Astronomy 2020 – Space Astronomy & Exploration **Fall 2020**
Homework #2 Due: Sep. 16, 2020

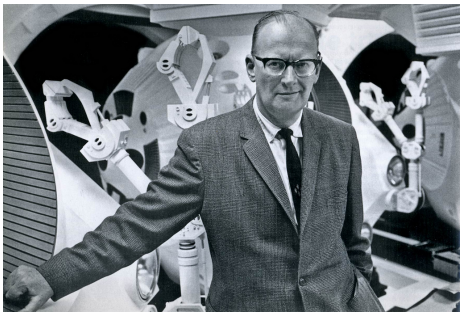
In questions 1-3 below, choose the best answer. Then explain your reasoning in a few complete sentences. Why is your answer correct?

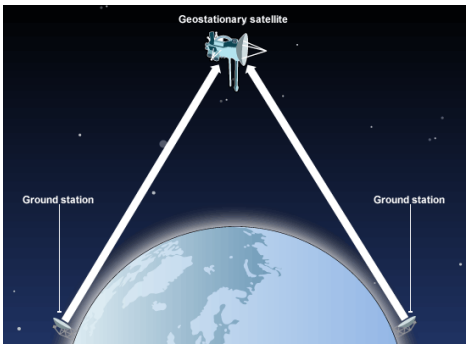
1. (2 pts). Artificial gravity equivalent to 1g can be achieved aboard a spacecraft by
   a. Firing the engines continuously to produce a constant acceleration of 1 meter/sec^2.
   b. Doing an initial engine burn to achieve a velocity of 0.9c and coasting to your destination at this speed according to Newton's first law.
   c. Rotating the spaceship with a centripetal acceleration that equals the acceleration of gravity on Earth's surface.
   d. All of the above.

2. (2 pts). The mass of Jupiter can be calculated by
   a. measuring the orbital period and distance of Jupiter's orbit around the Sun.
   b. measuring the orbital period and distance of one of Jupiter's moons from Jupiter.
   c. measuring the orbital speed of one of Jupiter's moons.
   d. knowing the Sun's mass and measuring how Jupiter's speed changes during its elliptical orbit around the Sun.
   e. knowing the Sun's mass and measuring the average distance of Jupiter from the Sun.

3. (2pts). When NASA's *Voyager 2* passed by Saturn, its speed increased (but not due to firing its engines). What must have happened?
   a. *Voyager 2* must have dipped through Saturn's atmosphere.
   b. Saturn's rotation must have sped up slightly.
   c. Saturn must have lost a very tiny bit of its orbital energy.
   d. Saturn must have captured an asteroid at precisely the moment that *Voyager 2* passed by.

4. (6 pts). The science fiction author, Arthur C. Clarke (*2001: A Space Odyssey*) was the first to conceive the idea that a satellite could be placed into geostationary orbit. A geostationary orbit is a circular orbit that lies above the Earth's equator, follows the direction of Earth's rotation, and has an orbital period that equals the Earth's rotational period (one day).





a. Using Newton's 2nd Law of Motion, the Law of Gravitation, the formula for centripetal acceleration, and the relationship between orbital velocity and period, derive an equation that relates the orbital period to the orbital radius.

b. Using this equation, calculate orbital radius of a satellite in geostationary orbit. How high is this above the Earth's surface in kilometers?

c. How does this altitude for a geostationary orbit compare to that for a satellite in Low Earth Orbit (LEO)?

5. (2 pts). Give an example in which thermal energy might be converted to gravitational energy.

6. (4 pts). Orbits.

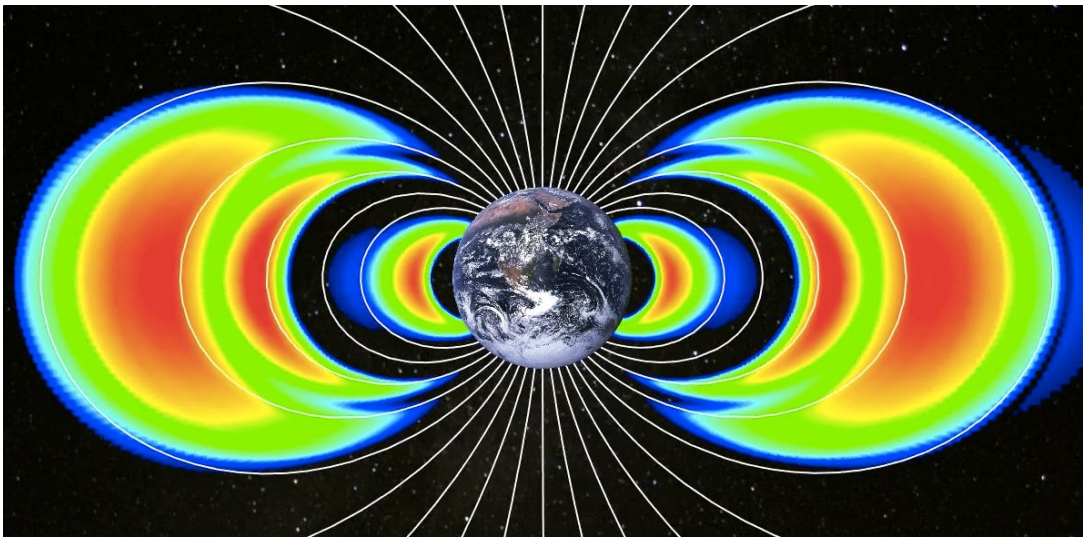
a. Suppose the Sun were replaced by a star with twice as much mass. Could Earth's orbit stay the same? Why or why not?

b. Suppose Earth doubled in mass but the Sun stayed the same as it is now. Could Earth's orbit stay the same. Why or why not?

7. (5 pts). Explorer 1 discovered the Van Allen radiation belts as shown below (color represents intensity of radiation).

a. Explain how these radiation belts are related to the Earth's magnetosphere?

b. How does this magnetic field protect us from harmful space radiation?



8. (4 pts). The Moon orbits Earth in an average of 27.3 days at an average distance of 384,000 kilometers. Using Newton's version of Kepler's third law that we derived as a class exercise, determine the mass of Earth.

9. (2 pts). Explain (a) why orbits cannot change spontaneously and (b) how a gravitational encounter can cause a change in orbit.

10. (2 pts). In 1961, Alan Shepard flew the first suborbital mission for NASA as part of Project Mercury. What was the trajectory for his Redstone rocket? Discuss what would have been required for Shepard to achieve orbit around the Earth as was done later by John Glenn.