SATELLITE GEODESY AND GNSS

ENGE 302

Lecture : 3 **Year : III**
Tutorial : 0 **Part : I**
Practical : 2

Course Objectives:
The objective of this course is to provide concepts of the principles of satellite geodesy and Global Navigation Satellite Systems (GNSS). By the end of the course the students will be able to analyze satellite data and perform geodetic computations for different engineering applications.

1 Introduction (3 hours)

1.1 Definition and scope of satellite geodesy
1.2 Historical overview
1.3 Role of satellites in geodetic measurements
1.4 Relationship with other branches of geodesy

2 Satellite Orbits and Dynamics (6 hours)

2.1 Kepler's laws of motion
2.2 Satellite orbits
2.3 Satellite orbits determination
2.4 Perturbations of satellite orbits
2.5 Coordinate systems and transformations
2.6 Time systems and synchronization

3 GNSS Constellations and Working Principles (5 hours)

3.1 GNSS constellations
3.2 Functional segments of GNSS: Space, control and user segment
3.3 Antenna and receiver characteristics
3.4 Triangulation and trilateration
3.5 Almanac and ephemeris

4 GNSS Signal and Range Determinations (6 hours)

4.1 GNSS signal structure
4.2 GNSS signals: Carriers and code
4.3 Navigation message
4.4 Ranging codes
4.5 Observables: Pseudorange and carrier phase

4.6 Pseudorange and carrier phase measurement
4.7 Doppler frequency
4.8 Carrier smoothing of the code

5 Errors and Accuracy in GNSS (6 hours)

5.1 Satellite and receiver clock error
5.2 Atmospheric: Troposphere and Ionosphere
5.3 Multipath signal
5.4 Receiver noise
5.5 Timing and orbital biases
5.6 Satellite geometry and dilution of precision (DOP)
5.7 Spoofing and selective availability
5.8 Estimation of error

6 Mathematical Models for GPS Positioning (4 hours)

6.1 Pseudo range point positioning
6.2 Carrier phase point positioning
6.3 Pseudo range relative positioning
6.4 Carrier phase relative positioning
6.5 Cycle slip detection and correction
6.6 Carrier phase ambiguity resolution

7 Static and Kinematic Positioning and Data Processing (6 hours)

7.1 Code and carrier based positioning
7.2 Precise point positioning (PPP)
7.3 Differential GNSS (DGPS, RTK)
7.4 Static positioning performance and applications
7.5 Semi and pseudo-kinematic: Rapid static performance and applications
7.6 Kinematic positioning performance and applications
7.7 GNSS data preprocessing
7.8 Least squares adjustment
7.9 GNSS data analysis software

8 GNSS Augmentation and other Navigation System (3 hours)

8.1 GNSS augmentation
8.2 Satellite based augmentation systems
8.3 Ground based augmentation systems
8.4 Inertial navigation system
8.5 Indoor position system
8.6 Pseudolite
8.7 Interoperability and integrity of GNSS

9 GNSS Receivers and Applications (6 hours)

9.1 Classification and selection of GNSS receiver
9.2 Low cost GNSS receivers
9.3 Smartphone for survey
9.4 Survey planning, specification and quality assurance
9.5 Special applications
  9.5.1 Geodetic surveying and mapping
  9.5.2 Navigation and transportation
  9.5.3 Earth deformation monitoring
  9.5.4 Structural health monitoring
  9.5.5 Atmospheric research

Practical (30 hours)

1. Exploration of GNSS data formats (RINEX, RINEX2)
2. Application of data processing software (e.g., RTKLIB, gLab)
3. Performance of single-point positioning (SPP)
4. Calculation of differential GPS (DGPS) corrections
5. Implementation of RTK positioning
6. Analysis of GNSS positioning results (Position accuracy, precision, reliability)
7. Evaluation of different GNSS processing options (e.g., ambiguity resolution techniques, ionosphere models)
8. Comparison of the performance of different GNSS constellations (GPS, GLONASS, Galileo, BeiDou)
9. Use of GNSS data for geodetic surveying and mapping
10. Application of GNSS techniques for PPP and geoid determination
11. Exploration of GNSS applications in navigation, transportation and earth deformation monitoring

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	3	4
2	6	6
3	5	8
4	6	8
5	6	8
6	4	6
7	6	8
8	3	4
9	6	8
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. NovAtel Inc. (2023). An introduction to GNSS: A primer in using Global Navigation Satellite Systems for positioning and autonomy (3rd Edition). NovAtel Inc.
2. Teunissen, P. J. G., Montenbruck, O. (Eds.). (2017). Springer handbook of global navigation satellite systems. Springer International Publishing.
3. Meyer, T. H. (2010). Introduction to geometrical and physical geodesy: Foundations of geomatics. Esri Press.
4. Hofmann-Wellenhof, B., Lichtenegger, H., Collins, J. (2001). Global positioning system: Theory and practice (Latest Edition). Springer-Verlag Wien GmbH.