

Introductory Astronomy

NAME:

Homework 16: Small Bodies of the Inner Solar System and Target Earth : Homeworks and solutions are posted on the course web site. Homeworks are **NOT** handed in and **NOT** marked. But many homework problems ($\sim 50\text{--}70\%$) will turn up on tests.

Answer Table

	a	b	c	d	e		a	b	c	d	e
1.	O	O	O	O	O	37.	O	O	O	O	O
2.	O	O	O	O	O	38.	O	O	O	O	O
3.	O	O	O	O	O	39.	O	O	O	O	O
4.	O	O	O	O	O	40.	O	O	O	O	O
5.	O	O	O	O	O	41.	O	O	O	O	O
6.	O	O	O	O	O	42.	O	O	O	O	O
7.	O	O	O	O	O	43.	O	O	O	O	O
8.	O	O	O	O	O	44.	O	O	O	O	O
9.	O	O	O	O	O	45.	O	O	O	O	O
10.	O	O	O	O	O	46.	O	O	O	O	O
11.	O	O	O	O	O	47.	O	O	O	O	O
12.	O	O	O	O	O	48.	O	O	O	O	O
13.	O	O	O	O	O	49.	O	O	O	O	O
14.	O	O	O	O	O	50.	O	O	O	O	O
15.	O	O	O	O	O	51.	O	O	O	O	O
16.	O	O	O	O	O	52.	O	O	O	O	O
17.	O	O	O	O	O	53.	O	O	O	O	O
18.	O	O	O	O	O	54.	O	O	O	O	O
19.	O	O	O	O	O	55.	O	O	O	O	O
20.	O	O	O	O	O	56.	O	O	O	O	O
21.	O	O	O	O	O	57.	O	O	O	O	O
22.	O	O	O	O	O	58.	O	O	O	O	O
23.	O	O	O	O	O	59.	O	O	O	O	O
24.	O	O	O	O	O	60.	O	O	O	O	O
25.	O	O	O	O	O	61.	O	O	O	O	O
26.	O	O	O	O	O	62.	O	O	O	O	O
27.	O	O	O	O	O	63.	O	O	O	O	O
28.	O	O	O	O	O	64.	O	O	O	O	O
29.	O	O	O	O	O	65.	O	O	O	O	O
30.	O	O	O	O	O	66.	O	O	O	O	O
31.	O	O	O	O	O	67.	O	O	O	O	O
32.	O	O	O	O	O	68.	O	O	O	O	O
33.	O	O	O	O	O	69.	O	O	O	O	O
34.	O	O	O	O	O	70.	O	O	O	O	O
35.	O	O	O	O	O	71.	O	O	O	O	O
36.	O	O	O	O	O	72.	O	O	O	O	O

Name:

001 qmult 00007 1 4 1 easy deducto-memory: reading-homework-self-testing done 2

1. Did you complete reading-homework-self-testing for the Introductory Astronomy Lecture (IAL) by the weekly due date?

a) YYYesssss! b) Jawohl! c) Da! d) Sí, sí. e) OMG no!

SUGGESTED ANSWER: (a),(b),(c),(d)

Wrong answers:

- e) As Lurch would say AAAARGH.

Redaction: Jeffery, 2008jan01

016 qmult 00100 1 4 3 easy deducto-memory: meteor/oid/rite

Extra keywords: Do NOT capitalize the boldface words. It would look bad.

2. Let's get the terminology straight once and for all.

- a) **METEORS** travel in space, **METEORIODS** shoot in the sky, and **METEORITES** hit the Earth.
 b) **METEORIODS** travel in space, **METEORITES** shoot in the sky, and **METEORS** hit the Earth.
 c) **METEORIODS** travel in space, **METEORS** shoot in the sky, and **METEORITES** hit the Earth.
 d) **METEOROLOGY** travels in space, **METEORLIGHTS** shoot in the sky, and **METEOREALIS** hits the Earth.
 e) **METEOROLOGY** travels in space, **METEORLIGHTS** shoot in the sky, and **MONTREAL** hits the Earth.

SUGGESTED ANSWER: (c) General knowledge and elimination help.

Wrong answers:

- e) Required Canadian content.

Redaction: Jeffery, 2001jan01

016 qmult 00300 1 4 4 easy deducto-memory: largest asteroid Ceres 1

3. The largest asteroid (i.e., non-comet minor planet confined within about the orbit of Jupiter) is:

a) Uranus. b) Io. c) Comet Halley. d) Ceres. e) Chicago.

SUGGESTED ANSWER: (d) Ceres is now also classified as a dwarf planet, but it's still an asteroid.

Wrong answers:

- a) A planet.
 b) A non-asteroidal moon of Jupiter.
 c) A comet clearly.
 e) A real asteroid according to Se-559, but obviously not a big one.

Redaction: Jeffery, 2001jan01

016 qmult 00510 1 1 4 easy memory: asteroid size distribution

4. The size distribution of asteroids is given in the following table.

Table: Approximate Number of Asteroids N Larger than Mean Diameter D

D (km)	N	D (km)	N
900	1	10.0	10,000
500	3	5.0	90,000
300	6	3.0	X

200	28	1.0	750,000
100	200	0.5	2×10^6
50	600	0.3	4×10^6
30	1100	0.1	25×10^6

NOTE.—The numbers for diameters larger than 500 km are exact counts. The numbers for diameters larger than 300 km and 200 km are nearly exact counts. The only source of uncertainty is that the mean diameters of asteroids are a bit uncertain and asteroids near the diameter bin boundaries lines may be marginally in the wrong diameter bin. It is likely that all asteroids larger than about 100 km have been discovered, but the table only gives approximate numbers for the bins from 100 km down in mean diameter. As the mean diameter get smaller, the number of asteroids become more and more uncertain. The sources are Wikipedia articles *Asteroid* and *List of Notable Asteroids*. The asteroids are the small rocky bodies inward of about Jupiter’s orbits that are not moons. Below about 10 meters in size scale, small bodies are considered meteoroids rather than asteroids, but there seems to be no exact lower cut-off for asteroid mean diameter.

The **UNSPECIFIED** asteroid number X in the table must be:

- a) 2. b) 20. c) 200. d) 200,000. e) 20×10^6 .

SUGGESTED ANSWER: (d)

Wrong answers:

- a) We know that there must be more than 90,000.

Redaction: Jeffery, 2008jan01

016 qmult 00600 1 4 3 moderate deducto-memory: asteroid origin

5. Asteroids (i.e., minor planets confined within about the orbit of Jupiter) are probably mainly:

- a) icy planetesimals left over from the formation of the Solar System.
 b) fragmented or unfragmented icy planetesimals or protoplanets left over from the formation of the Solar System.
 c) fragmented or unfragmented rocky planetesimals or protoplanets left over from the formation of the Solar System.
 d) star-like objects beyond the orbit of Pluto.
 e) star-like objects closer to the Sun than the orbit of Mars.

SUGGESTED ANSWER: (c)

Wrong answers:

- e) As Lurch would say: “Aaaarh.”

Redaction: Jeffery, 2001jan01

016 qmult 00700 1 4 1 moderate deducto-memory: Asteroid Belt location

6. The Asteroid Belt is located:

- a) between the orbits of Mars and Jupiter. b) between the orbits of Mercury and Venus.
 c) beyond the orbit of Pluto. d) inside the Sun. e) between the Sun and the orbit of Vulcan.

SUGGESTED ANSWER: (a)

Wrong answers:

- b) Nah.
 c) That’s the Kuiper Belt.
 d) Vaya.
 e) There is no Vulcan other than on *Star Trek*. But some folks once thought there might be a Vulcan, a planet closer to the Sun than Mercury.

Redaction: Jeffery, 2001jan01

016 qmult 00710 1 4 2 easy deducto-memory: asteroid asymmetry

7. An asteroid less than 300 km in size scale:

- a) must be spherical. b) can be asymmetric. c) must be cubical. d) must be green.
e) must be tetrahedral.

SUGGESTED ANSWER: (b)

Actually, larger than 300 km in size can be asymmetric too. But 300 km is probably roughly the dividing line if one had to choose.

Wrong answers:

- e) A four-sided figure with each side being triangular. It's a triangular pyramid.

Redaction: Jeffery, 2001jan01

016 qmult 00800 3 3 4 tough math: meteoroid kinetic energy

8. The kinetic energy of a body of speed v and mass m is given by the formula

$$E_{\text{kin}} = \frac{1}{2}mv^2 .$$

A typical meteoroid (a small body in space: it becomes a meteor in precise speech only when it penetrates the Earth's atmosphere) has a speed of order 30 km/s = 30,000 m/s relative to the Earth. Given that it has a mass of **1 g (note: 1 gram)**, what is the kinetic energy of this typical meteoroid? (Note that a 1 kg mass falling 1 m under the force of gravity near the Earth's surface acquires about 10 J of kinetic energy.)

- a) 10 J. b) 4.5×10^8 J. c) 9×10^8 J. d) 4.5×10^5 J. e) 9×10^5 J.

SUGGESTED ANSWER: (d)

The trick is to get the units right. Students have to know that grams must be converted to kilograms. Behold:

$$E_{\text{kin}} = \frac{1}{2}mv^2 = 0.5 \times 10^{-3} * (3 \times 10^4)^2 = 4.5 \times 10^5 \text{ J} .$$

Wrong answers:

- e) You forgot the 1/2.

Redaction: Jeffery, 2001jan01

016 qmult 00900 2 5 2 moderate thinking: asteroid discovery

9. The asteroids (i.e., minor planets confined within about the orbit of Jupiter) which were discovered early on are much larger than typical asteroids we discover today. Why?

- a) The biggest asteroids are more easily resolved. Thus they were found first.
b) The biggest asteroids tend to reflect the most sunlight, and thus they are brighter and more obvious. Therefore they were found first.
c) The biggest asteroids are simply much more numerous. Thus, the odds are that the biggest asteroids would be discovered first.
d) The biggest asteroids were found first just by accident.
e) The biggest asteroids cause huge gravitational perturbations of Jupiter's orbit. Early 17th century mathematical astronomers were able to deduce the approximate positions of the biggest asteroids. Subsequent searches quickly found these bodies.

SUGGESTED ANSWER: (b)

Wrong answers:

- a) Even the biggest asteroids aren't usually resolved. Ceres at opposition is only 0.732 arcseconds. And even if they are resolved, there disks hardly an eye-catcher.
c) No the biggest asteroids are least numerous.
d) No, the biggest ones were easy to find because of (b)
e) Can the minute asteroids that altogether total about 0.0003 Earth masses (Cox-293) perturb massive Jupiter significantly enough for anyone to calculate their positions? Well I don't know, but I doubt it. Anyway early Seventeenth century astronomers didn't have the Newton's laws of motion and gravity and couldn't have done the job.

Redaction: Jeffery, 2001jan01

016 qmult 01000 2 4 2 moderate deducto-memory: asteroid radioactive

10. Why couldn't radioactive potassium-40 (^{40}K : half-life 1.251(3) Gyr), thorium-232 (^{232}Th : half-life 14.05 Gyr), uranium-235 (^{235}U : half-life 0.7038 Gyr) uranium-238 (^{238}U : half-life 4.468 Gyr) have melted the rocky planetesimals (which were the parent bodies for the asteroids) and caused them to chemically differentiate?
- Because of their small size, the planetesimals will lose heat **SLOWLY** through their surface to space. Thus the heat from radioactive species with long half-lives cannot accumulate sufficiently to melt the planetesimals. It has been hypothesized that radioactive aluminum-26 (^{26}Al : half-life 0.717 Myr), which releases heat relatively quickly, accounts for heat accumulation sufficiently rapid to cause planetesimal melting.
 - Because of their small size, the planetesimals will lose heat **RAPIDLY** through their surface to space. Thus the heat from radioactive species with long half-lives cannot accumulate sufficiently to melt the planetesimals. It has been hypothesized that radioactive aluminum (^{26}Al : half-life 0.717 Myr), which releases heat relatively quickly, accounts for heat accumulation sufficiently rapid to cause planetesimal melting.
 - None of these radioactive isotopes were contained in the material that formed the planetesimals in the Asteroid Belt area of the Solar System. The radioactive isotopes are all highly **NON-VOLATILE**, and so **ONLY** condensed in the **INNER REGION** of the Solar System where almost all the material got incorporated into rocky planets. The radioactive isotopes in the rocky planets, of course, help to melt and elementally differentiate them.
 - None of these radioactive isotopes were contained in the material that formed the planetesimals in the Asteroid Belt area of the Solar System. The radioactive isotopes are all highly **VOLATILE**, and so **ONLY** condensed in the **FAR OUTER REGION** of the Solar System where almost all the material got incorporated into Uranus, Neptune, and icy planetesimals (Pluto being considered the largest of these). The radioactive isotopes in these gas giant planets and icy planetesimals, of course, help to melt and elementally differentiate them.
 - There is no known reason why they couldn't have. That they didn't is a mystery.

SUGGESTED ANSWER: (b) See Se-557.

The key point is that small bodies lose heat quickly.

Wrong answers:

- rapidly not slowly.
- Non-volatile elements condense out everywhere and these radioactive elements are non-volatile although potassium is chemically highly reactive which I guess means it's usually chemically bound to something else.
- These elements are not volatiles and students should recall that they are thought to help melt the inner planets.
- It's not a mystery. See the correct answer (b).

Redaction: Jeffery, 2001jan01

016 qmult 01500 1 4 5 easy deducto-memory: dinosauricidal Chicxulub

11. The supposed dinosauricidal impactor hit near:
- the Tunguska region in Siberia.
 - Flagstaff, Arizona.
 - Sudbury, Ontario.
 - Oak Ridge, Tennessee.
 - Chicxulub on the Yucatán Peninsula.

SUGGESTED ANSWER: (e)

Wrong answers:

- That was in 1908.

Redaction: Jeffery, 2001jan01

016 qmult 01510 1 4 3 easy deducto-memory: shoemaker-levy 9

12. "Let's play *Jeopardy!* For \$100, the answer is: This fragmented comet impacted on Jupiter in 1994."
 What is Comet _____, Alex?

- a) Tunguska b) Halley c) Shoemaker-Levy 9 d) Cobble-Dam IX e) Hale-Bopp

SUGGESTED ANSWER: (c)

Wrong answers:

- d) Sort of a synonym for the right answer.

Redaction: Jeffery, 2001jan01

016 qmult 01600 2 4 3 easy deducto-memory: impactor cube-law

13. Why is a 100-meter diameter Earth-bound impactor much more worrisome than a 10-meter diameter one?

- a) Mass and kinetic energy tend to be proportional to **DIAMETER**. The 100-meter impactor will thus tend to be ten times more devastating than the 10-meter one.
 b) Mass and kinetic energy tend to be proportional to the **SQUARE OF DIAMETER**. The 100-meter impactor will thus tend to be a hundred times more devastating than the 10-meter one.
 c) Mass and kinetic energy tend to be proportional to the **CUBE OF DIAMETER**. The 100-meter impactor will thus tend to be a thousand times more devastating than the 10-meter one.
 d) It is not more worrisome. The bigger the impactor, the less effect on the target.
 e) The smaller impactors always land in the oceans.

SUGGESTED ANSWER: (c)

Wrong answers:

- a) Mass and kinetic energy tend to go like the cube.
 b) Mass and kinetic energy tend to go like the cube.
 d) Not likely.
 e) No they don't.

Redaction: Jeffery, 2001jan01

016 qmult 01700 1 4 1 easy deducto-memory: asteroid 1950 DA

14. "Let's play *Jeopardy!* For \$100, the answer is: On date 2880 Mar16, this asteroid has a very small probability ($\sim 1/34000$ as of 2022) of making a continentally devastating impact on Earth."

What is _____, Alex?

- a) 1950 DA b) Ceres c) Shoemaker-Levy 9 d) Sedna e) Eros

SUGGESTED ANSWER: (a)

Wrong answers:

- b) Ceres at diameter 913 km would really rock us.

Redaction: Jeffery, 2001jan01