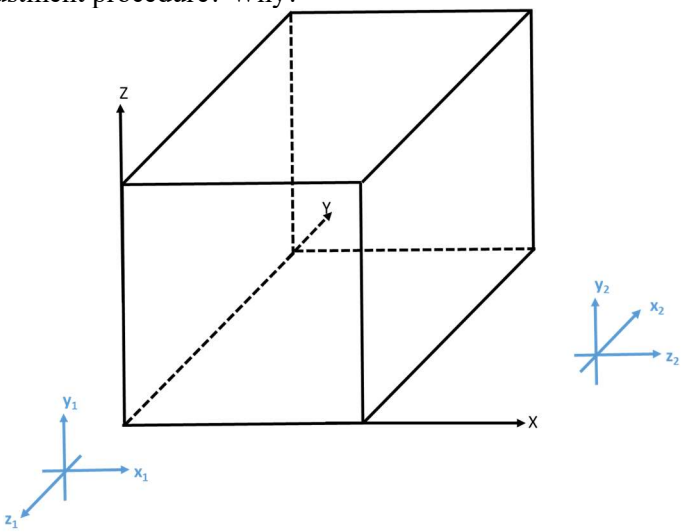
CANADIAN BOARD OF EXAMINERS FOR PROFESSIONAL SURVEYORS

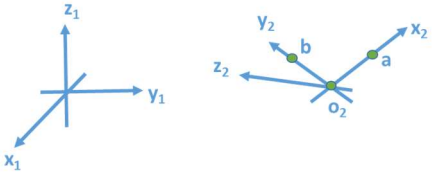
C7 – REMOTE SENSING & PHOTOGRAMMETRY — October 2021

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 2 pages. **Marks**

Q. No Time: 3 hours — Value — Earned

Q. No		Value	Earned
1.	a) Do we need Fiducial marks for metric digital cameras? Why? b) Briefly explain the following terms and how they are evaluated for a digital imaging system: 1) Geometric resolution, 2) Radiometric resolution, 3) Spectral resolution, and 3) Temporal resolution. c) Where in the image is there no Radial Lens Distortion? Why?	2 4 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? Why? 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 in the figure below – given that $r_{o_2a}^{x_1y_1x_1} = [-4 \quad 3 \quad 5]^T$ *and* $r_{o_2b}^{x_1y_1x_1} = [4 \quad -3 \quad 5]^T$? Briefly explain how did you drive such a rotation 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 	14	
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 60% overlap and 60% side lap?	8	
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 30 bits/pixel? d) What are the parameters that are solved for 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)?	2 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) What are the camera parameters that control its classification as whether it is narrow or wide-angle camera?	8 3 2	

7.	a) Height estimation using relief displacement measurements of objects closer to the nadir point is more precise than those that are farther. Do you agree with this statement? Why? b) How many collinearity equations can be established for an object point that has been observed in four images? c) What are the main characteristics/differences between supervised and unsupervised classification strategies? Tabulate your answer. d) Image residuals following the bundle adjustment procedure are always very small. Do you agree with this statement? Why?	2 1 3 2	
8.	a) What are the image formation principles used for 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? c) List two of the key advantages of increasing the overlap/side lap in an image block. d) List two of the key disadvantages of increasing the overlap/side lap in an image block.	2 1 2 2	
9.	a) How is the perspective center defined for the lens assembly for a digital camera system? b) What is meant by the precision of photogrammetric mapping? c) What is meant by the accuracy of photogrammetric mapping? d) List two of the key differences between an image and a map. e) 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? f) 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 1 1 2 4 4	
10.	a) What is the EM radiation waveband used in LiDAR remote sensing systems? Are they active or passive systems? b) What are the advantages of RADAR remote sensing systems? c) Could the following matrix be considered a rotation matrix? Why? $\begin{bmatrix} 0.7071 & 0.7071 & 0 \\ -0.7071 & 0.7071 & 0 \\ 0 & 0 & 1 \end{bmatrix}$	1 2 3	
	Total Marks:	100	