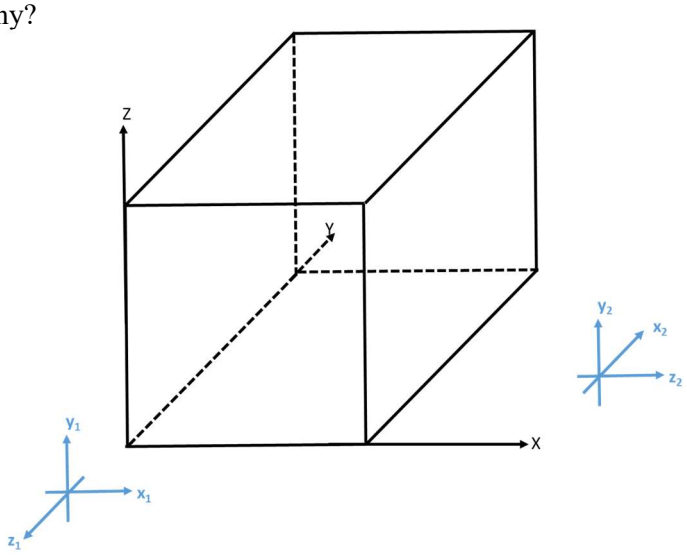
CANADIAN BOARD OF EXAMINERS FOR PROFESSIONAL SURVEYORS

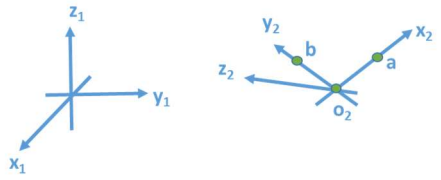
C7 – REMOTE SENSING & PHOTOGRAMMETRY — October 2023

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 10 questions on 3 pages. **Marks**

Q. No Time: 3 hours Value Earned

Q. No		Value	Earned
1.	a) What is the difference between metric and non-metric digital cameras? b) Briefly explain the following terms and how they are evaluated for a digital camera: 1) Geometric resolution, 2) Radiometric resolution, 3) Spectral resolution, and 3) Temporal resolution. c) Where in the image is there no Relief Displacement? Why? d) Why do we use the term "Pseudo Range" to denote the measured range by a GPS/GNSS receiver?	2 4 2 2	
2.	The Figure below shows a 3D schematic diagram of a building and the associated ground coordinate system (in black – upper case *XYZ*) as well as the image/camera coordinate systems for two images (in grey – lower case *xyz*) that have been captured around the building. What will be the approximate values you would use for the rotation angles (ω, φ, and κ) for these images in a bundle adjustment procedure? Please explain the logic you used to come up with these values. Would you expect any problem in the estimation of these rotation angles in the bundle adjustment procedure? Why? 	10	

3.	What is the rotation matrix that relates the coordinate systems, which share the same origin, in the figure below – given that $r_{o_2a}^{x_1y_1x_1} = [-4 \quad 3 \quad 5]^T$ *and* $r_{o_2b}^{x_1y_1x_1} = [4 \quad -3 \quad 5]^T$? Explain conceptually and numerically how did you drive such a rotation matrix. You should verify your answer by checking the orthogonality conditions of the derived matrix. Note: • $r_{o_2a}^{x_1y_1z_1}$ denotes the components of the vector o_2a w.r.t. the $x_1y_1z_1$coordinate system • $r_{o_2b}^{x_1y_1z_1}$ denotes the components of the vector o_2b w.r.t. the $x_1y_1x_1$coordinate system 	12	
4.	What is the <u>minimum number</u> and <u>optimal configuration</u> of Ground Control Points that are needed for (justify your answer) : • Dependent relative orientation of a stereo-pair, • Independent relative orientation of a stereo-pair, • Single photo resection, • Indirect geo-referencing of an image stereo-pair, and • Indirect geo-referencing of an image block with 70% overlap and 70% side lap?	7	
5.	a) Explain how you can use the spectral reflectance curve to identify the moisture content in vegetation and soil. b) One can argue that digital cameras can see through shadow. Do you agree with this statement? Why? c) What is the dynamic range of a color (RGB) digital camera that has 15 bits/pixel? d) What are the parameters that are solved for (you should explain what these parameters represent) in the following photogrammetric problems: 1) Single photo resection; 2) Photogrammetric intersection; 3) Bundle adjustment; 4) Bundle adjustment with self-calibration; 5) Dependent relative orientation for a stereo-pair; and 6) Independent relative orientation for a stereo-pair)?	1 2 2 6	

6.	a) Starting from the Collinearity equations derive the mathematical model associated with vertical photography. In other words, starting from the equations below for a general image: $x_a = x_p - c\frac{r_{11}(X_A - X_o) + r_{21}(Y_A - Y_o) + r_{31}(Z_A - Z_o)}{r_{13}(X_A - X_o) + r_{23}(Y_A - Y_o) + r_{33}(Z_A - Z_o)} + distortion_{x_a}$ $y_a = y_p - c\frac{r_{12}(X_A - X_o) + r_{22}(Y_A - Y_o) + r_{32}(Z_A - Z_o)}{r_{13}(X_A - X_o) + r_{23}(Y_A - Y_o) + r_{33}(Z_A - Z_o)} + distortion_{y_a}$ Derive the equations below for vertical photography (In your derivation, clearly state the assumptions you are making): $x_a = c * \frac{X_A}{H - h_A}$ and $y_a = c * \frac{Y_A}{H - h_A}$ b) The overlap percentage between successive images along a given flight line does not change. Do you agree with this statement? Why? c) One needs a minimum of three GNSS satellites for single point positioning using pseudo ranges. Do you agree with this statement? Why?	8 2 2	
7.	a) Height estimation using relief displacement measurements of objects farther away from the nadir point is more precise than those that are closer. Do you agree with this statement? Why? b) How many collinearity equations can be established for an object point that has been observed in five images? What is the redundancy when estimating the ground coordinates of the object point? State any assumptions made in this calculation. c) What are the main characteristics/differences between supervised and unsupervised classification strategies? Tabulate your answer. d) Image residuals from a bundle adjustment procedure are always very small. Do you agree with this statement? Why?	2 3 3 2	
8.	a) What are the image formation principles used in deriving the lens equation ($1/image\ distance + 1/object\ distance = 1/focal\ length$)? b) How far is the principal point from the nadir point for a vertical image? Why? c) List three advantages of increasing the overlap/side lap in an image block. d) List three reasons for GNSS/INS integration for direct geo-referencing of an imaging system.	2 1 3 3	
9.	a) How is the perspective center defined for the lens assembly of a digital camera system? b) The light ray from an object point to its corresponding image point does not follow a straight line. Do you agree with this statement? Why? c) What is the objective of establishing the interior orientation for a given camera? List the interior orientation parameters that we usually solve for. What are the alternative methodologies for deriving the interior orientation parameters of a photogrammetric camera? Which one would you prefer to adopt? Why? d) What is the objective of establishing the exterior orientation for a given image? List the exterior orientation parameters that we usually solve for. What are the alternative methodologies for deriving the exterior orientation parameters of an imaging system? Which one would you prefer to adopt? Why?	2 2 4 4	
10.	a) A GNSS receiver is better than a GPS receiver. Do you agree with this statement? Why? b) What is meant by x-parallax and y-parallax in stereo-images? c) Could the following matrix be considered a rotation matrix? Why? $\begin{bmatrix} 0.7071 & -0.7071 & 0 \\ 0.7071 & 0.7071 & 0 \\ 0 & 0 & 1 \end{bmatrix}$	2 2 3	
	Total Marks:	100	