Canadian Board of Examiners for Professional Surveyors
Core Syllabus Item
C 6: GEODETIC POSITIONING

Syllabus Topics:

Physical aspects of geodetic positioning:

- The Earth's gravity field and its effects on positioning,
- Geoid undulations and deflections of the vertical,
- The Geoid as reference Surface for Height,
- Determination of height by spirit levelling and gravity measurements.

Space reference systems:

- classical horizontal datum,
- classical vertical datum,
- modern 3D datum,
- modern vertical datum,
- temporal variations in coordinate systems.

Computation of coordinates:

- Relating angular measurements to 3D Cartesian coordinates, to ellipsoidal coordinates and to map projection coordinates (3D Cartesian local horizontal coordinates and their link to 3D Cartesian geocentric equatorial coordinates, Laplace corrections of the azimuths),
- Relating distance measurements to 3D Cartesian coordinates, to ellipsoidal coordinates and to map projection coordinates (distance reductions).

Time scales and astronomy:

- Time (atomic time, sidereal time, universal time),
- basic principle of determination of astronomical latitude and longitude,
- basic principle of determination of astronomical azimuth,
- determining latitude and azimuth from observations on Polaris and the Sun.

GPS and other GNSS:

- the propagation of electromagnetic waves,
- the signal structure of GPS,
- pseudo-range and phase observables,
- different error sources,
- different positioning modes (absolute, differential, RTK, PPP) and the obtainable accuracy
- recent developments (modernization of GPS and GLONASS, Galileo)

Recommended Prior Knowledge and Skills:

Item C 1: Mathematics

Item C 2: Least-Squares Estimation and Data Analysis

Item C 3: Advanced Surveying

Item C 4: Coordinate Systems and Map Projection [essential for C 6]

Learning Outcomes:

In order to satisfy the requirements of this syllabus item, candidates should be able to:

With respect to physical aspects of geodetic positioning:

- Explain the basics of the physical concept of the Earth's gravity field and how it affects coordinate systems and observations,
- Define the deflections of the vertical and evaluate their effects on positioning,
- Define the concept of geopotential numbers, and explain how geopotential numbers are obtained.

With respect to space reference systems:

- Explain the establishment of a classical horizontal datum, a classical vertical datum.
- Explain how modern 3D datums are established nowadays,
- Explain when and why there has been the evolution of datums in Canada : NAD27 – NAD83 – NAD83(CSRS) and the transformation between these datums.
- Explain the relationship between NAD83(CSRS) and the different ITRFs and the transformation between these different 3D coordinate systems.
- Explain the effect of plate tectonic on coordinates and their impact on the definition of coordinate systems and on transformations.
- Explain the underlying principle of the upcoming new Canadian vertical datum and the differences compared to the existing one.

With respect to computation of coordinates:

- Identify and select the appropriate coordinate system (either on a 3D space, on the ellipsoid or on the mapping plane) to be used in the support of a specific geodetic application.
- Reduce terrestrial observations (angular and distance measurements) collected on the Earth surface of the Earth relating them to the coordinate system chosen.
- Perform coordinate transformation between the above mentioned coordinate systems.

With respect to time scales and astronomy:

- Define the difference time scales their realisation and relationships.
- Explain the basic principles of the determination of astronomical latitude and longitude
- Explain the basic principles of determination of astronomical azimuth.
- Make observations, and determine values from them, on Polaris at anytime for latitude or for azimuth, on Polaris at the optimal time for latitude or for azimuth, on the Sun for latitude or azimuth.

With respect to GPS and other GNSS:

- Explain the complications of electromagnetic wave propagation in the conditions of ranging from an extra-terrestrial source to the surface of the Earth.
- Explain the concepts and the constituents of a GNSS,
- Explain the signal structure of GPS,
- Define the different types of GPS observations, pseudo-range, and phase observables, their characteristics and the associated mathematical model.
- Explain the different positioning modes (absolute, differential, RTK, PPP), and compare them in terms of observation methods, mathematical models, measuring procedure, receiver type, and achievable accuracy.
- Explain the error sources and achievable accuracy associated with each positioning mode.
- Design a GPS survey for a given application.
- Comment on recent developments (modernization of GPS and GLONASS, Galileo).

Essential Reference Material:

Anderson, J.M., and E.M. Mikhail [1998]. *Surveying: Theory and Practice* McGraw-Hill Book Company, ISBN 0-07-015914-9 hardcover.

A comprehensive treatment of surveying, now becoming a bit dated, but covers astronomical observations.

Ghilani, C.D. and P.R. Wolf [2008]. *Elementary Surveying: An Introduction to Geomatics*, 12th edition, Prentice Hall Canada Inc., ISBN 9780136154310 hardcover

Covers astronomical observations.

Héroux P. (ed) [2006]. "Canadian Spatial Reference System" issue, *Geomatica* Vol.60 Nr.2. (http://www.geod.nrcan.gc.ca/pdf/geomatica.pdf)

Hofmann-Wellenhof, B. and H. Moritz, [2005]. *Physical Geodesy*, 2nd edition, ISBN 3-21 1-83534-2.

Hofmann-Wellenhof, B. Lichtenegger H, and Wasle E. [2007]. *GNSS – Global Navigation Satellite Systems: GPS, GLONASS, Galileo, and more*, Springer, ISBN: 3211730125/ ISBN-13: 9783211730126.

Torge W. [2001]. *Geodesy*, Walter de Gruyter, N.Y., 3rd edition ISBN 3-110-17072-8.

Supplementary Reference Material:

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