CANADIAN BOARD OF EXAMINERS FOR PROFESSIONAL SURVEYORS

C6 – GEODETIC POSITIONING

October 2021

Note: This examination consists of 6 questions on 2 pages. **Marks**

Q. No	Time: 3 hours	Value	Earned
1.	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. 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. 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. 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.	5 4 6	
2.	Geodetic positioning is extremely affected by the gravity (or its potential) and the corresponding Earth's gravity field. a) What are the two components that constitute the gravity vector? What causes each component? b) Define a level surface and explain why it is also known as an equipotential surface. Then, discuss the properties of equipotential surfaces and give examples of known equipotential surfaces used previously and currently in geodetic positioning vertical datums. c) What is the geopotential number and what are the types of measurements required to determine it? How are geopotential numbers used to obtain orthometric heights?	3 7 5	
3.	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 equipment used, obtained measurements, and related applications. 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. 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 (φ_R, λ_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 (φ_K, λ_K, h_K) and obtained the slope distance S_{KR}, vertical angle γ_R, and azimuth α_{KR}. Describe in details the procedure with equations how will you compute (φ_R, λ_R, h_R). Assume the deflections of the vertical are small enough in the area and can be neglected without affecting the required accuracy.	10 15	

4.	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. 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. b) What is the typical accuracy of the astronomic azimuth determination using the method you used in (a) above?	8 2	
5.	Time and time systems are major components in geodetic positioning with all space borne techniques depending on very accurate time measurements and realizations of modern geodetic reference systems obtained using time varying parameters. a) Explain and differentiate between Sidereal Time, UT, UT1, TAI, and UTC, including what the acronyms stand for. b) Explain and differentiate between ICRS, ITRS, ITRF, and NAD83(CSRS), including what the acronyms stand for, how realizations are obtained, and the required parameters to transform between ITRF and NAD83(CSRS).	8 12	
6.	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. a) What are the differences between RTK and PPP techniques? Include what the acronyms stand for, observations, obtained accuracy, advantages, disadvantages, and possible applications. b) What is meant by DOP, PDOP, VDOP, and HDOP? How are PDOPs used in GPS surveys?	10 5	
	Total Marks:	100	