National Exams December 2014

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 model Casio and Sharp calculators are 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.

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, we use the *International Terrestrial Reference Frame* (ITRF) for positioning. Compare NAD83(CSRS+epoch) with ITRF by listing similarities and differences including the order of magnitude of their differences, if any.

2. **Computations of positions on the ellipsoid**
   If done correctly, 2-D relative positioning on the reference ellipsoid is equivalent to 3-D (spatial) relative positioning. Please discuss the following points/questions:
   - a) State the direct problems of 2-D and 3-D relative positioning, i.e., state the "given" the "observed" and "wanted" quantities.
   - b) For the each of the problems (2-D and 3-D) list the corrections (reductions) required to the raw observations (as discussed in point (a) above) and indicate whether they are of "physical" or "geometrical" type.
   - c) Discuss the complexity of the calculations involved in 2-D and 3-D relative positioning (only the direct problem).

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
   - b) The height system (e.g., orthometric, normal, etc.) on which each of them is based
   - c) The reference surface used to define them
   - d) Precision of the two datums
   - e) 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 observations from the terrain (where the measurements are done) onto the mapping plane we use what is termed as the "*grid factor*". Define "*grid factor*" and explain how it is used (Note: we often use the term "*combined scale factor*" instead of "*grid factor*").
   - b) Explain "*meridian convergence*". Is it important to apply the meridian convergence correction to the observed azimuths when using the *Universal Transverse Mercator* (UTM) projection? Please justify your answer by providing the expected magnitude of the meridian convergence both, at the UTM central meridian and at the UTM zone boundary. For your explanations you can use sketches if necessary.
   - c) What is MTM (3TM)? Name two conceptual differences between UTM and MTM

5. Satellite Positioning

a) GPS 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 GPS 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?
d) What is a GPS-RTK network? What is the principle of operation of such a network? What positioning accuracies can we achieve? Can you name one such network in Ontario and how a user can access it?

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) Nutation of the Earth's spin axis
b) Inertial reference coordinate system
c) Apparent coordinate system
d) Geopotential number
e) Helmert orthometric height
f) Conformal map
g) Satellite altimetry
h) Canadian Base Network (CBN)
i) Tissot's indicatrix
j) IERS

Marking Scheme

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

2. 20 marks total
   (a) 7 marks
   (b) 7 marks
   (c) 6 marks

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

4. 20 marks total
   (a) 8 marks
   (b) 7 marks
   (c) 5 marks

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

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

7. 20 marks total (2 marks each)

Geom-A3, December 2014