國立交通大學 106 學年度第 1 學期
博士班資格考筆試考試試題

土木工程學系 測量組(戊) 科目：專業科目(物理大地&衛星大地) 選考學生數：1 考試時間：120min

(open book 考試完畢考題可開放留存參考)

物理大地

1. 根據內政部所頒定一等水準測量作業規範，現行高程系統 TWVD2001 係以平均海水面作為高程起算之參考基準面。
   (a) 平均海水面與大地水準面有甚麼差異?你認為以平均海水面作為參考基準面與以大地水準面作為參考基準面哪一個比較合理，試申論之。
   (b) 在平均海水面作為參考面的概念下，如果我們一條水準路線從基隆的參考面出發，一路引到新竹南寮的潮位站，引回南寮潮位站的平均海水面，高程會回歸到零嗎? 試申論之(假定兩個站的平均海水面都是同一個時期的海水面觀測，不考慮觀測隨機誤差，只討論概念的系統誤差)? 如果以大地水準面當成參考面，情況又是如何?
   (c) 假定只給你水準儀跟水準尺，還有重力儀，你以水準網引接高程基準參考面。你可以推求水準控制網中各水準點的正高嗎? 你可以在各水準點標出下方(沿鉛錘線方向)大地水準面相對於水準點的位置嗎? 你可以在參考橢球坐標系統上標出各處的大地水準面位置嗎? 如果無法求出，你還需要甚麼樣的觀測來輔助?

2. 設 $P_n(\cos\Psi)$ 表示 n 階 Legendre 多項式，Ψ 為球面弧距，$0 \le \Psi \le \pi$
   (a) 試證明級數

$$\sum_{n=2}^{\infty}\frac{2n+1}{n-1}P_n(\cos\Psi)=\frac{1}{\sin(\Psi/2)}-6\sin\frac{\Psi}{2}-5\cos\psi-3\cos\Psi.\ln\left(\sin(\Psi/2)+\sin^2(\Psi/2)\right)+1$$

   (b) 試討論在 $\Psi \in [0,\pi]$ 的區間內，這個級數是否收斂?
   (c) 若以(a)之級數做為積分核函數，積分重力異常 Δg 以求高度為 R 的地表面擾動位

$$T=\frac{R}{4\pi}\iint_{\sigma}\left[\sum_{n=2}^{\infty}\frac{2n+1}{n-1}P_n(\cos\psi)\right]\Delta g d\sigma$$

   請問該如何解決核函數發散的問題?

3. 衛星測高(altimetry)可以提供延軌跡方向海水面高的觀測。若我們以 Inverse Vening Meinesz 公試計算重力異常，並因此解算大地起伏與大地水準面
   (a) 此方法會受到溫鹽效應造成的 Sea Surface Topography 影響嗎? 試申論之。
   (b) 從測高資料可否計算 Sea Surface Topography?

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Satellite Geodesy (open book)

1. Compare the satellite navigation systems GPS, BDS, GLONASS, based on (1) navigation satellites (the sky component) (2) signal structure, and (3) positioning accuracy. (30%)

2. Explain the perturbing forces acting on a low earth-orbiting satellite such as Taiwan FORMOSAT-2. (30%)

3. Explain how GRACE detects gravity changes.

(a) The key measurements of GRACE. (10%)

(b) How such measurements are used to compute gravity changes. (10%)

4. Answer the following questions about InSAR.

(a) What is the principle of InSAR? (10%)

(b) Show how InSAR is used in land subsidence detection. (10%)

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1. Please detail all you know about the **Height Modernization** including concepts, applications, advantages and limitations. (20%)

2. Please explain the difference between **standard deviation** and **root-mean-square-errors**. (10%)

3. There are many systematic errors that can affect GPS positioning accuracy. Show methods for reducing the following systematic errors.
   (a) Ionospheric effect (5%)
   (b) Tropospheric effect (5%)
   (c) Clock error (5%)

4. In the Gauss Markov model of parameter estimation, the design matrix can have rank defects.
   (a) Show one example for the Gauss Markov model with rank defects. (10%)
   (b) In your example, is the residual vector from the least-squares solution estimable (unique)? (5%)

5. There are several statistical testing widely applied in surveying.
   (a) For detecting "outliers" from observation, what statistical testing(s) could be applied? Please describe the(se) testing, including the null and alternative hypotheses, the statistic form, and probability density function on which the(se) testing are based. (15%)
   (b) What is "chi-squared test "(χ^2) and how it could be applied? (5%)

6. There is a distance between A and B, measured 5000 meters. The ellipsoid height is known to be 1000 meters at A and 10 meters at B. The geoid height is 15 meters at A and 0 meter at B.
   (a) What is the distance reduced to ellipsoid if the earth is taken as a sphere with 6371km radius? (10%, Please list all digits computed)
   (b) What would be the distance reduced if the orthometric height were used? (10%, Please list all digits computed)