PHYS 101, Fall 2006
Homework #1 solutions
100 points possible
(#1-15pts, #2-20pts, #3-15 pts, #4-10 pts, #5-10 pts, #6-20 pts, #7-10 pts)

1. (a) (Measure the angle of the Sun above the horizon between 12:30 pm and 1:30 pm in Charlottesville. State location, time, date, and show method.)
   You must show your work to receive full credit. You must also be close to the correct answer. If you're careful you should be within 1 or 2 degrees, but a bit more error is acceptable for this first assignment. Here are some sample dates:
   Sept. 14: about 55 degrees
   Sept. 17: about 54 degrees
   Sept. 20: about 53 degrees

   (b) At the equator on Sept. 21st, the sun will be directly overhead at noon (90 degrees). In Charlottesville it will be lower by our latitude, which is 38 degrees. Finally we must add the tilt of the Earth, which will be, for example, about 2-3 degrees a week before Sept 21st. So the angle should be 90 – 38 +2 (or 3) which gives 54 (or 55) degrees. The exact answer depends on the date of course.

2. Length of day questions
   Parts a-c:

You should have found fairly accurate answers using your globe and the method shown in class. For the longer days (such as June 21st in Fairbanks, for example) it's more difficult to get an accurate answer because of the shallow angle at which the string on your globe crosses the lines of longitude. On Dec 21st, the length of the day will be 24 hours minus what you found on June 21st, so there are no new measurements needed.

Then, www.weatherunderground.com hopefully confirmed your answers, but its stated "length of day" will be about 10 minutes longer than the purely geometric length found with your globe (which does not take into account the refraction of sun rays by the Earth's atmosphere).

Approximate numbers for length of day you should have found with your globe:

Location	June 21	Dec 21
Equator	12 h	12 h
Charlottesville	14 h 40 m	9 h 20 m
Edmonton	16 h 50 m	7 h 10 m
Fairbanks	21 h 40 m	2 h 20 m
Murmansk	24 h	zero

(d) Using the Mercator projection map, the straight line route from Washington D.C. to Moscow appears to go across the Atlantic Ocean, through northern Europe, skirting England and France perhaps (it's difficult to tell with a small map) through Poland and on to Moscow.

However, this is not even close to the actual shortest route. To find that, find the great circle that passes through the two cities. If you do this, you see that the shortest route actually goes through northeastern Canada, skirts southern Greenland, crosses Iceland and the middle of Sweden and on to Moscow.

Why the large discrepancy? The Mercator projection makes distances far above and below the equator appear much larger than they really are. So the great circle route described above, if followed on the flat map, would look much longer than the straight-line distance, when in fact it is shorter.

(e) To find a point opposite a given city on the globe, use any two different great circles passing through that city. Those great circles will intersect on the opposite side of the globe.

For Charlottesville, the opposite point is in the Indian Ocean, somewhat southwest of the southwest coast of Australia.

For Xian, China, the opposite point is in the Pacific Ocean, a little west of Santiago, Chile, approximately.

3. (a) See drawing on next page. The scale can be calculated in many ways. For example, the radius of the Earth on the homework assignment is about 4.25 mm. Then:

   (Earth-to-Moon)/(radius-of-Earth) = 380,000/6400 =(scaled-Earth-to-Moon)/4.25 mm

   which gives the scaled Earth-to-Moon distance to be 252 mm. Using the same method, the scaled Moon radius is about 1.15 mm

   (b) Again see the drawing on the next page. Several light rays emanating from the Moon (this light is reflected from the Sun--the Moon itself does not emit light) are shown. Notice that the rays that will hit the Earth are very nearly parallel.

   (c) The Earth does not usually block sunlight from hitting the Moon because the orbit of the Moon is tilted by about 5 degrees to the orbit of Earth around the Sun.

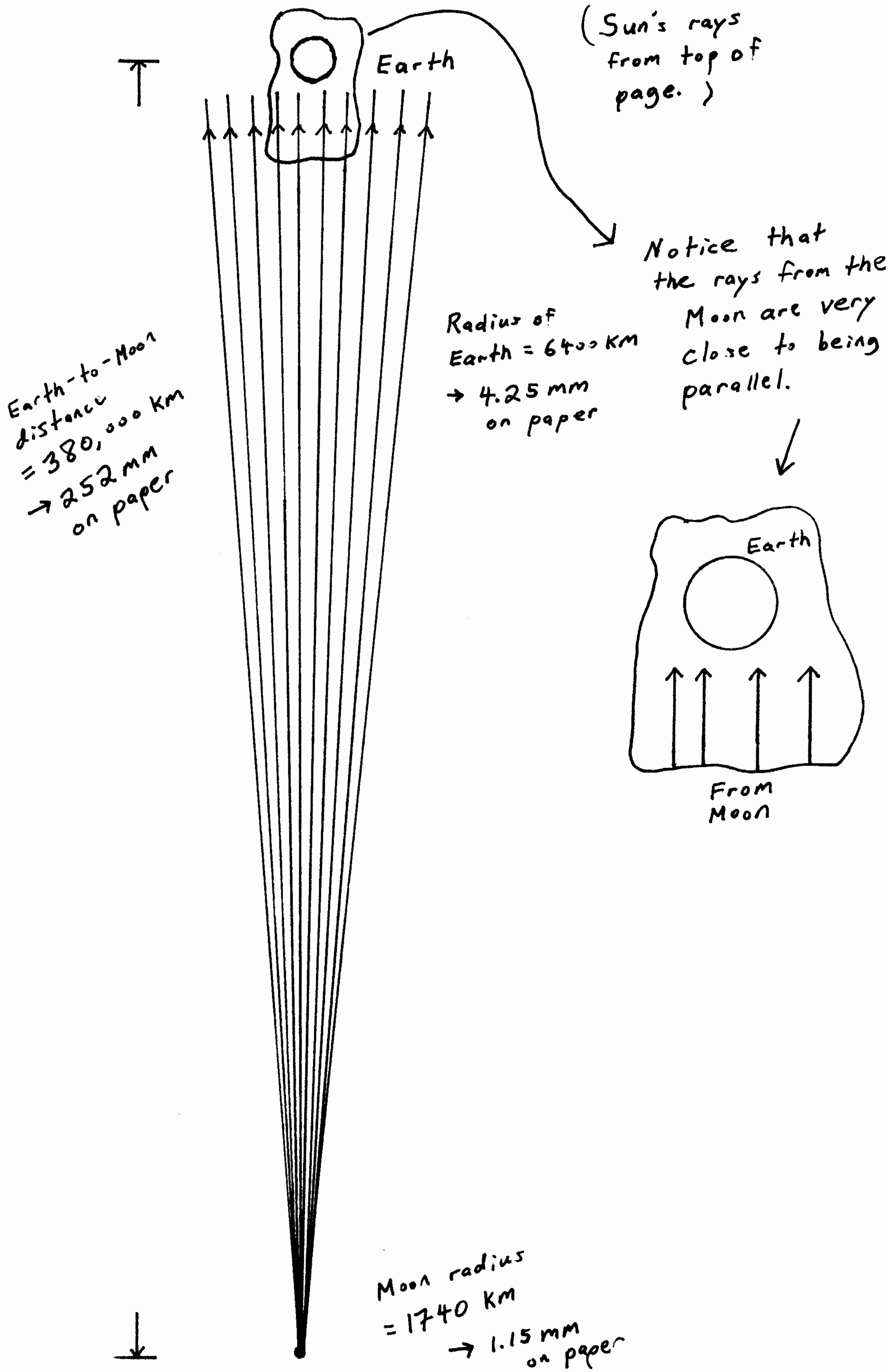
4. Although he did not invent it himself, Galileo very successfully used, in the early 1600's, the newly invented "spyglass" device (telescope) to make some very important discoveries about our solar system. One of these was that moons orbit the planet Jupiter. He published his findings about 1610 in his book "Sidereus Nuncius."

   This was a very surprising revelation, and contributed greatly to discrediting the Ptolemaic (Earth-centered) model. Why? Because the great appeal of the Ptolemaic model was that it made the Earth all-important and unique. It was thought that only the Earth was important enough to have objects in orbit around it. But Galileo's discovery of Jupiter's moons disproved this. Eventually the Copernican (Sun-centered) model was found to be much closer to the correct model of the solar system.

5. Because the orbit of Mars is outside the Earth’s orbit, it does not go through a complete range of phases. In particular, it can be full, but is never “new.” The “new” phase of Mars would require that Mars be located between the Earth and the Sun. This can’t happen for Mars.

6. (a) With this approximation, sunrise occurs at 6 am and sunset is at 6 pm. These are the same everywhere on Earth because of time zones. That is, people at different longitudes have their clocks set differently precisely so that their clocks will read 6 am at sunrise at that location.

   (b) From weatherunderground.com, sunrise and sunset for Charlottesville on Sept. 14^{th}, 2006 were 6:54 am and 7:23 pm, Eastern Daylight Time. Subtract an hour to get standard time: 5:54 am and 6:23 pm. These are close to the 6 am and 6 pm times in part (a), which uses the approximation that the Earth is not tilted. This is no surprise, because the effective tilt of the Earth is small in September (and in March). But it's


Earth
(Sun's rays from top of page.)
Earth-to-Moon distance = 380,000 km → 252 mm on paper
Radius of Earth = 6400 km → 4.25 mm on paper
Notice that the rays from the Moon are very close to being parallel.
Earth
From Moon
Moon radius = 1740 km → 1.15 mm on paper

large in December and June, so we'd expect the approximation to be worse at those times.

(c) You should show your work for at least one of these. As you proved in problem one, the Moon's rays are nearly parallel when they hit the Earth. For the Moon in position A, the rays from the Moon would first skim the surface of the Earth at noon, and last until midnight. So moonrise is (approximately) noon and moonset is at midnight.

position B: 6 pm to 6 am
position C: midnight to noon
position D: 6 am to 6 pm

(d) You must sketch these.

position A: half-illuminated on the right position B: full moon (full illumination)
position C: half-illuminated on the left position D: new moon (no illumination)

(e) If the Moon is half-illuminated on the left (as viewed from Charlottesville), it is in position C on our sketch, which means it rises at about midnight in the East, and sets at noon in the West. At 6 am it will be at its highest point for the day, in the southern sky, and at 9 am it will be about halfway between its highest point and setting. So at 9 am it will still be fairly high in the sky, and towards the southwest.

7. (a) As viewed from above the North pole, Earth rotates counter-clockwise.

   (b) You must sketch this to receive full credit. Just like the Sun and the Moon, the planets are so far away that their light rays arrive nearly parallel. If you draw these, you'll see that Planet A rises at about 2 am or 3 am, and sets at about 2 pm or 3 pm, and Planet B rises at about 8 am or 9 am, and sets at about 8 pm or 9 pm. You can be off a little from these answers, but you must have shown a sketch to justify your answers.