G9 Science: Class 14 Homework

Read the following excerpt and answer the questions below. Adapted from NASA – International Space Station http://www.nasa.gov/sites/default/files/atoms/files/np-2015-05-022-jsc_iss_utilization_guide_2015-508c.pdf

INTERNATIONAL SPACE STATION

The International Space Station (ISS) is a unique place – a convergence of science, technology and human innovation that makes research breakthroughs not possible on Earth. Along with the United States, Russia, Europe and Japan, Canada is a partner in the ISS

Since the first module of the ISS was launched in 1998, the ISS has circled the globe 16 times per day at 28,000 km/h at an altitude of about 370 km, covering a distance equivalent to the Moon and back daily. The Station is about as long as a Canadian football field, and has as much living space as a five-bedroom house.

Canada's contribution to the ISS is the Mobile Servicing System (MSS)—a sophisticated robotics suite that assembled the Station in space, module by module. Developed for the Canadian Space Agency by MDA of Brampton, Ontario, the MSS is comprised of:

- **Canadarm2**, a 17-metre long robotic arm
- **Dextre**, the Station's two-armed robotic "handyman" and
- The **Mobile Base** is a moveable work platform and storage facility

The space station is a microgravity laboratory in which an international crew of six people live and work. The space station has been continuously occupied since November 2000. In that time, more than 200 people from 15 countries have visited.

Crew members spend about 35 hours each week conducting research in many disciplines to advance scientific knowledge in Earth, space, physical, and biological sciences for the benefit of people living on our home planet. More than an acre of solar arrays provide power to the station, and also make it the next brightest object in the night sky after the moon.

Microgravity, or weightlessness, alters many observable phenomena within the physical and life sciences. Systems and processes affected by microgravity include surface wetting and interfacial tension, multiphase flow and heat transfer, multiphase system dynamics, solidification, and fire phenomena and combustion. Microgravity induces a vast array of changes in organisms ranging from bacteria to humans, including global alterations in gene expression and 3-D aggregation of cells into tissue-like architecture.

Extreme conditions in the ISS space environment include exposure to extreme heat and cold cycling, ultra-vacuum, atomic oxygen, and high energy radiation. Testing and qualification of materials exposed to these extreme conditions have provided data to enable the manufacturing of long-life reliable components used on Earth as well as in the world's most sophisticated satellite and spacecraft components.

Human Biology Research on the ISS


European Space Agency astronaut Samantha Cristoforetti exercises on the Advanced Resistive Exercise Device (ARED).

NASA's history has proven that humans are able to live safely and work in space. The ISS serves as a platform to extend and sustain human activities in preparation for long-duration, exploration-class missions. It provides opportunities to address critical medical questions about astronaut health through multidisciplinary research operations to advance our understanding and capabilities for space exploration. The multi-disciplinary biomedical research currently underway on the ISS include studies addressing behavioral health and performance, bone and muscle physiology, exercise countermeasures, cardiovascular physiology, nutrition, and immunology. These life sciences research studies aim to provide a thorough understanding of the many physiologic changes that occur in a microgravity environment.

Among the many physiological changes that occur in the human body include susceptibility to fainting after landing, vision changes potentially because of the harmful effects of microgravity on the eye and optic nerve, changes in blood volume, reduction in heart size and capacity, alterations in posture and locomotion, decreases in aerobic capacity and muscle tone, difficulty sleeping, increased risk for kidney stone formation, and weakened bones. The research focuses on astronaut health and performance and the development of countermeasures that will protect crew members from the space environment during long-duration voyages, evaluate new technologies to meet the needs of future exploration missions and develop and validate operational procedures for long-duration space missions.

Physics Research on the ISS

The ISS provides a long-duration spaceflight environment for conducting microgravity physical science research. The microgravity environment greatly reduces buoyancy driven convection, pressure head, and sedimentation in fluids. By eliminating gravity or using gravity as a factor in experimental design, the ISS allows physical scientists to better understand fluid physics; the dynamics of interfaces, such as the line of contact between a liquid and a gas; the physical behavior of systems made up wholly or partially of particles; combustion processes in the absence of buoyant convection and the properties of materials.

Fluid Physics - A fluid is any material that flows in response to an applied force; thus, both liquids and gases are fluids. Nearly all of the life support, environmental and biological, processes take place in the fluid phase. Fluid motion accounts for most transport and mixing in both natural and man-made processes as well as within all living organisms. Fluid physics is the study of the motions of liquids and gases and the associated transport of mass, momentum and energy. The low- gravity environment on the ISS offers a unique opportunity for the study of fluid physics and transport phenomena. The nearly weightless conditions allow researchers to observe and control fluid phenomena in ways that are not possible on Earth.

Earth and Space Science Research on the ISS

The presence of the space station in low-Earth orbit provides a vantage point for collecting Earth and space data. From an altitude of about 400 km, details in such features as glaciers, agricultural fields, cities, and coral reefs taken from the ISS can be layered with other sources of data, such as orbiting satellites, to compile the most comprehensive information available.

The expedition 41 crew took pictures of the Atlantic Hurricane Edouard.

While NASA and other space agencies have had remote-sensing systems orbiting Earth and collecting publically available data since the early 1970s, these sensors have been primarily carried aboard free-flying, unmanned satellites. These satellites have typically been placed into sun-synchronous polar orbits that allow for repeat imaging of the entire surface of the Earth with approximately the same sun illumination (typically local solar noon) over specific areas, with set revisit times—this allows for uniform data to be taken over long time periods and enables straightforward analysis of change over time.

The ISS is a unique remote sensing platform from several perspectives—unlike automated remote sensing platforms—it has a human crew, a low-orbit altitude, and orbital parameters that provide variable views and lighting. The presence of a crew provides options not available to robotic sensors and platforms, such as the ability to collect unscheduled data of an unfolding event using handheld digital cameras as part of the Crew Earth Observations facility and real-time assessment of whether environmental conditions (like cloud cover) are favorable for data collection.

QUESTIONS

1. What are the three Canadian contributions to the construction and maintenance of the International Space Station? **[3 marks]**

2. What is "microgravity" and explain how it would alter an activity such as brushing your teeth in the morning. **[3 marks]**

3. According to the article, the International Space Station travels at 5 miles per second (approximately 29 000 km/h). Explain how this speed relates to the astronaut's perception of microgravity. **[2 marks]**

4. What type of energy does the ISS use and why is this a good source of energy for the International Space Station? **[2 marks]**

5. List three physiological changes to the body during space travel. Why is it important to study these physiological changes? **[4 marks]**

6. The article mentions "using gravity as a factor in experimental design". Explain what this means and propose a simple experiment that can be done in space using gravity as a factor. **[3 marks]**

7. Name three advantages and one disadvantage of using the ISS to collect earth and space data. **[4 marks]**

8. Temper Foam or memory foam was originally developed to improve crash protection for astronauts in space. However, it is now used in mattresses, pillows, automobiles and sports safety equipment. Its high-energy absorption and soft characteristics not only offer superior protection but enhanced comfort and support. Research another technology that was originally intended for space travel but that is now widely commercialized. **[3 marks]**