

Required Constants

A number of constants are used in this analysis. These constants fall into two categories:

- Constants that refer to the Earth's characteristics.
These numbers are used for normalization of results -- they help establish a common frame of reference.
- General physical constants.

Earth-Focused Reference Values

$$M_E := 5.9722 \cdot 10^{24} \text{ kg} \quad \text{Mass of the Earth, Reference Unit}$$

$$v_{\text{earth}} := 11.2 \frac{\text{km}}{\text{s}} \quad \text{Escape velocity from Earth, Reference Unit}$$

$$\text{AU} := 149597870700 \text{ m} \quad \text{Astronomical Unit, Reference Unit}$$

$$r_{\text{Earth}} := 6378.1 \text{ km} \quad \text{Radius of the Earth, Reference Unit}$$

$$\rho_E := \frac{M_E}{\frac{4}{3} \cdot \pi \cdot r_{\text{Earth}}^3} = 5.5 \cdot \frac{\text{gm}}{\text{cm}^3} \quad \text{Density of the Earth, Reference Unit}$$

$$M_{\text{sun}} := 1.9891 \cdot 10^{30} \text{ kg} \quad \text{Mass of the Sun. This constant is need to determine the semi-major axis distance using Kepler's law. Kepler's law states that}$$

$$\frac{r_{\text{Planet}}^3}{T^2} = \frac{G \cdot M_{\text{Sun}}}{4 \cdot \pi^2} = K_{\text{Kepler}} \quad \text{Where } r_{\text{Planet}} \text{ is the semi-major axis of the planet orbit.}$$

Computational Constants

$$K_{\text{Kepler}} := \frac{\text{AU}^3}{\text{yr}^2} \quad \text{Constant used in Kepler's Law}$$

$$G := 6.6742 \cdot 10^{-11} \cdot \frac{\text{m}^3}{\text{kg} \cdot \text{sec}^2} \quad \text{Universal Gravitational Constant}$$

Data

name
 mass
 radius
 period
 density
 a_{gravity}
 v_{escape}
 r_{Orbit}
 T_{Surface}

:=

Planet	mass	radius	Period	density	g	ve	a	Tsurf	Teq	
Name	(EU)	(EU)	(1yr)	(EU)	(EU)	(EU)	(AU)	(K)	(K)	
Earth	1	1	1	1	1	1	1	288	254	
Mars	0.107	0.53	1.88	0.71	0.38	0.45	1.52	227	210	
Mercury	0.0553	0.38	0.24	0.98	0.38	0.38	0.39	440	434	
Venus	0.815	0.95	0.62	0.95	0.9	0.93	0.72	730	232	
Jupiter	318	10.97	11.86	0.24	2.64	5.38	5.2	152	110	
Ceres	0.000159	0.08	4.599	0.36	0.03	0.05	2.77	167	153	
Vesta	4.38E-05	0.04	3.629	0.59	0.02	0.03	2.36	166	166	
Saturn	95.2	9.14	29.46	0.12	1.14	3.23	9.54	134	81	
Pallas	3.53E-05	0.04	4.62	0.44	0.02	0.03	2.77	153	153	
Uranus	14.5	3.98	84.01	0.23	0.92	1.91	19.19	76	58	
Neptune	17.1	3.87	164.8	0.3	1.14	2.11	30.07	72	47	
Pluto	0.0022	0.18	247.7	0.37	0.07	0.11	39.48	40	41	
2005 QU182	0.0002	0.08	1215.26	0.36	0.03	0.05	113.58	41	24	
Quaoar	0.00017	0.08	285.97	0.35	0.03	0.05	43.6	41	39	
2002 TC302	0.00026	0.09	413.86	0.36	0.03	0.05	55.24	38	34	
Ixion	5.00E-05	0.05	249.95	0.38	0.02	0.03	39.68	43	40	

period := period·yr

mass := mass·Me

radius := r_{Earth} ·radius

Assign units to web page data.

Use Available Data to Compute Inputs to Similarity Index

$$g_{\text{Planet}}(M_{\text{Planet}}, r_{\text{Planet}}) := \frac{G \cdot M_{\text{Planet}}}{r_{\text{Planet}}^2}$$

Function to compute the gravitaional acceleration relative to Earth's at the surface.

$$A_{\text{gravity}} := \overrightarrow{g_{\text{Planet}}(\text{mass}, \text{radius})}$$

Compute a table.

$$\rho := \frac{\frac{\text{mass}}{\frac{4}{3} \cdot \pi \cdot \text{radius}^3}}{\rho_E}$$

Function to compute the density of a planet relative to the Earth's.

$$\text{EscapeVelocity}(M, r) := \frac{\sqrt{2 \cdot \frac{G \cdot M}{r}}}{v_{\text{earth}}}$$

Function to compute the escape velocity of a planet relative to the Earth's.

$$\text{EV} := \overrightarrow{\text{EscapeVelocity}(\text{mass}, \text{radius})}$$

Compute a table.

$$R_{\text{SemiMajor}}(\text{period}) := \left(K_{\text{Kepler}} \cdot \text{period}^2 \right)^{\frac{1}{3}}$$

Function to compute the orbital radius of a planet.

$$R := R_{\text{SemiMajor}}(\text{period})$$

Results

Orbital Radius

My calculation.

Web page.

	0		0
R =	1	$\cdot AU$	$r_{Orbit} =$
	1.52		1.52
	0.39		0.39
	0.73		0.72
	5.2		5.2
	2.77		2.77
	2.36		2.36
	9.54		9.54
	2.77		2.77
	19.18		19.19
	30.06		30.07
	39.44		39.48
	113.88		113.58
	43.41		43.6
	55.54		55.24

Surface Acceleration Due to Gravity

My calculation.

Web page.

	0		0
$A_{gravity} =$	1		$a_{gravity} =$
	0.38		0.38
	0.38		0.38
	0.9		0.9
	2.64		2.64
	0.02		0.03
	0.03		0.02
	1.14		1.14
	0.02		0.02
	0.91		0.92
	1.14		1.14
	0.07		0.07
	0.03		0.03
	0.03		0.03
	0.03		0.03
	0.03		0.03

More Results

Escape Velocity

My calculation.

	0
0	1
1	0.45
2	0.38
3	0.92
4	5.37
5	0.04
6	0.03
EV = 7	3.22
8	0.03
9	1.91
10	2.1
11	0.11
12	0.05
13	0.05
14	0.05
15	...

Web page.

	0
0	1
1	0.45
2	0.38
3	0.93
4	5.38
5	0.05
6	0.03
v _{escape} = 7	3.23
8	0.03
9	1.91
10	2.11
11	0.11
12	0.05
13	0.05
14	0.05
15	...

Density

My calculation.

	0
0	1
1	0.72
2	1.01
3	0.95
4	0.24
5	0.31
6	0.68
ρ = 7	0.12
8	0.55
9	0.23
10	0.3
11	0.38
12	0.39
13	0.33
14	0.36
15	...

Web page.

	0
0	1
1	0.71
2	0.98
3	0.95
4	0.24
5	0.36
6	0.59
density = 7	0.12
8	0.44
9	0.23
10	0.3
11	0.37
12	0.36
13	0.35
14	0.36
15	...

Earth Similarity Index Calculation

Mathcad Program

```

ESI(x, w, y) := "program to compute the 2 term Earth Similarity Index"
for i ∈ 0 .. rows(x) - 1
  α ← submatrix(x, i, i, 0, 1)
  βi ←  $\prod_{j=0}^{\text{rows}(y)-1} \left( 1 - \left| \frac{x_{i,j} - y_j}{x_{i,j} + y_j} \right| \right)^{\frac{w_j}{\text{rows}(y)}}$ 
β

```

Planetary Property	Reference Value	Weight Exponent
Mean Radius	1.0 Eu	0.57
Bulk Density	1.0 Eu	1.07
Escape velocity	1.0 Eu	0.70
Surface Temperature	288 K	5.58

Note: Eu = Earth's units

Internal ESI Calculation

$$\text{augment}\left[\text{name, ESI}\left[\text{augment}\left(\frac{\text{radius}}{r_{\text{Earth}}}, \text{density}\right), \begin{pmatrix} 0.57 \\ 1.07 \end{pmatrix}, \begin{pmatrix} 1 \\ 1 \end{pmatrix}\right]\right] =$$

My results

	0	1
0	"Earth"	1
1	"Mars"	0.82
2	"Mercury"	0.84
3	"Venus"	0.98
4	"Jupiter"	0.36
5	"Ceres"	0.41
6	"Vesta"	0.41
7	"Saturn"	0.28
8	"Pallas"	0.37
9	"Uranus"	0.46
10	"Neptune"	0.51
11	"Pluto"	0.51
12	"2005 QU182"	0.41
13	"Quaoar"	0.41
14	"2002 TC302"	0.43
15	"Ixion"	0.37
16	"Orcus"	0.35
17	"Eris"	0.53
18	"Makemake"	0.4
19	"2007 OR10"	0.43
20	"2007 UK126"	0.37
21	"Sedna"	0.42

Web site results

Earth	1
Mars	0.815
Mercury	0.84
Venus	0.979
Jupiter	0.36
Ceres	0.406
Vesta	0.414
Saturn	0.28
Uranus	0.455
Neptune	0.509
Pluto	0.512
2005 QU182	0.415
Quaoar	0.405
2002 TC302	0.422
Ixion	0.37
Orcus	0.34
Eris	0.53
Makemake	0.399
2007 OR10	0.429
2007 UK126	0.369
Sedna	0.418



Surface ESI Calculation

$$\text{augment}\left[\text{name, ESI}\left[\text{augment}\left(v_{\text{escape}}, T_{\text{Surface}}\right), \begin{pmatrix} 0.70 \\ 5.58 \end{pmatrix}, \begin{pmatrix} 1 \\ 288 \end{pmatrix}\right]\right] =$$

My results

	0	1
0	"Earth"	1
1	"Mars"	0.6
2	"Mercury"	0.42
3	"Venus"	0.2
4	"Jupiter"	0.24
5	"Ceres"	0.19
6	"Vesta"	0.15
7	"Saturn"	0.22
8	"Pallas"	0.13
9	"Uranus"	0.08
10	"Neptune"	0.07
11	"Pluto"	0.01
12	"2005 QU182"	0.01
13	"Quaoar"	0.01
14	"2002 TC302"	0.01
15	"Ixion"	0.01
16	"Orcus"	0.01
17	"Eris"	0.01
18	"Makemake"	0
19	"2007 OR10"	0
20	"2007 UK126"	0
21	"Sedna"	0

Web site results

Earth	1
Mars	0.595
Mercury	0.422
Venus	0.201
Jupiter	0.238
Ceres	0.18
Vesta	0.158
Saturn	0.217
Uranus	0.077
Neptune	0.067
Pluto	0.011
2005 QU182	0.009
Quaoar	0.009
2002 TC302	0.008
Ixion	0.009
Orcus	0.009
Eris	0.006
Makemake	0.005
2007 OR10	0.004
2007 UK126	0.005
Sedna	0



Global ESI Calculation

$$\text{augment} \left[\text{name, ESI} \left[\text{augment} \left(\frac{\text{radius}}{r_{\text{Earth}}}, \text{density}, v_{\text{escape}}, T_{\text{Surface}} \right), \begin{pmatrix} 0.57 \\ 1.07 \\ 0.7 \\ 5.58 \end{pmatrix}, \begin{pmatrix} 1 \\ 1 \\ 1 \\ 288 \end{pmatrix} \right] \right] =$$

My results

	0	1
0	"Earth"	1
1	"Mars"	0.697
2	"Mercury"	0.595
3	"Venus"	0.444
4	"Jupiter"	0.293
5	"Ceres"	0.277
6	"Vesta"	0.252
7	"Saturn"	0.245
8	"Pallas"	0.222
9	"Uranus"	0.187
10	"Neptune"	0.185
11	"Pluto"	0.075
12	"2005 QU182"	0.061
13	"Quaoar"	0.061
14	"2002 TC302"	0.057
15	"Ixion"	0.057
16	"Orcus"	0.056
17	"Eris"	0.054
18	"Makemake"	0.043
19	"2007 OR10"	0.044
20	"2007 UK126"	0.041
21	"Sedna"	0.013

Web site results

Earth	1
Mars	0.697
Mercury	0.596
Venus	0.444
Jupiter	0.292
Ceres	0.271
Vesta	0.256
Saturn	0.246
Uranus	0.187
Neptune	0.184
Pluto	0.075
2005 QU182	0.061
Quaoar	0.06
2002 TC302	0.057
Ixion	0.057
Orcus	0.054
Eris	0.054
Makemake	0.043
2007 OR10	0.043
2007 UK126	0.041
Sedna	0.013

