National Exams December 2017

04-Geom-A3, Geodesy and Positioning

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. This is a CLOSED BOOK EXAM.
   Approved Casio or Sharp calculator is permitted.

3. SIX (6) questions constitute a complete exam paper.
   The first six questions as they appear in the answer book will be marked.

4. Each question is of equal value. Marking scheme can be found on Page 4.

5. Most questions require an answer in essay format. Clarity and organization of the answers are very important. The candidate is strongly advised to provide succinct yet precise answers that demonstrate competency in the subject and language aptitude.

1. **Coordinate Systems, Reference Frames and Datums**
   - **a)** In Canada we use the *North American Datum 1983* (NAD83) for all positioning applications. NAD83 comes in different versions but two of them are most commonly used, namely NAD83(original) and NAD83(CSRS+epoch).
     - i. Which are the main differences between the above two versions of NAD83?
     - ii. What does the (CSRS+epoch) mean, and what is the importance of "epoch"?
   - **b)** Internationally, the *International Terrestrial Reference Frame* (ITRF) for positioning has been used. Compare NAD83(CSRS+epoch) with the ITRF(epoch) by listing similarities and differences including the order of magnitude of their differences, if any.

2. **Gravity Field and Geoid**
   - **a)** Define *gravity anomaly* in its most generic form. Based on your definition of the gravity anomaly define *free-air gravity* anomaly.
   - **b)** Which are the two fundamental data types (observations) needed for the practical calculation of the geoid using Stokes formula? Please explain how each data type is used.
   - **c)** What is the typical accuracy of modern geoid model and which are the factors that limit its accuracy (i.e., what would we need to do to increase its accuracy in the future?
   - **d)** Why do we need a geoid model in the geodetic computations?

3. **Height systems**
   In 2013, Canada replaced the old vertical datum CGVD28 with the new CGVD2013. Describe and compare both datums by briefly answering the following:
   - a) The fundamental (conceptual) difference between the two and their precision
   - b) The height system (e.g., orthometric, normal, dynamic or normal-orthometric) on which each of them is based
   - c) The reference surface used to define them
   - d) Describe one simple method to transform heights from CGVD28 to CGVD2013

4. **Map projections**
   Observations made in the field, regardless of how they were obtained (chain, compass, transit, total station, etc.,) must be projected (or reduced) first onto the reference ellipsoid (horizontal datum) and then onto the mapping plane using a specific map projection.
   - a) In order to project the distance measurements from the terrain (where the measurements are done) onto the ellipsoid, we use what is termed as the "*elevation factor*". Define "*elevation factor*" and explain how it is used.
   - b) Explain what "*map projection scale factor*" or simply "*scale factor*" is and how it is used.
   - c) What is "*grid factor*"? (Note: we often use the term "*combined scale factor*" instead of "*grid factor*")
   - d) What is MTM (3TM)? Name two conceptual differences between UTM and MTM

5. **Satellite Positioning**
   a) GNSS positions are referenced to the World Geodetic System of 1984 (WGS84). Are WGS84 and NAD83(CSRS+epoch) compatible? If yes, at what level of precision are they compatible?
   b) Are the GNSS positions in WGS84 compatible with the ITRF? Please justify you answer.
   c) What is GPS-PPP? Please describe briefly the concept of PPP and the field procedure we use to obtain positions. Discuss the accuracy in positioning one can achieve with PPP.

6. **Horizontal, vertical and three-dimensional networks; pre-analysis and post-analysis**
   After the completion of a least-squares adjustment of a geodetic network, we assess statistically the estimated parameters in order to establish a trust in them; this is known as geodetic network post-analysis. Post-analysis, among others, involves the calculation of confidence ellipses (2-D networks) or confidence ellipsoids (3-D networks). Such confidence ellipses or ellipsoids can be "*standard*", "*95%*" or other, and also "*out-of-context*" or "*in-context.*"
   a) What is "*standard error ellipse*" and what is "*standard error ellipsoid*?" What is the confidence level they define?
   b) What is the meaning of "*out-of-context*" and "*in-context*" (or simultaneous) ellipses or ellipsoids?
   c) How can we obtain the 95% confidence error ellipse from the standard error ellipse?

7. **Briefly describe the terms below (2-3 sentences for each). Sketches or graphs, wherever possible, are acceptable:**
   a) Meridian convergence
   b) Tissot's indicatrix
   c) Inertial reference coordinate system
   d) Apparent coordinate system
   e) Geopotential number
   f) Helmert orthometric height
   g) RINEX
   h) Conformal map
   i) Canadian Base Network (CBN)
   j) IERS

Marking Scheme

1. 20 marks total
   (a) 10 marks
   (b) 10 marks

2. 20 marks total
   (a) 4 marks
   (b) 5 marks
   (c) 6 marks
   (d) 5 marks

3. 20 marks total
   (a) 5 marks
   (b) 5 marks
   (c) 5 marks
   (d) 5 marks

4. 20 marks total
   (a) 8 marks
   (b) 4 marks
   (c) 5 marks
   (d) 3 marks

5. 20 marks total
   (a) 8 marks
   (b) 7 marks
   (c) 5 marks

6. 20 marks total
   (a) 8 points
   (b) 8 points
   (c) 4 points

7. 20 marks total (2 marks each)