CS-B Group 10 synopsis

Project topic:

Advanced Simulation System for Radiation Interaction and Space Bio-Mining Applications

Introduction:-

This project aims to develop a cutting-edge simulation system capable of simulating and monitoring the interactions of various types of radiations with materials of different properties, The system is also designed to explore the feasibility of bio-mining in outer space environments, leveraging microbial processes to extract valuable resources from extraterrestrial materials. It is crucial because it reduces radiation risks to humans, spacecrafts, rovers or any man-made objects; providing essential simulations for testing and optimizing technologies before testing it out in high risk environments. It is beneficial for space agencies, researchers as it can recreate how a material behaves in space and determine helpful results.

Methodology-

**• Techniques:-**

• Monte Carlo Simulations:

- Use Monte Carlo methods for radiation interaction modelling, as they are effective in tracking particle trajectories and interactions.

• Geant4 Toolkit:

- A widely used toolkit for particle physics and radiation simulations, essential for simulating radiation shielding and interaction.

• Computational Fluid Dynamics (CFD):

- To model the micro-environment within bioreactors in space bio-mining.

• Machine Learning:

- Integrate ML for predictive modelling of radiation effects and optimisation of bio-mining processes.

• Multi-Scale Modeling:

- Combine atomic-scale interactions with macroscopic behaviours to simulate both radiation effects and biological responses.

**• Tools:-**

• Simulation Software:

- Geant4 for radiation simulation.

- ANSYS Fluent or COMSOL Multiphysics for thermal and shielding analysis.

- MOOSE Framework for multiphysics simulations.

• Bioinformatics Tools:

- BLAST, Geneious, or custom ML models for studying microorganisms used in bio-mining.

• Programming Languages:

- Python, C++, or MATLAB for custom modeling and data analysis.

• Visualization Tools:

- ParaView or VisIt for 3D visualization of simulation results.

• Data Management:

- Use tools like Jupyter Notebooks or SQL databases for managing and analyzing simulation data.

Key Features:

• Radiation-

- Material Interaction Simulation: Simulates the effects of radiation (e.g., gamma rays, cosmic rays) on materials with varying physical, chemical, and structural properties. Analyzes potential material degradation, thermal changes, and protective capabilities for space applications.

• Bio-Mining Simulation-

- Simulates microbial processes to extract valuable metals and minerals from simulated extraterrestrial regolith and asteroid material. Evaluates the efficiency and sustainability of bio-mining in reducing the logistical challenges of space missions.

• Objectives:

- Develop an efficient, user-friendly simulation platform that integrates material science, microbiology, and space engineering. Assess the durability of materials exposed to space radiation and identify optimal materials for spacecraft and habitat construction. Investigate the potential of microbial life for sustainable resource extraction in outer space.

• Applications:

- Advancing material design for space exploration and terrestrial applications. Promoting sustainable space exploration by enabling resource utilization on-site.

• Expected Outcomes:

- A comprehensive simulation tool for academic and industrial research in space engineering and astrobiology. Insights into the design of radiation-resistant materials and habitats.