CANADIAN BOARD OF EXAMINERS FOR PROFESSIONAL SURVEYORS

SCHEDULE I / ITEM 3 **March 2009**
ADVANCED SURVEYING

Notes : This examination consists of 7 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.

Time: 3 hours

Q. No		Marks Value	Marks Earned
1	There is a dispute about the orientation of the side boundary of a parcel that was surveyed in 2000. The contention is that the NW corner is due North of the SW corner within ±5″. In researching the survey, you have found the fieldnotes which show that the SW corner was occupied with reference sights onto the NW corner and sights on Polaris, as follows. The zone clock times of observation are in Central Standard Time [CST] on 3 December 2000, as noted. Observations at Station SW: Station NW / Polaris / CST, 2000 12 03 000°00′00″ Polaris 000°18′51″ — 20h 30m 49s Polaris 180°16′50″ — 20h 31m 31s 180°00′01″ α Ursae Minoris: 2000 12 03, 0h00 UT: GHA 33° 35′ 22.8″, Declination 89° 16′ 09.70″ 2000 12 04, 0h00 UT: GHA 34° 34′ 44.4″, Declination 89° 16′ 10.04″ 2000 12 05, 0h00 UT: GHA 35° 34′ 06.4″, Declination 89° 16′ 10.36″ The SW corner is approximately 89°26′00″W and 43°05′24″N. Determine whether the contention is correct.	15	
2	Last July, a crew was to lay 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 [± 3 mm and ± 2 ppm; group refractive index: 1.000294497; design refractive index number or design refractivity: 282.106 at 12 C and 760 mmHg or 1013.25 mb] and reflector, is "1500.095" with an ambient temperature of − 25 C. Determine the current separation of the markers now and whether there is a significant difference, at 80 %, between the separation of the markers now compared to last July, assuming standard pressure.	10	

3	A distance of 2100 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 700 m at a time. With consideration for both random and systematic errors, explain which would be the better choice [2100 or 3x700] to measure the distance and why. In either use, the centering is ± 0.5 mm per metre of height, which can be taken as 1.6 m.	5	
4	In many elementary plane surveying textbooks, the determination of the additive constant, z_0, is usually presented in very simple terms, with a unique determination using three points [i.e., no redundancy]. Adding a correction to an observation should not unduly increase the uncertainty in the corrected value compared to the uncorrected value. a) Explain how the unique determination of z_0 would increase the uncertainty in the corrected distance and by how much, if the distance to be corrected was $\pm \sigma_s$ and the distances in the unique determination were also $\pm \sigma_s$. b) Explain how a collinear array of 5, preferably 6, points would improve the uncertainty in the value of z_0.	5 10	
5	The maximum allowable angular misclosure in a traverse of n_β angles is stated as M_β [at 99%]. a) Using the propagation of variance, develop 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. b) 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 $\pm \sigma_\beta$. c) Based on σ_β, develop an expression for the discrepancy, δ_s, between individual sets that would be used as a quality check at the time of observation. d) If σ_β were $\pm 3.9''$, what would be the value of the discrepancy if 3 sets were to be observed?	3 2 3 2	
6	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 local 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 1800 m from the shaft in an approximately E/W direction. The activity is at a latitude of 63°N. a) Suggest a method [observables, equipment, procedures] for determining the local grid azimuth of the course joining the last two stations of the drift traverse. b) 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. c) Explain what would contribute to the random uncertainty of that azimuth with some suggestion of the magnitude associated with each contribution.	10 10 10	

7	An extensometer mechanically measures the change in a distance to a precision that is much better than if the distance were to be determined in absolute terms. a) Give an example of an extensometer that could be used at several locations [i.e., between different pairs of anchor points] and of one that would remain *in situ* and explain why in both cases. b) Explain how an extensometer may be used to determine the strain between two reference points and what would be a typical value for the uncertainty in that strain if the two points were 40 m apart. c) Explain how extensometers at several locations within a concrete structure could be used to determine whether the behaviour of the structure is simply its reaction to the seasonal variation in ambient temperature.	5 5 5	
	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.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

E = 2.1x10^6 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

$$\varepsilon = \frac{\Delta f}{f}$$

$$c = [N_0 - N_a]s$$