

National Exams May 2011

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.
No calculator is needed nor permitted in this exam.
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 answer are important.

1. Coordinate Systems, Reference Frames and Datums

In Canada we use the North American Datum 1983 (NAD83) for all positional applications. NAD83 comes in different versions but two of them are most commonly used, namely NAD83(original) and NAD83(CSRs+epoch)

- a) Which reference ellipsoid is used in each of the above two datums?
- b) Which are the main differences between them?
- c) What does the (CSRs+epoch) mean, and what is the importance of “epoch”?
- d) NAD83(CSRs+epoch) is said to be linked to the ITRF96 via a 7-parameter similarity transformation. What does “ITRF96” stand for, and what is “7-parameter similarity transformation”?

2. Height systems

- a) Define geopotential number. What does it express physically? Using elementary equations, please show how we can determine the geopotential number of a point by observations.
- b) Define *normal* and *orthometric* heights. Based on your definitions, discuss the conceptual differences between these two height systems?
- c) What is the reference surface (datum) for *normal* and *orthometric* heights? Please explain.

3. Map projections

Observations made in the field, regardless of how they were obtained (chain, compass, transit, total station, etc..) must be projected (or reduced) onto the reference ellipsoid (horizontal datum) and then to the mapping plane using a specific map projection.

- a) In order to project the distance observations 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 meridian convergence correction when using the Universal Transverse Mercator (UTM) projection? Please justify your answer. For your explanations you can see sketches if necessary.

4. Inertial positioning, or Inertial Navigation Systems – INS

- a) What is the principle behind the operation of an INS? Briefly describe its components and their roles in the measurements. You can use sketches if necessary.
- b) Does the gravity field of the Earth play a role in an inertial navigation system? Please explain such a role and its importance in the positional accuracy.
- c) What are the differences between a platform INS and a strapdown INS?

5. Satellite Positioning

- a) The Global Positioning System (GPS) can be used for positioning in different observational modes depending on the application and accuracy required. Two of these modes include a) point positioning and b) relative GPS. For each of the modes describe the field procedure, the achievable accuracy and one typical application.
- b) GPS positions are referenced with respect 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?
- c) Are the GPS positions in WGS84 compatible with the ITRF? Please justify your answer.

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. Gravity field

In geodesy, gravity field studies are almost exclusively focused on the determination of the geoid.

- a) Define *geoid*.
- b) Which are the two fundamental data sets needed for the practical calculation of the geoid using Stokes integral? Please explain how each data set is used.
- c) Canada and the US have been leaders internationally in the adoption of “*height system modernisation*”. *Height Modernization* is an entirely new, innovative and cost-effective approach towards defining and accessing accurate heights in a vertical reference frame. In no more than about 250 words (about ½ typed page) describe the height modernization concept by making reference to the observational methods and their accuracy, the role of the geoid and its time variability.

8. Briefly describe the terms below (2-3 sentences for each). Sketches or graphs, wherever possible, are acceptable:

- a) Polar motion
- b) Atomic time
- c) Line of apsides
- d) GPS-RTK
- e) Gravity anomaly
- f) Canadian Base Network (CBN)
- g) ITRS
- h) VLBI
- i) RINEX
- j) IGS
- k) IUGG