

**ASSOCIATION OF CANADA LANDS SURVEYORS - BOARD OF EXAMINERS  
WESTERN CANADIAN BOARD OF EXAMINERS FOR LAND SURVEYORS  
ATLANTIC PROVINCES BOARD OF EXAMINERS FOR LAND SURVEYORS**

**SCHEDULE I / ITEM 3  
ADVANCED SURVEYING**

**September 2002**

**Note: This examination consists of 8 questions on 3 pages.**

<u>Q.No</u>		<u>Marks</u>																						
		<u>Value</u>	<u>Earned</u>																					
1	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, explain whether using the word "precision" is correct.	5																						
2	<p>The distance between points A and B was measured in three sections, with intermediate points P1 and P2 under the assumption that both P1 and P2 were in line with A and B. Subsequent alignment by theodolite in the direction from A to B revealed that P1 was 1.500 m to the left of the line AB and that P2 was 2.000 m to the right of the line AB. The measured distances were as follows.</p> <p>A to P1: 300.050 m P1 to P2: 299.950 m P2 to B: 300.147 m</p> <p>a) What are the corrections, to be added to each of the observed distances, to account for the mis-alignment of the intermediate points [P1 and P2] in order to obtain the straight line distance from A to B? b) If the uncertainty in any of the three alignment corrections is to be no more than <math>\pm 0.001</math> m, how well would the two lateral offsets have to be determined [i.e., <math>\sigma_{\text{offset}}</math>] and how might measuring the offsets be done to that precision? c) If the alignment had been done by observing angles at A from B to each of P1 and P2, how well would the angles have to be observed [i.e., <math>\sigma_{\beta}</math>] to result in alignment corrections that are <math>\pm 0.001</math> m [i.e., compatible with those in part b)?</p>	10																						
3	<p>Station AT [89°26'00" W; 43°05'24" N] was occupied with observations to station RO and <math>\alpha</math> Ursae Minoris [Polaris] as follows. The local clock times of observation have already been converted to UTC on 4 June 1993, as noted. From this one set of observations, determine the azimuth from AT to RO.</p> <p>Observations at Station AT:</p> <table style="width: 100%; border: none;"> <tr> <td style="width: 30%;">Station RO</td> <td style="width: 30%;">Polaris</td> <td style="width: 40%;">UTC, 1993 06 04</td> </tr> <tr> <td>000°00'00"</td> <td></td> <td></td> </tr> <tr> <td></td> <td>49°39'28"</td> <td>1h 44m 33s</td> </tr> <tr> <td></td> <td>229°40'56"</td> <td>1h 49m 46s</td> </tr> </table> <p>179°59'57"</p> <p><math>\alpha</math> Ursae Minoris:</p> <table style="width: 100%; border: none;"> <tr> <td style="width: 30%;"></td> <td style="width: 30%; text-align: center;">GHA</td> <td style="width: 40%; text-align: center;">Declination</td> </tr> <tr> <td>1993 06 04, 0h00 UT</td> <td style="text-align: center;">216°27'36.1"</td> <td style="text-align: center;">89°13'56.31"</td> </tr> <tr> <td>1993 06 05, 0h00 UT</td> <td style="text-align: center;">217°26'23.4"</td> <td style="text-align: center;">89°13'56.12"</td> </tr> </table>	Station RO	Polaris	UTC, 1993 06 04	000°00'00"				49°39'28"	1h 44m 33s		229°40'56"	1h 49m 46s		GHA	Declination	1993 06 04, 0h00 UT	216°27'36.1"	89°13'56.31"	1993 06 05, 0h00 UT	217°26'23.4"	89°13'56.12"	20	
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4	<p>Designing a survey scheme [i.e., deciding on the best choice of equipment and procedures] for horizontal positioning can often involve the process of pre-analysis, with the standard deviations of potential observables [<math>\sigma_{\beta_i}</math> for angles; <math>\sigma_{s_i}</math> for distances], potential geometry [expressed as approximate coordinates, <math>\mathbf{x}^0</math>] and a relative positioning tolerance [limit on relative ellipses at 95% of <math>a_{95}</math>].</p> <p>a) With reference to the appropriate equations and matrix expressions, explain how pre-analysis is performed.</p> <p>b) How would you ensure that the intended <math>\sigma_{\beta_i}</math> and <math>\sigma_{s_i}</math> are realized during the observations?</p>	14	
5	<p>For visible and near infra-red radiation and neglecting the effects of water vapour pressure, the refractive index, <math>n</math>, can be determined by</p> $n - 1 = \frac{0.269578[n_0 - 1]}{273.15 + t} p$ <p>The meteorological correction is in the sense that <math>s = s' + c_{\text{met}}</math>, with <math>c_{\text{met}} = k_{\text{met}}s'</math> with <math>k_{\text{met}} = [n_0 - n]/n</math>.</p> <p>a) Temperature and pressure are to be measured at each end of a 1600 m distance, the refractive index at each end will be calculated, and the average will be used to determine the meteorological correction, <math>c_{\text{met}}</math>. The instrument being used has <math>n_0 = 1.000294497</math> and the average temperature and pressure during the measurements are expected to be +30°C and 950 mb. What would be the largest values of <math>\sigma_t</math> and <math>\sigma_p</math> that, together, would result in a meteorological correction that would contribute uncertainty of no more than 2 ppm to the corrected distance?</p> <p>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?</p> <p>c) If the accuracy 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?</p>	16	
6	<p>The geometric deformation of a structure [in two dimensions (“horizontal”)] is to be monitored by repeated surveys of a network of strategically placed monuments. Some monuments are to serve as reference points [assumed to not be moving] and some are to serve as object points [purposely placed where deformation is expected]. They have coordinates <math>[(x_1, y_1, x_2, y_2, \dots)^T]</math> represented in the vectors, <math>\mathbf{x}_{\text{ref}}</math> and <math>\mathbf{x}_{\text{obj}}</math>, all in an isolated arbitrary local system [i.e., defined by assuming coordinate values for some of the <math>\mathbf{x}_{\text{ref}}</math>]. Each campaign of measurements will result in the least squares estimates of <math>\mathbf{x}_i = [\mathbf{x}_{\text{ref}} \ \mathbf{x}_{\text{obj}}]^T</math> and the deformation analysis will entail differencing each new <math>j^{\text{th}}</math> campaign with the first, i.e., <math>\mathbf{dx}_j = \mathbf{x}_j - \mathbf{x}_1</math>. What caution should be exercised when the <math>\mathbf{dx}_j</math> are based on such an isolated coordinate system in two dimensions?</p>	10	

7	<p>The additive constant [or system constant or zero correction], <math>z_0</math>, is a correction that is applied to the output of an EDM to account for the offset between the electronic and mechanical centres of an instrument and reflector combination.</p> <p>a) Explain how <math>z_0</math> can be uniquely determined.</p> <p>b) If each distance involved in the unique determination of <math>z_0</math> is <math>\pm 0.003</math> m, what is the consequent uncertainty in <math>z_0</math>?</p> <p>c) Normally corrections are expected to not significantly contribute to the uncertainty of the quantity that they are correcting. In what way could the uncertainty in <math>z_0</math> be improved?</p>	15	
8	<p>The normal levelling of a theodolite or total station, using the plate vial, may not be sufficient when considering the effect of the inclination of the standing axis on the HCR of an inclined sight.</p> <p>a) Explain why in the context of a single setup.</p> <p>b) Suggest at least one way in which the levelling of the instrument could be improved.</p> <p>c) Suggest at least one way in which a correction to the HCR could be determined.</p>	10	
	<b>Total Marks:</b>	100	

Some useful formulae follow.

$$\tan Z = \frac{-\sin t}{\tan d \cos j - \sin j \cos t}$$

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

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

$$\cos Z = \frac{\sin d}{\cos h \cos j} - \tan h \tan j$$

$$C_x = \mathbf{s}_0^2 [\mathbf{A}^T \mathbf{P} \mathbf{A}]^{-1}$$

$$P = Q^{-1}$$

$$C_l = \mathbf{s}_0^2 Q$$

$$p_1 = \frac{\mathbf{s}_x^2 + \mathbf{s}_y^2}{2}$$

$$p_2 = \sqrt{\frac{(\mathbf{s}_x^2 - \mathbf{s}_y^2)^2}{4} + (\mathbf{s}_{xy})^2}$$

$$a_s = \sqrt{p_1 + p_2}$$

$$b_s = \sqrt{p_1 - p_2}$$

$$2a_{a_s} = \arctan \left[ \frac{2\mathbf{s}_{xy}}{\mathbf{s}_y^2 - \mathbf{s}_x^2} \right]$$

$$\mathbf{s}_{\Delta x}^2 = \mathbf{s}_{x_1}^2 + \mathbf{s}_{x_2}^2 - 2\mathbf{s}_{x_1 x_2}$$

$$\mathbf{s}_{\Delta x \Delta y} = \mathbf{s}_{x_1 y_1} + \mathbf{s}_{x_2 y_2} - \mathbf{s}_{x_1 y_2} - \mathbf{s}_{x_2 y_1}$$

$$\mathbf{s}_{\Delta y}^2 = \mathbf{s}_{y_1}^2 + \mathbf{s}_{y_2}^2 - 2\mathbf{s}_{y_1 y_2}$$

$$c_{HCR} = e_i \cot z = e_i \tan v = i \sin a \tan v$$