

## Rocket Mass Characteristics V4.6

12/30/2009

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Rocket Stage	Feed System	Isp (sec) vac/sl	Propellant Mass (lbs) MI	Inert Mass (lbs) Ms	Payload Mass (lbs) Mp	Me	Mf	Mass Ratio	Structural Coefficient	Propellant Mass Fraction	Payload Mass Fraction	Ms --- MI
Titan II Stage 1	Pump	284/260	246846	9670	71581	81251	328097	4.04	0.038	0.962	0.279	0.04
Atlas E with Booster	Pump	293/248	248640	13924	1800	15724	264364	16.81	0.053	0.947	0.007	0.06
SpaceX Falcon1 Stg 1	Pump	304/255	59779	3527	10946	14473	74252	5.13	0.056	0.944	0.173	0.06
Delta II Stage 1 (7925)	Pump	302/255	211902	12518	27237	39755	251657	6.33	0.056	0.944	0.121	0.06
Titan I Stage 1	Pump	286/250	161688	9562	48890	58452	220140	3.77	0.056	0.944	0.285	0.06
Delta II Stage 1 (Delta-Thor XLT-C)	Pump	302/255	211203	13448	241390	254838	466041	1.83	0.060	0.940	1.075	0.06
Kosmos 3M Stage 1	Pump	291/248	180600	11600	49190	60790	241390	3.97	0.060	0.940	0.256	0.06
Ariane 5 ECA Cryogenic Core	Pump	434/318	374786	26455	68745	95200	469986	4.94	0.066	0.934	0.171	0.07
Soyuz Sustainer Stage 2	Pump	319/255	198636	14429	90731	105160	303796	2.89	0.068	0.932	0.426	0.07
Proton M Stage 1	Pump	316/285	924641	67460	529092	596552	1521193	2.55	0.068	0.932	0.533	0.07
Atlas V 400 CCB Stage 1	Pump	337/311	626308	45730	76516	122246	748554	6.12	0.068	0.932	0.114	0.07
Proton M Stage 2	Pump	327/230	344170	25800	159122	184922	529092	2.86	0.070	0.930	0.430	0.07
Kosmos 3M Stage 2	Pump	303/NA	41227	3163	4800	7963	49190	6.18	0.071	0.929	0.108	0.08
Angara 1.1 Stage 1	Pump	337/310	292333	22614	19644	42258	334591	7.92	0.072	0.928	0.062	0.08
Ariane 5G Cryogenic Core	Pump	431/318	350535	27557	68124	95681	446216	4.66	0.073	0.927	0.180	0.08
Proton M Stage 3	Pump	327/NA	102652	8140	48330	56470	159122	2.82	0.073	0.927	0.436	0.08
Black Arrow Stage 1	Pump	265/251	28735	2355	8667	11022	39757	3.61	0.076	0.924	0.279	0.08
Agena B-Mod 1	Pump	289/NA	15920	1352	8895	10247	26167	2.55	0.078	0.922	0.515	0.08
Titan II Stage 2	Pump	315/NA	57902	5029	8650	13679	71581	5.23	0.080	0.920	0.137	0.09
Atlas V 400 Centaur CIIS Stage 2	Pump	451/NA	45574	4220	20000	24220	69794	2.88	0.085	0.915	0.402	0.09
Soyuz Stage 3 (RD-0124)	Pump	359/NA	55997	5192	29542	34734	90731	2.61	0.085	0.915	0.483	0.09
Soyuz Conical Booster Stage 1	Pump	319/262	86332	8342	31405	39747	126079	3.17	0.088	0.912	0.332	0.10
Saturn V AS-501 St1	Pump	304/265	4389000	449200	1418800	1868000	6257000	3.35	0.093	0.907	0.293	0.10
Delta II Stage 3 (7925 Star 48B)	Solid Fuel	292/NA	4430	457	6479	6936	11366	1.64	0.094	0.906	1.326	0.10
Sea Dragon Stage 2 (proposed)	Pressure	409/NA	9606054	1025839	1100000	2125839	11731893	5.52	0.096	0.904	0.103	0.11
Saturn 1B Stage 1	Pump	294/264	910155	99797	310208	410005	1320160	3.22	0.099	0.901	0.307	0.11
Sea Dragon Stage 1 (proposed)	Pressure	284/242	25277480	2939715	68785	3008500	28285980	9.40	0.104	0.896	0.002	0.12
Ariane EPS AR5E	Pressure	321/NA	22046	2646	44093	46739	68785	1.47	0.107	0.893	1.786	0.12
Ariane EPS AR5G	Pressure	321/NA	21385	2646	44093	46739	68124	1.46	0.110	0.890	1.835	0.12
Saturn V AS-501 St3	Pump	423/NA	234100	29300	89800	119100	353200	2.97	0.111	0.889	0.341	0.13
Saturn V AS-501 St2	Pump	427/NA	946700	119200	352000	471200	1417900	3.01	0.112	0.888	0.330	0.13
SpaceX Falcon1 Stg 2	Pressure	320/NA	8881	1125	940	2065	10946	5.30	0.112	0.888	0.094	0.13
Titan I Stage 2	Pump	310/NA	39738	5184	3968	9152	48890	5.34	0.115	0.885	0.088	0.13
Centaur I	Pump	444/NA	27651	3688	10200	13888	41539	2.99	0.118	0.882	0.325	0.13

Ariane ESC-B	Pump	466/NA	55116	7400	44093	51493	106609	2.07	0.118	0.882	0.705	0.13
Ariane ESC-A	Pump	446/NA	32849	4600	44093	48693	81542	1.67	0.123	0.877	1.177	0.14
Black Arrow Stage 3	Solid Fuel	278/NA	694	108	213	321	1015	3.16	0.135	0.865	0.266	0.16
Delta II Stage 2 (Delta K)	Pressure	319/NA	13236	2092	6165	8257	21493	2.60	0.136	0.864	0.402	0.16
Black Arrow Stage 2	Pump	265/NA	6522	1060	1115	2175	8697	4.00	0.140	0.860	0.147	0.16
Breeze M	Pressure	326/NA	43652	7209	6415	13624	57276	4.20	0.142	0.858	0.126	0.17
Ariane Solid Booster	Solid Fuel	275/250	522495	88185	98592	186777	709272	3.80	0.144	0.856	0.161	0.17
Soyuz Fregat Stage 4	Pump	331/NA	11795	2094	11023	13117	24912	1.90	0.151	0.849	0.794	0.18
Ausroc III (proposed)	Pressure	293/241	2603	495	330	825	3428	4.16	0.160	0.840	0.107	0.19
Sprite Stage 2 (proposed)	Pressure	297/NA	9698	1851	3090	4941	14639	2.96	0.160	0.840	0.268	0.19
Angara 1.1 Stage 2 (Breeze M Core)	Pressure	326/NA	11244	2426	5974	8400	19644	2.34	0.177	0.823	0.437	0.22
Scout B Stage 1	Solid Fuel	259/232	18998	4484.2	12842.9	17327.1	36325.1	2.10	0.191	0.809	0.547	0.24
Scud A (R11)	Pressure	255/219	8168	2105	1521	3626	11794	3.25	0.205	0.795	0.148	0.26
Viking 4	Pump	231/198	8030	2200	528	2728	10758	3.94	0.215	0.785	0.052	0.27
Scout B Stage 2	Solid Fuel	273/232	7320	2044.7	3478.2	5522.9	12842.9	2.33	0.218	0.782	0.371	0.28
Scud B (R17)	Pump	247/230	8314	2432	2178	4610	12924	2.80	0.226	0.774	0.203	0.29
Aerobee 150A Sustainer	Pressure	227/198	1055	307	200	507	1562	3.08	0.225	0.775	0.147	0.29
Scout B Stage 3	Solid Fuel	281/233	2084	660	734.2	1394.2	3478.2	2.49	0.241	0.759	0.268	0.32
V2	Pump	239/203	19176	6246	2150	8396	27572	3.28	0.246	0.754	0.085	0.33
Scout B Stage 4	Solid Fuel	282/NA	456	178.2	100	278.2	734.2	2.64	0.281	0.719	0.158	0.39
Redstone Missile	Pump	249/218	37205	17697	6305	24002	61207	2.55	0.322	0.678	0.115	0.48
Wac Corporal Sustainer	Pressure	230/184	360	296	25	321	681	2.12	0.451	0.549	0.038	0.82

## EXPLANATIONS

### Given:

Ms = Inert Structural Mass (or Weight)  
 MI = Propellant (Fuel) Mass (or Weight)  
 Mp = Payload Mass (or Weight)  
 Me = Mp + Ms  
 Mf = Mp + Ms + MI

### Then:

Mass Ratio =  $Mf / Me$   
 Structural Coefficient =  $Ms / (Ms + MI)$   
 Propellant Mass Fraction =  $MI / (Ms + MI)$   
 Payload Mass Fraction =  $Mp / (Ms + MI)$

### Notes:

  Vacuum Isp Analytically Determined  
  Vacuum and Sea Level Isp Analytically Determined