ASTRONOMY 4800 **Exam #2 Solutions** **Nov. 16, 2022**

There are three short answer questions on this Exam. Each question is worth a slightly different number of points so plan to spend your time accordingly. There is one question per page. ***You are encouraged to use bullets or numbered partial sentences or tables or drawings to answer these questions****.*

1. **(35 points) NASA's Authorization & Appropriation Process.**
   a. (10 points). Roughly every two years, NASA is supposed to be "(re)authorized" by Congress. What is the purpose of the Authorization Bill? Discuss one requirement in the Authorization Bill for NASA passed earlier this year.

      The NASA authorization bill authorizes (but does not allocate funding for) the activities that are performed by NASA. Passing an authorization bill gives the programs that are authorized the ability to exist and operate, as well as establishes the terms under which NASA may operate. Authorization bills are separate from appropriations bills, which provide the funding needed to carry out the activities. One requirement from this year's NASA authorization bill is the creation of a "Moon to Mars office" as well as a "Moon to Mars program." The creation of this entities is noteworthy because a stated goal of the Artemis program is to use the Moon as a steppingstone for an eventual crewed mission to Mars.

   b. (15 pts) Discuss the process by which NASA's budget or appropriation is constructed and passed each year. Be sure to describe (1) the role of the Executive and Legislative branches and (2) the timetable from the first draft of the budget constructed by NASA to the President's budget presented to Congress to its final signature by the President.

      Planning for the budget begins up to two years before the budget will be passed. Preliminary budgets are sent to the Office of Budget and Management (OMB) for feedback. Around a year beforehand, the President proposes a budget for NASA. This budget is then sent to Congress. Both the Senate and the House of Representatives have authorization and appropriations committees. Authorization bills can establish or modify the activities of a government agency such as NASA, whereas appropriations bills are what actually allocate funding. Each house of Congress creates their own version of the budget within the appropriations committee. The two bills are then merged into one (called reconciliation), which is then voted on by both the Senate and the House before going to the White House to be signed into law by the President. Although the fiscal year begins on October 1, the budget often does not get passed on time.

   c. (10 pts) Currently, we are in a "continuing resolution" as far as the NASA appropriations for FY23 is concerned. What does this mean?

      When Congress is not able to pass a budget by the beginning of the fiscal year on October 1, they may pass a continuing resolution instead. The CR means that federal agencies will continue to be funded at the same level as they were in the previous budget. CRs only last for a limited period, or until a new appropriations bill is passed. The CR does not allow any "new starts" for funding new projects.

2. **(30 pts) Missions to the Moon and Mars**
   a. (10 pts). What are two of the science goals identified for the Artemis/CLPS program?

      One science goal for Artemis/CLPS is to explore lunar polar volatiles. These volatiles, including water ice, exist in "cold traps" in permanently shadowed craters near the poles. Studies can provide insight into the distribution and history of volatiles throughout the Solar System. Additionally, these volatiles could potentially be used as resources for long-term human missions to the Moon or further targets such as Mars.

      Another science goal is to study the formation and evolution of the Earth-Moon system. This means understanding the timing of a potential massive collision between a large impactor and the proto-Earth, as well as further measuring isotopic similarities and differences between the Earth and Moon. Performing experiments with both robotic and human missions to the lunar surface will greatly aid our understanding in this area.

   b. (10 pts). What do you think are the two top science goals for NASA's current Mars rovers that will lay the groundwork for a human mission to Mars?

      Understanding the level of radiation in space and on Mars is an extremely important science goal that relates directly to human exploration. The Radiation Assessment Detector (RAD) instrument on board the curiosity rover monitored radiation levels both on the journey to Mars, as well as on the Martian surface. Since radiation is potentially very harmful to human astronauts, understanding the level of radiation experienced on a journey to Mars is very important to assess risk levels for astronauts as well as develop ways to mitigate its harm.

      Another science goal is to study how in-situ resource utilization (ISRU) can be performed on Mars to supply crewed missions with the resources needed for survival. For example, the Mars Oxygen In-Situ Resource Utilization Experiment (MOXIE) is exploring how to turn carbon dioxide in the Martian atmosphere into oxygen, which could be used by astronauts to breathe or as rocket fuel.

   c. (10 pts). What are two lessons that we expect to learn from the Artemis program that will likely feed-forward to Mars?

      Since a human mission to Mars will likely include an extended stay for astronauts on the Martian surface, Artemis will test systems and technologies for sustained human presence on an extraterrestrial body. These include life support systems, habitats, and radiation protection infrastructure designed to sustain human life for periods of weeks to months. The Artemis program will also provide an opportunity to study how humans and robotic exploration can be used together. Though humans can often accomplish tasks more efficiently than a robot, robots can also potentially explore locations that are inaccessible to humans, such as permanently shadowed craters, where temperatures preclude human exploration. Artemis will allow us to optimize how best to use human and robotic exploration together.

3. (35 pts) The Planetary Science Decadal Survey.

a. (15 pts) The National Academy of Sciences conducts "Decadal Surveys" every 10 years in each of the space sciences. Why? What are the purposes and goals of these surveys?

The decadal survey is a chance for the scientific community to discuss how to prioritize their studies/missions for the upcoming decade. The purpose of the decadal survey is to identify the most interesting scientific questions in the field and to determine and plan the infrastructure needed to answer them. The result is that funding agencies such as NASA, NSF, and DOE can allocate funding appropriately. This ensures that the highest priority missions or studies are given sufficient resources even when funding may be limited. These surveys guide the funding decisions within the Congress.

b. (10 pts) What are two of the top science goals for this Planetary Decadal? What space missions will fulfill these goals?

The most recent planetary science decadal survey identifies two "priority flagship missions" with specific science goals. The report states that the Uranus Orbiter and Probe should be the highest priority and would transform our knowledge not just of Uranus, but of ice giant planets in general. Specifically, the mission would probe the atmosphere of Uranus directly. The report recommends that the Enceladus Orbilander be the second highest priority large mission. This mission would probe Enceladus, a moon of Saturn, for evidence of life by studying plume material from the body's interior ocean.

c. (10 pts) *Space Radiation* is an issue that is important for both robotic and human missions throughout the solar system. What is space radiation and describe how it is a problem for both astronauts and electronics in deep space?

Space radiation refers to energetic particles and electromagnetic radiation, originating from the Sun and from cosmic rays, which exist in outer space. We don't have to worry about this radiation on Earth because the atmosphere and the magnetosphere shield us from it. Outside of Earth's protective magnetic field and atmosphere, however, there is nothing to protect both astronauts and electronics from the damaging effects of space radiation. The harmful effects of radiation (ionizing radiation) for humans are well known, ranging from cancer to radiation sickness. Astronauts will certainly receive a large dose on the way to Mars, but more worrisome is the potential for an event such as a solar flare to increase the level of radiation significantly, leaving astronauts vulnerable. This high level of radiation could also damage sensitive electronic instruments needed for navigation or other important functions. Galactic cosmic rays are even more difficult to shield because they are higher energy than radiation from the Sun.