Summary of Lecture 6

Key points include:

1. Galileo did not invent the telescope, but he made his own and was the first that we know of to use a telescope for astronomical observations. This gave him far more precise observations than were possible with the naked eye.
2. His observations of Venus showed a full set of phases (new to full). This was consistent with the heliocentric (also known at that time as the Copernican) model, but not with the geocentric (also know at that time as the Ptolemaic) model.
3. Other discoveries of Galileo: (a) the Milky Way is made of stars, which are just too dim and/or far away to see individually, (b) the Moon has mountains and the Sun has spots (thus celestial bodies are not perfect), (c) the rings of Saturn. Most importantly, along with the phases of Venus, Galileo discovered that Jupiter has moons that move around Jupiter. This shows that Earth is *not* the center of all motion.
4. Galileo was also key in establishing modern principles of physics. In particular, he showed through experiment that many assumptions (codified in the writings of Aristotle) were wrong. For example, when we fly in an airplane (for Galileo it would have been a boat!), the air goes with us and we therefore don't sense the movement of the plane. Thus even if the Earth rotates and moves in an orbit, we need not feel that motion.
5. Galileo still did not see parallax of the stars, which suggested that the stars were extraordinarily far away. This troubled thinkers at the time because it seemed that a huge amount of space was wasted!
6. Contemporarily with Galileo, Tycho Brahe (Danish nobleman) coordinated by far the most accurate naked-eye observations ever performed. Brahe also made measurements of a comet which showed that it had to be outside the Earth's "influence" (i.e., farther than the Moon) and that it could not move in a circle. He also saw what we now call a supernova, which was also beyond the Moon, and which proved that the heavens can change.
7. Brahe's assistant Johannes Kepler analyzed the data. He was almost able to fit all the data with circular motion, but in a perfect example of what a scientist *should* do, he realized that there was a discrepancy in the orbit of Mars that could not be explained in this way.
8. This led to Kepler's Laws of planetary motion.

9. First law: the orbit of each planet around the Sun is an *ellipse* with the Sun at one focus.
10. Second law: As a planet moves in its orbit, the planet-Sun line sweeps out equal areas in equal times.
11. Third law: the square of the orbital period in years equals the cube of the semimajor axis of the orbit in au (au=average distance of Earth from Sun). Thus more distant planets move at slower average speeds.
12. Combined, the Sun-centered model based on these three laws provides spectacularly good agreement with the data.