# CANADIAN BOARD OF EXAMINERS FOR PROFESSIONAL SURVEYORS

## C7 – REMOTE SENSING & PHOTOGRAMMETRY     June 2020

**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 |
|---|---|---|---|
| 1. | a) Do we need Fiducial marks for metric analog cameras? Why? <br> 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. <br> c) Where in the image is there no atmospheric refraction? Why? | 2 <br><br> 4 <br><br><br><br> 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 ($\omega$, $\varphi$, and $\kappa$) 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? <br><br>  | 10 | |
| 3. | What is the rotation matrix that relates the coordinate systems in the figure below – given that $r_{o_2 a}^{x_1 y_1 x_1} = [6 \quad 8 \quad 10]^T$ and $r_{o_2 b}^{x_1 y_1 x_1} = [-6 \quad -8 \quad 10]^T$? Briefly explain how you derived such a rotation matrix. <br><br>  | 14 | |

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| 4. | What is the <u>minimum number</u> and <u>optimal configuration</u> of ground control points that are needed for (justify your answer) :<br>• Independent relative orientation of a stereo-pair,<br>• Dependent relative orientation of a stereo-pair,<br>• Single photo resection,<br>• Indirect geo-referencing of an image stereo-pair, and<br>• 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. | 2 | |
| | b) One can argue that digital cameras can see through shadow. Do you agree with this statement? Why? | 2 | |
| | c) What is the dynamic range of a color digital camera that has 24bits/pixel? | 2 | |
| | 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)? | 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:<br><br>$$x_a = x_p - c \frac{r_{11}(X_A - X_o) + r_{21}(Y_A - Y_o) + r_{31}(Z_A - Z_o)}{r_{13}(X_A - X_o) + r_{23}(Y_A - Y_o) + r_{33}(Z_A - Z_o)}$$<br><br>$$y_a = y_p - c \frac{r_{12}(X_A - X_o) + r_{22}(Y_A - Y_o) + r_{32}(Z_A - Z_o)}{r_{13}(X_A - X_o) + r_{23}(Y_A - Y_o) + r_{33}(Z_A - Z_o)}$$<br><br>Derive the equations below for vertical photography (In your derivation, clearly state the assumptions you are making) :<br><br>$$x_a = c * \frac{X_A}{H - h_A} \text{ and } y_a = c * \frac{Y_A}{H - h_A}$$ | 8 | |
| | b) Explain the conceptual basis of the Collinearity Equations, Direct Linear Transformation, Projective Transformation, and Rational Functional Models for relating corresponding scene and object coordinates. | 6 | |
| 7. | a) How would the camera aperture size affect the following:<br>1. Aberrations,<br>2. Chromatics aberrations,<br>3. Diffraction,<br>4. Depth of field,<br>5. Depth of focus, and<br>6. Motion blur? | 4 | |
| | b) What are the main characteristics/differences between supervised and unsupervised classification strategies? **Tabulate your answer**. | 4 | |
| 8. | a) What are the image formation principles used for deriving the lens equation ($1/image\ distance + 1/object\ distance = 1/focal\ length$)? | 3 | |
| | b) You are given a stereo-pair with identified thirty-five tie points. List the balance between the observables and the unknown parameters in a bundle adjustment procedure to solve for the exterior orientation parameters as well as the ground coordinates of tie points. Can you estimate the involved unknown parameters? Why? | 3 | |

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| 9. | a) | How is the perspective center defined for the lens assembly for a digital camera system? Would that be different for an analog camera? | 3 | |
| | b) | Give a brief definition of the following entities: nadir point, nodal points, principal point, principal distance, focal point, focal length, principal planes, as well as optical axis of a lens system. | 3 | |
| | c) | What is the objective of establishing the Interior Orientation? What are the alternative methodologies for deriving the Interior Orientation Parameters (IOP) of a photogrammetric camera? Which one would you prefer to adopt? Why? | 3 | |
| | d) | What is the objective of establishing the Exterior Orientation? What are the alternative methodologies for deriving the exterior orientation parameters of an imaging system? | 3 | |
| 10. | a) | What is the EM radiation waveband used in LiDAR remote sensing systems? Are they active or passive systems? | 2 | |
| | b) | What are the advantages of RADAR remote sensing systems? | 2 | |
| | c) | Could the following matrix be considered a rotation matrix? Why? $$\begin{bmatrix} 0.7071 & -0.7071 & 0 \\ 0.7071 & 0.7071 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$ | 4 | |
| | | **Total Marks:** | 100 | |