

## Astronomy 102A

**Homework 1: Scientific Notation, Units, Math, Angles, Plots, Motion, Orbits** Not to be handed in. Homework solutions are posted already.

001 qmult 00050 1 3 2 easy math: scientific notation

1. The quantity  $2.9979 \times 10^{10}$  cm/s is the same as:
- a) 29979000 cm/s.      b) 29979000000 cm/s.      c)  $2.9979 \times 10^{10}$  km/s.      d) the speed of sound.  
e) 2.9979 cm/s.

**SUGGESTED ANSWER:** (b) All the student needs to know is scientific notation and units.

**Wrong answers:**

- c) Same number, different units: not the same quantity.  
d) It's the speed of light, not sound.

**Redaction:** Jeffery, 2001jan01

001 qmult 00070 1 4 3 easy deducto-memory: SI and MKS

2. "Let's play *Jeopardy!* For \$100, the answer is: The international standard units for science and probably the most common subset of these units."

What are the \_\_\_\_\_ units and \_\_\_\_\_ units, Alex?

- a) British Imperial; Btu      b) SI; HMS      c) SI; MKS      d) British Imperial; MKS  
e) ancient Babylonian; HMS

**SUGGESTED ANSWER:** (c)

**Wrong answers:**

- b) HMS could be hectometers, milligrams, and seconds or Her Majesty's Ship.

**Redaction:** Jeffery, 2001jan01

001 qmult 00100 1 4 4 easy deducto-memory: light-year definition

3. A light-year is:
- a) the opposite of a leap year.      b) less filling.      c) the cause of eclipses.      d) the distance light travels in one year.  
e) the time it takes the Earth to return to the same point relative to the fixed stars.

**SUGGESTED ANSWER:** (d) A super easy deducto-memory question: the answer is the definition.

**Wrong answers:**

- b) That's beer not year.  
e) That's a sidereal year.

**Redaction:** Jeffery, 2001jan01

001 qmult 00110 1 1 1 easy memory: parsec

4. A parsec (pc) is:
- a) about 3 light-years.      b) the same as a light-year.      c) about the same as a light-year.  
d) the distance light travels in a year.      e) about 2 light-years.

**SUGGESTED ANSWER:** (a)

**Wrong answers:**

d) This is what a light year is.

**Redaction:** Jeffery, 2001jan01

001 qmult 00150 2 5 4 moderate thinking: micro-century lecture

**Extra keywords:** Requires deduction, but a calculation works too.

5. “Let’s play *Jeopardy!* For \$100, the answer is: The approximate length of a standard university lecture as pointed out by Nobel-prize-winning physicist Enrico Fermi.”

What \_\_\_\_\_, Alex?

- a) is a century      b) seems like a century      c) is a centi-century      d) is a micro-century  
e) is a milli-century

**SUGGESTED ANSWER:** (d) This interesting tidbit is mentioned by HRW-9. In fact the question can be answered by deduction: a centi-century is a year; a milli-century is a bit more than a month. Thus the only possible answer is a micro-century.

We can do the calculation:

$$\begin{aligned} & 10^{-6} \times 100 \text{ years} \times 365.25 \text{ days/year} \times 1440 \text{ minutes/day} \\ & = 3.6525 \times 1.440 \times 10^1 \text{ minutes} \\ & = 52.596 \text{ minutes} \approx 50 \text{ minutes} \end{aligned}$$

which is indeed a standard lecture. As Marilyn Monroe said in *Some Like it Hot*, “it makes a girl think.”

**Wrong answers:**

- a) C’mon.  
b) I am not prepared to accept this answer.  
c) It may seem like this too.  
e) I’m sure it never seems like this.

**Redaction:** Jeffery, 2001jan01

001 qmult 00200 1 3 4 easy math: light-minute

6. About how many kilometers are there in a light-minute? Recall the speed of light is  $2.9979 \times 10^{10}$  cm/s.

- a)  $2.9979 \times 10^{10}$  km.      b)  $3 \times 10^{10}$  km.      c)  $1.8 \times 10^{12}$  km.      d)  $1.8 \times 10^7$  km.      e)  $3 \times 10^7$  km.

**SUGGESTED ANSWER:** (d) An easy math question:

$$60 \times 3 \times 10^5 \text{ km/s} = 1.8 \times 10^7 \text{ km} .$$

Students do need to know that  $10^5$  cm = 1 km.

**Wrong answers:**

- a) C’mon.

**Redaction:** Jeffery, 2001jan01

001 qmult 00210 1 3 3 easy math: length of day in seconds

7. “Let’s play *Jeopardy!* For \$100, the answer is: 86400.”

What is the length of \_\_\_\_\_ in seconds, Alex?

- a) a minute      b) an hour      c) a day      d) a year      e) four score and sevens years

**SUGGESTED ANSWER:** (c)

**Wrong answers:**

- d) The length of a year in seconds is  $\pi \times 10^7$  to within 0.5 %.

**Redaction:** Jeffery, 2001jan01

001 qmult 00300 1 1 1 easy memory: astronomical unit

8. The mean distance from the Earth to the Sun in astronomical units (AU) is:

- a) 1 AU.      b) 40 AU.      c)  $1.496 \times 10^{13}$  cm.      d) 1.5 AU.      e) 8 arcminutes.

**SUGGESTED ANSWER:** (a) Super-easy memory question.

**Wrong answers:**

- c) This not in AU.

**Redaction:** Jeffery, 2001jan01

001 qmult 00400 1 4 1 easy deducto-memory: relevant physical scales

9. Name three astronomically relevant physical scales.

- a) The Earth-Moon distance, the Earth-Sun distance, and the radius of the Galactic disk.  
 b) The Earth-Moon distance, the Earth-Sun distance, and the length of a snail's trail.  
 c) The Earth-Moon distance, the Earth-Paris distance, and the length of a snail's trail.  
 d) The Earth-Moon distance, the Earth-Sun distance, and the Las Vegas-Reno distance.  
 e) The Earth-Moon distance and the Earth-Sun distance.

**SUGGESTED ANSWER:** (a)

**Wrong answers:**

- b) A snail's trail!

**Redaction:** Jeffery, 2001jan01

001 qmult 00500 1 4 4 easy deducto-memory: irrelevant physical scale

10. Name a physical scale that is **NONE** too relevant to astronomy.

- a) The Earth-Moon distance.  
 b) The Earth-Sun distance.  
 c) The radius of the Galactic disk.  
 d) The Las Vegas-Reno distance.  
 e) The radius of the Galactic halo. The Galactic halo is a spherical mass distribution surrounding the Galactic disk. It has relatively little luminous matter, but apparently a lot of dark matter.

**SUGGESTED ANSWER:** (d)

**Wrong answers:**

- a) C'mon

**Redaction:** Jeffery, 2001jan01

001 qmult 00600 1 3 2 easy math: Earth speed on equator

11. The Earth rotates once a day and has an equatorial radius of 6378 km. What is the speed of a point on the equator relative to a system orbiting with the Earth, but not rotating?

a) 1 km/s.    b) 0.46 km/s.    c)  $3 \times 10^5$  km/s.    d) 1 km.    e) 0.46 km.

**SUGGESTED ANSWER:** (b) In this question we can ignore the small difference between solar and sidereal day. It makes most sense to use the sidereal day, but that day is a bit less than the 24 hour standard solar day. In fact the standard solar day is actually a bit less than the true mean solar day. The solar day is slowly increasing in time and the standard solar day was chosen to agree with the true mean solar day of about 1900.

Fortran Code

```

print*
pi=acos(-1.)
radeartheq=6.378136e+6 ! Cox-340
daysec=86400.
daysid=.99726968
veq=2.*pi*radeartheq/daysec ! This is, of course relative to Sun.
print*, 'The synodic equatorial speed is ',veq ! 463.831 m/s
veq=2.*pi*radeartheq/(daysec*daysid) ! This is relative to fixed stars
print*, 'The sidereal equatorial speed is ',veq ! 465.101 m/s
acf=veq**2/radeartheq
print*, 'The equatorial centrifugal force per mass is ',acf ! 3.39157E-02

```

**Wrong answers:**

- c) This is the speed of light.
- d) Wrong units.
- e) Wrong units.

**Redaction:** Jeffery, 2001jan01

001 qmult 00620 2 5 4 moderate thinking: falling speed

12. The acceleration due to gravity of a free-falling object on the surface of the Earth is  $g = 9.8 \text{ m/s}^2$ . If an object falls from rest and one can neglect air resistance, what is its speed after 3 seconds?

a)  $9.8 \text{ m/s}^2$ .    b) 9.8 m/s.    c) 0.1 m/s.    d) about 30 m/s.    e) 98 m/s.

**SUGGESTED ANSWER:** (d) A rate times a time gives the amount. In this case

$$v = gt = 9.8 \text{ m/s}^2 \times 3 \text{ s} = 29.4 \approx 30 \text{ m/s} .$$

**Wrong answers:**

- a) Wrong units.

**Redaction:** Jeffery, 2001jan01

001 qmult 00700 1 3 2 easy math: light travel time to Proxima Cen

13. Proxima Centauri is 4.2 light-years from the Earth. How many years does it take for light to travel from Proxima to Earth?

a) 4.2 light-years.    b) 4.2 years.    c) 4.2 seconds.    d) 8 minutes.    e) Millions of years.

**SUGGESTED ANSWER:** (b) A give away easy question, unless something is very wrong.

**Wrong answers:**

- a) Wrong units.

**Redaction:** Jeffery, 2001jan01

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001 qmult 00900 1 4 3 easy deducto-memory: Pluto-Sun distance

14. Pluto's mean distance from the Sun is about:

- a) 1 AU.
- b) 0.1 AU.
- c) 40 AU.
- d) 1 light-year.
- e) 1.2 AU.

**SUGGESTED ANSWER:** (c) Students will probably not remember the value. They must deduce the right answer. More exactly Pluto's mean distance from the Sun is 39.44 AU.

**Wrong answers:**

- a) This is the Earth-Sun distance.
- b) This is less than the Earth-Sun distance and Pluto is an outer planet.
- d) Light-years are interstellar distances.
- e) 1.2 should seem way too close to Earth.

**Redaction:** Jeffery, 2001jan01

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001 qmult 01000 1 3 2 easy math: light travel time to Moon

15. The mean distance from the Moon to the Earth is  $3.844 \times 10^{10}$  cm and the speed of light is  $2.998 \times 10^{10}$  cm/s. How long does it take light to travel from the Moon to the Earth?

- a) 8 minutes.
- b) 1.28 seconds.
- c) No time at all.
- d) 30 seconds.
- e) 30 arcminutes.

**SUGGESTED ANSWER:** (b) An easy math question. But the students have to understand how speed time and distance relate:  $d = vt$ , and so  $t = d/v$ .

**Wrong answers:**

- a) 8 minutes, 20 seconds is about the time it takes light to travel from the Sun to the Earth.
- c) Light has a finite speed: this answer is impossible.
- e) An arcminute is an angular unit, not a time unit.

**Redaction:** Jeffery, 2001jan01

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001 qmult 01200 1 4 4 easy deducto-memory: Pluto and Neptune

16. Which is the outermost planet in our solar system from the Sun? Why is the outermost planet not always the same planet? **HINT:** You may have to look some information up.

- a) Pluto is always the outermost planet of the solar system.
- b) Uranus is always the outermost planet of the solar system.
- c) The outermost planet is either **PLUTO** or **URANUS**. Most of the time Pluto is the outermost planet, but because of its very elliptical orbit Pluto is sometimes within the orbit of Uranus and then Uranus is the outermost planet. In the period 1979 February 7 to 1999 February 11 Uranus was the outermost planet.
- d) The outermost planet is either **PLUTO** or **NEPTUNE**. Most of the time Pluto is the outermost planet, but because of its very elliptical orbit Pluto is sometimes within the orbit of Neptune and then Neptune is the outermost planet. In the period 1979 February 7 to 1999 February 11 Neptune was the outermost planet.
- e) The outermost planet is either **MERCURY** or **NEPTUNE**. Most of the time Mercury is the outermost planet, but because of its very elliptical orbit Mercury is sometimes within the orbit of Neptune and then Neptune is the outermost planet. In the period 1979 February 7 to 1999 February 11 Neptune was the outermost planet.

**SUGGESTED ANSWER:** (d) An easy memory/deduction question. The somewhat right answer is specified by Se-543. But for a more trustworthy answer I went to the Lowell observatory: <http://www.lowell.edu/users/buie/pluto/> Sky & Telescope confirms the 1999feb11 date and says variants may be for the center of mass of the Pluto-Charon system. CBS news says Pluto will again be within the orbit of Neptune in 2227.

**Wrong answers:**

- a) Not so. The question itself rules this answer.
- b) Come on. Recall the mnemonic: Man very early made jars stand up nearly perpendicularly.
- c) Answer (b) all over again.
- e) Mercury is the innermost planet.

**Redaction:** Jeffery, 2001jan01

001 qmult 01300 1 1 4 easy memory: degree, arcminute, arcsecond

17. How many degrees in a circle, arcminutes in a degree, and arcseconds in an arcminute?

- a) 100, 10, 10.      b) 360, 10, 10.      c) 360, 100, 100.      d) 360, 60, 60.      e) 360, 24, 60.

**SUGGESTED ANSWER:** (d) Those ancient Mesopotamians used a sexagesimal system for astronomy although not consistently. Probably, they didn't like complex division and choose a base of 60 because it has 12 whole number factors. This ancient sexagesimal system is also why hours have 60 minutes and minutes have 60 seconds.

**Wrong answers:**

- a) All things are wrong.

**Redaction:** Jeffery, 2001jan01

001 qmult 01310 2 4 3 moderate deducto-memory: fist angle

18. A fist at arm's length spans about how many degrees?

- a) About 1°.      b) About 18°.      c) About 10°.      d) 360°.      e) 180°.

**SUGGESTED ANSWER:** (c)

**Wrong answers:**

- d) Pretty big fist.

**Redaction:** Jeffery, 2001jan01

001 qmult 01320 2 5 4 easy memory: satellite angular separation

19. A human-made, Earth-orbiting satellite is passing by Polaris. At closest approach it is about a fist at arm's length away in angular separation.

- a) The closest approach is about 10° in angle and about 10 light years in space.
- b) The closest approach is about 100° in angle and about 100 light years in space.
- c) The closest approach is about 360° in angle and you **CANNOT** tell the spatial separation with the information given.
- d) The closest approach is about 10° in angle and the spatial separation is virtually the same as the Earth-Polaris spatial separation since the Earth-satellite spatial separation is negligible for most purposes compared to the Earth-Polaris spatial separation.
- e) The closest approach is about 10° in angle and also about 10° in spatial separation.

**SUGGESTED ANSWER:** (d)

**Wrong answers:**

- e) Degrees are not spatial units.

**Redaction:** Jeffery, 2001jan01

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001 qmult 01400 1 4 1 easy deducto-memory: linear function

20. A straight line on a plot represents a/an \_\_\_\_\_ function.

- a) linear    b) inverse-square    c) quadratic    d) logarithmic    e) perpendicular

**SUGGESTED ANSWER:** (a) Line, linear: it makes sense right.

**Wrong answers:**

- e) As Lurch would say: “Aaaarh.”

**Redaction:** Jeffery, 2001jan01

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001 qmult 01420 1 4 2 easy deducto-memory: inverse-square function

21. A curve on a plot that decreases as 1 over the square of the horizontal axis coordiante represents a/an \_\_\_\_\_ function.

- a) linear    b) inverse-square    c) quadratic    d) logarithmic    e) perpendicular

**SUGGESTED ANSWER:** (b)

**Wrong answers:**

- e) As Lurch would say: “Aaaarh.”

**Redaction:** Jeffery, 2001jan01

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001 qmult 01430 1 1 2 easy memory: aplot

22. On a standard logarithmic or log plot an axis unit is:

- a) one.    b) a power of ten.    c) one or two.    d) one, two, or three.    e) a power of one.

**SUGGESTED ANSWER:** (b)

**Wrong answers:**

- e) As Lurch would say: “Aaaarh.” Any power of one is still one.

**Redaction:** Jeffery, 2001jan01

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001 qmult 01510 2 5 2 moderate thinking: center of mass calculation

**Extra keywords:** If they’ve never seen this question before, they must think.

23. Say you have a set of masses  $m_1$ ,  $m_2$ , etc. at positions  $x_1$ ,  $x_2$ , etc. Their center of mass position  $x_{cm}$  along the  $x$ -axis is given in general by

$$x_{cm} = \frac{m_1x_1 + m_2x_2 + \dots}{m_1 + m_2 + \dots},$$

where “...” just means “and so on.” This formula follows from the definition of center of mass as the mass-weighted average position of a body. Now I give you a special case of  $m_1 = 9$  kg at  $x_1 = 0$  m and  $m_2 = 1$  kg at  $x_2 = 10$  m. What is the center of mass position of the masses in the special case?

- a) 0 m.    b) 1 m.    c) 5 m.    d) 9 m.    e) 10 m.

**SUGGESTED ANSWER:** (b) The calculation is, of course,

$$x_{\text{cm}} = \frac{m_1 x_1 + m_2 x_2}{m_1 + m_2} = \frac{(9 \times 0) + (1 \times 10)}{9 + 1} = \frac{10}{10} = 1 \text{ m} .$$

**Wrong answers:**

- c) This is the simple average position of the masses.

**Redaction:** Jeffery, 2001jan01

001 qmult 01530 3 1 4 tough memory: comet orbit eccentricities

24. Most comets that are gravitationally bound to the Sun have very elliptical orbits. This means that the eccentricity of their orbits is:

- a) exactly zero.      b) almost zero.      c) exactly 1.      d) much bigger than zero in some sense.  
e) bigger than 1.

**SUGGESTED ANSWER:** (d) To rule out answers in this case one has to remember both that bound orbit eccentricities must be in the range  $[0, 1]$  and that a very elliptical orbit means a very eccentric one. Thus a large eccentricity is one that is much larger than zero in a sense, but still less than or equal to 1.

**Wrong answers:**

- a) Exactly wrong.  
b) Almost exactly wrong.  
c) Some comets may have this eccentricity as nearly as one can ever have an exact value for a quantity that is continuous.  
e) This is the hard one to remember is not defined for closed orbits.

**Redaction:** Jeffery, 2001jan01

001 qmult 01600 2 1 5 moderate memory: two-body elliptical orbits

25. There are two gravitationally-bound bodies isolated in space. Describe their motion.

- a) The **LARGER** mass body orbits the **SMALLER** mass body in a circle.  
b) The **SMALLER** mass body orbits the **LARGER** mass body in a circle.  
c) The two bodies orbit their joint center of mass in ovals.  
d) The two bodies orbit their joint center of mass in circles always.  
e) The two bodies orbit their joint center of mass in ellipses.

**SUGGESTED ANSWER:** (e)

**Wrong answers:**

- c) An oval is not a definite mathematical description.  
d) They could orbit in circles, but not always. How they orbit depends on the initial conditions.

**Redaction:** Jeffery, 2001jan01

001 qmult 01700 1 1 1 easy memory: planets move about the Sun

26. To very good approximation the planets move in:

- a) elliptical orbits with the Sun at one focus of the ellipse.  
b) circular orbits with the Sun at circle center.  
c) elliptical orbits with the Sun at the center of ellipse. (The center of the ellipse is where the major and minor axes cross.)

- d) planar orbits with the Sun at plane center.
- e) spherical orbits with the Sun at sphere center.

**SUGGESTED ANSWER:** (a)

**Wrong answers:**

- b) To fair approximation the planets do move in circular orbits with the Sun at circle center. Perhaps, one could even say to good approximation, not very good approximation I'd say. Anyway answer (a) is better.
- d) Planar orbits? Well I suppose in the sense that elliptical orbits are confined to a plane. But does a plane have a center?
- e) What are spherical orbits?

**Redaction:** Jeffery, 2001jan01

001 qmult 01720 2 1 2 moderate memory: speed on orbit

27. A planet is orbiting the Sun in an **ELLIPTICAL** orbit.

- a) It moves fastest at **APHELION** and slowest at **PERIHELION**.
- b) It moves fastest at **PERIHELION** and slowest at **APHELION**.
- c) It moves fastest at **HELLION** and slowest at **ANTIHELLION**.
- d) It moves at a constant speed.
- e) It doesn't move at all.

**SUGGESTED ANSWER:** (b)

**Wrong answers:**

- a) Exactly wrong.
- d) If the orbit were circular, this would be true.
- e) As Lurch would say: "Aaarrh."

**Redaction:** Jeffery, 2001jan01

001 qmult 01800 1 4 1 easy memory: eccentricity and distance variation

28. The eccentricity of a body in orbit about the Sun is 0.20. How does its distance from the Sun vary?

- a) At **APHELION** the body is **20 %** farther from the Sun than the standard mean distance. At **PERIHELION** it is **20 %** closer to the Sun than the standard mean distance.
- b) At **APHELION** the body is **10 %** farther from the Sun than the standard mean distance. At **PERIHELION** it is **20 %** closer to the Sun than the standard mean distance.
- c) At **APHELION** the body is **20 %** farther from the Sun than the standard mean distance. At **PERIHELION** it is **10 %** closer to the Sun than the standard mean distance.
- d) The distance does not vary. The orbit is circular.
- e) The orbit is extremely elliptical. At **APHELION** the planet is well beyond the orbit of **PLUTO**. At **PERIHELION** the planet is well within the orbit of **VULCAN**. Vulcan is an asteroid (sometimes called a planet in the past) that is within the orbit of Mercury. The body is clearly a comet.

**SUGGESTED ANSWER:** (a) The definitions of aphelion and perihelion can be guessed if they are not known.

**Wrong answers:**

- e) In the 19th century Vulcan was a planet predicted to exist between Mercury and the Sun. Some observers claimed to have seen it. But they were mistaken. *Star Trek* revived Vulcan as Spock's home planet, but presumably it's around some other star than the Sun.

**Redaction:** Jeffery, 2001jan01