CBEPS CCEAG

Canadian Board of Examiners for Professional Surveyors

Conseil canadien des examinateurs pour les arpenteurs-géomètres

S3 – Geodesy

Content

- This document is a high-level curriculum design which captures the principles, competencies, learning outcomes and syllabus items proposed for the updated curriculum specific to S3 – Geodesy.

S3: GEODESY **LEARNING OBJECTIVES** **Establish the fundamental knowledge in reference systems (coordinate systems & time systems), geodetic positioning process (conventional, and satellite), map projection systems**			
Key Principles	Motivation	Syllabus Items	Competencies and /Learning Outcomes
REFERENCE SYSTEMS, GEODETIC COORDINATE COMPUTATIONS AND MAP PROJECTIONS	Surveyors need to understand the fundamentals of reference systems and be able to compute coordinates and transform between systems as appropriate.	● History and Relevance ○ Definition, Branches, Categories ○ Uses ○ Relation to the other Scientific Disciplines ○ Relevant National and International Organizations ● Earth and Its Motions ○ Annual & Diurnal ○ Precession ○ Nutation ○ Free Nutation (Polar Motion) ● Earth and Its Deformation in Time ○ Tide ○ Theory of Isostasy (Equilibrium) ○ Post Glacial Rebound ○ Plate Tectonics ● Earth and Its Atmosphere ○ Physical Properties ○ Wave Propagation o Temporal Variations ○ Gravitational Field ● Reference Systems (Definitions, Realizations and Transformations) ○ Terrestrial ○ Celestial ○ Orbital	**Competencies** ● Identify appropriate reference systems for different observation types ● Apply corrections and reductions to terrestrial observations for gravitational and geometrical effects ● Identify the geodetic processes used in datum realizations ● Implement forward and inverse coordinate computations on a reference surface and in three dimensions ● Identify and apply the necessary mathematical processes to move between different reference systems ● Distinguish different geodetic reference systems and use them in real-world situations ● Differentiate the properties, advantages, and disadvantages of map projections in North America to apply the relevant system to survey projects ● Develop and employ processes for geodetic coordinate computations in reference systems and projections of different kinds by prescribing the necessary mathematical processes ● Use processes for transforming data into appropriate reference systems and coordinates ● Evaluate projected data by applying an understanding of distortions in map projections (conformal, equivalence, equidistance, planar) and how distortions are represented mathematically ● Perform ground to map projection system transformation and vice-versa

		○ Time ● Reductions of Conventional Geodetic Measurements to the Reference Ellipsoid ● Coordinate Computations ○ 2D (spherical and ellipsoidal approximations) ○ 3D ○ Astronomic ● Map Projection Systems ○ Surfaces and Distortions ○ Classification of Map Projection Systems ○ Cylindrical, Conic and Stereographic Map Projections ○ Coordinate Computations on Map Projection Systems ○ Coordinate Transformations (Ground to Map Projection and vice versa)	● Demonstrate when and how geodetic positioning processes should be applied using real world examples (observations, corrections, reductions, position computations on ellipsoid, and projection on the mapping plane) ● Differentiate alternative reference systems and projections for observation, processing, and presentation of results **Learning outcomes** ● Summarize the history of geodesy and its relevance to the current practice of geomatics engineering ● Describe organizations related to reference systems and frames ● Identify and assess relevance of earth motions and deformations to positioning tasks ● Demonstrate how to use astronomical observations for computing latitude, longitude and azimuth ● Explain why reference systems evolve over time and how to deal with the effects ● Describe the problems of map projections and the surfaces involved in map projections and the fundamental equations of those surfaces ● Distinguish different reference systems used in geodesy ● Determine how to apply geodetic reference systems to real-world situations ● Select the appropriate coordinate system to be used in the support of a specific geodetic application and evaluate that choice with reference to limitations and accuracy of the system ● Distinguish different types of Geodetic Datums, Spatial Reference Frames and Systems used in North America ● Evaluate reference systems and anticipated reference frame realizations

S3: GEODESY **LEARNING OBJECTIVES** **Establish the fundamental knowledge in Earth's gravity field, geoid computations, vertical datum, height systems**			
Key Principle	Motivation	Syllabus Items	Competencies and Learning Outcomes
GRAVITY FIELD AND HEIGHT SYSTEMS	Earth's gravity field has a direct effect on all survey measurements as well as on the geoid. Earth's gravity field is used as a reference for positions, especially elevations	● Earth's Gravity Field ● Gravity Measurements ○ Satellite ○ Terrestrial ● Gravity Fundamentals and Characteristics ○ Real and Normal Gravity ○ Equipotential Surfaces ● Geoid Computation ● Gravimetric and Astro-Geodetic Geoid ● Mean Sea Level & Sea Surface Topography ○ Tide Gauges ○ Satellite Altimetry ● Geodetic Leveling ● Height Systems and Transformations ● Vertical Datum ○ Geoidal Models ○ Leveling Based Datums ○ Ellipsoid	**Competencies** ● Evaluate observations and data in relation to earth's gravity field ● Use knowledge of the relationship between deflection of vertical, gravity field, and geoid to interpret and transform surveying observations ● Implement the vertical or 3rd dimension of coordinate systems ● Distinguish between vertical datums and geoid models used in North America ● Apply transformation processes to convert between vertical reference systems ● Distinguish geoid from mean sea level, and interpret tide gauge observations and other sea surface information in the context of sea surface topography ● Differentiate realizations of vertical reference systems used in Canada in terms of accuracy and suitability for different project types ● Develop processes for converting observations between vertical reference systems and their realizations, including identifying and retrieving information needed to execute transformations ● Explain mathematically how the gravity field of the Earth is measured, the geoid is computed, and relate this to different height systems **Learning outcomes** ● Compute heights in different height systems

			• Describe how fundamentals of the Earth's gravity field are applied to surveying techniques and computation • Describe and evaluate the impact of gravity on measurements and on reference systems • Demonstrate the relationship between equipotential surfaces and gravity field to determine survey requirements at different scales • Evaluate alternative height systems to determine their suitability for different project types • Assess quality of geoid- or levelling-based vertical reference systems based on available gravity or levelling observations, computational processes, and properties of Earth's gravity field • Identify, compare and differentiate between height systems

S3: GEODESY LEARNING OBJECTIVES Establish the fundamental knowledge in Satellite Geodesy and Its Application in Surveying and Mapping			
Key Principles	Motivation	Syllabus Items	Competencies and Learning Outcomes
SATELLITE POSITIONING SYSTEMS	GNSS is an important tool in surveying; it is important to be able to associate the right tool to the right task by understanding the advantages and limitations that GNSS provides	● Development and Evolution of Satellite Systems (strengths and limitations) ● System Components ● Positioning Modes ○ Point/Differential ○ Post-Processing/Real-Time ○ Static/kinematic ● Satellite Signals ○ EM Propagation and Modulation Techniques ○ Basic Signal Structure ○ Signal Modernization ● Receivers' hardware components ● Observation Types & Equations ● Errors and Biases and Mitigation Strategies ○ Satellite Based ○ Signal Propagation Media based ○ Receiver Based ● Solutions ○ Point Positioning ○ Differential Positioning ○ Other Types of Observation Combination ● Types and Applications of Adjustment ● Coordinate Transformation ● Interoperability (Data Formats)	**Competencies** ● Evaluate, correct and process GNSS observations ● Distinguish different types of GNSS observations (pseudo-range, and phase), their characteristics, and their corresponding mathematical models ● Describe the basic elements, concepts and configuration of satellite systems and their relevance to the survey profession ● Identify error sources, biases and achievable accuracy associated with each positioning mode to apply appropriate mitigation strategies ● Describe, compare, and differentiate between different GNSS positioning modes and implement the appropriate mode for applications **Learning outcomes** ● Plan and implement specific procedures for using high precision GNSS ● Implement processes to cancel and/or mitigate GNSS errors and biases in different applications ● Describe and evaluate the strengths and limitations of different GNSS constellations

		• GNSS Networks in North America and around the World (CACS, CORS, IGS) • GNSS Network Establishment Consideration • GNSS Data Processing Algorithms	• Describe complications of electromagnetic wave propagation in the conditions of ranging from an extra-terrestrial source to the surface of the Earth • Identify the basic elements, concepts and configuration of satellite systems including some of the common terms relevant to surveying • Identify the error sources and evaluate achievable accuracy associated with each GNSS positioning method • Describe GNSS network considerations and relate them to GNSS network adjustments • Describe Virtual Reference System (VRS) and Satellite Based Augmented Systems (SBAS)