CANADIAN BOARD OF EXAMINERS FOR PROFESSIONAL SURVEYORS
ATLANTIC PROVINCES BOARD OF EXAMINERS FOR LAND SURVEYORS

SCHEDULE I / ITEM 3 — March 2008
ADVANCED SURVEYING

Notes : This examination consists of 7 questions on a total of 4 pages.

Although programmable calculators may be used, candidates must show all formulae used, the substitution of values into them, and any intermediate values to 2 more significant figures than warranted by the answer. Otherwise, full marks may not be awarded even though the answer is numerically correct.

Q. No	Time: 3 hours	Marks Value	Marks Earned
1	There is a dispute about the orientation of the front boundary of a parcel that was surveyed in 1991. The contention is that the SE corner is due East of the SW corner within ±5″. In researching the 1991 survey, you have found the fieldnotes which show that the SW corner was occupied with reference sights onto the SE corner and sights on Polaris, as follows. The zone clock times of observation are in Central Daylight Saving Time [CDT] on 12 May 1991, as noted. Observations at Station SW: Station SE Polaris CDT, 1991 05 12 000°00′12″ 268°49′09″ 19h 16m 21.5s 88°48′39″ 19h 19m 36.1s 180°00′16″ α Ursae Minoris: GHA Declination 1991 05 12, 0h00 UT 193°59′34.2″ 89°13′33.00″ 1991 05 13, 0h00 UT 194°58′30.1″ 89°13′32.67″ 1991 05 14, 0h00 UT 195°57′24.0″ 89°13′32.36″ Station SW is approximately 103°49′45″W and 49°38′50″N. Determine whether the contention is correct.	20	
2	Last July, a crew laid out a 1500 m distance from one survey marker to set a second survey marker. Even though the temperature was + 30 C, they did not apply a meteorological correction but simply used the display value of "1500.000". You have just measured between the two markers and the uncorrected display, using the same instrument [± 5 mm and ± 5 ppm; n_0 = 1.0002936, design refractive index number or design refractivity: 278.367 at 15 C and 760 mmHg] and reflector, is "1500.077" with an ambient temperature of – 30 C. Determine whether there is a significant difference between the separation of the markers now compared to last July, assuming standard pressure.	10	

3	A distance of 1500 m is to be measured. One EODMI, ± 3 mm and ± 2 ppm, can measure the overall distance. Another, ± 2 mm and ± 2 ppm, would have to measure 500 m at a time. Explain which would be the better choice to measure the distance and why.	10	
4	Canadian Special Order Levelling instrumentation and procedures are very similar to those of the US FGCC First Order Class I except that the latter is slightly more stringent and requires that the "… difference between backsight and foresight distances at each set-up and their total for each section" are "not to exceed 2 m …" with maximum lengths of sight of 50 m. Normally, invar double scale rods and a high precision level [M • 40X, sensitivity • 10″/div] with parallel plate micrometer are used and "not to exceed" is interpreted as being at 99%. A crew has done several days of levelling as part of their work on a project just across the border in the US. On their return, the crew chief claims that their pacing the sight lengths was sufficient to meet the First Order Class I specifications. a) With appropriate statistical considerations, determine whether he was correct in that claim. b) Explain whether the nature of the terrain would influence the validity of his method and whether pacing is susceptible to any particular types of blunders or mistakes that might be significant. c) Explain whether there would have been any way of checking the balancing of the lengths of sight during a setup and how that could or should have been done.	10 5 5	
5	The ratio of misclosure ["RoM"] in a traverse is often called the "precision" of the traverse. By addressing what contributes to the uncertainty associated with the RoM in a traverse joining two pairs of coordinated monuments, explain whether using the word "precision" is correct and, if not, what would be a better term and why.	10	
6	The maximum allowable angular misclosure in a traverse of n_β angles is stated as M_β [at 99%]. a) Determine an expression for the standard deviation, σ_β, of each of the n_β angles, considering that each would contribute equally to the actual misclosure m_β. If there were 5 angles in the traverse and $M_\beta = 10'' [n_\beta]^{1/2}$, what should be the standard deviation of the average of each angle? The average from n_s sets of an angle would then have a standard deviation of $\pm \sigma_\beta$. b) Based on σ_β, determine an expression for the allowable discrepancy, δ_s, between individual sets that would be used as a quality check at the time of observation. If σ_β were ± 3.9″, what would be the value of the discrepancy if 3 sets were to be observed?	5 5	

7	Usually, the purpose of a geodetic network [directions, zenith angles, spatial distances] is to determine the positions of the stations involved. However, if a network includes points on a sensitive structure and is repeatedly re-observed, the data can be used to monitor the geometric deformation of the structure. And, usually then, the "absolute", rather than "relative", movement of the structure points [the "object points"] can be described with respect to the network stations [the "reference points"]. The relative movement of points within the structure usually involved geotechnical instrumentation. a) Explain the concerns that should be regarded when dealing with "absolute" monitoring over the long term [annually for decades] and what is normally done about these concerns. b) Explain why geotechnical instrumentation is more likely used to monitor relative movement and provide an example to substantiate your explanation.	10 10	
	Total Marks:	100	

Percentiles of the χ^2 distribution:

	0.50	0.70	0.80	0.90	0.95	0.975	0.99	0.995
1	0.455	1.07	1.64	2.71	3.84	5.02	6.63	7.88
2	1.39	2.41	3.22	4.61	5.99	7.38	9.21	10.60
3	2.37	3.66	4.64	6.25	7.81	9.35	11.34	12.84

Some potentially useful formulae are given below.

$$\tan Z = \frac{-\sin t}{\tan\delta\cos\varphi - \sin\varphi\cos t}$$

$$\sin Z = -\frac{\sin t\cos\delta}{\cos h}$$

$$\sin Z = \frac{\sin p}{\cos\varphi}$$

$$\cos Z = \frac{\sin\delta}{\cos h\cos\varphi} - \tan h\tan\varphi$$

$$\sin\beta_1 = \frac{b_1\sin\alpha_1}{a};\quad \sin\beta_2 = \frac{b_2\sin\alpha_2}{a}$$

$$\sigma_\beta^2 = \frac{\tan^2\beta}{b^2}\sigma_b^2 + \frac{\tan^2\beta}{a^2}\sigma_a^2 + \left(\frac{b^2}{a^2\cos^2\beta} - \tan^2\beta\right)\sigma_\alpha^2$$

$$\sigma_{y_n}^2 = \sum_{i=1}^{n-1}(x_n - x_i)^2\sigma_{\beta_i}^2$$

$$\sigma_{y_n}^2 = \sum_{i=1}^{n-1}(x_{i+1} - x_i)^2\sigma_{\alpha_i}^2$$

$$\sigma_s^2 = a^2 + b^2 s^2$$

$$d\delta = 8'' \frac{pS}{T^2} \frac{dT}{dx}$$

$$T = \frac{\sum_{i=1}^{n} \left[(h_{i+1} - h_i)(T_i + T_{i+1}) \right]}{2(h_n - h_1)}$$

$$\Delta h_w = \frac{w}{aE} \left(Lh - \frac{h^2}{2} \right)$$

$$n_a = 1 + \frac{0.359474(0.0002936)\,p}{273.15 + t}$$

$$\Delta N_1 = 281.8 - \frac{0.29065\,p}{1 + 0.00366086t}$$

$$\Delta N_1 = 278.4 - \frac{0.29065\,p}{1 + 0.00366086t}$$