7.94	
30000000	13.11	12.55	12.06	11.62	11.22	10.87	10.54	10.25	9.97	9.72	
40000000	15.13	14.49	13.92	13.42	12.96	12.55	12.17	11.83	11.52	11.22	
50000000	16.92	16.20	15.56	15.00	14.49	14.03	13.61	13.23	12.87	12.55	
60000000	18.54	17.75	17.05	16.43	15.87	15.37	14.91	14.49	14.10	13.75	
70000000	20.02	19.17	18.42	17.75	17.14	16.60	16.10	15.65	15.23	14.85	
80000000	21.40	20.49	19.69	18.97	18.33	17.75	17.22	16.73	16.29	15.87	
90000000	22.70	21.74	20.88	20.12	19.44	18.82	18.26	17.75	17.27	16.84	
100000000	23.93	22.91	22.01	21.21	20.49	19.84	19.25	18.71	18.21	17.75	
200000000	33.84	32.40	31.13	30.00	28.98	28.06	27.22	26.46	25.75	25.10	
300000000	41.45	39.68	38.13	36.74	35.49	34.37	33.34	32.40	31.54	30.74	
400000000	47.86	45.82	44.02	42.42	40.98	39.68	38.50	37.41	36.42	35.49	
500000000	53.51	51.23	49.22	47.43	45.82	44.37	43.04	41.83	40.71	39.68	
600000000	58.61	56.12	53.92	51.96	50.19	48.60	47.15	45.82	44.60	43.47	
700000000	63.31	60.62	58.24	56.12	54.22	52.50	50.93	49.49	48.17	46.95	
800000000	67.68	64.80	62.26	59.99	57.96	56.12	54.44	52.91	51.50	50.19	
900000000	71.79	68.73	66.04	63.63	61.48	59.52	57.75	56.12	54.62	53.24	
1000000000	75.67	72.45	69.61	67.08	64.80	62.74	60.87	59.16	57.58	56.12	
2000000000	107.02	102.46	98.44	94.86	91.64	88.73	86.08	83.66	81.43	79.37	
3000000000	131.07	125.49	120.56	116.18	112.24	108.68	105.43	102.46	99.73	97.20	
4000000000	151.34	144.90	139.22	134.15	129.60	125.49	121.74	118.31	115.15	112.24	
5000000000	169.21	162.00	155.65	149.99	144.90	140.30	136.11	132.28	128.75	125.49	
6000000000	185.36	177.47	170.50	164.30	158.73	153.69	149.10	144.90	141.04	137.46	
7000000000	200.21	191.68	184.16	177.47	171.45	166.00	161.05	156.51	152.34	148.48	
8000000000	214.03	204.92	196.88	189.72	183.29	177.47	172.17	167.32	162.85	158.73	
9000000000	227.01	217.35	208.82	201.23	194.40	188.23	182.61	177.47	172.73	168.36	
10000000000		239.29	229.11	220.12	212.11	204.92	198.41	192.49	187.07	182.08	177.47