**CANADIAN BOARD OF EXAMINERS FOR PROFESSIONAL SURVEYORS**

## C6 – GEODETIC POSITIONING

**October 2023**

**Note: This examination consists of 5 questions on 2 pages.** **Marks**

| Q. No | Time: 3 hours | Value | Earned |
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| 1. | One of the classic definitions of Geodesy was "*Geodesy is the determination of the Earth's gravity field potential function*". Another one was "*Geodesy is the measurement and representation of the Earth and its gravity field*".<br>a) What is the relationship between the gravity potential and the gravity vector?<br>b) What are the components that constitute the Earth's gravity vector? What causes each component? Which component is the largest? What are the locations on the Earth's surface where each component has its smallest and largest value?<br>c) Define a level surface and discuss its properties in detail. Give examples of known level surfaces used in geodetic positioning and how each one was/is obtained.<br>d) How is the geopotential number defined? How are geopotential numbers used to obtain different types of heights? Which quantity (or parameter) will govern the obtained height type? | 3<br>7<br>5<br>5 | |
| 2. | Since the wide utilization of GPS, several people support the fact that astronomical measurements became obsolete. However, astronomical observations, especially for azimuth determination, are still important in geodetic positioning and the related highly accurate applications.<br>a) Discuss the procedure of the observation and computation of astronomic azimuth using Polaris and the Sun. Explain the differences between observing Polaris and the Sun. Give the equation and explain its parameters. Indicate which parameters are known, observed, or unknown.<br>b) What is the typical accuracy of the astronomic azimuth determination using the method you used in a) above? What are the main factors affecting such value and how can you improve it?<br>c) Differentiate between Sidereal Time, Solar Time, GMST, GAST, UT, UT1, TAI, and UTC, including what the acronyms stand for and how the UTC is obtained. | 9<br>3<br>8 | |
| 3. | Depending on the application, either the 3D Cartesian geocentric coordinates (x, y, z) or the Ellipsoidal coordinates (φ, λ, h) are used. Hence, it is always a common practice to perform transformations between them.<br>a) Define each of the Ellipsoidal coordinates (φ, λ, h). Then, draw a figure of the ellipsoid, showing the (φ, λ, h) and the 3D Cartesian geocentric coordinates (x, y, z) of a single point.<br>b) Write down the equations to transform from Ellipsoidal coordinates (φ, λ, h) to 3D Cartesian geocentric coordinates (x, y, z). Explain all parameters used.<br>c) Write down the equations to transform from 3D Cartesian geocentric coordinates (x, y, z) to Ellipsoidal coordinates (φ, λ, h). Explain all parameters used and the implemented procedure. | 6<br>6<br>6 | |

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| 4. | Surveyors will be always involved in working with local and global (geocentric) coordinate systems as well as the implementation of the required transformations. This mainly depends on the used equipment, obtained measurements, and related applications.<br>a) Define each of the following 3D coordinate systems: local astronomical, local geodetic, global (geocentric) astronomical, and global (geocentric) geodetic. Include figures in your answer.<br>b) Consider the following scenario: it is required to establish a new geodetic control station in the area (station R) and obtain its Ellipsoidal coordinates ($\varphi_R$, $\lambda_R$, $h_R$) in NAD83 (CSRS). However, you don't have access to GPS equipment, only a total station. You occupied a nearby control station (station K) with known ellipsoidal coordinates ($\varphi_K$, $\lambda_K$, $h_K$) and obtained the slope distance $S_{KR}$, vertical angle $\gamma_R$, and azimuth $\alpha_{KR}$. Describe in detail the procedure with equations how you will compute ($\varphi_R$, $\lambda_R$, $h_R$). Assume the deflections of the vertical are small enough in the area and can be neglected without affecting the required accuracy. | 8<br>12 | |
| 5. | With the evolution of GPS as the most common GNSS, surveyors have been using it on a daily basis with implementing different techniques. In addition, other GNSSs have been developed and used worldwide.<br>a) Discuss in detail the RTK technique. Include what the acronym stands for, when it should be used, observations, tools, obtained accuracy, advantages, disadvantages, and possible applications.<br>b) In some of the RTK applications, a virtual reference station (VRS) is created. Explain this concept and how it is implemented.<br>c) What other GNSSs are currently available with GPS?<br>d) What is meant by WADGPS, LADGPS, and WAAS? How are they implemented and what are their main applications?<br>e) What is meant by DOP, PDOP, VDOP, and HDOP? How are PDOPs used in GPS surveys? How are DOPs computed? | 7<br>3<br>3<br>5<br>4 | |
| | **Total Marks:** | 100 | |