Astronomy 102, Fall 2003

Exam 1 Solutions

Note that I include some commentary on some of these problems. This is *not* to say that I expected you to write this much on the exam. I merely do this to help explain why I graded the way I did, to help you understand why the answer is what it is, or to let you know what many of you did wrong.

1. (e). The same face of the Moon is always pointed towards Earth. That means if you're standing on that face, you're always pointed towards Earth, so the Earth will stay in your sky.

2. (a). You know the average orbital radius is less than that of the Earth (since it spends all its time closer to the Sun than the Earth does), so therefore it will have a period lower than 1 year.

3. (d).

4. (c). A solar eclipse is when the Moon gets in the way of the Sun, so from the Earth, the Moon is in front of the Sun. When the Moon and the Sun are in the same direction, the side of the Moon lit by the Sun is the side we can't see, and that's a new moon.

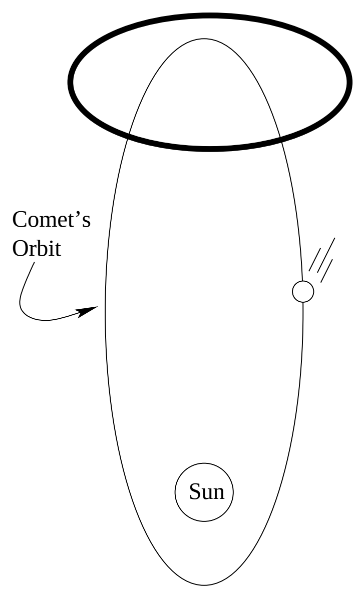
5. (c). This was a little tricky, in that we haven't talked at all about a potential difference between gravitational and inertal mass. However, it was defined in the problem enough to figure it out, and what we *have* discussed about gravity should have been enough to rule out all the other options.

6. (b)

7. (d)

8. (b)

9. Note that for this problem, you did *not* need to write an explanation. On homework, yes; and, on tests, when you have to do a calculation, you need to show your work. But here, all that was asked was to circle where you'd find the comet. I should note, though, that one person who got the wrong answer did get some partial credit for writing something insightful and correct in his explanataion.

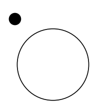


The explanation, of course, is that since the comet is moving slower when it is farther from the Sun, it spends more time in that part of the orbit. Therefore, if you look for the comet at a random time, you it is more likely to be out there.

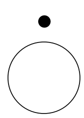
10. A *lot* of you had trouble with this problem. What tripped you up was that there were *two* pieces of information, and you needed *both* of them to figure the problem out. Many of you read as far as the Sun being at the zenith and seemed to stop reading, thinking that this was a repeat of a problem from the first homework set. Another common pattern was using the first piece of information for the first part, and the second piece of information for the second part.

(a) The Sun only passes through your zenith if you're between the tropics, i.e. with latitude between -23.5° and +23.5°. However, this is not the answer to the problem. Consider latitude +23.5°: the Sun passes the zenith on the summer solstice, when the Sun is at declination +23.5°. On this day, the middle of summer, the day is *longer* than the night in the northern hemisphere! But we know that the sun was only observed to be up for 12 hours. The only place where the length of the daytime and nighttime are the same when the Sun is passing the zenith is $\boxed{\text{on or extremely near to the equator}}$.

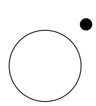
(b) You're on the equator. Daytime is always very close to 12 hours long on the equator. Many of you used this to conclude (incorrectly) that we can't know what time of year this is. However, look back to the first piece of information: the Sun passing the zenith. This only happens when the Sun's declination matches your latitude. On the equator, the latitude is 0°, and the only time the sun is at 0° declination is on the two equinoxes in late March (spring) and late September (autumn) respectively.



11. **(a)** ____________________



(b) ____________________



(c) ____________________

12. **(a)**

$$P^2 = A^3$$
$$P = \sqrt{A^3} = \sqrt{3 \times 3 \times 3} = \sqrt{27}$$
$$\boxed{\text{P=5 years}}$$

(to one significant figure).

(b) It's certainly possible. All we're told is the *average* distance from the Sun; that average distance is greater than Earth's 1 AU. The orbit might potentially be elliptical enough that it dips inside the Earth's orbit. From the information provided, we don't know if it *will*, but it's possible.

13.

(a) With this problem, it's crucial to use the right numbers. Many of you who started with the right equation plugged in the wrong numbers. When you use an equation, you have to understand what it means and what all the values that go into the equation means.

We can figure out how much somebody weighs by figuring out the force of gravity on them (which is, after all, the definition of weight):

$$m\, g_J \;=\; \frac{G\, M_J\, m}{{R_J}^2}$$

where M_J is the mass of Jupiter, m is the mass of the person (not known), g_J is the gravitational acceleration at the surface of Jupiter (not known), and R_J is the radius of Jupiter (*not* the distance of Jupiter from the Sun!). We have two unknowns here... but one of them is on both sides of the equation, so divide it out.

$$g_J \;=\; \frac{G\, M_J}{{R_J}^2}$$

At this point, we can plug in numbers from the front of the test to find that:

$$g_J \;=\; 24.8\,\frac{\mathrm{m}}{\mathrm{s}^2}$$

To figure out the weight, we need to know m. You *could* convert the weight given (150 lbs) into Newtons and divde by g (for Earth) to get m, multiply that by g_J, and get the right answer. (Many of you did this and got full credit.) Instead, though, let's just notice that:

$$\frac{g_J}{g_E} \;=\; \frac{24.8}{9.8} \;=\; 2.53$$

...which tells you immediately that somebdoy at the surface of Jupiter (which, incidentally, is gaseous, so don't try to stand there) will weigh 2.5 times what they do on Earth:

$$w_J \;=\; (2.53)(150\,\mathrm{lbs}) \;=\; \boxed{380\,\mathrm{lbs}}$$

(Note: a few of you worried about significant figures, as it's ambiguous whether 150 lbs has 2 or 3 significant figures. However, it doesn't matter, as $9.8\,\mathrm{m/s^2}$ only has two significant figures, so that's all the answer should have. I only took off if you gave more than three significant figures; in general, I don't care if you have one too many.)

(b) 68kg. Mass doesn't change based on where you are.

14.

(a)

$$d \;=\; \frac{1}{p}$$

so...

$$p \;=\; \frac{1}{d}$$

when d is in pc and p is in arcsec. We can then figure out that the parallax of the Andromeda Galaxy would be:

$$p \;=\; \frac{1}{800{,}000}'' \;=\; 1.25 \times 10^{-6\,\prime\prime}$$

(or $1 \times 10^{-6\,\prime\prime}$, one millionth of an arcsecond, to one significant figure). You would need to measure parallax at *least* this well to measure the distance to the Andromeda Galaxy, ideally a factor of five or ten better. The best we can do right now with parallax is about $10^{-3\,\prime\prime}$, so this is not how we know the distance to M31.

(b) Many of you noted that 30 AU is insignificant in comparison to 800,000 pc, so Neptune is not appreciably closer to M31 than Earth is. This is correct, but in so saying you are implicitly assuming a "flat Earth" model, where everything is "up". The planets are up, the stars are farther up.... The real Universe, of course, is three-dimensional, and Neptune may not even be in the same direction as M31! In fact, it may be every so very slightly farther from Neptune to M31 than from Earth; it all depends on where Neptune is in it's orbit. And, even if all three were lined up, the difference might be 31 AU rather than 29 AU. More likely, they're off at some different angle, and you'd have to do a bunch of messy trig to find out the difference in the distance. Ultimately, though, it doesn't matter, since only have the M31 distance to one significant figure, and any difference is going to be *way, way, way* less than that...so the distance from Neptune to M31 is 800,000 pc.

This does *not* mean, however, that you'd need to measure angles to the same precision! Think about how parallax works. You look at something from two points of view, and measure the difference in the direction from one point of view to the other. Neptune's orbit is 30 times the size of Earth's orbit, so there's going to be a much bigger parallax as measured from Neptune! In fact, it will be 30 times bigger, so you only need to measure angles to:

$$(30)(1.25 \times 10^{-6}) \; = \; \boxed{4 \times 10^{-5\prime\prime}}$$

This still isn't good enough to get Andromeda (if we can only measure to a milliarcsecond), but we are doing better than we did on Earth.

(c) The disadvantage is that Neptune's orbital period is much longer than Earth's. Therefore, you'd have to wait a very long time (about 80 years) to get from one side of Neptune's orbit to another.

Many of you suggested handing the project off between generations of a way of getting around the disadvantage. This isn't getting around the disadvantage; this is accepting it.

Note that the important thing about parallax is getting the measurements from two points of view. So why wait? If you can afford to send a space station out to Neptune, you might well be able to send out one in the opposite direction to the other side of Neptune's orbit. Make you're measurements and compare data, and you're done all at once. Or, you can do half as well if you compare measurements from Neptune with measurements made on Earth, and save yourself the expense of sending out a second space station.