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

SCHEDULE I / ITEM 3 **October 2006**
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.

Time: 3 hours

Q. No		Marks Value	Marks Earned
1	The maximum allowable angular misclosure in a traverse of n_β angles is stated as M_β at 99%. a) Determine the standard deviation, σ_β, of each individual angle [i.e., the average from n_s sets], considering that each would contribute equally to the actual misclosure m_β. b) If the averaged angle is then $\pm\sigma_\beta$, determine the allowable discrepancy, δ_s, between individual sets that would be used as a quality check at the time of observation.	10	
2	Points A, B, C, D, and E are in order along a practically straight line. Points A and B have known coordinates and can be considered as errorless. Point E is to be coordinated off points A and B through a traverse having points C and D as intermediate stations. Each point is approximately 200 m from its immediate neighbour. The included angle at B, C, or D is ~ 180° and the line of the five points can be considered as parallel to the x coordinate axis. a) If each of the included angles has a standard deviation of $\pm$ 5″, what is the lateral random error [i.e., σ_y] associated with the position of point E? b) What equipment and procedures would you recommend to achieve a standard deviation of $\pm$ 5″ in an angle? c) If azimuths, rather than included angles, were observed [$\pm$ 5″] at points B, C, and D, what would be the random lateral error in the position of point E? d) What equipment and procedures would you recommend to achieve a standard deviation of $\pm$ 5″ in an azimuth? e) Explain what would be the dominant random error and dominant systematic error influence affecting this traverse when i) observing angles only, and ii) observing azimuths only. f) Explain why observing azimuths might be preferred over observing included angles in this situation [with reference to your answer to part e of this question].	20	

3	Station AT [79°21′00″W; 43°47′30″N] was occupied with observations to station RO and α Ursae Minoris [Polaris] as follows. The zone clock times of observation are in Eastern Daylight Time [EDT] on 5 August 1995, as noted. From this one set of observations, determine the azimuth from AT to RO.
	
	Observations at Station AT:
	Station RO Polaris EDT, 1995 08 05
	000°00′02″
	    46°02′25″ 20h 10m 05s
	    226°02′41″ 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″
		20	

4	Canadian Special Order Levelling procedures require that "… difference between backsight and foresight distances at each set-up and their total for each section not to exceed 5 m …" with maximum lengths of sight of 50 m. Normally, invar double scale rods and a level [M • 40X, sensitivity • 10″/div] with parallel plate micrometer are used. How well would the lengths of sight have to be determined [i.e., σ_s]? How would they be measured? Interpret "not to exceed" as being at 99%.	15	
5	For visible and near infra-red radiation and neglecting the effects of water vapour pressure, the refractivity correction, ΔN, can be determined by $$\Delta N_i = N_D - N_i = 281.8 - \left[\frac{0.29065\,p}{1 + 0.00366086\,t} \right]$$ The meteorological correction is in the sense that $s = s' + c_{met}$, with $c_{met} = \Delta N_i s'$. a) Temperature and pressure are to be measured at each end of a 1400 m distance, the refractivity correction at each end will be calculated, and the average value of ΔN_i will be used to determine the meteorological correction, c_{met}. The instrument being used has a design n_D = 1.0002818 [so that N_D = 281.8] and the average temperature and pressure during the measurements are expected to be +35°C and 1000 mb. What would be the largest values of σ_t and σ_p that, together with equal contribution to $\sigma_{\Delta N}$, would result in a meteorological correction that would contribute uncertainty of no more than 2 ppm to the corrected distance? b) What equipment should be used and what procedures should be followed in order to ensure that the required precisions in temperature and pressure are met? c) If the accuracy [not "precision"] of a distance is to be degraded by no more than 2 ppm as a result of the meteorological correction, what concerns would you have in deciding on equipment and procedures for measuring temperature and pressure?	10	

6	Observations on α *Ursae Minoris*, are done at $\phi \geq 50°$ in many locations in Canada. As with any other angular measurement, averaging the determinations, by the hour angle method, from several sets improves the precision of the azimuth. The accuracy of the determination would also be improved with several sets. Assuming that an instrument comparable in precision to a Wild T2 [micrometer: 1"; 28X; plate vial: 20"/div; index vial: 30" with coincidence viewing] were being used and that the RO is at least 250 m away, explain a) what systematic influences would affect a single determination, or set, and b) how the accuracy would be improved with several sets.	10	
7	The additive constant [or "system constant" or "zero correction"], z_0, is a correction that is applied to the output of an EODMI, $s = s' + z_0$, to account for the offset between the electronic and mechanical centres of an instrument and reflector combination. The magnitude of z_0 can be as high as 35 mm to 90 mm depending on the reflector mounting and EODMI/reflector combination. a) Explain how z_0 can be uniquely determined, independent of any other information. b) If each distance involved in the unique determination of z_0 is ± 0.002 m, what is the consequent random uncertainty in z_0? c) If the same EODMI as in part b is used elsewhere, say s_i' ± 0.002 m, what is the random uncertainty in the corrected distance, s_i? d) Normally corrections are expected to not significantly contribute to the uncertainty of the quantity that they are correcting. In what way could the random uncertainty in z_0 be improved? e) i. What type of error contaminates an uncorrected distance, s', if z_0 is not applied? ii. How would that error affect the accuracy and the precision of a traverse involving n_d distances between two pairs of control points? iii. How would it affect the accuracy and the precision of a traverse involving n_d distances in a loop?	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.

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

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

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

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

$$-\frac{\Delta^2}{2S}$$

$$\sigma_c = \pm 0.5 mm\, h; \quad \sigma_l = \pm 0.2\, div$$

$$\sigma_{\delta_c}^2 = \frac{\sigma_{c_{AT}}^2 + \sigma_{c_{TO}}^2}{s^2}; \quad \sigma_{\delta_l}^2 = \sigma_l^2 \tan^2 v$$

$$\sigma_{\delta_p}^2 = \frac{1}{2}\left[\pm\frac{45''}{M}\right]^2; \quad \sigma_{\delta_r}^2 = \frac{1}{2}\left[\pm 2.5''\, div\right]^2$$

$$\sigma_{\beta_c}^2 = \frac{\sigma_{c_{FROM}}^2}{s_{FROM}^2} + \frac{\sigma_{c_{TO}}^2}{s_{TO}^2} + \left[\frac{1}{s_{FROM}^2} + \frac{1}{s_{TO}^2} - \frac{\cos\beta}{s_{FROM} s_{TO}}\right]\sigma_{c_{AT}}^2$$

$$\sigma_{\beta_l}^2 = \sigma_l^2\left[\tan^2 v_{FROM} + \tan^2 v_{TO}\right]$$

$$\sigma_{\beta_p}^2 = \left[\pm\frac{45''}{M}\right]^2; \quad \sigma_{\beta_r}^2 = \left[\pm 2.5''\, div\right]^2$$

$$\sigma_{\beta_{rep}}^2 = \frac{2\sigma_s^2}{n^2} + \frac{2\sigma_p^2}{n}; \quad \sigma_{\beta_{dir}}^2 = \frac{2\sigma_s^2}{n} + \frac{2\sigma_p^2}{n}$$

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

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

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

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

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