INTRODUCTION TO CUBESATS

ENAS 202

Lecture : 3 **Year : II**
Tutorial : 1 **Part : I**
Practical : 0

Course Objectives:
The objective of this course is to provide the fundamental understanding of the terms and design process of a popular nano-satellite standard called the “CubeSat.” Students will also learn about the limitations of the space environment and systems engineering in the process.

1 Small Satellites and the Rise of a Standard (6 hours)

1.1 Faster, better, cheaper
1.2 1990s satellite design and development
1.3 Satellite in a Can: “CanSat”
1.4 The CubeSat standard
1.5 Amateur radio community
1.6 Early years of CubeSat
1.7 Current state of the standard
1.8 CubeSat design essentials
1.9 Satellite and space related developments in Nepal
1.10 Current Nepali satellite/CubeSat projects

2 CubeSat Design Process Overview (3 hours)

2.1 From paper to space
2.2 Lean satellite design philosophy
2.3 Reverse satellite timeline philosophy
2.4 CubeSat design reviews
2.5 System block diagrams
2.6 CubeSat safety review
2.7 Frequency coordination with international telecommunication union (ITU)
2.8 Satellite launch agreements
2.9 Budgets, payments and financial considerations
2.10 Procurement and logistics
2.11 Space law and deorbit requirement considerations

3 CubeSat Mission Design (9 hours)

3.1 Mission statement and objectives
3.2 Mission requirements
3.3 Requirement allocation sheet (RAS)
3.4 Mission success criteria
3.5 CubeSat mission case studies
3.6 State of art
3.7 CubeSat systems-level state-of-art
3.8 Constellation designs
3.9 Formation flying
3.10 Deep space missions
3.11 Fly-by missions
3.12 Deorbit missions

4 CubeSat Hardware (12 hours)

4.1 Commercial off-the-shelf (COTS) technologies
4.2 The printed circuit board
4.3 CubeSat bus standards
4.4 On-board computer (OBC)
4.5 Electrical power system (EPS)
4.6 Solar panel designs (SP)
4.7 Communication system (COM)
4.8 CubeSat structure design (STR)
4.9 CubeSat attitude determination and control system (ADCS)
4.10 Thermal design considerations
4.11 Deployables
4.12 Design models and system redundancies
4.13 Interface control document (ICD) and harnessing
4.14 Manufacturing techniques and design for manufacturing (DFM)
4.15 CubeSat integration facilities

5 CubeSat Software (6 hours)

5.1 Review of C programming language
5.2 Integrated development environments (IDE)
5.3 Free and open-source software (FOSW)
5.4 Flight software (FSW)
5.5 Fault detection, isolation and recovery (FDIR)
5.6 CubeSat operating system (OS)
5.7 CubeSat operational algorithms
5.8 CubeSat simulations

6 CubeSat Testing (6 hours)

6.1 Triple T standard: Test, test, test
6.2 Space environment overview
6.3 Popular CubeSat orbits
6.4 The ISO 19683:2017 satellite testing standards
6.5 Component screening
6.6 Thermal vacuum testing (TVT) and thermal baking (TB)
6.7 Vibration testing (VT)
6.8 Radiation testing (RT)
6.9 Anechoic chamber testing (ACT)
6.10 Long duration tests (LDT) and long range tests (LRT)
6.11 Qualification, proto-flight and acceptance testing
6.12 Acoustics, spacecraft charging and other tests
6.13 Testing platforms (Flat-Sats, electrical ground support equipment)

7 Launch, Ground Segment and Operations (6 hours)

7.1 CubeSat common launchers
7.2 Communication frequencies, modulations
7.3 IARU, API and ITU coordination
7.4 Ground stations
7.5 Antenna designs and considerations
7.6 Ground sensor terminals
7.7 Wireless communications link budget
7.8 CubeSat failures

Tutorial (15 hours)

1. CubeSat terminologies assignment
2. CubeSat mission design assignment
3. Requirement allocation sheet (RAS) assignment
4. System block diagrams assignment
5. CubeSat structure design
6. Power budget calculation
7. Link budget calculation
8. CubeSat design assignment

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapter	Hours	Marks distribution*
1	6	10
2	3	5
3	9	10
4	12	15
5	6	10
6	9	10
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. Cappelletti, C., Battistini, S., Malphrus, B. K. (Eds.). (2020). Cubesat handbook: From Mission Design to Operations. Academic Press.
2. Pelton, J. N., Madry, S. (2020). Handbook of Small Satellites. Springer International Publishing, Cham. https://doi. org/10.1007/978-3-030-20707-6.
3. Kim, S., Maeda, G., Cho, M. (2019). BIRDS Program Digital Textbook. MEXT.
4. Kirkpatrick, D. (1999). Space mission analysis and design (Vol. 8). J. R. Wertz, W. J. Larson, & D. Klungle (Eds.). Torrance: Microcosm.
5. https://www.iso.org/standard/66008.html