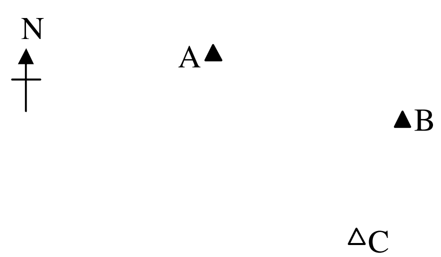
CANADIAN BOARD OF EXAMINERS FOR PROFESSIONAL SURVEYORS

C-4 COORDINATE SYSTEMS & MAP PROJECTIONS **March 2012**

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.

Note: This examination consists of 6 questions on 3 pages. **Marks**

Q. No	Time: 3 hours	Value	Earned
1.	An open traverse consisting of three points A, B and C are shown in Figure 1. The UTM map coordinates of points A and B are known with those of point C to be determined. The coordinates of known points and other quantities required for this problem are provided as follows: • UTM map coordinates of point A: (X = 564,464.558 m, Y = 5,589,480.673 m); • UTM map coordinates of point B: (X = 564,702.284 m, Y = 5,588,965.983 m); • Geodetic coordinates of point B: (Latitude = 50° 26′ 56.8740″, Longitude = -122° 05′ 19.1800″) • Average latitude for the traverse site: 50° 25′ 00″ • Ellipsoidal parameters: a = 6378137.0000 m; e^2 = 0.006694380025; and e'^2 = 0.006739496780 • Ellipsoidal distance from B to C: S_{BC} = 8,525.725 m. • The angle measured at the ground surface point B between line BA and line BC: 210° 37′ 29.0″  **Figure 1 (Not to scale)** If the traverse is in the UTM zone 10 (λ_0= -123°), calculate the UTM coordinates (to 3 decimal places) of point C and the geodetic azimuth (in degrees, minutes, one decimal second) of line B to C (applying all possible corrections to the measurements).	30	
2.	a) Using well-labelled sketches only, illustrate the Mercator and the polar Stereographic projections in the Northern hemisphere; give one sketch for the Mercator projection and the other sketch for the polar Stereographic projection. The sketches must show the projections of the **Equator**, **Central Meridian**, **parallels** and **meridians** with the appropriate relationship between the lines of the graticule clearly illustrated.	14	

	b) Give one advantage and one disadvantage of the Mercator projection.	3	
3.	a) What is a geoid datum? How is it different from CGVD28? b) What is a Hybrid datum? What is its role with regard to geoid datum and CGVD28? c) What is the main goal of the Canadian Spatial Reference System? Discuss the various components of this System. d) Discuss what would be the most desirable outcome with regard to NAD83 (CSRS) should Canada adopt a geoid datum.	5 3 5 3	
4.	a) Explain with reasons, which of the celestial reference coordinate systems would be easier to use to point out a star to a friend in your neighborhood? Describe this coordinate system with the aid of a well-labelled sketch showing its origin, its reference plane, its rectangular coordinate axes and the representation of the angles to be measured to locate an astronomical object in the system. b) Discuss one important disadvantage of this coordinate system with regard to other celestial coordinate systems. c) What are the fundamental differences between this system and a typical terrestrial coordinate system?	8 2 4	
5.	a) What are the important uses of reference ellipsoids? b) Explain clearly the term "conformality" with respect to the exactness of angle measurement, direction measurement and point scale. c) Describe "conformality" and "equivalency" in terms of the sizes, shapes and orientations of Tissot indicatrices.	3 3 6	
6.	Explain and give the important applications of the following as used in Coordinate Systems and Map projections. a) Gaussian fundamental quantities b) Cauchy –Riemann equations c) Reference frame d) Natural coordinates	 3 2 2 4	
	Total Marks:	100	

Some potentially useful formulae are given as follows:

$$T - t = \frac{(y_2 - y_1)(x_2 + 2x_1)}{6R_m^2}$$

where $y_i = y_i^{UTM}$; $x_i = x_i^{UTM} - 500{,}000$; $R_m = \sqrt{MN}$ is the Gaussian mean radius for the average latitude for the site; N and M are radii of curvature in the prime vertical direction and in the meridian plane evaluated at the average latitude for the site, respectively; and x_i^{UTM} and y_i^{UTM} are the UTM Easting and Northing coordinates respectively, for point *i*.

$$N = \frac{a}{\sqrt{\left(1 - e^2 \sin^2 \phi\right)}}; \; M = \frac{a\left(1 - e^2\right)}{\left(1 - e^2 \sin^2 \phi\right)^{3/2}}$$

UTM average line scale factor, $\bar{k}_{UTM} = 0.9996\left[1 + \frac{x_u^2}{6R_m^2}\left(1 + \frac{x_u^2}{36R_m^2}\right)\right]$;

where $x_i = x_i^{UTM} - 500{,}000$; $\quad x_u^2 = x_1^2 + x_1 x_2 + x_2^2$

Grid convergence, $\gamma_B = \Delta\lambda \sin\phi\left[1 + \frac{\Delta\lambda^2 \cos^2\phi}{3(20265)^2}\right]$; where $\Delta\lambda = (\lambda - \lambda_0)$ (in arc-seconds) for any given longitude λ with central longitude at λ_0.

Given: $X = f(\phi, \lambda)$ $\qquad Y = g(\phi, \lambda)$

$$m_1^2 = \frac{f_\phi^2 + g_\phi^2}{R^2}; \qquad m_2^2 = \frac{f_\lambda^2 + g_\lambda^2}{R^2 \cos^2\phi}; \qquad p = \frac{2\left(f_\phi f_\lambda + g_\phi g_\lambda\right)}{R^2 \cos\phi}$$

$$\frac{d\Sigma'}{d\Sigma} = m_1 \times m_2 \sin A'_p$$

$$\sin A'_p = \frac{f_\lambda g_\phi - f_\phi g_\lambda}{\sqrt{\left(f_\lambda g_\phi - f_\phi g_\lambda\right)^2 + \left(f_\phi f_\lambda + g_\phi g_\lambda\right)^2}}$$

$$\tan\mu_m = \frac{f_\varphi}{g_\varphi}$$

$$\tan\mu_s = \frac{g_\phi \cos\phi \cos A + g_\lambda \sin A}{f_\phi \cos\phi \cos A + f_\lambda \sin A}$$

$$\tan\left(180^\circ - A'\right) = \frac{\tan\mu_m - \tan\mu_s}{1 + \tan\mu_m \tan\mu_s}$$

$$\sin\left(\frac{\omega}{2}\right) = \frac{(a - b)}{(a + b)}$$

$$x = (N + h)\cos\phi\cos\lambda$$
$$y = (N + h)\cos\phi\sin\lambda$$
$$z = \left[\left(1 - e^2\right)N + h\right]\sin\phi$$