AS106: Development of Space Instruments (16 lectures in 24 hrs)
(A certificate course for UG, PG and PG+ students)
***Instructors:** S. K. Chakrabarti, S. Palit, D. Bhowmick*

Syllabus

*Introduction**(1 Lecture)***

Instructor: S. Palit

Overview of balloon and rocket-borne space instruments; Science with small space instruments/payloads: Astronomy and Astrophysics, Ionospheric and Atmospheric science, Climate science, Space weather; Why do we go to space? Basics of rocket science; Basic physics principles involved: gravity, buoyancy, drag, propulsion; Safety protocols and regulations.

*Science and missions conducted by ICSP**(1 Lecture)***

Instructor: S.K. Chakrabarti

Expertise/facilities available at ICSP; Overview of DIGNITY series balloon missions; Science with rockets; Overall scientific achievements; Future goals and missions.

Mission Planning (2 Lecture)

Instructor: S. Palit

Scientific goals; Defining mission objectives and feasibilities; Timing of the mission; Choice of balloon, rocket size, payload weight and optimization; Designing a mission profile (ascent, data collection, descent); Environmental considerations (temperature, pressure, radiation); Data acquisition: frequency, latency; Budget and resource allocation; Permissions and protocols; Activity: Formulating a sample mission plan in groups.

*Computer model, performance and sensitivity analysis**(1 Lecture)***

Instructor: S. Palit

Computer model (mass model) of the instruments and whole payload; Monte-Carlo study of photon detection performance and sensitivity; Study of atmospheric absorption and scattering; Background sources and simulation; Attitude measurement and control; Activity: demonstration of GEANT4-mass model and background calculation.

*Payload design and Integration**(2 Lecture)***

Instructor: D. Bhowmick

Scientific instruments: detectors, collimators, shielding, coincidence; Sensors (temperature, pressure, attitude, etc.); Cameras; Communication devices (GPS); Attitude control system; Structural design and materials; Power systems and energy management; Integration of payload components; Small rocket fabrication; Activity: Sketching and discussing payload designs.

*Basics of electronics**(2 Lecture)***

Instructor: D. Bhowmick

Working with diode, transistors, capacitors, OP-AMP etc.; Handling power supply; AMU (6, 9 DOF, accelerometer, gyroscope, magnetometer combination); Communication devices and data transmission; Localization (lat, lon, altitude) with GPS; Interfacing sensors with microcontrollers (Arduino); Activity: Hands-on sensor integration with microcontrollers.

*Testing and optimization**(2 Lecture)***

Instructor: D. Bhowmick

Scientific instruments: Instrument performance testing with radiation sources, calibration and testing of instruments, environmental effect (pressure, temperature response) on scientific instruments, testing of data acquisition systems; Other sensors: testing of temperature and pressure sensors, testing of attitude (AMU)

sensors, testing the performance of positioning and communication (GPS) module; Activity: demonstration of calibration and testing.

***Launch Mechanics and Procedures*(1 Lecture)**

Instructor: D. Bhowmick

Balloon inflation and launch procedures; Rocket assembly and launch procedures; Weather considerations and launch window selection; Tracking and recovery strategies; Reusability of instruments; Activity: preparing a mock launch checklist.

***Data analysis and interpretation*(2 Lecture)**

Instructor: S. Palit

Data retrieval and storage methods; Basic data analysis techniques (plotting, statistical analysis); Background subtraction; Atmospheric correction; Basic temporal and spectral analysis; Interpreting sensor data (e.g., altitude, speed, environmental conditions); Use of software tools for data analysis (MATLAB, Python, ROOT); Data analysis pipeline; Activity: Writing a basic temporal and spectral fitting code with root.

***Introduction to relevant Software and programming language* (2 Lecture)**

Instructor: S. Palit

Introduction to Python, Scipy, and Astropy; Data analysis with ROOT; Basic overview of GEANT4 and its applications; Basic microcontroller programing (Adruino); Overview of Astronomical and solar physics softwares and applications; Activity: Basic data analysis with Python and Scipy.

***Sitapur Observatory trip*(1 night)**

Instructors: Devendra Bisht, Ashish Raj, Kuldeep Belwal, Mohit Bisht, Shraddha Biswas

Discussion on the observables in the night sky, software guided observation using optical telescopes; hands-on experience on telescope assembling.