CANADIAN BOARD OF EXAMINERS FOR PROFESSIONAL SURVEYORS

C-4 COORDINATE SYSTEMS & MAP PROJECTIONS **October 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 5 questions on 3 pages. **Marks**

Q. No	Time: 3 hours	Value	Earned
1.	a) Discuss the properties of the Polar Stereographic projection and the Mercator projection, with regard to aspects, distortion characteristics, and representation of graticule. b) Two of the important considerations in the choice of a suitable map projection for navigation purposes are how the projection represents bearings in relation to navigation compass bearings and how it distorts scale. With regard to these two considerations, discuss the suitability of the Mercator projection and the Polar Stereographic projection for navigational purposes in the Canadian Arctic region (North of the 68th parallel).	15 6	
2.	a) Describe the geodetic (curvilinear) coordinate system, terrestrial geocentric (Cartesian) coordinate system, and map projection coordinate system with regard to origins and orientation of axes. Give one important disadvantage and one example of each of the coordinate systems. b) Clearly explain the steps and the parameters involved in the transformation of coordinates of a point in the geodetic (curvilinear) coordinate system into the corresponding coordinates in the terrestrial geocentric (Cartesian) coordinate system.	16 5	
3.	a) Describe how the reference ellipsoid and the geoid relate with the surface of the earth, the direction of gravity and with each other. Give one example of the reference ellipsoid and of a typical geoid model, used in Canada. b) Explain the relationship between a reference ellipsoid and a horizontal datum. Give one example of a horizontal datum. c) Discuss the differences between the geoid and the CGVD28.	8 2 6	
4.	a) Describe the horizon coordinate system with the aid of a well-labeled 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 this system. b) Discuss one important disadvantage of the horizon coordinate system with regard to other celestial coordinate systems. c) What are the fundamental differences between the horizon coordinate system and the Local Astronomic coordinate system?	6 2 4	

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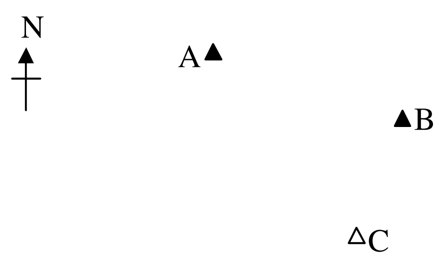
<td>5.</td>
<td>An open traverse consisting of three points A, B and C is shown in Figure 1. The UTM map coordinates of points A and B are known with those of point C to be determined. The coordinates of the known points and other quantities required for this problem are provided as follows:
• UTM map 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 necessary corrections to the measurements).</td>
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<td>Total Marks:</td>
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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*.

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

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 $x_i = x_i^{UTM} - 500{,}000$; $\quad x_u^2 = x_1^2 + x_1x_2 + x_2^2$

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

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

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

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

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

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

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

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

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