National Exams May 2010

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.
   Candidates may use one of two calculators, a Casio or Sharp approved models.

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**
   Suppose that you want to determine your position in terms of astronomical latitude and longitude (Φ, Λ) using astronomical observations to Polaris. Your observations are performed in the Local Astronomic (LA) coordinate system, whereas the position of Polaris is known in the Apparent Right Ascension system (or Apparent Places AP-system).
   a) Which are the quantities (observables) are you need to measure?
   b) In what coordinate system would your position (Φ, Λ) be referenced?
   c) Write the transformation equation between LA and AP that establishes the mathematical relationship between your position (Φ, Λ) and the position of the Sun. Please use rotation matrices and explain the angles involved.

2. **Height systems**
   a) Define geopotential number. What does it express physically? Can we determine the geopotential number of a point by observations? How?
   b) Define *dynamic* and *orthometric* heights. What is the conceptual difference between these two height systems?
   c) Can the orthometric height be calculated accurately? Please justify your answer
   d) What is the reference surface (datum) for *dynamic* heights?

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) before any map projection is attempted.
   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.
   b) When we project azimuth (or bearing) measurements onto the ellipsoid we usually apply at least one important correction, which is known as "*complete Laplace correction*". What is "*complete Laplace correction*" and what is it due to? What is the order of magnitude of this correction and when can we omit it?

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) Why is it important to know accurately the gravity field of the Earth when using an inertial navigation system?
   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) Name two sources of systematic errors in the GPS observables and give the order of their magnitude. How can we reduce or eliminate these errors with field procedures?

6. **Horizontal, vertical and three-dimensional networks; pre-analysis and post-analysis**
   After the completion of a least-squares adjustment, we assess statistically the estimated parameters in order to establish a trust in them or check their compatibility with a previous adjustment. For the former case, we calculate 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**
   a) Define *gravity anomaly* in its most generic form. Based on your definition define "*refined Bouguer*" gravity anomaly.
   b) Which are the <u>two</u> fundamental data sets needed for the practical calculation of the geoid using Stokes integral? Please explain how each data set is used.