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

SCHEDULE I / ITEM 3 — October 2008
ADVANCED SURVEYING

Notes : This examination consists of 8 questions on a total of 5 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 1995. The contention is that the SW corner is due West of the SE corner within ±5″. In researching the 1995 survey, you have found the fieldnotes which show that the SE corner was occupied with reference sights onto the SW corner and sights on Polaris, as follows. The zone clock times of observation are in Eastern Daylight Saving Time [EDT] on 5 August 1995, as noted. Observations at Station SE: Station SW Polaris EDT, 1995 08 05 000°00′02″ 90°21′30″ 20h 10m 05s 270°21′46″ 20h 10m 35s 179°59′58″ α Ursae Minoris: GHA Declination 1995 08 05, 0h00 UT 276° 07′ 05.1″ 89° 14′ 19.48″ 1995 08 06, 0h00 UT 277° 05′ 44.2″ 89° 14′ 19.58″ 1995 08 07, 0h00 UT 278° 04′ 23.7″ 89° 14′ 19.71″ Station SE is approximately 79°21′00″W and 43°47′30″N. Determine whether the contention is correct.	15	
2	Last February, a crew laid out a 1200 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 "1200.000". You have just measured between the two markers and the uncorrected display, using the same instrument [± 3 mm and ± 2 ppm; n_0 = 1.0002936, design refractive index number or design refractivity: 278.367 at 16 C and 760 mmHg or 1013.25 mb] and reflector, is "1199.939" with an ambient temperature of +20 C. Determine whether there is a significant difference between the separation of the markers now compared to last February, assuming standard pressure.	10	

3	A distance of 1800 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 600 m at a time. With consideration for both random and systematic errors, explain which would be the better choice [1800 or 3x600] to measure the distance and why.	5	
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. With appropriate statistical considerations, determine whether he was correct in that claim.	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 [not "control"] 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 associated with the average of each angle [from n_s sets]? 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 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	The only access to a 3 m diameter drift that is 400 m below the surface is through a vertical shaft that is 4 m in diameter and is at one end of the drift. There are grid-coordinated points on the surface as close as 10 m from the mouth of the shaft which has a concrete collar extending 2 m beyond the opening of the shaft. The sump is 500 m below the surface. A traverse has been run along the drift with points attached to one side of the wall, spaced every 200 m, to a total of 1600 m from the shaft. The activity is at a latitude of 63°N. a) Suggest a method for determining the grid azimuth of the course joining the last two stations of the drift traverse. b) Explain what would contribute to the random uncertainty of that grid azimuth with some suggestion of the magnitude associated with each contribution and their total. c) Explain what geodetic "corrections" would have to be applied to the observations in order to result in a proper grid azimuth and suggest their magnitudes.	10 10 10	
8	The geodetic observable of height difference [ΔH], when repeated and differenced [$\delta\Delta H$], can be used with the horizontal separation [s_H] of two bench marks to determine the "geodetic" tilt between the two points. A tiltmeter can be installed at a location in a structure and interfaced for computer controlled repeated data collection, resulting in "geotechnical" tilt at that point. High precision geodetic equipment and procedures can result in a precision of the geodetic tilt that is comparable to that of the geotechnical. With regard for long term monitoring, compare the geodetic and geotechnical tilt determinations with some explanation of the advantages and disadvantages of each when monitoring a man-made structure that is sensitive to seasonal variations in temperature and humidity.	15	
	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.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$\varepsilon_A = \frac{206264.8}{b}\sqrt{e_1^2 + e_2^2}$$

$$\Delta H = \frac{PH}{aE}$$

E = 2.1×10^6 kgcm^{-2}

$$T = 2\pi\sqrt{\frac{H}{g}}$$

g = 980 cms^{-2}

$$e = \frac{30hHdv^2}{P}$$

$$r_0 = r_2 - \frac{P_1(r_1 - r_2)}{P_2 - P_1}$$

$$r = \frac{\pi d^4 E}{64RP}$$

$$\theta = \frac{d\tan\phi\left(1-\varepsilon^2\sin^2\phi\right)^{\frac{1}{2}}}{a}$$

$$\Delta\gamma = \frac{\Delta E\tan\phi}{R}$$

6378206.4 m, 0.0822718948

6378137.0 m, 0.081819191