Homework 3: Comparative Planetology

Astronomy 140
(Based on the York College lab manual for ASTR140)

The members of the solar system are often separated into two groups: the Earthlike **terrestrial planets** (Mercury, Venus, Earth & Mars) and the **gas giants** (Jupiter, Saturn, Uranus & Neptune), which are Jovian, or like Jupiter. Along with the major 8 planets are other bodies in the solar system that are more difficult to categorize, such as Pluto, asteroids and comets. Consider the following:

- What are the overall properties of solar system bodies and their orbits?
- Do the different classes of object share any characteristics?
- What properties distinguish terrestrial and gas planets?
- How do Pluto, comets and asteroids compare to the major planets?

Data

The data are listed in the following **graphs** and tables. They are organized more or less into general categories of orbits, basic physical properties, rotation information and satellites. The largest **asteroid**, Ceres, and the famous **comet** Halley are also included.

Look for correlations between the different properties (for example, are the largest planets generally the most massive?).

New Terms

A few terms have not yet been covered in class:

Albedo: The reflectivity of the visible surface (1 = 100% reflective = shiny, and 0 = completely absorbing = black).

Oblateness: The difference from a spherical shape: 

Obliquity: The angle between a planet's equator and the ecliptic (23.5° for Earth).

Exercises

Please answer on a separate sheet. Refer mostly to the **graphs** to answer the questions unless explicitly directed to use the tables. Each question is worth 5 points.

Orbits

1. Discuss the distinctions between the **orbital sizes** and **orbital periods** of the terrestrial and gas planets. Are the two groups distinguishable by their orbits?

2. Using the values of *a* and *P* for at least 3 planets, verify **Kepler's third law**. (Hint: the value of P^2/a^3 should be the same for all of them.)

3. To which group does **Pluto** seem to fit based on its orbit?

4. Do **comets** distinguish themselves by their orbital properties? Which properties are unusual compared to the planets?

5. Do the other **minor bodies** Ceres and Pluto also have any of these unusual orbital properties? If so, which one(s)?

Physical Data

6. Discuss the terrestrial/gas giant distinctions based on their **sizes**, **masses** and **densities**.

7. Based on these data, why do you think Jupiter has so many **moons** and Venus has none?

8. Can we conclude anything about the **composition** of the planets based on these data? Please explain.

9. Based on these data, does **Pluto** most resemble a terrestrial or gas planet?

10. Do the other **minor bodies** Ceres and comet Halley fit into either group based on these data? If so, to which do they belong? (Note that they may not belong to the same group.)

11. Refer to the **data table**. Do the planets resemble the **Sun** in any way? If so, list which properties are similar and for which planets. (Be careful about exponential notation: 3E+04 means 3,000 or "a 3 with 4 zeroes after it.")

Rotation

12. Discuss the terrestrial/gas giant distinctions based on their **rotation speeds**, **oblateness** and **magnetic fields**.

13. Do you see any connection between **rotation** and **magnetic field** strength? If so, please explain. Be careful not to include any bodies without this information (refer to the table).

14. Give 2 reasons explaining why **Saturn** is so **oblate** or flattened (see Figure 12.1c, page 303 in your text). You will need to refer to other graphs. It may be helpful to consider why it is more oblate than Jupiter.

15. To which group, terrestrial or Jovian, do the **minor bodies** Pluto, Ceres and comet Halley seem to fit based on these data? (They may not all belong to the same group.)

Temperature

16. Discuss the terrestrial/gas giant distinctions based on their **temperatures** and **albedos**.

17. Since albedo indicates how much sunlight is absorbed by a planet, we should expect some trend between **albedo** and **temperature**. Is one apparent? If not, which property or properties seem(s) important for determining temperature? You will need to refer to other graphs.

18. Why do **Venus** and the **Earth** have steady day/night temperatures, but **Mars**, which is similar in many respects, does not? You may need to refer to the table and your book for supplemental information (Sections 7.2, 9.5 and 10.5).

19. Give 2 reasons why **Mercury** has such an enormous **day/night difference** in temperature. You will need to refer to other graphs and the table.

Pluto's status

20. Please answer the following question concisely and completely, using full sentences and proper grammar, and in *only 100–200 words*. Do you think **Pluto** should be considered a full-fledged **planet** like the Earth or Jupiter, or a **minor body** like a comet or asteroid? Your answer should not rely solely on your gut feeling or opinion! Please refer to the **data** you have been examining and cite **examples**. You may want to refer to your book for more information (Sections 13.8–13.10) but rely mostly on the data from this lab and use your own words.

Comparative Planetology Data

	Star	Terrestrial Planets				Gas Giants					Asteroid	Comet
Orbits	Sun	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune	Pluto	Ceres	Halley
semi-major axis (AU)		0.39	0.72	1	1.52	5.2	9.54	19.18	30.06	39.44	2.77	17.80
period (yr)		0.24	0.62	1	1.88	11.86	29.46	84.01	164.8	248.6	4.60	76.6
eccentricity		0.206	0.007	0.017	0.093	0.048	0.056	0.047	0.009	0.249	0.079	0.967
inclination (°)		7.00	3.39	0.01	1.85	1.31	2.49	0.77	1.77	17.2	10.58	52.04

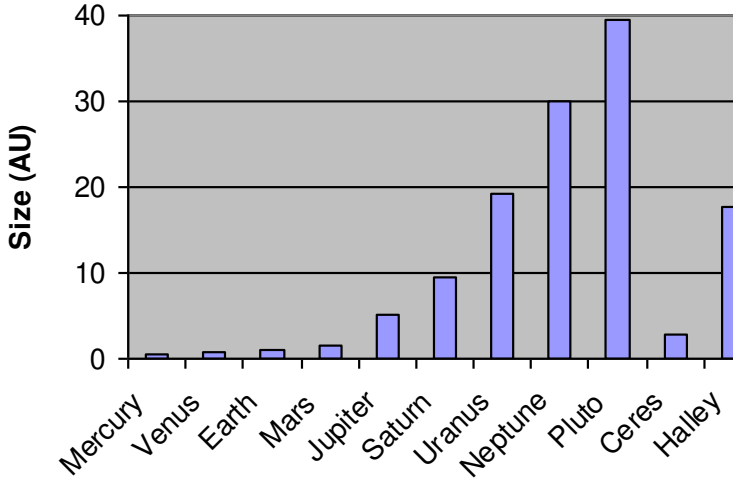
Physical Data	Sun	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune	Pluto	Ceres	Halley
radius (km)	696,000	2,440	6,052	6,378	3,394	71,492	60,268	25,559	24,766	1,137	480	16
mass (kg)	2E+30	3E+23	5E+24	6E+24	6E+23	2E+27	6E+26	9E+25	1E+26	1E+22	9E+20	1E+14
mass/Earth's	333,333	0.06	0.82	1	0.11	318.26	95.14	14.54	17.09	0.002	0.0001	2E-11
density (kg/m^3)	1410	5430	5240	5520	3930	1330	690	1270	1640	2060	2700	170

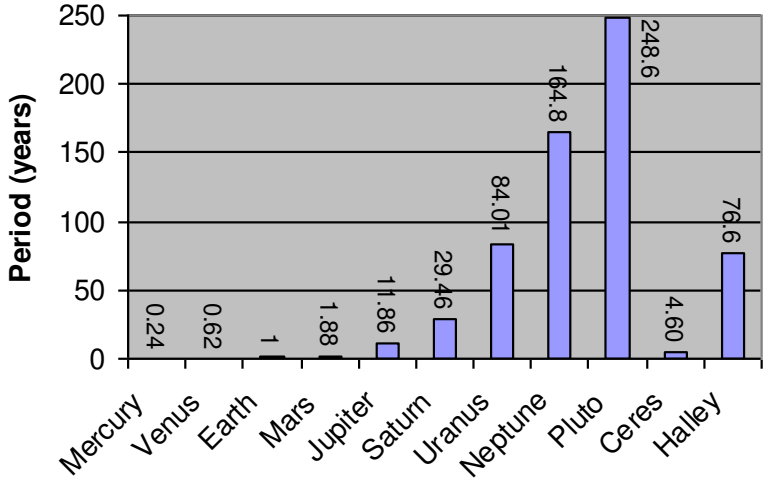
Rotation	Sun	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune	Pluto	Ceres	Halley
rotation rate (days)	30	58.6	243	0.9973	1.026	0.41	0.44	0.72	0.67	6.39	0.378	2.17
rotation speed (km/hr)	6,074	11	7	1,674	866	45,650	35,859	9,294	9,677	47	332	2
oblateness	0	0	0	0.0034	0.0052	0.062	0.096	0.06	0.02	0		
magnetic field (gauss)	3000	0.003	0	0.31	0.0004	4.28	0.22	0.23	0.13			
obliquity (°)	7.3	0.0	-2.6	23.5	25.2	3.1	26.7	-82.0	29.0	-58.0	10	

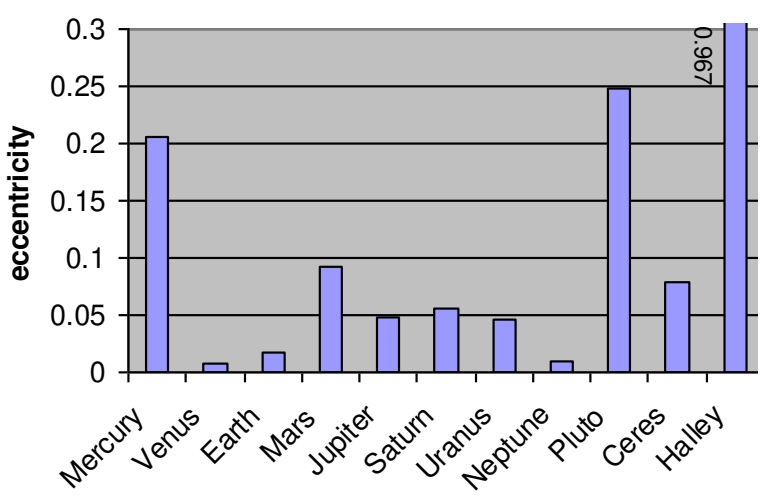
Temperature	Sun	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune	Pluto	Ceres	Halley
Albedo		0.06	0.76	0.4	0.16	0.51	0.5	0.66	0.62	0.5	0.073	0.04
day surf. temp. (K)	5770	700	730	290	300	124	97	58	56	40		330
night surf. temp. (K)		100	730	290	210	124	97	58	56	40		

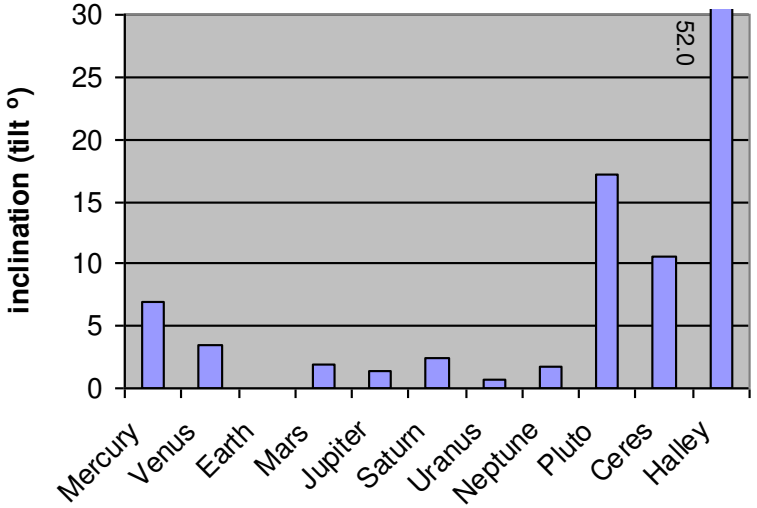
Extras	Sun	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune	Pluto	Ceres	Halley
satellites	zillions	0	0	1	2	63	37	27	13	3	0	0
rings	yes	no	no	no	no	yes	yes	yes	yes	no	no	no
atmosphere	all gas	no	thick	thick	thin	all gas	all gas	all gas	all gas	thin?	no	rarely

Orbits

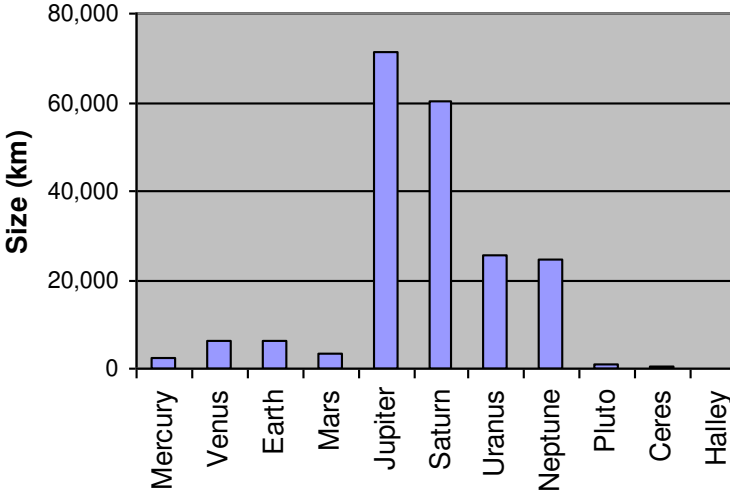

Size (AU)
40
30
20
10
0
Mercury
Venus
Earth
Mars
Jupiter
Saturn
Uranus
Neptune
Pluto
Ceres
Halley

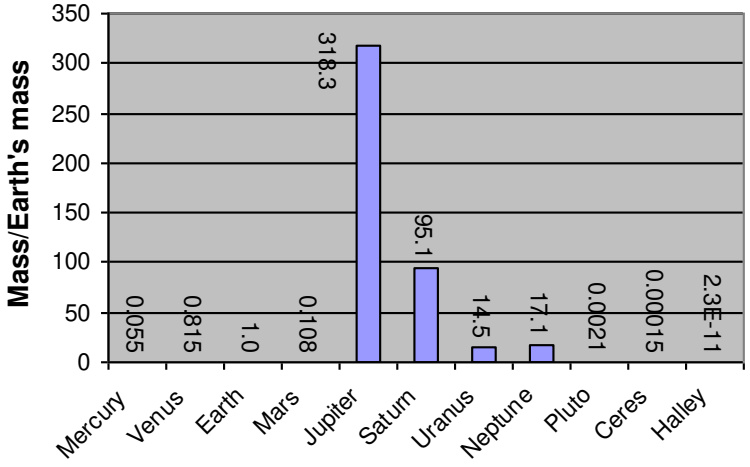

Period (years)
250
200
150
100
50
0
0.24
0.62
1
1.88
11.86
29.46
84.01
164.8
248.6
4.60
76.6
Mercury
Venus
Earth
Mars
Jupiter
Saturn
Uranus
Neptune
Pluto
Ceres
Halley

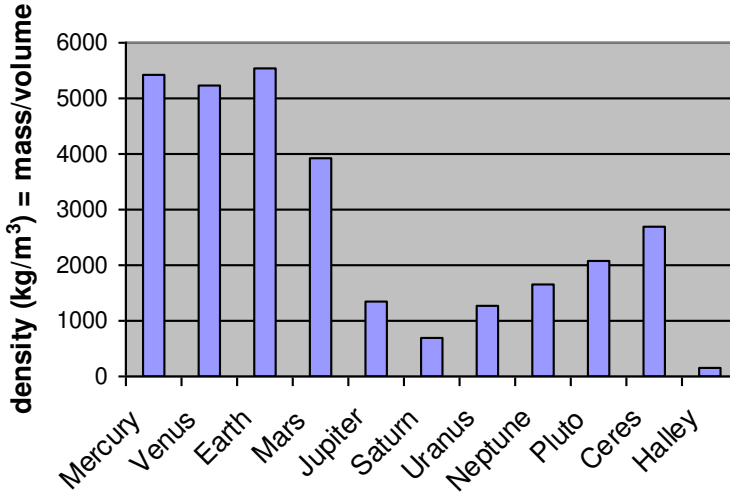

eccentricity
0.3
0.25
0.2
0.15
0.1
0.05
0
0.967
Mercury
Venus
Earth
Mars
Jupiter
Saturn
Uranus
Neptune
Pluto
Ceres
Halley

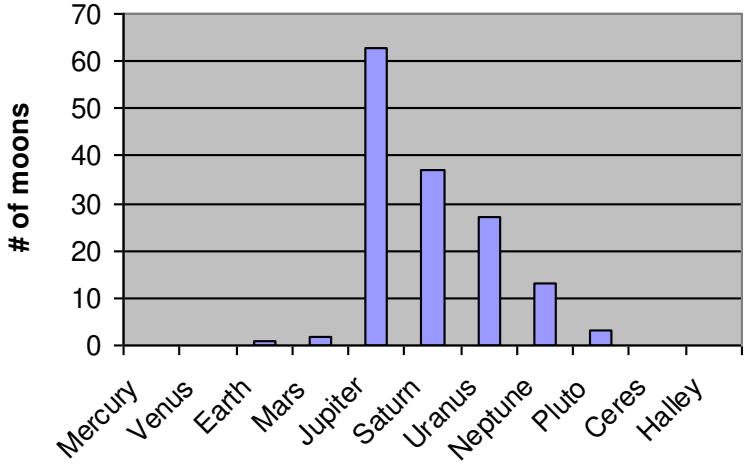

inclination (tilt °)
30
25
20
15
10
5
0
52.0
Mercury
Venus
Earth
Mars
Jupiter
Saturn
Uranus
Neptune
Pluto
Ceres
Halley

Physical Data

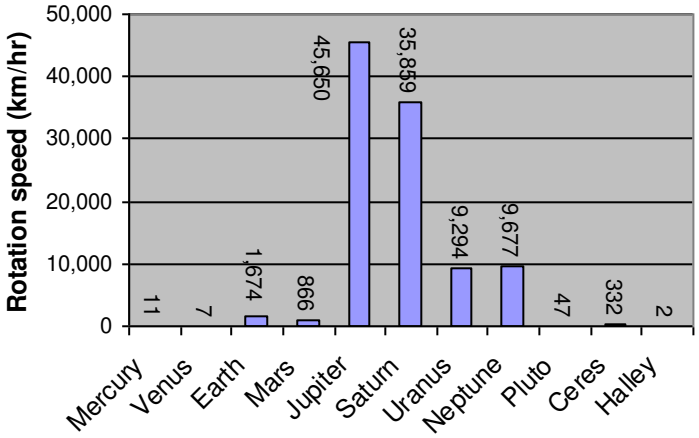


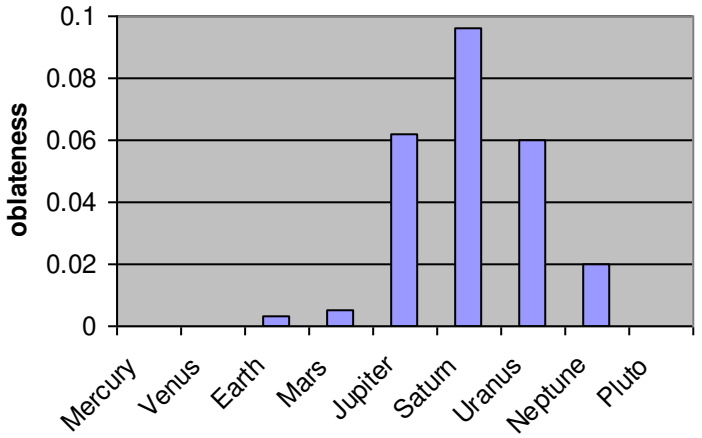


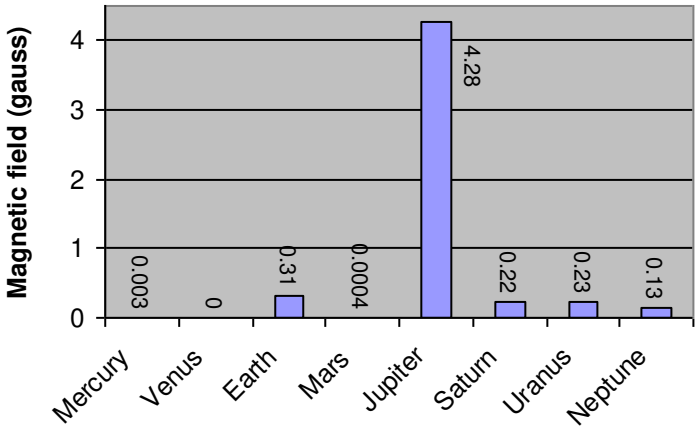


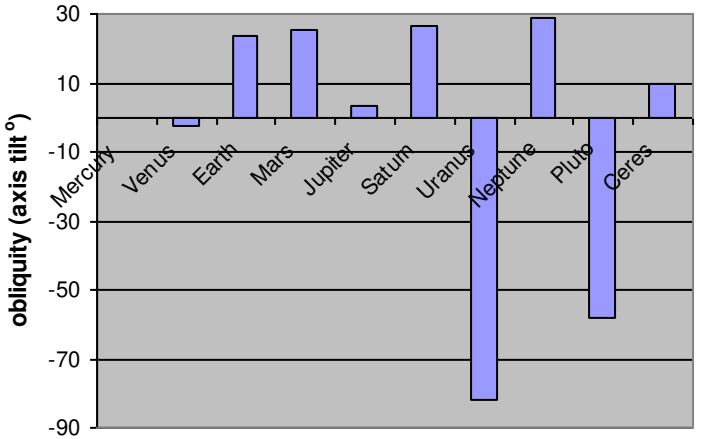


Rotation


Rotation speed (km/hr)
50,000
40,000
30,000
20,000
10,000
0
11
7
1,674
866
45,650
35,859
9,294
9,677
47
332
2
Mercury
Venus
Earth
Mars
Jupiter
Saturn
Uranus
Neptune
Pluto
Ceres
Halley


oblateness
0.1
0.08
0.06
0.04
0.02
0
Mercury
Venus
Earth
Mars
Jupiter
Saturn
Uranus
Neptune
Pluto


Magnetic field (gauss)
4
3
2
1
0
0.003
0
0.31
0.0004
4.28
0.22
0.23
0.13
Mercury
Venus
Earth
Mars
Jupiter
Saturn
Uranus
Neptune


obliquity (axis tilt °)
30
10
-10
-30
-50
-70
-90
Mercury
Venus
Earth
Mars
Jupiter
Saturn
Uranus
Neptune
Pluto
Ceres

Temperature