

CANADIAN BOARD OF EXAMINERS FOR PROFESSIONAL SURVEYORS

C6 - GEODETIC POSITIONING

March 2018

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 for the answer. Otherwise, full marks may not be awarded even though the answer is numerically correct.

Note: This examination consists of 5 questions on 2 pages.

<u>Q. No</u>	<u>Time: 3 hours</u>	<u>Marks</u>	
		<u>Value</u>	<u>Earned</u>
1.	<p>a) Explain the acronyms ITRS and ITRF. What is the difference between <i>the</i> ITRS and <i>an</i> ITRF.</p> <p>b) The ITRF2014 was obtained by combining the time series of 4 major space geodetic techniques. Name those four techniques and describe their basic functional principle. What are their individual contributions in terms of strengths and weaknesses related to the ITRF2014 realization (or an ITRF realization in general)?</p> <p>c) Explain in details the transformation from ITRF2014 to NAD83(CSRS). Give the formulas and explain the different parameters involved. In order to perform this transformation you need the corresponding parameter set. How and where do you get it? Give the order of magnitude by which the coordinates change. Justify your answer.</p>	5 15 15	
2.	<p>The coordinates of marker <i>A</i> have been obtained from a PPP solution using GPS data from a 24 hour session collected in January 2015. The Cartesian 3D-coordinates are related to ITRF2014 at epoch 2015.1 and have a standard deviation of better than 1 cm.</p> <p>Marker A : 1393242.087 m -4218354.797 m 4561660.113 m</p> <p>a) Give a rough estimation of latitude and longitude of Marker A. (<i>just giving a numerical result without explanations will not be accepted</i>). The format of [degree minutes seconds] should be used for the final result.</p> <p>b) A similar GPS survey on the same marker A is carried out 3 years later in January 2018. A PPP solution yields its corresponding 3D-coordinates with respect to ITRF2014 at epoch 2018.1. Compared to 2015.1 do you expect the coordinates to have changed and if yes, why? And by what amount? Justify your answer.</p> <p>c) You transform both sets of coordinates referring to the same ITRF2014 but stemming from two different epochs (2015 and 2018) to NAD83(CSRS) using the transformation procedure as described in 1b). Do you expect the NAD83(CSRS) coordinates to have changed from 2015 to 2018 and if yes, why? And by which amount? Justify your answer.</p> <p>d) Explain (<i>without any actual numerical calculation</i>) how you obtain UTM coordinates of Marker A with respect to NAD83(CSRS). You may assume that the starting point are 3D-Cartesian coordinates with respect to NAD83(CSRS).</p>	6 5 5 4	

3.	In Canada a new vertical datum has recently be introduced, replacing the old CGVD28 one. What is this new vertical datum called? How is it defined, realized and maintained?	10	3.																																										
4.	<p>You are in charge of digitizing and georeferencing old topographic maps to NAD83. The total area covered is about 2 x 4 km.</p> <p>a) On the maps you find a mention of NAD27 and a coordinate grid. Explain how you proceed to establish the reference to NAD83, knowing that you need an accuracy of 2 m?</p> <p>b) In the case where absolutely no information is given on the maps (no datum, no north orientation, no scale), how would you proceed?</p>	5 5																																											
5.	<p>GPS is a navigation system and its basic task is to provide the facility to determine an instantaneous 3D-position, worldwide and 24 hours a day independent of weather conditions.</p> <p>a) A standalone <u>low-cost</u> GPS receiver relies on code observations (also called pseudo-range observations). Explain what, besides the 3D Cartesian geocentric equatorial coordinates (x,y,z) and an unknown clock bias ($c1$), has to be introduced as fourth unknown.</p> <p>b) Give the observation equation of a pseudo-range observation. In order to determine the unknowns, which information is needed and where does the receiver get this information from? What accuracy can be achieved by this type of solution?</p> <p>An often used quality indicator is the so-called PDOP. It is obtained from the cofactor matrix: $Q_{xx} = (A^T A)^{-1}$, where A is the design matrix.</p> <p>c) Explain in details how the design matrix A is obtained. Give its dimension.</p> <p>d) Given the following (4 x 4) Q_{xx} – matrix :</p> <table style="margin-left: auto; margin-right: auto; border-collapse: collapse;"> <tr> <td></td> <td></td> <td style="text-align: center;">x</td> <td style="text-align: center;">y</td> <td style="text-align: center;">z</td> <td style="text-align: center;">c1</td> <td></td> </tr> <tr> <td></td> <td></td> <td colspan="4" style="text-align: center;">-----</td> <td></td> </tr> <tr> <td style="padding-right: 10px;">Q_{xx}</td> <td style="padding-right: 5px;">=</td> <td style="padding-right: 5px;">x </td> <td style="padding-right: 5px;">0.42</td> <td style="padding-right: 5px;">0.02</td> <td style="padding-right: 5px;">-0.08</td> <td style="padding-right: 5px;">-0.02</td> </tr> <tr> <td></td> <td></td> <td style="padding-right: 5px;">y </td> <td style="padding-right: 5px;">0.02</td> <td style="padding-right: 5px;">0.80</td> <td style="padding-right: 5px;">-0.27</td> <td style="padding-right: 5px;">0.18</td> </tr> <tr> <td></td> <td></td> <td style="padding-right: 5px;">z </td> <td style="padding-right: 5px;">-0.08</td> <td style="padding-right: 5px;">-0.27</td> <td style="padding-right: 5px;">2.78</td> <td style="padding-right: 5px;">-1.66</td> </tr> <tr> <td></td> <td></td> <td style="padding-right: 5px;">c1 </td> <td style="padding-right: 5px;">-0.02</td> <td style="padding-right: 5px;">0.18</td> <td style="padding-right: 5px;">-1.66</td> <td style="padding-right: 5px;">1.15</td> </tr> </table> <p>Explain the acronym PDOP. What is its use? Calculate the corresponding PDOP from the given Q_{xx} – matrix.</p> <p>e) Explain with formulas but without actual calculation how you obtain the HDOP (horizontal DOP) and the VDOP (vertical DOP). Which information is missing for an actual calculation?</p>			x	y	z	c1				-----					Q_{xx}	=	x	0.42	0.02	-0.08	-0.02			y	0.02	0.80	-0.27	0.18			z	-0.08	-0.27	2.78	-1.66			c1	-0.02	0.18	-1.66	1.15	4 8 3 5	
		x	y	z	c1																																								

Q_{xx}	=	x	0.42	0.02	-0.08	-0.02																																							
		y	0.02	0.80	-0.27	0.18																																							
		z	-0.08	-0.27	2.78	-1.66																																							
		c1	-0.02	0.18	-1.66	1.15																																							
Total Marks:		100																																											