CANADIAN BOARD OF EXAMINERS FOR PROFESSIONAL SURVEYORS

C-4 COORDINATE SYSTEMS & MAP PROJECTIONS

March 2011

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 7 questions on 3 pages. **Marks**

Time: 3 hours

Q. No		Value	Earned
1.	The geodetic coordinates of a point in Datum '1' are given as (ϕ_1, λ_1, h_1), where ϕ_1 is the geodetic latitude, λ_1 is the geodetic longitude and h_1 is the ellipsoidal height. Describe (without providing any specific equation(s)) the steps involved (in logical sequence) and the quantities required for computing the UTM coordinates (E_2, N_2) and the orthometric height (H_2) of the same point in Datum '2', assuming the reference coordinate systems of Datum '1' and Datum '2' are perfectly aligned (but different origins) with that of a particular ITRF (International Terrestrial Reference Frame) datum.	14	
2.	Clearly explain the essential differences between the following items and discuss the use of each item in Geomatics. Your explanation and discussion must clearly demonstrate your understanding of each item. a. Footpoint latitude and Isometric latitude b. Scale factor and Line scale c. Graticule and Grid	 5 4 4	
3.	Explain the differences between the Conventional Terrestrial (CT) system and a geodetic datum. Give an example of CT system and describe generally its characteristics, including how it is realized.	15	
4.	Answer the following with respect to the (x, y, z) astronomic coordinate system. a. Define the (x, y, z) astronomic coordinate system with regard to its origin and the orientation of its axes. b. Determine (with reasons) which of the following would affect the astronomic latitude and longitude coordinates of a given point on the Earth's surface: i) a translation of the coordinate origin of the (x, y, z) system; ii) a general rotation of the (x, y, z) system c. Determine (with reasons for each case) which of the following would be affected if the (x, y, z) axes are rotated about the z-axis: astronomic latitude, astronomic longitude, astronomic azimuth. d. Assume that the (x, y, z) axes of an ellipsoid coordinate system are parallel to the (x, y, z) astronomic coordinate system. Explain if the geodetic and astronomic meridian planes for a given point on the Earth's surface are also parallel. Your explanation must demonstrate that you understand what the two meridian planes are.	 4 4 3 4	

5.	a. On a UTM projection, calculate the meridian convergence (to the nearest arc second) for point A with latitude (ϕ = 53° 42′ 28″ N) and longitude (λ = 112° 18′ 29″W), given the longitude of the central meridian, $\lambda_0 = 111^\circ$ W and the following equation: $$\gamma = L\left(1+\frac{L^2}{3}\left(1+3\eta^2\right)\cos^2\phi\right)\sin\phi$$ where γ is the meridian convergence; $\eta^2 = e'^2\cos^2\phi$; e'^2 =0.006739496780; and $L=(\lambda-\lambda_0)$ expressed in radians. b. What would be the longitude of a point with the same numeric value for convergence, but opposite algebraic sign? c. Determine the UTM zone number and the zone range for the location of point A.	7 2 2	
6.	The map projection equations relating map projection coordinates (x, y) with the corresponding geographic coordinates (ϕ, λ) can be given as $$x = R\lambda \qquad y = R\ln\tan\left(45^\circ+\frac{\phi}{2}\right)$$ where R is the mean radius of the spherical earth with the following as the first derivatives of the relationships: $$x_\phi = 0 \qquad y_\phi = \frac{R}{\cos\phi} \qquad x_\lambda = R \qquad y_\lambda = 0$$ Answer the following questions: a. Calculate the area distortion factor and indicate if this projection is equal-area. b. Deduce from (a) above if this projection is conformal and explain if the directions of maximum and minimum distortions exist in the projection. c. Calculate the grid azimuth of any of the projected meridians. d. Given a curve of constant azimuth of 30° on the spherical earth, calculate the distortion in the azimuth of this curve after projection. e. Based on your answers in the above calculations, explain what a loxodrome will look like on this projection and suggest the most likely name for this type of projection.	5 3 2 5 3	
7.	Answer the following: a. What is the main use of a map projection in map making? Give an example of how a map projection is accommodated when producing survey plans. b. Discuss three important advantages of computing geodetic positions on a conformal projection plane as compared to computing them on an equal-area projection. c. What is (T-t) correction? This correction is composed of two parts in conformal stereographic double projections; explain the two parts with an approximate magnitude of each correction.	3 6 5	
	Total Marks:	100	

Some potentially useful formulae are given as follows:

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

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

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

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

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

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

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

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