

National Exams May 2012

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 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

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).

- a) Which are the main differences between the above two versions of NAD83?
- b) What does the (CSRs+epoch) mean, and what is the importance of “epoch”?
- c) Internationally, we use the *International Terrestrial Reference Frame* (ITRF) for positioning. Please compare NAD83(CSRs+epoch) with ITRF by listing similarities and differences including the order of magnitude of their differences, if any.

2. Height systems

- a) In Canada we currently use the *Canadian Geodetic Vertical Datum* of 1928 (CGVD28) for heights. CGVD28 is based on the “*Normal Orthometric Heights*”. What are normal orthometric heights and what is their conceptual difference from the more traditional “*Helmert orthometric heights*”?
- b) Canada and the US have been leaders internationally in the adoption of “*height system modernisation*”. *Height Modernization* is an 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.

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) 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 *isometric latitude*. What is its role in the Universal Transverse Mercator (UTM) projection?

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) Name two important error sources of an INS and give their order of magnitude.
- c) What are the differences between a platform INS and a strapdown INS?

5. Satellite Positioning

- a) GNSS: What does this acronym stand for and which are its components? Please discuss briefly how GNSS, will enhance geodetic positioning/navigation applications when fully operational.
- b) 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?
- c) Are the GPS positions in WGS84 compatible with the ITRF? Please justify you 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) Define *deflection of the vertical*. Please identify one geodetic positioning application of your choice that requires the knowledge of the deflection of the vertical.

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

- a) Precession of the Earth’s spin axis
- b) UTC
- c) Apparent coordinate system
- d) GPS-RTK
- e) Satellite altimetry
- f) Canadian Base Network (CBN)
- g) MEMS
- h) VLBI
- i) RINEX
- j) IAG
- k) IERS