Mars physical and orbital statistics, comparisons

NOTE! The Greek letters and some other symbols in the following have been written like [*omega*] or [*sigma*] because they are not universally supported by web browsers.

First some brief comparisons of the inner planets' properties. Later more detailed information about Mars' orbital and physical statistics.

Planetary statistics comparisons (ref. *)

	MERCURY	VENUS	EARTH	Moon	MARS
Mass (kg)	3.303e+23	4.869e+24	5.976e+24	7.349e+22	6.421e+23
Mass (Earth's mass = 1)	5.5271e-02	.81476	1	1.2298e-02	1.0745e-01
Equatorial radius (km)	2 439.7	6 051.8	6 378.14	1 737.4	3 397.2
Equatorial radius (Earth = 1)	3.8252e-01	.94886	1	2.7241e-01	5.3264e-01
Mean density (g/cm^3)	5.42	5.25	5.515	3.34	3.94
Tilt of axis (degrees)	0.00	177.36	23.45	1.5424	25.19
Rotational period (days)	58.6462	-243.0187	0.99727	27.32166	1.025957
Equatorial surface gravity (m/sec^2)	2.78	8.87	9.78	1.62	3.72
Equatorial escape velocity (km/sec)	4.25	10.36	11.18	2.38	5.02
Mean distance from the Sun (km)	57 910 000	108 200 000	149 600 000	Distance from Earth 384 400	227 940 000
Mean distance from the Sun (Earth = 1)	0.3871	0.7233	1	1	1.5237

Orbital period (days)	87.969	224.701	365.256	27.32166 Around Earth	**686.98**
Mean orbital velocity (km/sec)	47.88	35.02	29.79	1.03	**24.13**
Orbital eccentricity	0.2056	0.0068	0.0167	0.0549	**0.0934**
Orbital inclination (degrees)	7.004	3.394	0.000	5.1454	**1.850**
Visual geometric albedo	0.10	0.65	0.37	0.12	**0.15**
Magnitude (Vo)	-1.9	-4.4	-	-12.74	**-2.01**
Mean surface temperature	179°C	482°C	15°C	107°C (day) -153°C (night)	**-63°C**
Maximum surface temperature	427°C	?	?	123°C	**20°C**
Minimum surface temperature	-173°C	?	?	-233°C	**-140°C**
Atmospheric pressure (bars)	?	92	1.013	-	**0.007**

Atmospheric composition

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(He      42%     CO₂  96.5%    N₂    78.1%              -
 S       42%     N₂    3+%     O₂    20.9%
 O₂      15%     CO   40ppm    Ar    0.93%
 Others 1% )     H₂O 1–40ppm   CO₂   0.035%
                 H₂S  ~3ppm    Ne    0.0018%
                 HDO  1.3ppm   He    0.0005%
                 HCl  0.5ppm   CH₄   1.7ppm
                 COS  0.3ppm   Kr    1.1ppm
                 SO₂ 0.1+ppm   H₂    0.5ppm
                 S₁₋₈ 20ppb    O₃    0.04ppm
                 SO   ~20ppb
                 HF   5–10ppb
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CO₂	**95.32%**
N₂	**2.7%**
Ar	**1.6%**
O₂	**0.13%**
CO	**0.07%**
H₂O	**0.03%**
Ne	**0.00025%**
Kr	**0.00003%**
Xe	**0.000008%**
O₃	**0.000003%**

More detailed characteristics of Mars (ref. **):
Planetary constants

Planetary radius (a ; km)	3394 (Earth: 6378)
Surface gravity (g ; m/s^2)	3.72 (Earth: 9.81)
Mean molecular weight (m ; g/mole)	43.4 (Earth: 29)
Molecular gas constant (R ; J/kgK)	192 (Earth: 287)
Specific heat constant (c_p ; J/kgK)	860 (Earth: 1000)
R/Specific heat constant ($[kappa]=R/c_p$; ----)	0.223 (Earth: 0.287)

Ratio of specific heats ($[gamma]=c_p c_v$; ----)	1.3 (Earth: 1.4)
R/g ; km/K	0.0515 (Earth: 0.0293)
Solar day ($[delta]$; s)	88775 (Earth: 86400)
Planetary rotation time ($[omega]$; 1/s)	$0.7088*10^{-4}$ (Earth: $0.7294*10^{-4}$)
Year (sols (Earth days))	669 (687) (Earth: 365 (365))
Orbital eccentricity (----)	0.093 (Earth: 0.017)
Orbital inclination (degrees)	25 (Earth: 23.5)
Sun-planet distance (AU)	1.38-1.67 (Earth: 0.98-1.02)
Surface pressure, varies 25-30% on Mars (p_s ; mbar(hPa))	6-8 (Earth: 1013)
Atmospheric mass, varies 25-30% on Mars (p_s/g ; kg/m^2)	160-220 (Earth: 10300)

Planetary parameters

Planetary equilibrium temperature (T_e ; K)	210 (Earth: 256)
Mean scale height ($H=RT_e/g$; km)	10.8 (Earth: 7.5)
Adiabatic lapse rate, assumed no condensation ($G_a=g/c_p$; K/km)	4.5 (Earth: 9.8)
Mean lapse rate, lower atmosphere ($G=-dT/dz$; K/km)	~2.5 (Earth: 6.5)
Brunt-Väisälä frequency (N ; 1/s)	$~0.60*10^{-2}$ (Earth: $1.12*10^{-2}$)
Stability ($S=N^2H=R(G_a-G)$; m/s^2)	~0.38 (Earth: 0.95)
Diurnal phase speed, equatorial ($a[omega]$; m/s)	241 (Earth: 465)
External gravity wave speed (sqrt(gH) ; m/s)	201 (Earth: 271)
Speed of sound (sqrt($[gamma]$gH) ; m/s)	229 (Earth: 321)
Internal gravity wave speed (NH ; m/s)	65 (Earth: 84)
Lamb's parameter ($4[omega]^2a^2/g$; km)	62.23 (Earth: 88.47)
Rossby deformation radius ($L_r=NH/[omega]$; km)	920 (Earth: 1150)
External Froude number (sqrt(F_e)=sqrt(gH/$[omega]$a) ; ----)	0.83 (Earth: 0.58)
Internal Froude number ($F_i=NH/[omega]a$; ----)	0.27 (Earth: 0.18)
Atmos. visible optical depth, variations due to dust storms, on Earth clouds ($[tau]$; ----)	0.1-10 (Earth: 0.2-100)
Atmos. thermal IR emissivity, variations due to dust storms, on Earth clouds ($[epsilon]$; ----)	0.15-0.8 (Earth: 0.4-1.0)
Atmos. heat storage ($c_pT_ep_s/g$; J/m^2)	$3.4*10^7$ (Earth: $260*10^7$)
Potential atmos. col. cooling rate ($[sigma]_BT_e^4$; W/m^2)	110 (Earth: 240)
pot. atm. col. cooling rate with $[epsilon]$=0.32 (Mars), 0.7 (Earth) ($[epsilon][sigma]_BT_e^4$; W/m^2)	35 (Earth: 170)
$t_c=(c_pT_ep_s/g)/([epsilon][sigma]_BT_e^4)$; sols)	~11 (Earth: ~180)
Rad. damping time, lower atmos. (t_r ; sols)	~2 (Earth: >20)
$1/F_r=[omega]t_c$; ----)	70 (Earth: 1100)

Thermal Rossby number ($R_T=F_eF_r$; ----)		0.01 (Earth: 0.0003)	

Orbital characteristics		**Orientation of Polar axis**	
Semimajor axis (AU)	1.52366	Right ascension (degrees)	317.61
Eccentricity	0.0934	Declination (degrees)	52.85
Inclination (degrees)	1.8504	Obliquity relative to orbital plane (degrees)	25.19
Longitude of Ascending node (degrees)	49.59		
Longitude of perihelion (degrees)	335.94	**Time properties**	
Mean daily motion (degrees)	0.52405	Length of sidereal day	24h ,37min, 22.663±0.002s 88642.663±0.002s
Mean longitude (degrees)	0.89		
Mean orbital velocity around Sun (km/sec)	24.13	Mean orbital period	686.98 Earth days, 669.60 Mars solar days
L_S of perihelion (degrees)	250.87	Length of mean solar day	88775.2s

Geophysical parameters			
Mass - GM (km^3/s^2)	42828.3±0.1	Mean radius (of sphere of equal volume, km)	3389.92±0.04
Mass (kg)	6.4185e23	Radius and direction of principal axes of 2nd-degree triaxial ellipsoid (radius (km), latitude (degrees), longitude (degrees))	3394.5±0.3 0.7±0.2 18.5±0.8W 3399.2±0.3 -2.0±0.2 108.4±0.8W 3376.1±0.4 87.9±0.2 128.8±6.3W
Volume (m^3)	1.6318e22		
Mean density (g/cm)	3.9335±0.0004		
J_2	1960.454e6	Total surface area (m^2)	1.4441e14
C/MR^2	0.345 - 0.365	Ratio of surface area to that of Earth	0.2825
Center of mass/center of figure offset (km)	2.50±0.07	Ratio of surface area to Earth's land area	0.976
cf. offset in direction of (lat.), (long. W)	-62.0±3.7 87.7±3.0	Area of perennial south polar cap (km^2)	88 000
Magnetic dipole moment (T/m^3)	8e11 (<1e-4 that of Earth)	Area of perennial north polar cap (km^2)	837 000
Surface gravity at pole (m/s^2)	3.758	Area of polar layered region (excluding perennial cap, south, km^2)	1 395 000
Surface gravity at equator (m/s^2)	3.711	Area of polar layered region (excluding perennial cap, north, km^2)	395 000
Ratio of equatorial surface gravity to that of Earth	0.3795		

Mean escape velocity (km/s)	5.027

Atmospheric properties

Atmospheric pressure (varies seasonally / spatially, mbar)	5 - 9 (global annyal average 5.6)	Mass of seasonal north polar cap deposit (kg)	3.5e15
Average columnar mass of atmosphere (kg/m^2)	150	Mass of seasonal south polar cap deposit (kg)	8.1e15
Average mass of atmosphere (kg)	2.17e16	Dry adiabatic lapse rate (K/km)	4.5
Mean atmospheric scale height (at T=210K, km)	10.8	Mean atmospheric lapse rate (observed, K/km)	~2.5
Atmospheric visible depth	0.1 - 10		

Atmospheric composition by volume   Atmospheric isotopic ratios

CO_2 (varies with season as much as 30%)	95.32%	^{12}C / ^{13}C	90±5 (=1.011x Earth's)
N_2	2.7%	^{14}N / ^{15}N	170±15 (=0.625x Earth's)
Ar	1.6%	^{16}O / ^{18}O	490±25 (=1.002x Earth's)
O_2	0.13%	^{36}Ar / ^{38}Ar	5.5±1.5 (=1.038x Earth's)
CO	0.07%	^{40}Ar / ^{36}Ar	3000±500 (=10.135x Earth's)
H_2O (varies with season/location)	0.03%; global average 0.016%	^{129}Xe / ^{132}Xe	$2.5\pm^2_1$ (=2.577x Earth's)
Ne	2.5 ppm	D / H	(9±4)e-4 (=5.625x Earth's)
Kr	0.3 ppm	^{14}N / ^{15}N	
Xe	0.08 ppm		
O_3 (varies with season/location)	0.04 - 0.2 ppm		

Representative chemical composition of soil   Thermal properties

SiO_2	43.4%

Solar constant at mean Mars distance from Sun (W/m^2)	588.98 (1367.6 at 1 AU distance)
Average surface temperature (K)	210.1

Fe_2O_3	18.2%		
Al_2O_3	7.2%		
SO_3	7.2%	Range of surface temperature (K)	~ 140 - 300
MgO	6.0%		
CaO	5.8%		
Na_2O	1.34%		
Cl	0.8%		
P_2O_5	0.68%	Surface bolometric albedo	0.25 (range 0.08 - 0.40)
TiO_2	0.6%		
MnO	0.45%		
Cr_2O	0.29%		
K_2O	0.10%	Surface mean thermal inertia	6.5e-3cal/(cm^2s^(1/2)K) 272.J/(m^2s^(1/2)K)
CO_3	<2%		
H_2O	0 - 1%		
		Surface thermal inertia range	1 - 15e-3 cal/(cm^2s^(1/2)K) 42.-628.J/(m^2s^(1/2)K)

References:
(*) - From "Views of the Solar system" pages.
(**) - From *H.H.Kieffer et al: Mars (1992)*