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The University of Zambia

School of Engineering

Department of Geomatic Engineering

2019/2020 Academic Year

Deferred Examinations- January 2021

GEE 3622: Principles of Data Acquisition and Processing

Time: Three (3) Hours

Instructions:

1. This Examination is **Closed Book**
2. Calculators are permitted
3. Time allowed is **Three (3) Hours**
4. **Answer: ALL QUESTIONS FROM SECTION (A) AND ONE FROM SECTION (B)**
5. Where necessary, Show All the work leading to the solution
6. Total marks for this Examination paper is 100

Please! Do Not Turn This Page Until Instructed By The Invigilator

SECTION A

Question One (16+9) marks

(a) Define the following photographic terms:

- Aperture - opening of lens
- F-number
- Illuminance
- Depth of field
- Principle point
- Ground nodal point*
- Air base *
- X-parallax *

(10)

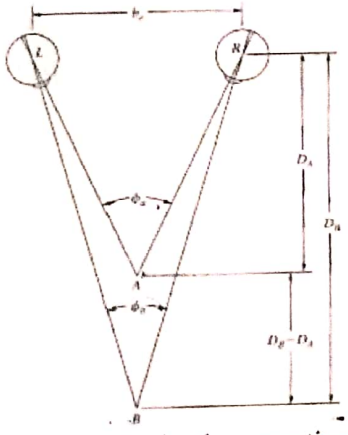
(b) What are the relationships between?

- F-number and shutter speed
- Film speed and emulsion grain size
- Resolution and emulsion grain size

(9)

Question Two (8+4+4+9) marks

(a) Choose between (a) or (b) to complete the statement below correctly:



(8) Stereoscopic depth perception is a function of the (a) parallactic (b) orthorgonal angles. Parallactic angle is the angle of intersection of optical axes that converge on a certain point. The (a) nearer (b) further the object the (a)smaller (b) greater the parallactic angle and vice versa. The depth between object A and B (DB-DA) is perceived as the (a) sum (b) difference in their parallactic angles (φa-φb)

(b) x-parallax is the change in position of an object from one photo to the next caused by aircraft's

motion (True or False)

(c) illuminance is a degree of brightness received per unit area of the image plane (a) after (b) during exposure

(d) The image distance for a photograph of an object, which is located 4.5 meters from the camera, is 76.5mm. What image distance is required for perfect focus if the object is in infinity?

Question Three (4+10+2+9)

Remote sensing is a method of obtaining information from distant objects without direct contact.

The table below shows some key characteristics of remote sensing. Align the characteristics on the left with the correct definition on the right side of the table.

Spectral Differentiation	a) Refers to the use of many images of the same region acquired over time
Radiometric Differentiation	b) Every sensor is limited in respect to the size of the smallest area that can be separately recorded as an entity on an image
Spatial Differentiation	c) Refers to the detection of differences in the brightness of objects and the features
Temporal Dimension	d) Refers to observed spectral differences in the energy reflected or emitted from features of interest

a) Illustrate briefly, the major divisions of the electromagnetic spectrum.

b) In Remote sensing, what is meant by the term "atmospheric windows"?

c) All radiation used for remote sensing pass through the earth's atmosphere. Scattering is the redirection of electromagnetic energy by particles suspended in the atmosphere. Briefly, explain three types of scattering involved.

SECTION B

Question Four (3+22) marks

Laser scanning in geomatics is used for topographic mapping and close range 3D object recording.

i. Name three(3) basic sensor hardware for laser mapping

ii. An airplane carrying an Airborn Laser scanning (ALS) system emits a laser pulse with a pointing angle of α=5.000° that takes 0.0051110 millisecond to reach an object on the ground and return to the sensor. At the same time, an onboard GPS-INS system measures the position of the laser coordinates as x=100.00m, Y=100.00m, Z=1000.00m, and the orientation as ω=f=k=0.

What is the location of the object on the ground?

Formulas:

Formula 1.

$D=c.t/2$

Formula 2.

$$\begin{pmatrix} X_A \\ Y_A \\ Z_A \end{pmatrix} = \begin{pmatrix} X_S \\ Y_S \\ Z_S \end{pmatrix} + M \begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos(\alpha) & \sin(\alpha) \\ 0 & -\sin(\alpha) & \cos(\alpha) \end{pmatrix} \begin{pmatrix} 0 \\ 0 \\ -D \end{pmatrix}$$

X_A, Y_A, Z_A : point coordinates

X_S, Y_S, Z_S : scanner position coordinates

M: the Rotation matrix from the scanner to the ground system

α : is the pointing angle

Question Five (6+3+2+4+10) marks

a)

i. Describe the main parts of frame aerial camera

ii. List three functions of the filter in the lens cone assembly of an aerial camera

iii. Mention two types of laboratory procedures for calibration of the camera

iv. List at least four(4) interior orientation parameters that are determined during the calibration process of an aerial camera

b) Discuss the characteristic curve H and D, or D-log- E curve.

----------End of Exams----------

The University of Zambia

School of Engineering

Department of Geomatic Engineering

2018/2019 Academic Year

Second-Half Year Final Examinations

GEE 3622: Principles of Data Acquisition and Processing

Time: Three (3) Hours

Instructions

1. This Examination is **Closed Book**
2. Calculators are permitted
3. Time allowed is **Three (3) Hours**
4. **Answer: ALL QUESTIONS FROM SECTION (A) AND ONE FROM SECTION (B)**
5. Show all the work leading to the solution
6. Total marks for this Examination paper is 100

Please! Do Not Turn This Page Until Instructed By The Invigilator

SECTION A

Question 1 (25 marks)

a) A vertical aerial photograph was taken with a 152.4-mm-focal-length camera from a flying height of 1385 m above datum. Images a and b of two ground points A and B appear on the photograph, and their measured photo coordinates are x_a = -52.35 mm, y_a = 48.27 mm, x_b = 40.64 mm and y_b = 43.88 mm. Determine the horizontal length of line AB if elevations of points A and B are 204 and 148 m above datum, respectively.

b) A distance ab on a vertical photograph is 65.0 mm, and the corresponding ground distance AB is 1150 m. If the camera focal length is 152.4 mm, what is the flying height above the terrain upon which line AB is located?

Assume that the values given for focal length, photo distance and ground length contain random errors of ± 0.005 mm, ±0.50 mm, and ±0.30 m respectively. What is the expected error in the computed flying height?

Question 2 (25 marks)

a) Discuss and give examples of the terms:

i) Active Remote and
ii) Passive Remote sensor systems

b) Mention three (3) most common bands of the electromagnetic spectrum used for remote sensing.

c) When electromagnetic radiation strikes matter, it interacts with it in possibly four main ways; Name the four (4) processes involved?

d) Three main types of scattering important to remote sensing are: Explain their effects.
- Rayleigh scattering
- Mia scattering
- Nonselective scattering

Question 3 (25 marks)

a) Spatial and non-spatial data are the two types of data to be entered in a GIS. Give a brief description of Spatial and non-spatial data?

b) Briefly describe what the terms digitizing and scanning mean in GIS data entry?

c) What are the two main types of data formats used in GIS?

d) Give three (3) advantages and disadvantages of Vector Data?

e) What does the term "Georeferencing" mean?

SECTION B

Question 4 (25 marks)

a) Explain the main principle behind laser mapping systems. What is the basic sensor hardware for laser mapping systems?

b) An airplane carrying an airborne laser scanning (ALS) system emits a laser pulse with a pointing angle of $\alpha=5.000°$ that takes 0.0051110 millisecond to reach an object on the ground and return to the sensor. At the same time, an onboard GPS-INS system measures the position of the laser coordinates as X=100.00m, Y=100.00m, Z=1000.00m, and the orientation as $\omega=\phi=\kappa=0$. What is the location of the object on the ground?

c) The rotation matrix R (ω,ϕ,κ) rotates the coordinate system of a tilted photograph to the coordinate system parallel to the reference ground system.

Determine the rotation angles (ω,ϕ,κ) if R has the following form:

$$R = \begin{pmatrix} 0.999910 & 0.013319 & 0.001635 \\ -0.013351 & 0.999671 & 0.021907 \\ -0.001343 & -0.021927 & 0.999759 \end{pmatrix}$$

(Formulas: sin φ= r13, tan κ= -r12/r11, tan ω=-r23/r33)

Question 5 (25 marks)

A project area is 16 km long in the east-west direction and 10.5 km wide in the north-south direction. It is to be covered with vertical aerial photography having scale of 1:12,000. A camera having a 152.4-mm-focal-length lens and a 230-mm square format is to be used. The nominal end lap and side lap are to be 60 and 30 percent, respectively. Beginning and ending flight lines are to be positioned along the boundaries of the study area. The only base map available for the area is at a scale of 1: 24,000. This map indicates that the average terrain elevation is 300 m above datum.

Compute the following data for the flight crew:

i. Flying height above mean sea level

ii. Ground coverage per image

iii. Distance between two successive axes of the strips.

iv. Number of flight lines required

v. Total number of photos needed

vi. Spacing of flight lines on the map

End of Examination

The University of Zambia

School Of Engineering

Department of Geomatic Engineering

20162017 Academic Year Second Half Year

FINAL EXAMINATIONS

GEE 3622: Principles of Data Acquisition and Processing

Monday 28th August 2017

TIME:Three (3) Hours

INSTRUCTIONS:

1. This examination is Closed Book
2. Calculators are permitted
3. ANSWER **ALL** questions from **SECTION A** and one (1) question from **SECTION B**
4. Show all the work leading to the solution
5. Total marks for this examination paper is 100
6. **[ ]** indicates allocated marks for the question

Question 1 (25 marks)

a) Outline **THREE (3)** types of scattering that occur in the earth's atmosphere, giving any possible wavelength dependency of each scattering type.

b) State whether true or false:

i. Active Remote – detect only reflected sunlight or thermal IR and microwaves

ii. Passive Remote – beam own artificially produced energy to a target and record reflected component

iii. The entire range of EMR comprises the electromagnetic spectrum subdivided in divisions called wavelengths that share common characteristics.

iv. Three forms of energy transfer include: absorption, reflection and transmittance

v. The Sun is the major supplier of EM energy incident on the Earth – providing energy needed for terrestrial life and the natural processes operating in the atmosphere, water and upper layers of solid Earth.

vi. EMR travels in a straight path at the speed of light – postulated by Albert Einstein in 1905 as ~ 300,000 km/sec

vii. Electromagnetic Radiation (EMR) is light energy detected when it comes into contact with an object

viii. The visible portion of the EM Spectrum ranges from 0.4m to 0.70m

ix. The most common bands of the EM spectrum used for remote sensing are cosmic, gamma and x-rays.

x. Remote sensing depends upon operation in wavelength regions of spectrum where spectral signatures occur for identification purposes.

Question 2 (25 marks)

1. A mapping project is designed to use aerial photography at a scale of 1:10000 for a preliminary design of a development project covering an area of 20 x 15km. If a 15/23 camera is used with end and side overlaps of 60% and 30% respectively, calculate the following parameters if a flight plan along the longer side of the project boundary is to be prepared at a map scale of 1:20,000;
   i. total number of flight lines
   ii. total number of photographs to cover the project area

Question 3 (25 marks)

a. Explain the term **depth of perception** with respect to stereoscopic viewing.

b. Given that the shortest distance of clear stereoscopic depth perception for an average eye base of 65mm is 250mm, calculate the maximum Parallactic angle.

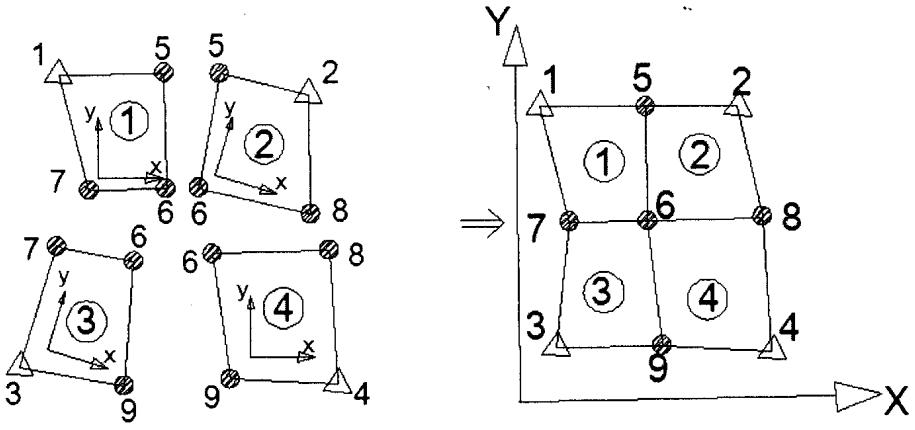
c. Given that the maximum distance at which the stereoscopic depth perception is possible is approximately 600m, calculate the minimum Parallactic angle.

d. Name **THREE (3)** instruments used to measure image coordinates and briefly outline the measurement process involved.

SECTION B

Question 4 (25 marks)

1. The figure below shows four models (1-4) which are observed independently.



a. Briefly, define the adjustment involved in these models?

b. Calculate,
   i. Total number of observation
   ii. Total number of Unknowns
   iii. Number of redundant observations
   iv. Which points represent the tie-points?
   v. Which points represent the control points?

c. Why is the similarity (conformal) transformation used in the Block adjustment by independent models?

d. Mention at least five (5) sources of errors that are normally taken into account in aerial triangulation.

Question 5 (25 marks)

The figure below shows an overlapping pair of truly vertical aerial photographs taken at equal flying height H above mean sea level (MSL) and having equal focal length f. The corresponding images of the ground point P are P_L on the left photo and P_R on the right photograph, respectively. The ground coordinate system XYZ has its origin at the MSL level location O of the left photo camera exposure station, i.e. the **X** and **Y** axes are parallel to the x and y axes of the photo system.

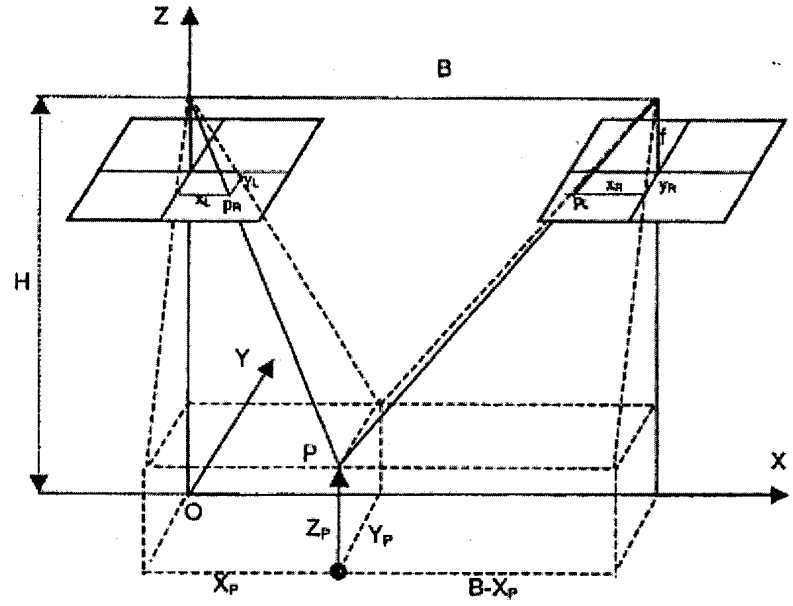
a) Derive the basic parallax equations for the ground coordinates of point P based on the illustrated geometry of the overlapping truly vertical photos.

b) Compute the ground coordinates $\mathbf{X_pY_pZ_p}$ of point **P** using the previously derived parallax equations for the photo stereo pair, whose Focal length **f**=152mm, the air base **B**=1815m and the flying height **H**=3000m;

and the photo-coordinates of point **P** are:

for the left photo: x_L = +80.00mm y_L = -50.00mm, and

for the right photo: x_R = -20.00mm, y_R = -50.00



END OF EXAMINATION

******GOOD LUCK ******

The University of Zambia
School of Engineering
Department of Geomatic Engineering
2015/2016 Academic Year Examinations

Monday, 5th September, 2016

GEE 3622: PRINCIPLES OF DATA ACQUISITION AND PROCESSING

Time: Three (3) Hours

Instructions:

1. This Examination is Closed Book
2. Calculators are permitted
3. Time allowed is Three (3) Hours
4. Answer: **BOTH** Questions from **Section A** and **TWO (2)** from **Section B**
5. **Answers to Section A and B MUST be answered in separate booklets.**
6. Show all the work leading to the solution
7. Total marks for this Examination paper is 100

WARNING! WARNING!

Bringing unauthorized material or pre-written notes in the examination venue will render you expelled indefinitely from the University. Being involved in any way in a leakage of an examination question paper will also render you expelled indefinitely.

Be Honest.

Be Confident.

Enhance the image of the University

SECTION A (Answer both questions 1 and 2)

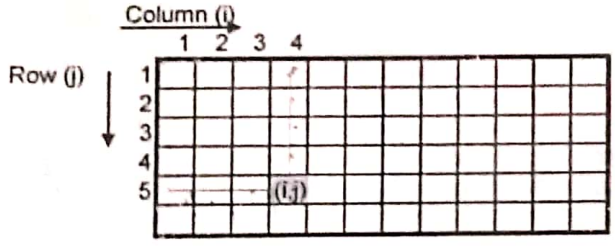
Question 1 (6+14+ 3+2) marks

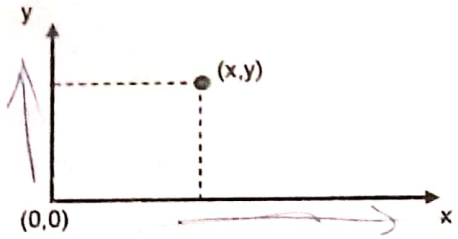
(a) State whether each of the following is **true** or **false** about remote sensing.

i. Provides only image data – DN values
ii. Requires ground data for georeferencing.
iii. It is a technique used to determine position (X, Y, Z) by the use of a minimum of three satellites.
iv. Measurements relate to the surface reflectance characteristics.
v. Measurements are done in-situ.
vi. It is weather independent.

(b) Georeferencing is an important component of geometric correction in image processing.

i. What is georeferencing?
ii. Study the image and map coordinate systems below. Image uses column-row (I,j) coordinate system whereas map uses a Cartesian coordinate system with (x,y)





iii. Calculate the map position (x,y) for image position (10,20) using the following equations:

i. $x = -10 + 5i - j$ and $y = 5 + 2i + 2j$

iv. Given the map coordinates of the top left corner of the image as x = 642785m, y = 8298133m and the resolution of 10m for the image, calculate map coordinates of the image coordinates (i,j) using the given coordinates and resolution. (Do not use the equations above).

(c) What is the purpose of resampling in image processing?

(d) What is the difference between linear contrast stretch and Histogram equalisation?

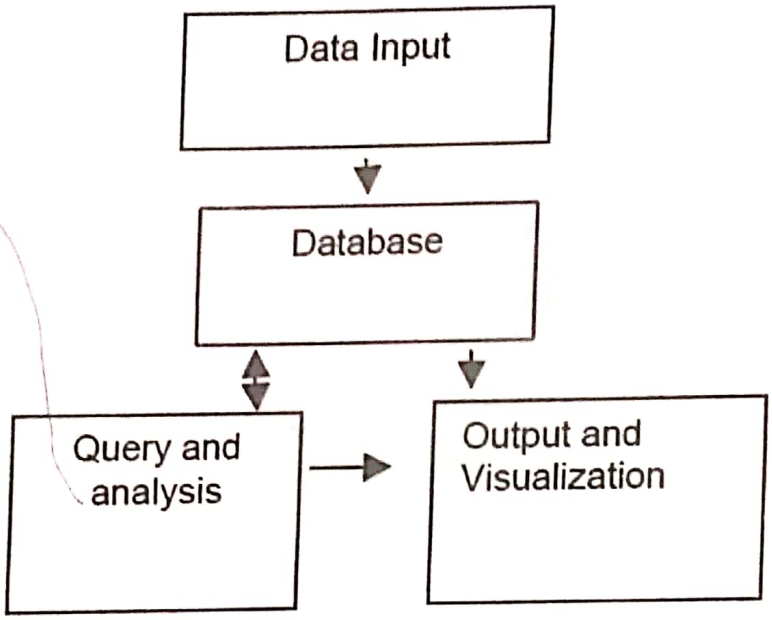
Question 2 (4+8+10+3) marks

(a) State whether each of the following is best represented as **Vector** or **Raster** model in a Geographic Information System (GIS).

i. For analysis of a road network
ii. For analysis of satellite images.

(b) The figure below depicts the function components of a GIS. Associate each of the following terms with the appropriate functional component. (The first term Paper Map is used as Input and serves as an example).

i. DBMS (Database Management System)
ii. Scanner
iii. Buffer
iv. What....if...?



(c) Analytical **GIS** functions are classified into five groups of functional classes. List the **five (5)** classes.

① - Data capture.
- Data compilat

(d) What are the **three (3)** challenges one would face when using secondary data in a GIS?

- Data Storage
- Data Manul
- Data representat.

(i)

(ii)

(iii)

SECTION B (Answer any two questions)

Question 3 (3+4+3+6+9) marks

a) Explain the meaning of stereoscopic depth perception.
b) Given that the shortest distance of clear stereoscopic depth perception for the average eye base of 65 mm is 250 mm and that the minimum distance at which the stereoscopic depth perception is possible is approximately 600m:
Compute,
   I. The maximum Parallactic angle, φ(max).
   II. The minimum Parallactic angle, φ(min).
c) Define the term "Vertical Exaggeration".
d) What is the approximate vertical exaggeration for a vertical photo taken with 152.4-mm focal length camera having a 23-cm square format if the photos were taken with 60% endlap. Assume b_e/h is 0.15.
e) Assuming the principle point to be at the intersection of lines joining opposite corner fiducial points, calculate the coordinates of those fiducial points in the conventional xy coordinate system if their comparator coordinates XY are as in the table below.

Fiducial points	X(mm)	Y(mm)
A	87.294	210.223
B	199.826	96.996
C	313.054	209.555
D	200.512	322.768

Question 4 (3+2+2+3+3+2+2+2+2+2+2) marks

a) List **three (3)** parameters of inner orientation?
b) A study area is 10 km wide in the east-west direction and 16 km long in the north-south direction. A camera having a 152.4-mm-focal-length lens and a 230-mm format is to be used. The desired photo scale is 1:25, 000 and the nominal endlap and sidelap are to be 60 and 30 percent. Beginning and ending flight lines are to be positioned along the boundaries of the study area. The only map available for the area is at a scale of 1: 62,500. This map indicates that the average terrain elevation is 300 m above datum.

i) In which direction must the aircraft fly and why?
ii) Find the flying height (**H**) above terrain.
iii) Determine ground coverage per image.
iv) Determine ground separation between photos on a line for 40 percent advance per photo
v) Assuming an aircraft speed of 160 km/hr, calculate the time between exposures
vi) Compute the average number of photos per 16-km line
vii) Determine the separation distance between flight lines
viii) Find the number of flight lines required to cover the 10-km study area width
ix) Find the spacing of flight lines on the map (1: 62,500 scale)
x) Find the total number of photos needed.

Question 5 (2+3+4+2+14) marks

a) The image-to-ground coordinate relationship of a point P is established through the collinearity model and is represented by the collinearity equations:

$$x = x_p - c \cdot \frac{r_{11}(X-X_o) + r_{21}(Y-Y_o) + r_{31}(Z-Z_o)}{r_{13}(X-X_o) + r_{23}(Y-Y_o) + r_{33}(Z-Z_o)}$$

$$y = y_p - c \cdot \frac{r_{12}(X-X_o) + r_{22}(Y-Y_o) + r_{32}(Z-Z_o)}{r_{13}(X-X_o) + r_{23}(Y-Y_o) + r_{33}(Z-Z_o)}$$

Identify the quantities involved in the above equations which refer to the following:

i) The measured image point coordinates → x, y,
ii) Interior orientation parameters of the camera – x_p, y_p, c
iii) Exterior orientation parameters of the image under consideration X_o, Y_o, Z_o, ω, φ, κ
iv) The ground coordinates of point – X, Y, Z.

b) A pair of overlapping vertical photographs was taken from a flying height of 1,233 m above sea level with a 154.4-mm-focal-length camera. The air base was 390 m. With the photos properly oriented, parallax bar readings of 12.57 mm and 13.04 mm were obtained with the floating mark set on the principle points O_1 and O_2, respectively. On the left photo *b* was measured as 93.73 mm and on the right photo *b'* was measured as 93.30 mm. Parallax bar readings of 10.96 mm and 15.27 mm were taken on points A and B. Also, the x and y photo coordinates of points A and B measured with respect to the flight axes on the left photo were x_a= 53.41 mm, y_a= 50.84 mm, x_b=88.92mm, and y_b = -46.69 mm. Calculate the elevations of points A and B and the horizontal length of line AB.

$h_A = H - B\frac{f}{p_a}$ $X_A = B\left(\frac{x_a}{p_a}\right)$ → 427.579

.....END OF EXAM.....

$X_A =$

$c = b' - r_{01}$

$c = b - r_{02}$.

$C = \frac{c_1 + c_2}{2}$.

$\frac{x_a}{X_A} = \frac{f}{H - h_A}$

$X_A = \frac{x_a}{f}(H - h_A)$

$p_a = C + r_a$.

$p_b = C + r_b$.

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The University of Zambia

School of Engineering

Department of Geomatic Engineering

2013 ACADEMIC YEAR

SECOND HALF YEAR EXAMINATIONS - JULY 2014

COURSE NAME: **PHOTOGRAMMETRY I**

COURSE CODE: **GEO 3322**

TIME: **THREE (3) HOURS**

TOTAL MARKS: **100**

INSTRUCTIONS

1. **Answer: ALL THREE** (3) QUESTIONS from SECTION A and **ANY** ONE QUESTION from SECTION B
2. This EXAMINATION is Closed Book
3. Calculators are permitted
4. Show all the work leading to the solution

SECTION A

Question 1

a)

i. Provide the definition of space resection

ii. How many and which are the unknown parameters for space resection

iii. What mathematical expression is used to determine the unknown parameters of the space resection

iv. What is required to be known to solve for the unknown parameters?

b) A project area is 16 km wide in east-west direction and 10.4 km long in north-south direction. It is to be covered with photos in scale 1:12000. The nominal end-lap and side-lap are to be 60% and 30%, respectively. A camera having a 152.4-mm-focal length lens and a 230-mm square format is to be used.

Compute:

i. Ground coverage

ii. The distance between two successive axes of the strips.

iii. Base in the strip

iv. Number of photos per strip (assuming two extra photos at each end of the strip to ensure coverage)

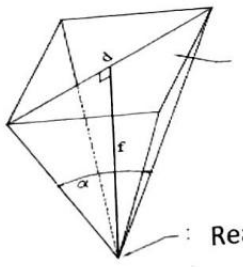
v. The intervalometer setting necessary to obtain the desired end-lap, assuming the aircraft flies at a velocity of 192km/h.

(13+10) marks

Question 2

a) Provide the definition of collinearity condition and give its mathematical expression. Explain the terms used in the mathematical expression.

b) The figure below shows the angular field of view of a camera. Calculate the angular field of view for a nominal 152-mm focal-length camera with a 23cm square format. State whether this is a wide angle, normal angle or super-wide angle type of a single-lens frame camera.



Focal Plane

α =Angular field of View

Rear Nodal point of lens

Hint: Use the formula:

$$\alpha = 2\tan^{-1}\left(\frac{d}{2f}\right)$$

(18+7) marks

Question 3

a) A pair of overlapping vertical photographs was taken from a flying height of 1,233 m above sea level with a 154.4-mm-focal-length camera. The air base was 390 m. With the photos properly oriented, parallax bar readings of 12.57 mm and 13.04 mm were obtained with the floating mark set on the principle points O_1 and O_2, respectively. On the left photo *b* was measured as 93.73 mm and on the right photo *b'* was measured as 93.30 mm. Parallax bar readings of 10.96 mm and 15.27 mm were taken on points A and B. Also, the x and y photo coordinates of points A and B measured with respect to the flight axes on the left photo were x_a= 53.41 mm, y_a= 50.84 mm, x_b=88.92mm, and y_b = -46.69 mm. Calculate the elevations of points A and B and the horizontal length of line AB.

b) Name the instrument usually employed to measure the position of a point in a photograph.

c) What are the systematic errors contained in the measured photo-coordinates that disturb the ideal linear relation between the perspective centre, the image point and the ground point?

(15+2+8) marks

SECTION B

Question 4

a) Assuming the principle point to be at the intersection of lines joining opposite corner fiducial points, calculate the coordinates of those fiducial points in the conventional xy coordinate system if their comparator coordinates XY are as in the table below.

Fiducial points	X(mm)	Y(mm)
A	87.294	210.223
B	199.826	96.996
C	313.054	209.555
D	200.512	322.768

b) Define the following photogrammetric terms, give the number of the corresponding parameter elements required for their determination and name them.

i. Basic interior orientation

ii. Relative orientation

iii. Absolute orientation

iv. Exterior orientation

(13+12) marks

The University of Zambia
School Of Engineering
Department Of Geomatic Engineering

2012 Academic Year Second Semester
FINAL EXAMINATIONS

GE 212: Introduction to Geomatics

Monday 19th August 2013

TIME:Three (3) Hours

INSTRUCTIONS:

1. This examination is Closed Book
2. Calculators are permitted
3. ANSWER ALL questions
4. Show all the work leading to the solution
5. Total marks for this examination paper is 100
6. [ ] indicates allocated marks for the question
7. Answer: each section in a separate answer booklet:

Section A: GIS & Remote Sensing

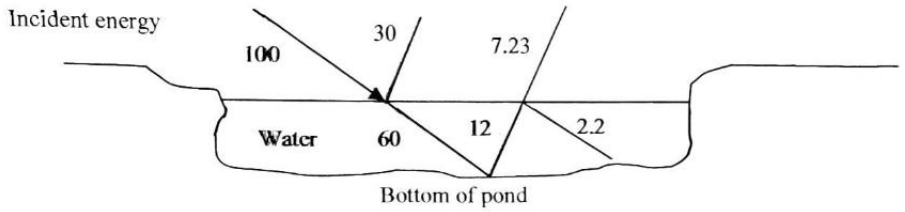
Question 1 [25 Marks]

a) Briefly but precisely explain GIS application in geomatic engineering. [4]

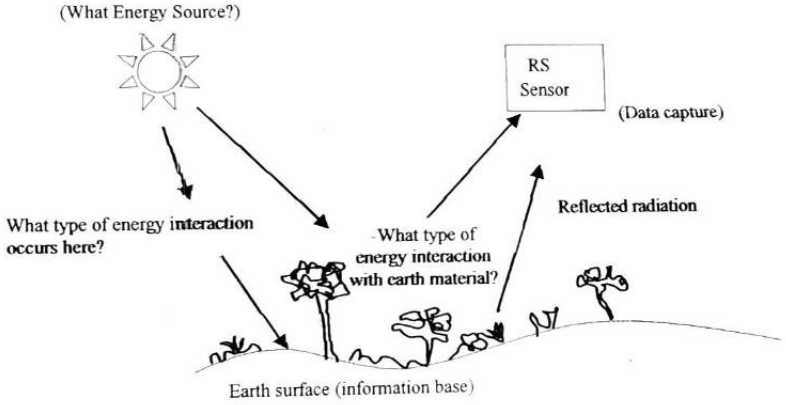
b) Briefly explain two (2) sources and/two(2) methods of spatial data capture. [4]

c) In GIS, the spatial framework can be represented in different ways. Explain with the aid of sketches the vector and raster GIS data models. [4]

d) Compute the total amount of energy reflected from the pond shown below if 30% of the energy incident on the water surface is reflected, 10% is absorbed, 60% is transmitted, and 20% of what hits the bottom of the pond is reflected. [3]



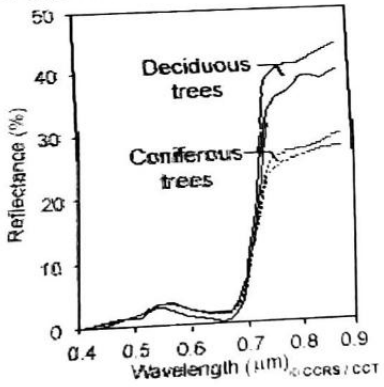
e) Below is a diagram showing the operation of the passive Remote Sensing system. Explain the types of energy interaction at each of the two stages identified on the diagram. [5].



f) The figure of reflectance curves below shows the spectral response patterns of deciduous and coniferous trees.

i. Which range of the wavelength is the visible portion and the near-infrared (NIR) of the electromagnetic spectrum? [2]

ii. State why it would be difficult to distinguish the two types of trees in the visible portion and easier in the NIR portion [3]



SECTION B: Surveying and Photogrammetry

Question 2 [25 Marks]

a) Global positioning system is nowadays the cutting edge technology of providing one's location.
   i) List four(4) advantages of GPS **[4]**
   ii) List three(3) limitations of GPS **[3]**

b) Given: A line of levels to be run from BM10 to BM11. At BM 10 the elevation is 101.325m. The level is set up at A,B,C,and D. Backsights and foresights are as follows.

Station	Backsight	Foresight
A	1.350	1.200
B	0.503	2.100
C	0.150	0.250
D	3.800	0.450

All the level setups are equally distant between back- and foresight points to reduce error to a minimum. Work out the levels to find the elevation of BM 11. **[12]**

c) With the help of sketches, describe the two types of coordinate systems used in surveying for identifying a point. **[6]**

Question 3 [25 Marks]

a) List at least four aberrations that cause different rays to converge to different points. Explain two of them in detail. **[4]**
b) State the main difference between vertical and tilted photographs. **[4]**
c) Explain the photographic terms: principle point, exposure station, endlap, sidelap, strip and block. **[12]**
d) Define 'scale of a photograph'. **[2]**
e) Mention three major applications of photogrammetry. **[3]**

SECTION C: Cartography

Question 4 [25 Marks]

Cartography should be considered a complete and independent science as well as a practical profession with specialised techniques.

a) It is a symbiosis of both theoretical and practical procedures. Clearly explain this statement. Cite an example in your answer. **[6]**

b) What is a primary topographic map and how else can it be called? Give a Zambian example **[5]**

c) The normal tasks of a cartographer are:
   i. to select required data for the map and
   ii. to process those data into a map.

   List five (5) tasks a cartographer has to undertake under **(ii) "to process those data into a map".** [10]

d) Where and when was the Zambia Survey Department first setup? **[4]**

The University of Zambia

School Of Engineering

Department of Geomatic Engineering

2012 Academic Year Second Semester

FINAL EXAMINATIONS

GE 332: Photogrammetry I Wednesday 28th August 2013

TIME:Three (3) Hours

INSTRUCTIONS:

1. This examination is Closed Book
2. Calculators are permitted
3. ANSWER **ALL** questions from **SECTION A** and one (1) question from **SECTION B**
4. Show all the work leading to the solution
5. Total marks for this examination paper is 100
6. **[ ]** indicates allocated marks for the question

Question 1 (20 marks)

a) Explain in details the effects of systematic errors on the image coordinates. Include sketches in your answer where necessary. **[16]**

b) During relative orientation of a photographic model, the same relative relationship between diapositives that existed at the time of photography is recreated. State the condition for relative orientation. **[2]**

c) After relative orientation, a true 3-D model is formed. State two important steps that are performed in the absolute orientation of model. **[2]**

Question 2 (20 marks)

a) Explain the meaning of the following photographic terms

i. Depth of field**[1]**
ii. Illuminance**[1]**
iii. F-stop **[1]**
iv. Isocenter**[2]**
v. Swing angle**[1]**
vi. Crab angle**[1]**
vii. Dead area**[2]**
viii. Air base**[1]**

b) In analytical photogrammetry, we often deal with matrix rotations in a plane for image points that must satisfy the orthogonality conditions. Given the following transformation:

$$\begin{pmatrix} X \\ Y \end{pmatrix} = \begin{pmatrix} 0.36 & 0.69 \\ 0.19 & 0.27 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix}$$

With the help of unit vectors

$$\mathbf{i} = \begin{pmatrix} \cos\alpha \\ \sin\alpha \end{pmatrix}, \qquad \mathbf{j} = \begin{pmatrix} -\sin\alpha \\ \cos\alpha \end{pmatrix}$$

State **three** (3) orthogonality conditions that must be satisfied for an orthogonal matrix and prove that the above transformation does not represent a rotation. **[10]**

Question 3 (20 marks)

a) Explain the following terms;
   i. Photographic properties of a film **[4]**
   ii. Metric photogrammetry **[2]**

b) Mention two important functions of filters in aerial cameras **[2]**

c) Two types of lenses are commonly used to manipulate light. These are concave (negative) and convex (positive) lenses. With the help of simple sketches, draw three different types of each these lenses showing how light is manipulated after passing through them. **[12]**

Question 4 (20 marks)

a) A shutter speed of 1/1000 is desired to obtain a sharp image at f/4.0, what f/number should be used to achieve the same result at a shutter speed of 1/500? **[6]**

b) With the help of well-labelled diagrams, describe the five (5) major lens aberrations that affect image quality. **[10]**

c) Explain the main differences between perspective and orthogonal projections. **[4]**

SECTION B

Question 5 (20 marks)

a) Assume two road intersections shown on a photograph can be located on a 1:25,000 scale topographic map. The measured distance between the intersections is 47.2 mm on the map and 94.3 mm on the photograph.
   i. What is the scale of the photograph? **[3]**
   ii. At that scale, what is the length of a fence line that measures 42.9 mm on the photograph? **[3]**

b) The length of line AB and the elevation of its endpoints, A and B, are to be determined from a stereopair containing images **a** and **b**. The camera used to take the photographs has a 154.4-mm lens. The flying height was 1200m (average for two photos) and the air base was 600m. The measured photographic coordinates of points A and B in the "flight line" coordinate

system are x(a)=54.61 mm, x(b)=98.67 mm, y(a)=50.80 mm, y(b)=-25.40 mm, x'(a)=-59.45mm, and y'(b)=-27.39 mm.

Find the length of line AB and the elevation of A and B. **[14]**

Question 6 (20 marks)

a) Explain the term depth of perception with respect to stereoviewing **[2]**

b) Given that the elevation of point C is 200m above MSL and that the parallax reading for the same point is 11.89mm and that of point A is 10.96mm, the parallax constant is 80.71mm. Calculate the parallax difference between the two points and the elevation of point A if the flying height for a pair of photos is 1000m. **[3]**

c) A mapping project is designed to use aerial photography at a scale of 1:10000 for a preliminary design of a development project covering an area of 20 x 15km. If a 15/23 camera is used with end and side overlaps of 60% and 30% respectively, calculate the following parameters if a flight plan along the longer side of the project boundary is to be prepared at a map scale of 1:20,000;

i. total number of flight lines **[3]**
ii. total number of photographs to cover the project area **[3]**
iii. spacing between boundaries and extreme flight lines close to the boundary **[3]**
iv. total number of models **[3]**
v. the required intervalometer setting that will achieve the desired end lap if the aircraft speed is 300km/h **[3]**

END OF EXAMINATION

*****GOOD LUCK *****

Chingeom Slavon Chiomlo

REVISION QUESTIONS AUGUST 2017

GEE 3622-PRINCIPLES OF DATA ACQUISITION & PROCESSING

GROUP 1

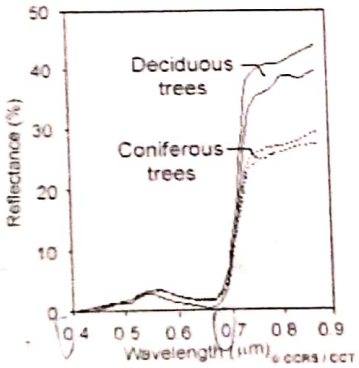
Figure 1 of reflectance curves; show the spectral response patterns of deciduous and coniferous trees.

(a) Which range of the wavelength is the visible portion of the electromagnetic spectrum? 0.4 - 0.7

(b) Which range is the near-infrared (NIR) portion? 0.7 - 0.9 (0.7 - 1.5)

(c) Explain why it would be difficult to distinguish the two types of trees in the visible portion. Low Reflectance.

(d) Explain why it would easier to distinguish the two types of trees in the NIR portion. Although both reflect a significant portion of incident radiation, it is clear & separable.



NIR - 0.7mm - 1.5 mm
MIR - 1.5 - 5.6mm
FIR - 5.6 - 1000mm

Figure 1: Reflectance curves for Deciduous trees and Coniferous trees

(a) Visible: 0.4 – 0.7 μm

(b) NIR: 0.7 – 0.9 μm

(c) The reflectance in the visible portion for both trees is low, and not clearly separable

(d) In the near-infrared, although both types reflect a significant portion of the incident radiation, they are clearly separable.

Atmospheric scattering occurs when the particals or gaseous molecules present in the atmosphere interact with the electromagnetic radiation and cause it to be redirected from its original path.

Mention three types of scattering that take place and give one example for each.

(Rayleigh scattering- blue wavelengths scattered 5 times as often as red. Creates blue sky , Mie scattering smoke, dust, volcanic material and salt crystals scatter longer radiation wavelengths and Non-selective scattering- suspended aerosols (with diameters at least 10x larger than wavelengths) including all Mia particles and water droplets and ice crystals, scatter longer radiation wavelengths

State whether true or false:

Active Remote – detect only reflected sunlight or thermal IR and microwaves (False)

Passive Remote – beam own artificially produced energy to a target and record reflected component (False)

The entire range of EMR comprises the electromagnetic spectrum subdivided in divisions called wavelengths **that share common characteristics. (False – Ans. Spectral Bands)**

Three forms of energy transfer include: absorption, reflection and transmittance (False. Ans- conduction, convection and radiation)

The Sun is the minor **supplier of EM energy incident on the Earth – providing energy needed for terrestrial life and the natural processes operating in the atmosphere, water and upper layers of solid Earth**. (false)

EMR travels in a straight path at the speed of light – postulated by Albert Einstein in 1905 as ~ 300,000,000 km/sec (false. Ans. 300,000km/sec)

Electromagnetic Radiation (EMR) is light energy detected when it comes into contact with an object (False. Ans EM)

The visible portion of the EM Spectrum ranges from 4 · m to 7 · m (False. Ans. 0.4 · m to 0.7 · m)

The most common bands of the EM spectrum used for remote sensing are cosmic, gamma and x-rays. (false. Ans. ultraviolet (UV), visible, infrared (IR) and microwave.

Remote sensing depends upon operation in wavelength regions of spectrum where spectral signatures occur for identification purposes. (true)

$h_a = H - \frac{Bf}{P_a}$

GROUP 2

The figure below shows an overlapping pair of truly vertical aerial photographs taken at equal flying height H above mean sea level (MSL) and having equal focal lenths f. The corresponding images of the ground point P are P_L on the left photo and P_R on the right photograph, respectively. The ground coordinate system XYZ has its origin at the MSL level location O of the left photo camera exposure station, i.e. the **X** and **Y** axes are parallel to the x and y axes of the photo system.

a) Derive the basic parallax equations for the ground coordinates of point P based on the illustrated geometry of the overlapping truly vertical photos.

b) Compute the ground coordinates $\mathbf{X_pY_pZ_p}$ of point **P** using the previously derived parallax equations for the photo stereo pair, whose
focal length **f**=152mm, the air base **B**=1815m and the flying height **H**=3000m;
and the photo-coordinates of point **P** are:
for the left photo: x_L = +80.00mm y_L = -50.00mm, and
for the right photo: x_R = -20.00mm, y_R = -50.00

left − right

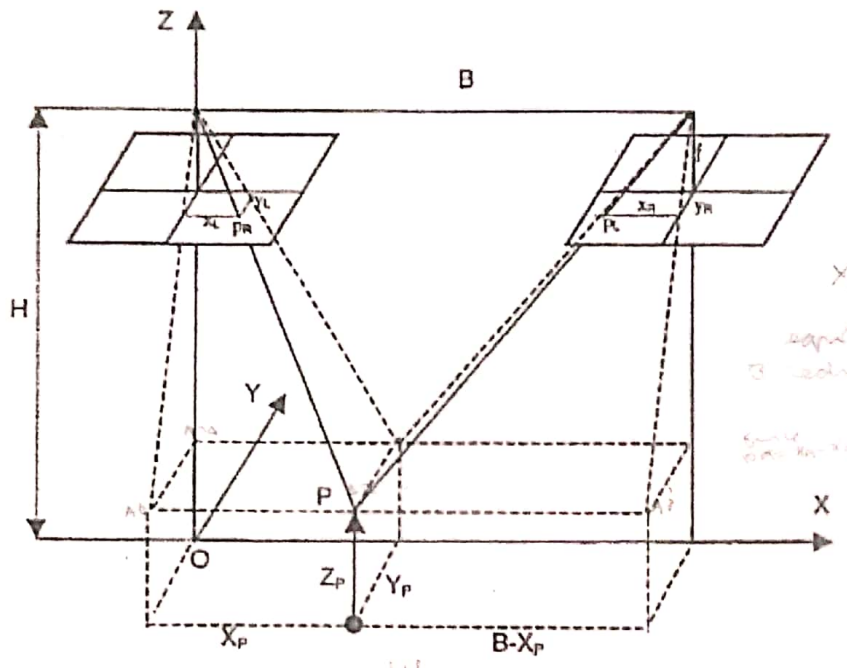
$Pa = xa - x'a$

$Pa = 100$

$H_A = H - \frac{Bf}{Pa}$

$X_p = B \frac{xa}{Pa}$

$= 1815 \frac{(80.00)}{100}$



a) Given that the elevation of point C is 200m above MSL and that the parallax reading for the same point is 11.89mm and that of point A is 10.96mm, the parallax constant is 80.71mm. Calculate the parallax difference between the two points and the elevation of point A if the flying height for a pair of photos is 1000m.

b) A mapping project is designed to use aerial photography at a scale of 1:10000 for a preliminary design of a development project covering an area of 20 x 15km. If a 15/23 camera is used with end and side overlaps of 60% and 30% respectively, calculate the following parameters if a flight plan along the longer side of the project boundary is to be prepared at a map scale of 1:20,000;

i. total number of flight lines

ii. total number of photographs to cover the project area

iii. total number of models

GROUP 3

What is Photogrammetry?

Photogrammetry is the science and technology of obtaining spatial measurements and other geometrically reliable derived products from photographs.

Explain the main differences between perspective and orthogonal projections.

Perspective projection is obtained by projecting an object to a projection plane with a bundle of rays from projection center located in finite distance from the projection plane, Angular relations between object features and image features are not the same.
Orthogonal projection is the parallel projection of an object to the chosen plane (map)

Name three (3) instruments used to measure image coordinates and briefly outline the measurement process involved.

i. Monocomparator- each photo is measured separately

ii. Stereocomparator- simultaneous identification and measurement of image points on two photographs

iii. Analytical plotter- projective relations between each model point and corresponding image points are implemented analytically

GROUP 4

Explain the term depth of perception with respect to stereoscopic viewing.

Stereoscopic depth perception is a function of the parallactic angles. Parallactic angle is the angle of intersection of optical axes that converge on a certain point.

The nearer the object the greater the parallactic angle and vice versa. The depth between object A and B (DB-DA) is perceived as the difference in their parallactic angles (QA-QB)

a) Given that the shortest distance of clear stereoscopic depth perception for an average eye base of 65mm is 250mm, calculate the maximum Parallactic angle.

Stereoscopic Depth Perception

① NB.
Shortest distance of clear Stereoscopic depth perception for the average eye base of 65mm is 250mm
∴ Max parallactic angle will be

$$\Phi(max) = 2\tan^{-1}\frac{32.5mm}{250mm} \approx 15^\circ$$

b) Given that the maximum distance at which the stereoscopic depth perception is possible is approximately 600m, calculate the minimum Parallactic angle.

$$= 2\tan^{-1}\frac{32.5}{600\,000}$$

$$= 0^\circ 0' 22''$$

② Maximum distance at which the stereoscopic depth perception is possible is approx 600 m

$$\Phi(min) = 22''$$

List at least three examples of close range photogrammetry in each of the following applications

I. Information System – Image database, building quality management, project Planning
Building information system

II. Engineering - measurement of large civil engineering sites
- pipeline and tunnel measurements, mining, deformation measurements

III. Automotive, machines and shipbuilding industries - inspecting of tooling jigs, Reversing of engineering design model, manufacturing control, Robot calibration

IV. Medicine and Physiology
Plastic surgery, tooth measurements, orthodontic deformation.

V. Forensic including Police work
- accident investigation, scene of crime measurement
- person measurement

GROUP 5

a) In analytical photogrammetry, we often deal with matrix rotations in a plane for image points that must satisfy the orthogonality conditions. Given the following transformation:

$$\begin{pmatrix} X \\ Y \end{pmatrix} = \begin{pmatrix} 0.36 & 0.69 \\ 0.19 & 0.27 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix}$$

With the help of unit vectors

$$\mathrm{i} = \begin{pmatrix} \cos\alpha \\ \sin\alpha \end{pmatrix}, \qquad \mathrm{j} = \begin{pmatrix} -\sin\alpha \\ \cos\alpha \end{pmatrix}$$

State **three** (3) orthogonality conditions that must be satisfied for an orthogonal matrix and prove that the above transformation does not represent a rotation.

(i) $\mathrm{i}^T\mathrm{i} = \cos^2\alpha + \sin^2\alpha = 1$ where $\mathrm{i}^T\mathrm{i} = r_{11}^2 + r_{21}^2$

$R = (\mathrm{i}, \mathrm{j})$, $R = \begin{pmatrix} r_{11} & r_{12} \\ r_{21} & r_{22} \end{pmatrix}$

(ii) $\mathrm{j}^T\mathrm{j} = \sin^2\alpha + \cos^2\alpha = 1$ where $\mathrm{j}^T\mathrm{j} = r_{12}^2 + r_{22}^2$

(iii) $\mathrm{i}^T\mathrm{j} = -\cos\alpha\sin\alpha + \sin\alpha\cos\alpha = 0$ where $r_{11}r_{12} + r_{21}r_{22} = 0$

case (i) $\mathrm{i}^T\mathrm{i} = r_{11}^2 + r_{21}^2$

$\mathrm{i}^T\mathrm{i} = 0.36^2 + 0.19^2 = 0.1657 \neq 1$

The figure below shows four models (1-4) which are observed

case (ii) $r_{12}^2 + r_{22}^2$

$0.69^2 + 0.27^2 = 0.5490 \neq 1$

$\mathrm{i}^T\mathrm{j}$

independently

case (iii) $r_{11}r_{12} + r_{21}r_{22}$

$\mathrm{i}^T\mathrm{j} = (0.36)(0.69) + (0.19)(0.27) \neq 0$

Mention at least five (5) sources of errors that are normally taken into account in aerial triangulation

- Film shrinkage
- Principle point displacement
- Lens distortion
- Atmospheric refraction
- Earth curvature
- Instrument error
- Observation errors

Outline at least three (3) advantages of control extension by aerial triangulation

i. Reduction in the amount of Field data
ii. Inaccessible areas can be accommodated
iii. Photo control is established in best location with the stereomodels
iv. Model setup time is reduced

Calculate

Total number of observation

(32)

Total number of Unknowns

(26)

Number of redundant observations

(6)

Which points represent the tie-points

(5,6,7,8,9)

Which points represent the control points

(1,2,3,4)

Briefly, define the adjustment involved in these models?

The models are:

displaced (two translations, Xu,Yu)

rotated (rotation angle, k) and

scaled (scale factor,m)

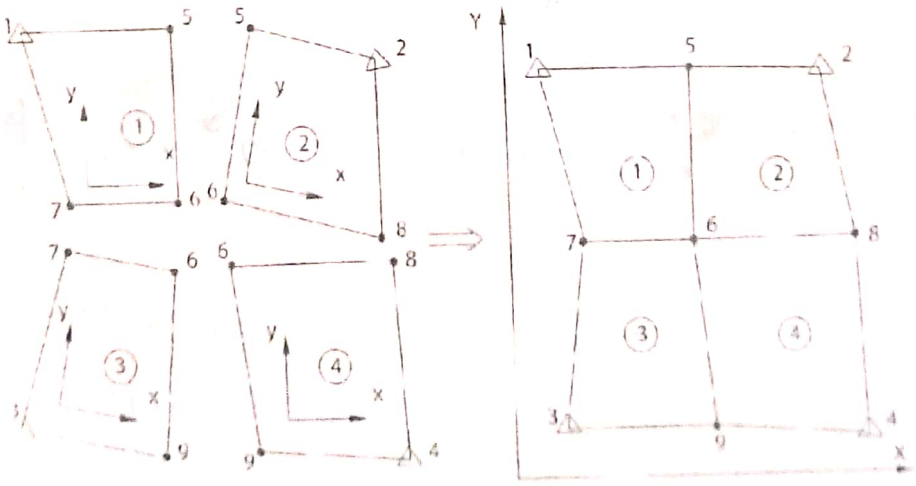
So that:

the tie points fit together as well as possible and

the residual discrepancies at the control points are as small as possible.

Why is the similarity (conformal) transformation used in the Block adjustment by independent models?

- The scale, position and orientation of the models may be changed but not its shape



2c. Contact printing, emulsion side of a negative is in direct contact with the unexposed emulsion contained on printing material placed together in a contact printer & exposed with emulsion of the positive facing light source.
Projection: negative is placed in the projector of the printer and illum
Instead from above.

Question 2 [10+9+6 marks]

a) With the help of a sketch, explain the term 'Parallactic angle' and state how it is related to stereoscopic depth perception.

b) In an ideal optical system, all rays of light from a point in the object plane would converge to the same point in the image plane, forming a clear image. The influences which cause different rays to converge to different points are called aberrations. Mention and briefly explain 3 types of aberrations

c) The image distance for a photograph of an object, which is located 4.5 meters from the camera, is 76.5mm. What image distance is required for perfect focus if the object is in infinity?

Question 3 [8+10+7 marks]

a) Mention two effects on the aerial photo image when a photo is taken at a height of 2500 m above the terrain with a 300-mm lens, compared to a photo taken with a 150-mm lens (assume the same flying height above the terrain and same film in both cases).

b) A single ray of light travelling through air (index 1.0003) enters a glass lens (index 1.575) having a radius of 47.5 mm. If the light ray is parallel to and 9.5 mm above the optical axis of the lens, what are the angles of incidence and refraction?

c) Briefly distinguish between contact printing and projection printing of a photographic emulsion.

SECTION B

Question 4 [16+9 marks]

a) Define the following photogrammetric terms:
- Filter – only allows certain wavelengths of energy to pass through lens and expose film
- Density
- Contrast
- Resolution of a lens – sharpness of lens.

b) Explain briefly,
- 'Depth of field' – Area of focus behind & infront of object (subject
- The principle difference between a 'map' and a 'photo'

Question 5 [10+15 marks]

a) Discuss the characteristic curve H and D, or D-log- E curve.

b) Discuss the darkroom procedure for black and white emulsion. Explain when and why a 'safe' light can be used in a darkroom

The University of Zambia
School of Engineering
Department of Geomatic Engineering
2018/2019 Academic Year
Second-Half Year Term Test

GEE 3622: Principles of Data Acquisition and Processing (Photogrammetry)

Friday 6th September 2019

Time: Two (2) Hours

Instructions

1. This TEST is **Closed Book**
2. Calculators are permitted
3. Time allowed is Two (2) Hours
4. **Answer: ALL QUESTIONS FROM SECTION (A) AND ONE FROM SECTION (B)**
5. Show all the work leading to the solution
6. Total marks for this TEST paper is 100

SECTION A

Question 1 [9+9+7 marks]

a) Define the following photogrammetric terms:
- Aperture – A hole / opening through lens where light travels
- Latent image – An emulsion exposed to light containing an invisible image of ob
- Illuminance – Brightness or amount of light recieved per unit area of
- Principle point – intersection of liner joining opposite fiducial marks.
- fog
- Brightness factor – ratio of d over f or $\sqrt{\frac{dR}{f^2}}$ diameter of camera image distance to focal l
- Epipolar plane
- Principle distance
- Flying height – altitude of camera

b) What are the relationships between?
- F-number and shutter speed
- Film speed and emulsion grain size
- Resolution and emulsion grain size

c) An aerial camera makes an exposure at a shutter speed of 1/1,000 sec. If the aircraft speed is 500 miles per hour, how far will the aircraft travel during the exposure?

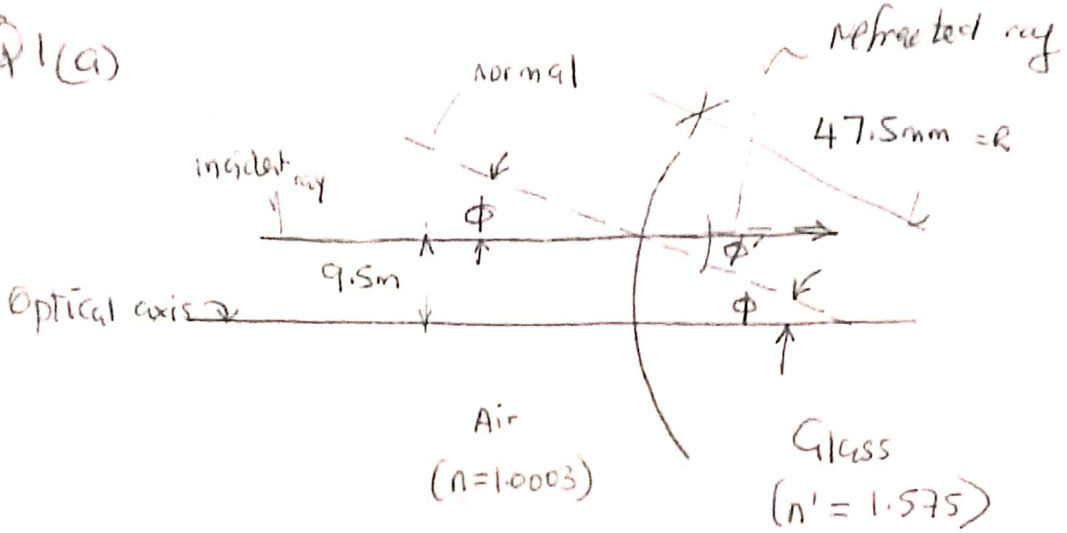
image plane during exposure

* film speed & emulsion grain: Large grain size require a faster film speed while small grain require slower film speed.
* Resolution and Emulsion grain: Large grain produce lower resolution (sharpness) of image while small grains produce higher resolution of image
* f-number & shutter speed: Are both inverly proportional to one another. when aperture is widened, shutter speed is increased

MODEL ANSWERS
GEE 3622
TERM 3 TEST
2017.

SHARON CHIYESU CHIKOMBO

Q1(a)



$\sin\Phi = \frac{9.5}{47.5}$ from which $\Phi =$ $\Phi = 11.54^0$

Applying Snell's law

$n \sin\Phi = n' \sin\Phi'$

$\sin^{-1}\left[\frac{1.0003 \sin 11.54^0}{n'} = n' \sin\Phi'\right]$

$1.0003 \left[\frac{9.5\,mm}{47.5\,mm}\right] = 0.20006$: $\Phi' = \sin^{-1} 0.20006$

$= 11.54^0$

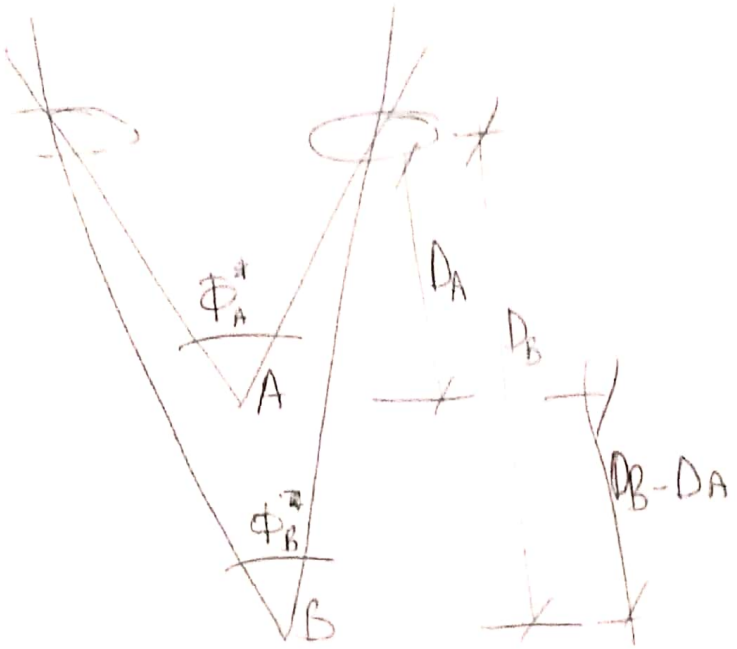
$\sin\Phi = \frac{1.575 \sin(11.54)}{1.0003}$

(10)

$\Phi = 18.36^0$

$\Phi' = 7.29^0$

Q1 (b)



Parallactic angle is the angle of intersection of optical axes that converge on a certain point the nearer the object the greater the parallactic angle and vice versa.

The depth of object A and B ($D_B - D_A$) is perceived as the difference in their parallactic angles ($\Phi_A - \Phi_B$).

(c) The collinearity condition states that the perspective center (L), the image point (a) and the object point (A) must ~~lie~~ lie on a straight line (3)

$$x_a = x_0 - f\,\frac{(X_A - X_L)m_{11} + (Y_A - Y_L)m_{12} + (Z_A - Z_L)m_{13}}{(X_A - X_L)m_{31} + (Y_A - Y_L)m_{32} + (Z_A - Z_L)m_{33}}$$

$$y_a = y_0 - f\,\frac{(X_A - X_L)m_{21} + (Y_A - Y_L)m_{22} + (Z_A - Z_L)m_{23}}{(X_A - X_L)m_{31} + (Y_A - Y_L)m_{32} + (Z_A - Z_L)m_{33}}$$

where x_a, y_a are measured image coords

X_A, Y_A, Z_A are unknown object coords

X_L, Y_L, Z_L are unknown elements of exterior orientation

$m_{11} \ldots$ are elements of the rotation matrix with embedded rotation angles ω, ϕ, κ which are also unknown elements of exterior orientation.

f is the focal length of the camera

Q2 (a)

Parallax - apparent shift in the position of an object w.r.t a frame of reference, caused by a shift in the position of observation

Principal Point - of a photograph is the foot of the perpendicular dropped from the rear nodal of the lens to the focal plane.

Luminance - is the degree of brightness received per unit area of the image plane during exposure.

Exposure Station - is the position of the camera at the instant of exposure.

Interior Orientation Parameters - refers to the coords of principal point & the focal length.

Exterior Orientation Parameters - refers to the position and angular orientation of the camera at the instant of exposure

Fiducial marks - marks on the sides or corners of a photograph that define the coordinate system of a photograph once joined together.

2(b) A map is an orthogonal projection whilst a photograph is a central or perspective projection.

(4)

Q 2(c) Slow shutter speed – large f-stop – small ϕ of lens opening

Fast shutter speed – small f-stop – large ϕ of lens opening

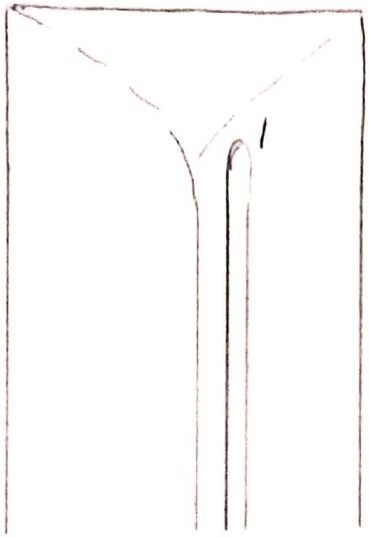
- Larger grains – faster film – short exposure time
  Smaller grains – slow film – longer exposure time
- large grains – less resolution power
  Smaller grains – higher resolution power

(7)

Q3 (a)

A(87.254, 210.223)

B(199.826, 96.996)



Q3 (a)

A(87.294, 210.223)

B(199.826, 96.996)

C(313.054, 209.555)

D(200.512, 322.768)

Step 1: We compute the coords of the intersection of line $\overrightarrow{AC}$ with line $\overrightarrow{BD}$ in this system

From equation of a straight line $y = mx + c$

line $\overrightarrow{AC}$

$210.223 = 87.294m + c$

$209.555 = 313.054m + c$

from which

$m = -0.00296$

$c = 210.421$

line $\overrightarrow{BD}$

$96.996 = 199.826m + c$

$322.768 = 200.512m + c$

from which

$m = 329.114$

$c = -65662.479$

$y = -0.00296x + 210.421 \quad \cdots (1)$

$y = 329.114x - 65662.479 \quad \cdots (2)$

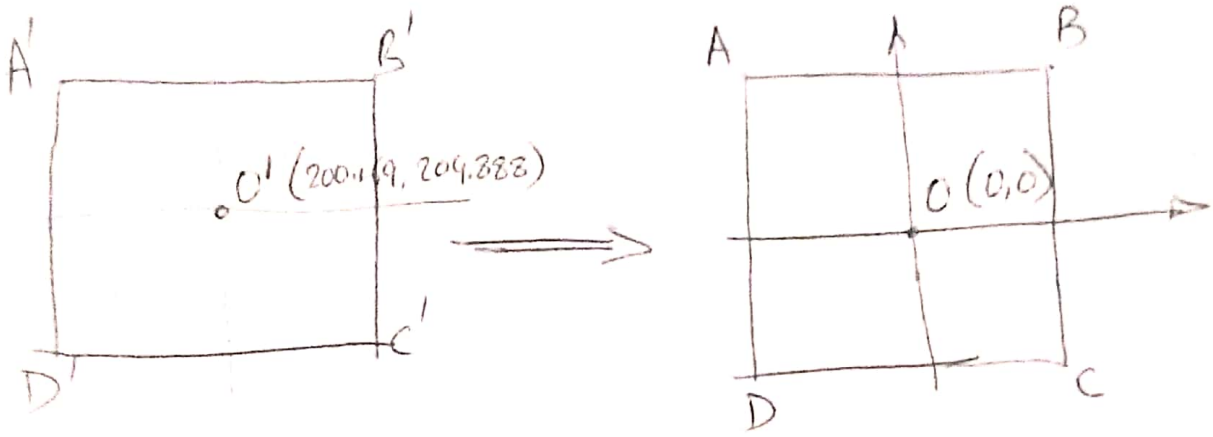
$-329.117x = -65877.960$

$x = 200.169$

$\therefore \quad y = 209.888$

$\therefore O' = (200.169, 209.888)$

But the the conventional system has origin (0) at (0,0);



$\therefore A = A' - O'$

$= (87.294 - 200.169,\ 210.223 - 209.888)$

$= -112.875,\ 0.335$

Do for B, C and D.

Q3(b) $\alpha = 2\tan^{-1}\left(\frac{d}{2f}\right)$

$= 2\tan^{-1}\left(\frac{\sqrt{(23^2 + 23^2)}}{2 \times 15.2\text{ cm}}\right)$

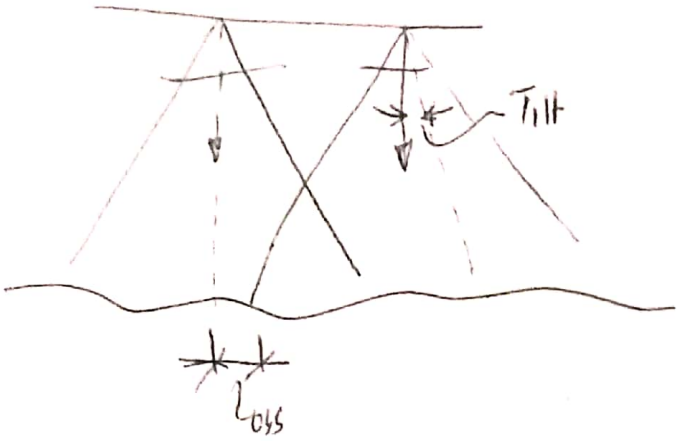
$= 2\tan^{-1}(1.0699642)$

$\alpha = 93.87°$ Wide angle camera

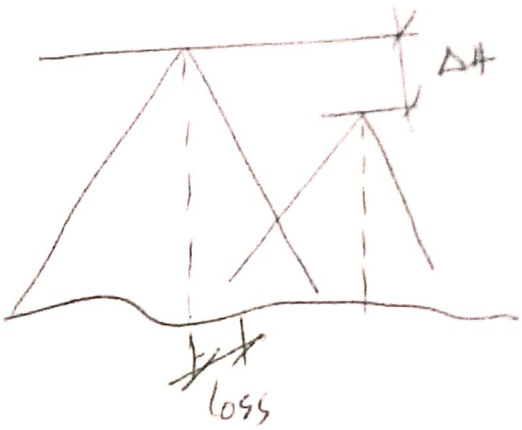
Wide Angle Camera

Q4(a) loss of Stereoscopic Coverage

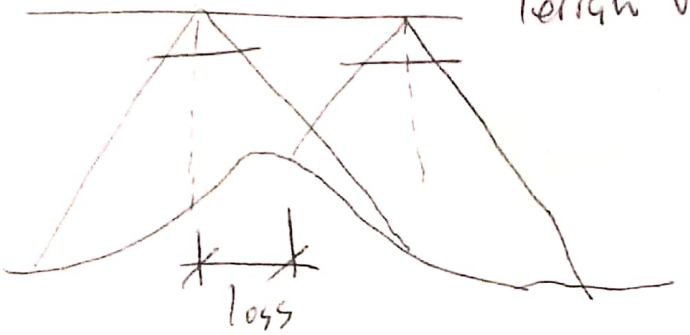
Due to Tilt



Unequal Flyn Height



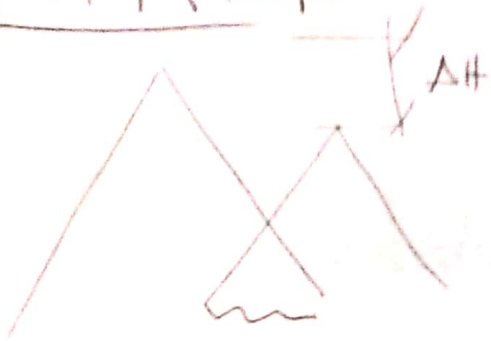
Terrain Variation



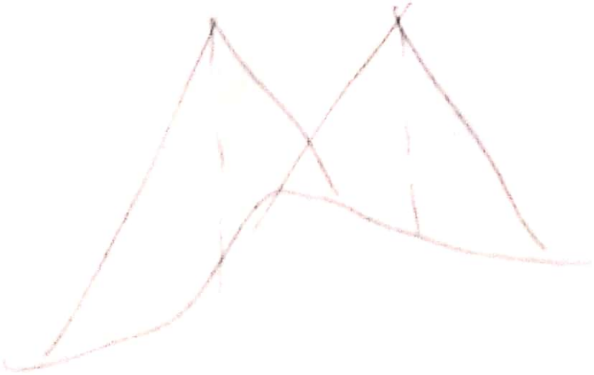
Q4 (a)

Tilt

Unequal flying Height



Terrain variation



4(b) $PE = \frac{G - B}{G} \times 100$

$PS = \frac{G - W}{G} \times 100$

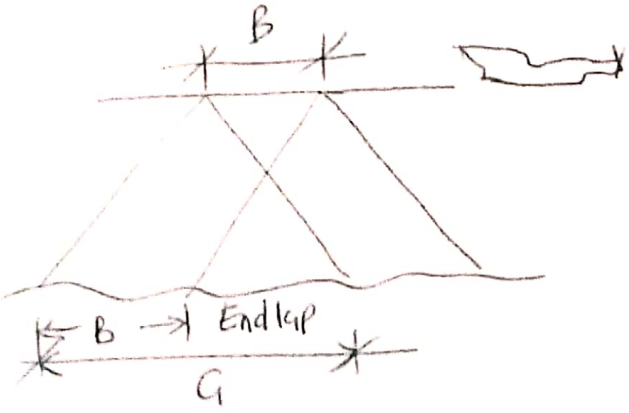
Solution

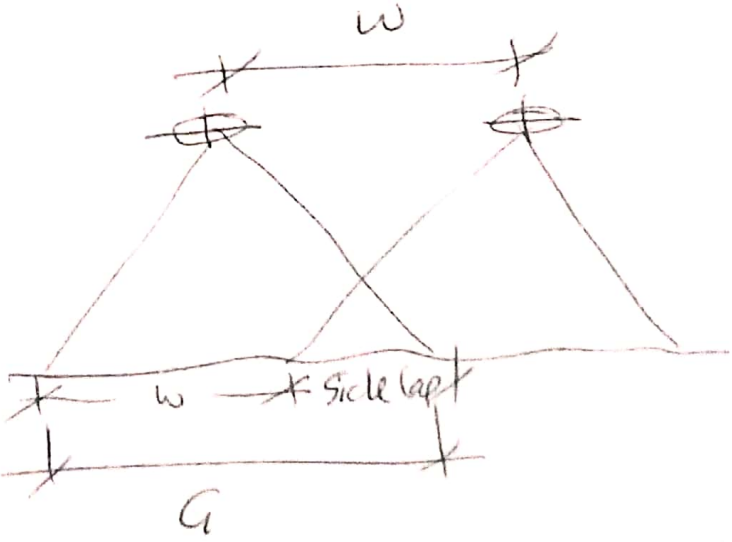
Average Scale $= \frac{f}{H} = \frac{152.4}{2440(1000)} = \frac{1}{16,000}$

Grond Coverage: $G = \left(\frac{23\,cm}{1/16,000}\right)\left(\frac{1m}{100cm}\right) = 3680m$

$PE = \frac{3680m - 1400}{3680} \times 100 = \underline{\underline{62\%}}$ (4)

$PS = \frac{3680 - 2500}{3680} \times 100 = \underline{\underline{32\%}}$





A(c) Refer to Example (b) in Aerial Camera Notes

Solution

$$D = (325 \text{ km/h})\left(\frac{1}{250} \text{ sec}\right)\left(\frac{1 \text{ h}}{3600 \text{ sec}}\right)\left(\frac{1000 \text{ m}}{1 \text{ km}}\right)$$

= Distance plane travels during exposure

= 0.361 m

$$d = 0.361\left(\frac{152.4}{5200}\right)$$

= distance image moves during exposure

= 0.0106 mm

(b)

Q5 (a) Relief displacement is the shift or displacement in the photographic position of an image caused by the relief of the object i.e its elevation above or below a selected datum.

Q5(b) Select datum at the base of the tower.
Then flying height above datum is

$$H = 535 - 259 = 276\ m$$

By equation, $h = \frac{dH}{r}$

$$h = \frac{(54.1)(276)}{121.7} = \underline{\underline{123\ m}}$$

$$= 100,500$$

$$\frac{20.1}{1:25000} = 502,500$$

$$\frac{20.1}{} = 402,000$$

$$R = \frac{152 \times 10^{-3}}{5000 - 1960} = \frac{1}{\pi} : 20,000$$

$$f = 152 \qquad V = \frac{152 \times 10^{-3}}{5000 - 2000} = \frac{152 \times 10^{-3}}{3800}$$

$$f_h = 5000 \qquad \frac{1}{\lambda} \quad 1:25000$$

$$e = 1200$$

Q5(c)

$P_a = x_a - x'_a = 54.61 - (-59.45) = 114.06mm$

$P_b = x_b - x'_b = 98.67 - (-27.39) = 126.06mm$

$X_A = B\frac{x_a}{P_a} = \frac{600 \times 54.61}{114.06} = 287.27m$

$X_B = B\frac{x_b}{P_b} = \frac{600 \times 98.67}{126.06} = 469.63m$

$Y_A = B\frac{y_a}{P_a} = \frac{600 \times 50.80}{114.06} = 267.23m$

$Y_B = B\frac{y_b}{P_b} = \frac{600 \times (-25.40)}{126.06} = -120.89m$

$AB = [(469.63 - 287.27)^2 + (-120.89 - 257.23)^2]^{1/2}$

$= \underline{428.8m}$

$h_A = H - \frac{Bf}{P_a} = 1200 - \frac{600 \times 152.4}{114.06} = \underline{398m}$

$h_B = H - \frac{Bf}{P_b} = 1200 - \frac{600 \times 152.4}{126.06} = \underline{475m}$

Chigeon Sharon Chelombo

Model Answers

Question 1

a) –Shape of object, which relates to the general form, configuration of an individual object

-Size, varies with photo scale

- pattern, relates to the spatial arrangement of objects. The repetition of certain general forms is characteristic of many objects both natural and man made,(parking for cars)
- Tone, refers to color or relative shades of gray of images. It is related to reflectance of light from objects
- Texture, the frequency of tone changes in photographic images. It is product of their individual shape, size, pattern,shade,tone
- Shadows, the shape or outline of a shadow affords a profile view of objects
- Site or location of objects in relation to other features

b) – Type of camera has to be suitable for a purpose required

- Camera calibration parameters should be available
- Type of photographic emulsion, good stable film support, suitable filters
- Limitation on the amount image blurring due to camera and aircraft motion
- Selection of suitable flying height due to technique to be employed and nature of terrain
- Photographic overlap should fit required task. The most common is 60% and 20% for end and side overlap respectively. To increase accuracy of aerial triangulation end and side overlap are sometimes increased
- Tilt and crab of photos within 3 degrees and 5 degrees,respectively
- Proper direction of flight lines
- The use of auxiliary instruments
- Time of photography
- Sterescopic plotter consideration
- Calibration data

Question 2

a) Perspective projection is obtained by projecting an object to a projection plane with a bundle of rays from projection center located in finite distance from the projection plane, Angular relations between object features and image features are not the same.
Orthogonal projection is the parallel projection of an object to the chosen plane(map)

Question 3

a) – f-number is the ratio of focal length 'f' to a lens opening 'd'

-aperture is a lens opening with a diametr d which regulates thye amount of light which enters to the objective and exposes the photographic film

- illuminance is a degree of brightness received per unit area of the image plane during exposure

Question 5

a) x-parallax is the change in position of an image from one photo to the next caused by aircraft's motion

Points A and B are imaged on two overlapped photos as a'b' and a"b". Because point B is higher (closer to camera) than A, the movement of image b" across the image plane was greater than a". It means that the parallax of point B, pxb=x'b-x'b" is greater than A, pxa=x'a-x"a. The parallax of any point is related to the elevation of the point(greater for higher points)

Question 4

b)

i) Stereoscopic depth perception is a function of the parallactic angles. Parallactic angle is the angle of intersection of optical axes that converge on a certain point. The nearer the object the greater the parallactic angle and vice versa. The depth between object A and B (DB-DA) is perceived as the difference in their parallactic angles (QA-QB)

Model Answers GE 332 Photogrammetry I December 2004 Examinations

Question 1

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The University of Zambia
School of Engineering
Department of Geomatic Engineering
2016/2017 Academic Year Term 3 Test

GEE 3622: Principles of Data Acquisition and Processing

Friday 21st July, 2017

Instructions

1. This TEST is Closed Book
2. Calculators are permitted
3. Time allowed is Two (2) Hours
4. **Answer: A TOTAL OF FOUR QUESTIONS: ANSWER ALL FROM SECTION (A) AND ONE FROM SECTION (B)**
5. Show all the work leading to the solution
6. Total marks for this TEST paper is 100

SECTION A

Question One (10+5+10 marks)

a. A single ray of light travelling through air (index 1.0003) enters a convex glass lens (index 1.575) having a radius of 47.5 mm. If the light ray is parallel to and 9.5 mm above optical axis of the lens, what are the angles of incidence and refraction?

b. With the help of a sketch, explain the term 'Parallactic angle' and state how it affects object distances.

c. Provide the definition of collinearity condition and give its mathematical expression. Explain the terms used in the mathematical expression.

Question Two (14+4+7 marks)

a. Briefly, define the following photogrammetric terms:
   - Pallarax
   - Principal Point
   - Illuminance
   - Exposure Station
   - Interior orientation parameters
   - Exterior orientation parameters
   - Fiducial Marks

b. Briefly, state the main difference between a map and a photograph.

c. State briefly, the relationships between?
   - f-number and shutter speed
   - Film speed and emulsion grain size
   - Resolution and emulsion grain size

Question Three (20+5 marks)

a. Assuming the principle point to be at the intersection of lines joining opposite corner fiducial points, calculate the coordinates of those fiducial points in the conventional xy coordinate system if their comparator coordinates XY are as in the table below.

Fiducial points	X(mm)	Y(mm)
A	87.294	210.223
B	199.826	96.996
C	313.054	209.555
D	200.512	322.768

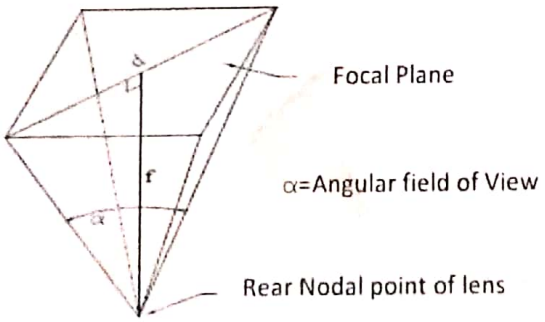
$(y_2 - y_1) = m(x_2 - x_1)$

$y = mx_1 + c_1$

$y = mx_2 + c_2$

$A = A' - o'$

b. The figure below shows the angular field of view of a camera. Calculate the angular field of view for a nominal 152-mm focal-length camera with a 23cm square format. State whether this is a wide angle, normal angle or super-wide angle type of a single-lens frame camera.



SECTION B

Question Four (15+10 marks)

a. With the help of sketches, show how stereoscopic coverage is lost due to
   i) Tilt
   ii) Unequal flying heights
   iii) Terrain variations

b. Air base of a stereopair is 1400m and flying height above ground is 2400m. Camera has a 152.4 mm focal length and 23-cm format.
   i) What is the percent end lap?
   ii) Assuming spacing between adjacent lines is 2500m, what is the percent side lap?

c. An aerial camera with IMC (Image Motion Compensation) is used to acquire photography at a flying height of 5200 m above ground. The focal length is 153.15 mm. The aircraft is flying at 325 km/hr and an exposure time of 1/250 second is used. How far across the focal plane must film travel during the exposure in order to obtain an image with no image motion blurring?

Question Five (4+6+15 marks)

a. What is relief displacement?

b. A vertical photo is taken from a height of 535 m above the datum. The elevation of the base of tower is 259m and the relief displacement'd' is measured as 54.1 mm. The radial distance to the top of the tower is 121.7 mm. What is the height of the tower?

c. The length of line AB and the elevation of its endpoints, A and B, are to be determined from a stereopair containing images a and b. The camera used to take the photographs has a 152.4-mm lens. The flying height was 1200 m (average for the two photos) and the air base was 600 m. The measured photographic coordinates of points A and B in the "flight line" coordinate system are x_a = 54.61 mm, x_b = 98.67 mm, y_a = 50.80 mm, y_b = -25.40 mm, x'_a = -59.45 mm, and x'_b = -27.39 mm. Find the length of line AB and the elevations of A and B.

Chigeon
Sharon
Chilombo

The University of Zambia

School of Engineering

Department of Geomatic Engineering

2014/2015 Academic Year Term 3 TEST

GEE 3622: Principles of Data Acquisition and Processing
FRIDAY 22nd MAY 2015
Time: Two (2) Hours

Instructions

1. This TEST is Closed Book
2. Calculators are permitted
3. Time allowed is Two (2) Hours
4. Answer: ALL QUESTIONS FROM SECTION (A) AND ONE FROM SECTION (B)
5. Show all the work leading to the solution
6. Total marks for this TEST paper is 100

SECTION A

Question 1 [10+5+10 marks]

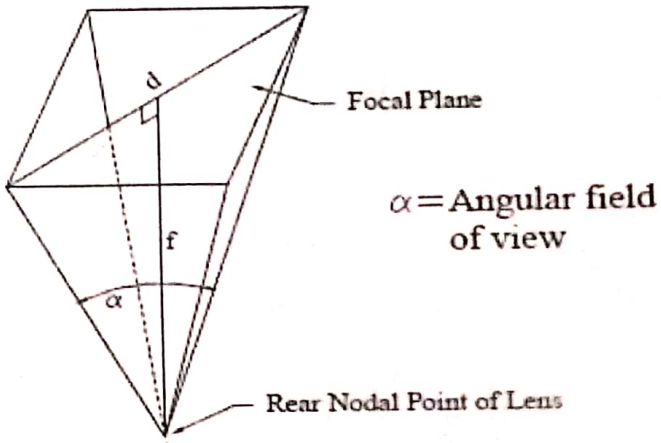
a) Define the following photogrammetric terms:

- Exposure Station
- Interior orientation parameters
- Exterior orientation parameters

- Focal Plane
- Fiducial Marks

b) The figure below shows the field of view of a a typical single lens camera.

Given that f=150 mm and d= 23cm, compute the angular field of view α.



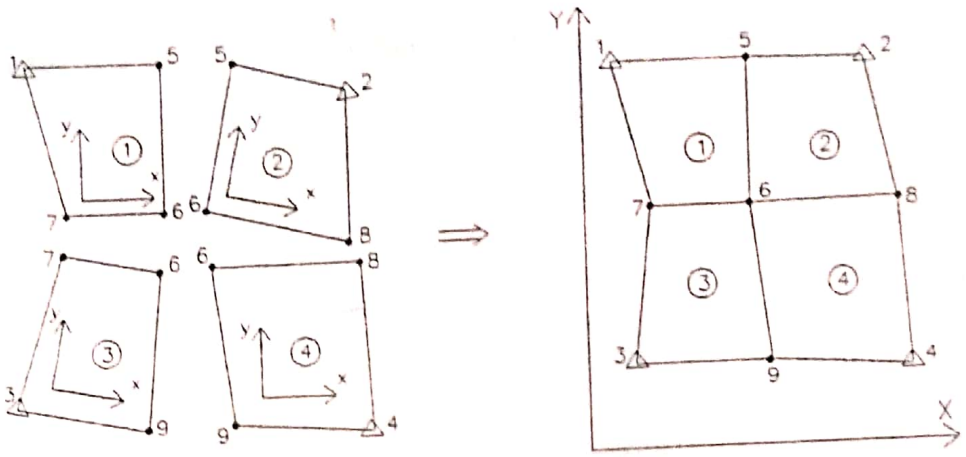
c) With the help of sketches, briefly, explain the following terms:

- Principle Point
- Conjugate Principle Point
- Ground Nadir Point
- Object Space
- Image Space

Question 2 [5+10+5+5 marks]

a) Explain the main purpose of aerial triangulation.

b) The figure below shows the planimetric block adjustment by independent models.



i. Briefly, state the planimetric adjustment involved.

ii. Which points refer to the 'control' points?

iii. Which points refer to the 'Tie' points

Question 3 [5+5+5+5+5 marks]

A project area is 16 km wide in the east-west direction and 10.4 km long in the north-south direction. A camera having a 152.4-mm-focal-length lens and a 230-mm format is to be used. The desired photo scale is 1:12, 500 and the nominal end lap and side lap are to be 60 and 30 percent, respectively. Beginning and ending flight lines are to be positioned along the boundaries of the study area. The only map available for the area is at a scale of 1: 50,000. This map indicates that the average terrain elevation is 300 m above datum. Compute the following data for the flight crew:

i. Flying height above mean sea level

ii. Ground coverage

iii. Distance between two successive axes of the strips.

iv. Number of flight lines

v. Total number of photos

SECTION B

Question 4 [10+5+10 marks]

a. Explain the difference between a vertical photograph and a tilted photo.

b. What is relief displacement?

c. A vertical photo is taken from a height of 535 m above the datum. The elevation of the base of tower is 259m and the relief displacement 'd' is measured as 54.1 mm. The radial distance to the top of the tower is 121.7 mm. What is the height of the tower?

Question 5 [10+5+10 marks]

a. With the help of a sketch, explain the term 'Parallactic angle' and state how it affects object distances.

b. What is 'Parallax?'

c. Elevation of point C is given as 200.00m above sea level and parallax bar reading r(c) = 11.89 mm. Assuming that a pair of overlapping photos were taken from H = 1000m, constant of parallax bar C = 80.71mm and parallax bar reading of point A is equal r(a) = 10.96 mm. Calculate the elevation of point A.

Bessface

chisem Sharon chilombo

The University of Zambia

School of Engineering

Department of Geomatic Engineering

2013 ACADEMIC YEAR

SECOND HALF TERM 3 TEST - MAY 2014

COURSE NAME: **PHOTOGRAMMETRY I**

COURSE CODE: **GEO 3322**

TIME: **TWO (2) HOURS**

TOTAL MARKS: **100**

INSTRUCTIONS

1. **Answer: ALL FOUR** (4) QUESTIONS from SECTION A and ANY **ONE QUESTION** from SECTION B
2. This TEST is Closed Book
3. Calculators are permitted
4. Show all the work leading to the solution

SECTION A

Question 1

a) Define briefly, the following photographic terms:

- F-number
- Nadir point
- Principle distance
- Flying height
- Fiducial marks
- Brightness factor

b) The image distance for a photograph of an object, which is located 4.5 meters from the camera, is 76.5mm. What image distance is required for perfect focus if the object is in infinity?

c) An aerial camera makes an exposure at a shutter speed of 1/1,000 sec. If the aircraft speed is 500 miles per hour, how far will the aircraft travel during the exposure?

(12+4+4) marks

Question 2

a. Name the instrument usually employed to measure the position of a point in a photograph.

b. What are the systematic errors contained in the measured photo-coordinates, that disturb the ideal linear relation between the perspective center, the image point and the ground point?

(4+16) marks

Question 3

a) What is meant by a vertical photograph?

b) What are the effects of tilt and relief displacement on a photo?

c) A vertical photograph captured at a flight height of 2000' above sea level shows a radio tower with a base elevation 540' above the same datum. The image of the

tower has a relief displacement of 1.33". The distance from the photograph' s principal point to the top of the tower is 5.97". What is the height of the tower?

$h = \frac{H \cdot b}{r}$

(4+8+8) marks

Question 4

a) Describe the meaning of photosensitivity and spectral sensitivity of photographic material.

b) What are the relationships between?

- F-number and shutter speed
- Film speed and emulsion grain size
- Resolution and emulsion grain size

c) Mention and explain one of the methods of camera calibration.

(4+6+10) marks

SECTION B

Question 5

The figure below shows an overlapping pair of truly vertical aerial photographs taken at equal flying height H above mean sea level (MSL) and having equal focal lenths f. The corresponding images of the ground point P are P_L on the left photo and P_R on the right photograph, respectively. The ground coordinate system XYZ has its origin at the MSL level location O of the left photo camera exposure station, i.e. the **X** and **Y** axes are parallel to the x and y axes of the photo system.

a) Derive the basic parallax equations for the ground coordinates of point P based on the illustrated geometry of the overlapping truly vertical photos.

b) Compute the ground coordinates $\mathbf{X_pY_pZ_p}$ of point **P** using the previously derived parallax equations for the photo stereo pair, whose
focal length **f**=152mm, the air base **B**=1815m and the flying height **H**=3000m;
and the photo-coordinates of point **P** are:
for the left photo: x_L = +80.00mm y_L = -50.00mm, and
for the right photo: x_R = -20.00mm, y_R = -50.00

tower has a relief displacement of 1.33". The distance from the photograph' s principal point to the top of the tower is 5.97". What is the height of the tower?

$$h = \frac{H \cdot D}{r}$$

(4+8+8) marks

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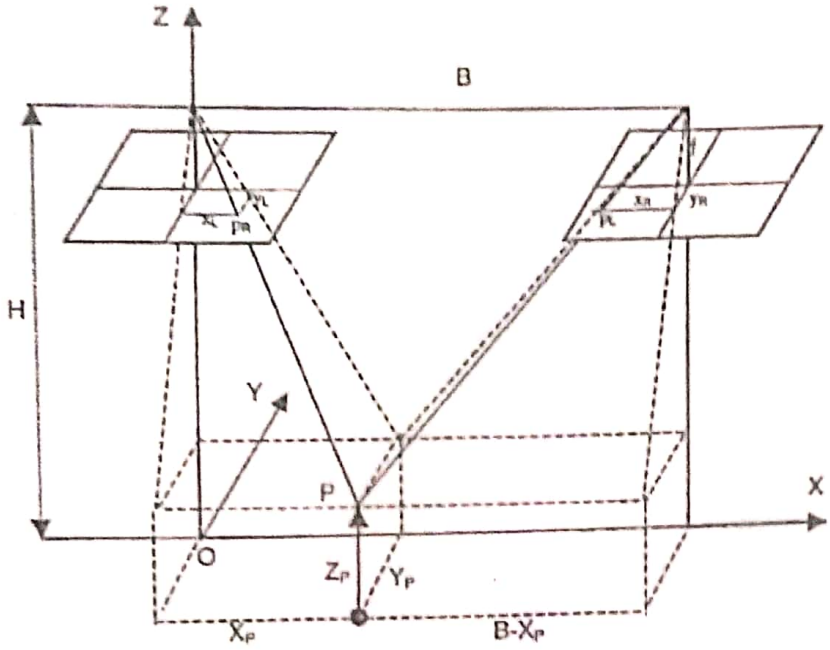
and the photo-coordinates of point **P** are:
for the left photo: x_L = +80.00mm y_L = -50.00mm, and
for the right photo: x_R = -20.00mm, y_R = -50.00



(14+6) marks

Question 6

The image coordinates of three points **A, B, C** and of the principal points **P** and **Q** on two overlapping vertical aerial photos were as follows

Point	Left photo		Right photo	
	x(mm)	y(mm)	x(mm)	y(mm)
P	0.0	0.0	-89.2	0.0
Q	+89.4	0.0	0.0	0.0
A	+12.8	+44.6	-76.6	+44.2
B	+16.4	+6.3	-72.8	+5.9
C	+20.2	-30.7	-69.6	-31.2

Given that the ground coordinates of A and C were 60,000mE, 72000mN and 61260mE, 71200m N respectively, estimate those of **B**.

(20) marks

Chilombo Chigeon Sharon

UNIVERSITY OF ZAMBIA

MID–SECOND SEMESTER TEST
MARCH 2012
GE 332
Photogrammetry I

Instructions:
Time: THREE (2) hours
Answer **ALL** questions from section A and **ONE** from section B

SECTION A

Question ONE(1)

a) Define briefly, the following photographic terms:
- Aperture - lens opening
- F-number - the ratio of the focal length to the diameter of the lens opening
- Illuminance - the amount of light received per unit area on the image plane during exposure
- Nadir point -
- Principle distance -
- Flying height - altitude of the camera
- Side lap - adjacent flight strips overlap

b) An aerial camera makes an exposure at a shutter speed of 1/1,000 sec. If the aircraft speed is 500 miles per hour, how far will the aircraft travel during the exposure?

c) What are the causes of radial lens distortion? List two of its characteristics. Use sketches to illustrate your answer
Radial lens distortion is caused from faulty grinding of the lens.

d) What are the relationships between?
- F-number and shutter speed
- Film speed and emulsion grain size
- Resolution and emulsion grain size

(6+7+6+6) marks

Question TWO (2)

a) What is meant by a vertical photograph? What is meant by a nearly vertical photography?

b) A vertical photograph captured at a flight height of 2000′ above sea level shows a radio tower with a base elevation 540′ above the same datum. The image of the tower has a relief displacement of 1.33". The distance from the photograph's principal point to the top of the tower is 5.97". What is the height of the tower?

c) Mention and explain one of the methods of camera calibration.

d) The line lies on fairly level terrain. Find the approximate flying height above terrain if the camera focal length = 90mm and the section line ab = 100mm (on photo) and on terrain AB = 1000m.

(7+5+8+5) marks

Question THREE (3)

(a) Discuss the darkroom procedure for black and white emulsion. Explain when and why a 'safe' light can be used in a darkroom

(b) Discuss the characteristic curve H and D, or D-log- E curve.

(c) Define the following terms:

- Filter
- Density
- Contrast
- Resolution

(d) Explain briefly,

- 'Depth of field'
- What are the effects of tilt and relief displacement on a photo?

(7+5+8+5) marks

SECTION B

Question FOUR (4)

a) Discuss briefly,

i. The principle difference between a 'map' and a 'photo'

ii. Virtual and Real Image formation

b) What is meant by exterior orientation? What parameters are involved?

c) An aerial camera with IMC (Image Motion Compensation) is used to acquire photography at a flying height of 5200 m above ground. The focal length is 153.15 mm. The aircraft is flying at 325 km/hr and an exposure time of 1/250 second is used. How far across the focal plane must film travel during the exposure in order to obtain an image with no image motion blurring?

(10+8+7) marks

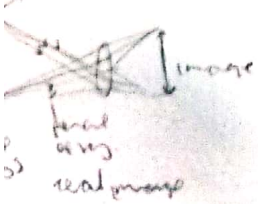
Question FIVE (5)

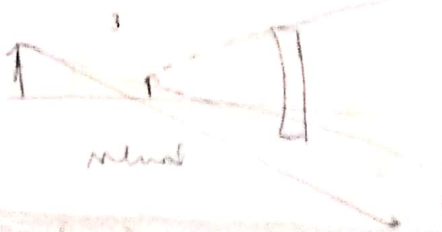
a) Describe the meaning of photosensitivity and spectral sensitivity of photographic material.

b) What is a diapositive and give one example?

c) Define the following photographic terms:

- Nodal points
- focal points
- focal length **Focal length is defined as the distance from the focal plane to the center of the lens when focused at infinity (figure 6.4).**





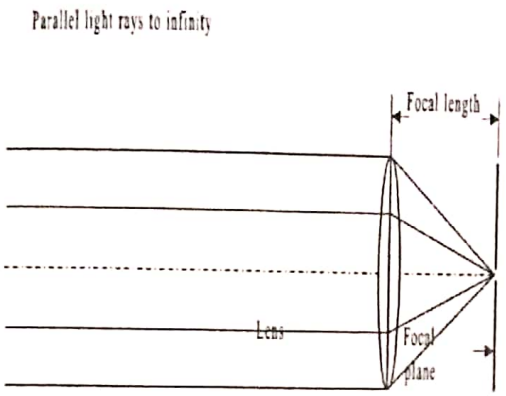


Figure 6.4. Focal length of a simple lens. (From Paine, 1981)

d) The image distance for a photograph of an object, which is located 4.5 meters from the camera, is 76.5mm. What image distance is required for perfect focus if the object is in infinity?

(10+3+6+6) marks

To the Students_GEE 3622,

DISCLAIMER!

The following revision questions are not intended to replace your course study obligations but merely to guide you on some of the obvious knowledge you are expected to have understood in your course work.

REVISION KIT GEE 3622

Question 1

A film in a camera with a 40-mm-focal-length lens is properly exposed with a lens-opening diameter of 5 mm and an exposure time of 1/125 sec (condition 1). If the lens opening is increased to 10 mm and the scene brightness does not change, what exposure time should be used to maintain proper exposure (condition 2)?

Question 2

An aerial camera with forward-motion compensation and a 152.4mm focal length is carried in an airplane travelling at 280 km/h. if flying height above terrain is 3200 m and if the exposure time is $\frac{1}{250}$ s, what distance (in millimetres) must the film be moved across the focal plane during exposure in order to obtain a clear image?

Question 3

The images of the top and bottom of a utility pole are 113.6 mm and 108.7mm respectively, from the principal point of a vertical photograph. What is the height of the pole if the flying height above the base of the pole is 834m?
Assume that the random error in each measured photo distance is ±0.10 mm and that the error in the flying height is ±2.0m, what is the expected error in the computed height of the utility pole?

Question 4

a) What do you understand by the term Aerial Triangulation?

b) Describe the planimetric block adjustment by independent models

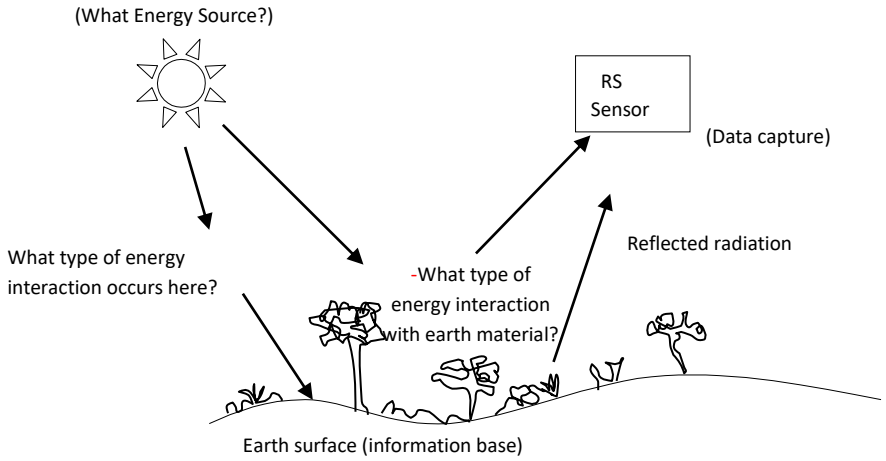
c) Formulate the observation equations for a tie point and for the control point using the plane similarity transformation

Question 5

Describe how the "flight line" axis system is created. What are the causes of y-parallax? Describe the principle of the floating mark.

Question 6

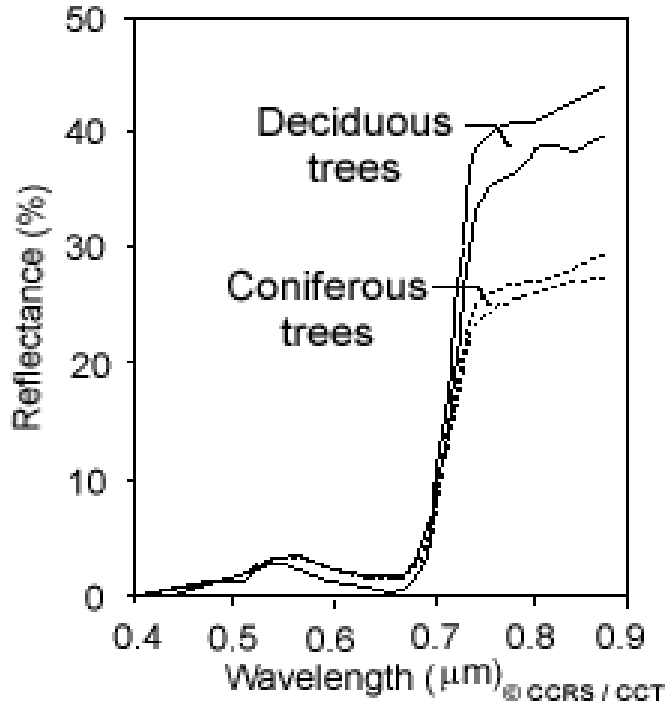
a) Explain what is meant by "Remote Sensing" and give two examples of it's application in Geomatic engineering? [5]
b) Explain the operation of the passive Remote Sensing system with the aid of the incomplete diagram below and the questioned posed thereon and then clearly draw and label the diagram. [10].



Question 7

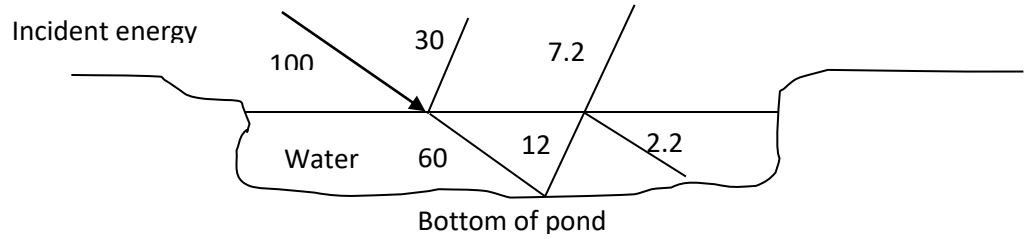
The figure of reflectance curves below shows the spectral response patterns of deciduous and coniferous trees.

a. What is the electromagnetic spectrum? [3]
b. Which range of the wavelength is the visible portion and the near-infrared (NIR) of the electromagnetic spectrum? [2]
c. State why it would be difficult to distinguish the two types of trees in the visible portion and easier in the NIR portion [3]



Question 8

a) Compute the total amount of energy reflected from the pond shown below if 30% of the energy incident on the water surface is reflected, 10% is absorbed, 60% is transmitted, and 20% of what hits the bottom of the pond is reflected. [3]



b) Remote Sensing systems can be broadly categorised as Active or Passive. Explain an Active Remote Sensing systems. [6]

c) Why do most of the environmental objects radiate some energy form? As such mention the energy propagation principal concerning all the environmental components. [4]

Question 9

a) 3,000 x 3,000 pixel image comprised of 3 spectral channels. Each pixel is 8-bits per channel. How many bytes of computing memory are required? If transfer rate over computer network is 100,000 bytes/s, how long will it take to transfer image?

b) Explain the theory that 'The object point and image point of a lens system are said to be conjugate points'.

c) Discuss three types of lens aberrations and further mention two types of geometrical lens distortions.

Question 10

a. A distance ab on a vertical photograph is 65.0 mm, and the corresponding ground distance AB is 1153 m. if the camera focal length is 153.19 mm, what is the flying height above the terrain upon which line AB is located?

b. From 9(a), assume that the values given for focal length, photo distance and ground length contain random errors of ± 0.005 mm, ±0.50 mm, and ±0.30 m respectively. What is the expected error in the computed flying height?

Question 11

a) Illustrate by using ray diagrams the formation of real and virtual images for convex and concave type of lenses
b) With the help of sketches, draw ray diagrams showing the following lens types:
    1. Double concave negative
    2. Plano concave negative
    3. Meniscus concave negative
    4. Double convex positive
    5. Plano convex positive
    6. Meniscus convex positive

Question 12

a) Mention three (3) most common bands of the electromagnetic spectrum used for remote sensing.
b) When electromagnetic radiation strikes matter, it interacts with it in possibly four main ways; Name the four (4) processes involved?
c) Three main types of scattering important to remote sensing are: Explain their effects.
    - Rayleigh scattering
    - Mia scattering
    - Nonselective scattering
d) Discuss and give examples of the terms:

    i) Active Remote and
    ii) Passive Remote sensor systems

Question 13

a) Define briefly, th**e** following photographic terms:
    - F-number
    - Nadir point
    - Principle distance
    - Flying height
    - Fiducial marks
    - Brightness factor

Question 14

The image coordinates of three points **A, B, C** and of the principal points **P** and **Q** on two overlapping vertical aerial photos were as follows

Point	Left photo		Right photo	
	x(mm)	y(mm)	x(mm)	y(mm)
P	0.0	0.0	-89.2	0.0
Q	+89.4	0.0	0.0	0.0
A	+12.8	+44.6	-76.6	+44.2
B	+16.4	+6.3	-72.8	+5.9
C	+20.2	-30.7	-69.6	-31.2

Given that the ground coordinates of A and C were 60,000mE, 72000mN and 61260mE, 71200m N respectively, estimate those of **B**.

Prepared by: Z.Zulu, Lecturer, Geomatic Eng Dept, Room F07, School of Engineering.

Sharon chigoon Chilombo

THE UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING

DEPARTMENT OF GEOMATIC ENGINEERING

2011 ACADEMIC YEAR SECOND SEMESTER

FINAL EXAMINATIONS

GE 212: INTRODUCTION TO GEOMATICS

TIME: THREE HOURS

INSTRUCTIONS:

1. **This examination is <u>Closed Book</u>**

2. **Calculators are permitted**

3. ANSWER: ALL Four (4) questions

4. **Show all the work leading to the solution**

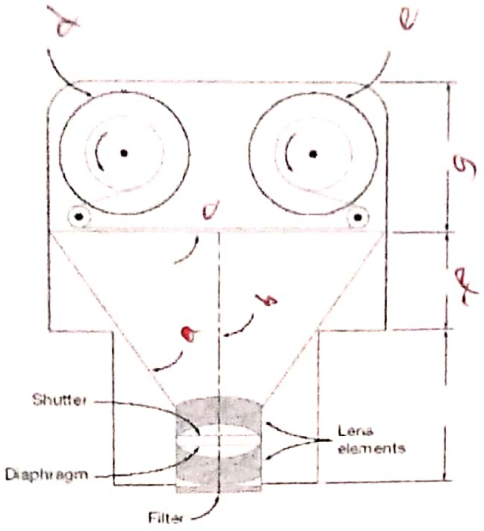
5. **Total marks for this examination paper is 100**

Question 1 (25 Marks) (Surveying)

SECTION A

Question One (15+10 marks)

a) Below is a diagram of a single lens frame camera.



i) Name the parts labelled a,b,c,d,e,f and g.
ii) What is the purpose of camera calibration?
iii) What are the three elements of interior orientation?

b) What is relative orientation of a photographic stereopair?
c) Mention and explain two methods of relative orientation. Indicate all the elements or parameters that are involved during the orientations.
d) Explain what is meant by space resection and space intersection.

Question Two (15+10 marks)

a) Define the following terms:
- Pallarax
- Principal Point
- Nadir
- Isocenter

b) Briefly, state the main difference between a vertical photograph and a tilted photograph.

c) The distance between two points, measured on a vertical photograph, is 5.21 cm. The distance between these same two points, measured on a 1:50000 scale map, was found to be 1.43 cm. The average ground elevation between the two points is 300 m above mean sea level. Find the flying height at which the photograph was taken if the focal length used is 152.4 mm.

Question Three (15+10 marks)

a) Given the following 3x3 rotation matrices around the x-axis, y-axis and z-axis, respectively, derive the rotation matrix R(ω,ϕ,κ) which converts the measured image coordinate system(camera coordinate system) x,y,-f to the camera system x'y'z' parallel to the reference system. Assume that ω,ϕ,κ are clockwise rotation angles around x,y,z, respectively.

$$R(\omega) = \begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos\omega & \sin\omega \\ 0 & -\sin\omega & \cos\omega \end{pmatrix}, \quad R(\phi) = \begin{pmatrix} \cos\phi & 0 & -\sin\phi \\ 0 & 1 & 0 \\ \sin\phi & 0 & \cos\phi \end{pmatrix}, \quad R(\kappa) = \begin{pmatrix} \cos\kappa & \sin\kappa & 0 \\ -\sin\kappa & \cos\kappa & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

Hint:

$$R(\omega, \phi, \kappa) = R(\kappa)R(\phi)R(\omega) = \begin{pmatrix} r_{11} & r_{12} & r_{13} \\ r_{21} & r_{22} & r_{23} \\ r_{31} & r_{32} & r_{33} \end{pmatrix}$$

b) Calculate the elements of the rotation matrix R, when ω= -0.0396 gon, ϕ=0.3070 gon and κ= -102.1708 gon.

SECTION B

Question Four (15+10 marks)

a) With the help of sketches, show how stereoscopic coverage is lost due to
   i) Tilt
   ii) Unequal flying heights
   iii) Terrain variations

b) Air base of a stereopair is 1400m and flying height above ground is 2400m. Camera has a 152.4 mm focal length and 23-cm format.
i) What is the percent endlap?
ii) Assuming spacing between adjacent lines is 2500m, what is the percent side lap?

Question Five (15+10 marks)

In an ideal optical system, all rays of light from a point in the object plane would converge to the same point in the image plane, forming a clear image. The influences which cause different rays to converge to different points are called aberrations.

a. Mention and briefly explain six types of aberrations. Support your answer with sketches of the aberration types.
b. Draw ray diagrams for a typical convex lens for a real and virtual image formation.

THE UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING

DEPARTMENT OF GEOMATIC ENGINEERING

2011 ACADEMIC YEAR SECOND SEMESTER
FINAL EXAMINATIONS

GE 332: PHOTOGRAMMETRY I

TIME: THREE HOURS

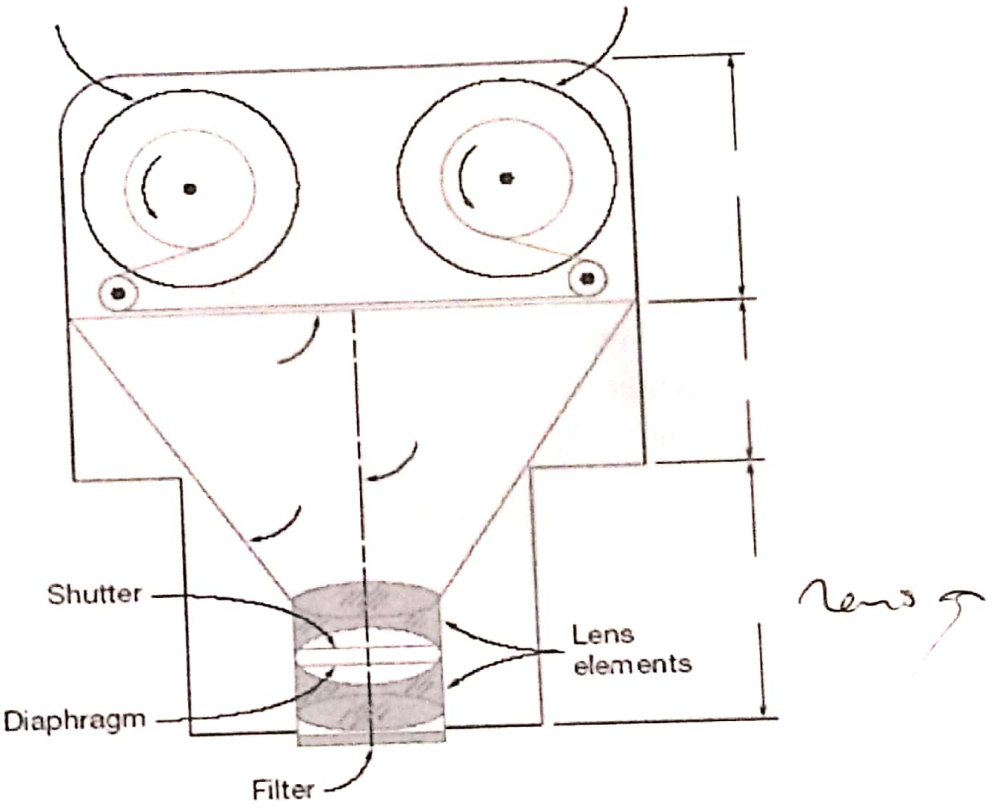
INSTRUCTIONS:

1. This examination is Closed Book
2. Calculators are permitted
3. ANSWER: ALL THREE (3) questions from Section A and ANY One question from Section B.
4. Show all the work leading to the solution
5. Total marks for this examination paper is 100

SECTION A

Question One (7+2+3+3+6+4 marks)

a) Below is a diagram of a single lens frame camera.



i) Name the parts labelled a,b,c,d,e,f and g.
ii) What is the purpose of camera calibration?
iii) What are the three elements of interior orientation?

b) What is relative orientation of a photographic stereopair?
c) Mention and explain two methods of relative orientation. Indicate all the elements or parameters that are involved during the orientations.
d) Explain what is meant by space resection and space intersection.

Question Two (16+4+5 marks)

a) Define the following terms:
- Pallarax
- Principal Point
- Nadir
- Isocenter

b) Briefly, state the main difference between a vertical photograph and a tilted photograph.

c) The distance between two points, measured on a vertical photograph, is 5.21 cm. The distance between these same two points, measured on a 1:50000 scale map, was found to be 1.43 cm. The average ground elevation between the two points is 300 m above mean sea level. Find the flying height at which the photograph was taken if the focal length used is 152.4 mm.

Question Three (15+10 marks)

a) Given the following 3x3 rotation matrices around the x-axis, y-axis and z-axis, respectively, derive the rotation matrix R(ω,ϕ,κ) which converts the measured image coordinate system(camera coordinate system) x,y,-f to the camera system x'y'z' parallel to the reference system. Assume that ω,ϕ,κ are clockwise rotation angles around x,y,z, respectively.

$$R(\omega) = \begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos\omega & \sin\omega \\ 0 & -\sin\omega & \cos\omega \end{pmatrix}, \quad R(\phi) = \begin{pmatrix} \cos\phi & 0 & -\sin\phi \\ 0 & 1 & 0 \\ \sin\phi & 0 & \cos\phi \end{pmatrix}, \quad R(\kappa) = \begin{pmatrix} \cos\kappa & \sin\kappa & 0 \\ -\sin\kappa & \cos\kappa & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

Hint:

$$R(\omega,\phi,\kappa) = R(\kappa)R(\phi)R(\omega) = \begin{pmatrix} r_{11} & r_{12} & r_{13} \\ r_{21} & r_{22} & r_{23} \\ r_{31} & r_{32} & r_{33} \end{pmatrix}$$

b) Calculate the elements of the rotation matrix R, when ω= -0.0396 gon, ϕ=0.3070 gon and κ= -102.1708 gon.

SECTION B

Question Four (5+5+5+5+5 marks)

a) With the help of sketches, show how stereoscopic coverage is lost due to :

i) Tilt
ii) Unequal flying heights
iii) Terrain variations

b) Air base of a stereopair is 1400m and flying height above ground is 2400m. Camera has a 152.4 mm focal length and 23-cm format.

i) What is the percent *endlap*?
ii) Assuming spacing between adjacent lines is 2500m, what is the percent *side lap*?

Question Five (3+18+4 marks)

In an *ideal* optical system, all rays of light from a point in the object plane would converge to the same point in the image plane, forming a clear image.

a) What term is used for the *influences* which cause different rays to converge to different points?

b) Mention and briefly explain **six (6)** types of the *influences* mentioned in (a). Support your answer with sketches of the aberration types.

c) Draw ray diagrams for a typical convex lens for a real and virtual image formation.

University of Zambia
University Examinations- July 2001
SE 332
Photogrammetry I

Time: Three (3) hours
Answer **ALL** questions from section A and only **ONE** from section B

.....

SECTION A

Question 1

a) Define the following photographic terms:
   - Scale of photograph
   - Photosensitivity
   - F-number
   - Dead area
   - Flying height

b) What are the main technical requirements for planning of aerial photographs?

c) Using a camera with 150 mm focal length and 230 square millimeters format and assuming that the average photobase is 69 mm, the distance between successive strips is 161 mm and photo scale 1: 30 000, calculate the following parameters;

   - End and side overlap of photographs
   - Size of overlapped area at photo scale and in terrain
   - Air base
   - Flying height

(10 + 5 + 10)

Question 2

a) Using a clearly labeled diagram, describe the functions of the main parts of an aerial camera.

b) Discuss the importance of camera calibration and indicate what information relating to the camera forms part of the calibration certificate.

c) What are the major steps involved in processing of black and white film?

(8 + 9 + 8)

Question 3

a) A shutter speed of 1/1000 is desired to obtain a sharp image at f/4.0, what f/number should be used to achieve the same result at a shutter speed of 1/500?

b) With the help of well-labeled diagrams, describe the five (5) major lens aberrations that affect image quality.

c) Explain the main differences between perspective and orthogonal projections.

(8 + 10 + 7)

SECTION B

Question 1

a) Explain the following terms;
- Stereoscopic depth perception
- Stereoscopic model
- Floating mark
- X- parallax

b) The length of line AB and the elevation of its endpoints, A and B, are to be determined from a stereopair containing images a and b. The camera used to take the photographs has a 154.4-mm lens. The flying height was 1200 m (average for two photos) and the air base was 600 m. The measured photographic coordinates of points A and B in the "flight line" coordinate system are x(a) = 54.61 mm, x(b) = 98.67 mm, y(a) = 50.80 mm, y(b) = -25.40 mm, x'(a) = -59.45 mm, and x'(b) = -27.39 mm. Find the length of line AB and the elevations of A and B.

(8 + 17)

Question 2

a) Name the seven basic characteristics of photographic images that are considered in photographic interpretation and give an example of how each may be used to identify a particular object.
b) Derive the parallax equation for determination of a point elevation from x-parallax measured on a pair of vertical photographs.
c) Show with figure and equation how an image point is displaced due to relief of terrain.
d) Compare the advantages and disadvantages of the pocket and mirror stereoscopes

(7 + 7 + 7 + 4)

University of Zambia
School of Engineering
Department of Surveying

May 2000 Examinations
SE 332 – Photogrammetry I

Answer ALL questions from section A and ONLY 3 from Section B
Time Allowed: 3 Hrs

SECTION A

Question 1 (20)

(a) Define the following terms and give their use in photogrammetric applications;
1. Intervalometer
2. Electromagnetic spectrum
3. Spectral signature
4. Diapositive
5. Photographic material

(b) Given a photogrammetric project covering a rectangular area measuring 50 x 35 Km and that the client desires a mapping scale of 1:5000 by means of a stereoplotter with photo/model ratio of 1:1, calculate the flying height of the aircraft above datum and above ground if the terrain is flat at an altitude of 1260m using a 15/23 camera.

Question 2 (20)

(a) What is meant by the term camera calibration? Give any one detailed method used for calibration in a laboratory environment.
(b) Give at least five of the interior orientation parameters determined during the camera calibration process?

SECTION B

Question 1 (20)

(a) What are the major systematic errors that are corrected during refinement of coordinates?
(b) Derive from first principles the formula for calculating the distortions due to relief displacement of vertical photographs

Question 2 (20)

A project area is 16Km in East-West and 10.4 Km in North-South. The project area is to be mapped by photogrammetric techniques at a scale of 1:12000. The end and side lap for the project is 60% and 30% respectively using a 15/23 camera. Calculate the following parameters.

(a) Dimensions of the square ground coverage
(b) Distance between two successive strip
(c) Number of flight lines
(d) The air base
(e) Total number of photos required to cover the project area

Question 3 (20)

(a) Using a well-labelled diagram, explain what is meant by optical and differential rectification? Give examples in which the two methods are applied.
(b) In making photo controls, artificial targets are used in practice. However, such targets have disadvantages when used. Clearly describe the two main disadvantages
(c) Give the three main methods used in the establishment of ground control points in photogrammetric mapping.

Question 4 (20)

(a) Describe the five main ways in which electromagnetic radiation is propagated during interaction with earth objects.
(b) Name the seven main direct and indirect characteristics used in photo interpretation
(c) Give the main advantages of colour infrared photographs. State the applications where CIR photographs are highly suitable compared to Black and White photographs.

End of exam
Good Luck!!!!!!!

Question 4 (25 marks)

a) Explain the main principle behind laser mapping systems. What is the basic sensor hardware for laser mapping systems?

b) An airplane carrying an airborne laser scanning (ALS) system emits a laser pulse with a pointing angle of $\alpha=5.000^{\circ}$ that takes 0.0051110 millisecond to reach an object on the ground and return to the sensor. At the same time, an onboard GPS-INS system measures the position of the laser coordinates as X=100.00m, Y=100.00m, Z=1000.00m, and the orientation as $\omega=\phi=\kappa=0$. What is the location of the object on the ground?

c) The rotation matrix R (ω,ϕ,κ) rotates the coordinate system of a tilted photograph to the coordinate system parallel to the reference ground system.

Determine the rotation angles (ω,ϕ,κ) if R has the following form:

$$R = \begin{pmatrix} 0.999910 & 0.013319 & 0.001635 \\ -0.013351 & 0.999671 & 0.021907 \\ -0.001343 & -0.021927 & 0.999759 \end{pmatrix}$$

(Formulas: $\sin\varphi = r13$, $\tan\kappa = -r12/r11$, $\tan\omega = -r23/r33$)

Question 5 (25 marks)

A project area is 16 km long in the east-west direction and 10.5 km wide in the north-south direction. It is to be covered with vertical aerial photography having scale of 1:12,000. A camera having a 152.4-mm-focal-length lens and a 230-mm square format is to be used. The nominal end lap and side lap are to be 60 and 30 percent, respectively. Beginning and ending flight lines are to be positioned along the boundaries of the study area. The only base map available for the area is at a scale of 1: 24,000. This map indicates that the average terrain elevation is 300 m above datum.

Compute the following data for the flight crew:

i. Flying height above mean sea level

ii. Ground coverage per image

iii. Distance between two successive axes of the strips.

iv. Number of flight lines required

v. Total number of photos needed

vi. Spacing of flight lines on the map

End of Examination

GROUP 3

What is Photogrammetry?

Photogrammetry is the science and technology of obtaining spatial measurements and other geometrically reliable derived products from photographs.

Explain the main differences between perspective and orthogonal projections.

Perspective projection is obtained by projecting an object to a projection plane with a bundle of rays from projection center located in finite distance from the projection plane, Angular relations between object features and image features are not the same.

Orthogonal projection is the parallel projection of an object to the chosen plane (map)

Name three (3) instruments used to measure image coordinates and briefly outline the measurement process involved.

i. Monocomparator- each photo is measured separately

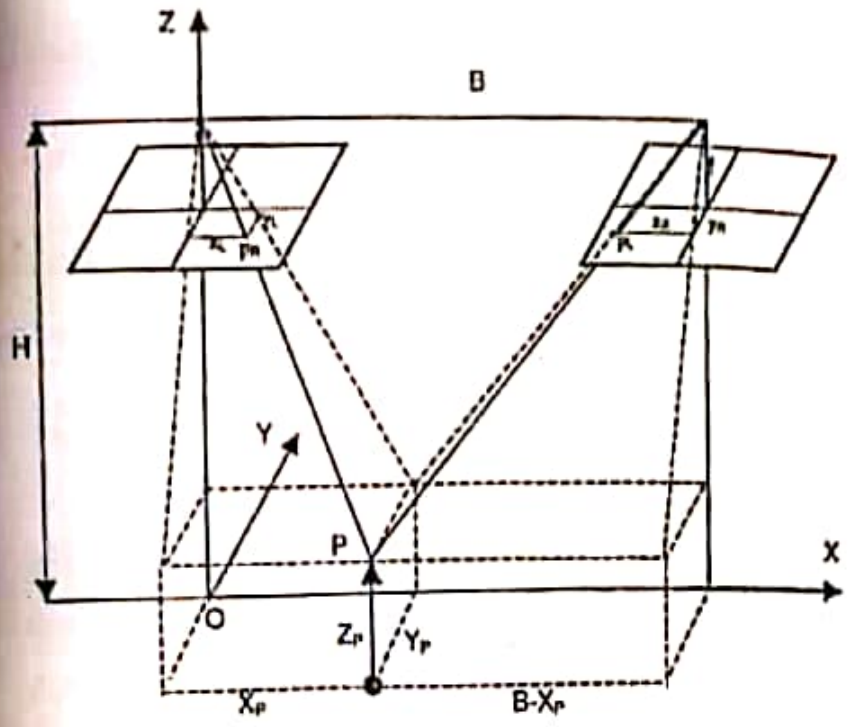
ii. Stereocomparator- simultaneous identification and measurement of image points on two photographs

iii. Analytical plotter- projective relations between each model point and corresponding image points are implemented analytically

GROUP 4

Explain the term depth of perception with respect to stereoscopic viewing.

Stereoscopic depth perception is a function of the parallactic angles. Parallactic angle is the angle of intersection of optical axes that converge on a certain point.



(14+6) marks

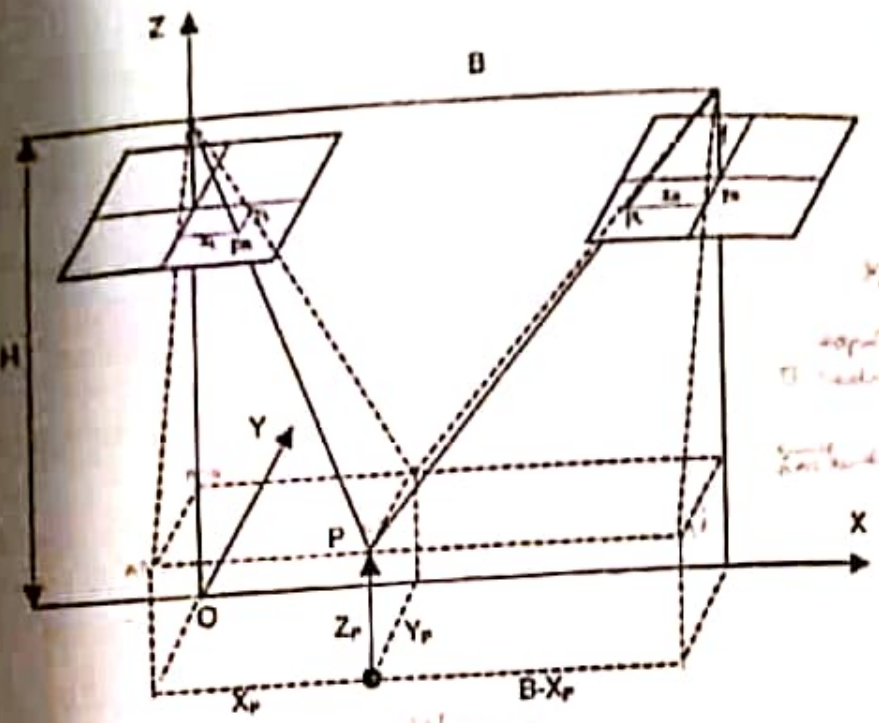
Question 6

The image coordinates of three points **A, B, C** and of the principal points **P** and **Q** on two overlapping vertical aerial photos were as follows

Point	Left photo		Right photo	
	x(mm)	y(mm)	x(mm)	y(mm)
P	0.0	0.0	-89.2	0.0
Q	+89.4	0.0	0.0	0.0
A	+12.8	+44.6	-76.6	+44.2
B	+16.4	+6.3	-72.8	+5.9
C	+20.2	-30.7	-69.6	-31.2

Given that the ground coordinates of A and C were 60,000mE, 72000mN and 61260mE, 71200m N respectively, estimate those of **B**.

(20) marks



a) Given that the elevation of point C is 200m above MSL and that the parallax reading for the same point is 11.89mm and that of point A is 10.96mm, the parallax constant is 80.71mm. Calculate the parallax difference between the two points and the elevation of point A if the flying height for a pair of photos is 1000m.

b) A mapping project is designed to use aerial photography at a scale of 1:10000 for a preliminary design of a development project covering an area of 20 x 15km. If a 15/23 camera is used with end and side overlaps of 60% and 30% respectively, calculate the following parameters if a flight plan along the longer side of the project boundary is to be prepared at a map scale of 1:20,000;

i. total number of flight lines

ii. total number of photographs to cover the project area

iii. total number of models

Atmospheric scattering occurs when the particals or gaseous molecules present in the atmosphere interact with the electromagnetic radiation and cause it to be redirected from its original path. Mention three types of scattering that take place and give one example for each.

(Rayleigh scattering- blue wavelengths scattered 5 times as often as red. Creates blue sky . Mie scattering smoke, dust, volcanic material and salt crystals scatter longer radiation wavelengths and Non-selective scattering- suspended aerosols (with diameters at least 10x larger than wavelengths) including all Mia particles and water droplets and ice crystals, scatter longer radiation wavelengths

State whether true or false:

Active Remote – detect only reflected sunlight or thermal IR and microwaves (False)

Passive Remote – beam own artificially produced energy to a target and record reflected component (False)

The entire range of EMR comprises the electromagnetic spectrum subdivided in divisions called wavelengths that share common characteristics. (False – Ans. Spectral Bands)

Three forms of energy transfer include: absorption, reflection and transmittance (False. Ans- conduction, convection and radiation)

The Sun is the minor **supplier of EM energy incident on the Earth – providing energy needed for terrestrial life and the natural processes operating in the atmosphere, water and upper layers of solid Earth.** (false)

EMR travels in a straight path at the speed of light – postulated by Albert Einstein in 1905 as ~ 300,000,000 km/sec (false. Ans. 300,000km/sec)

SECTION A

Question 1

a) Define briefly, the following photographic terms:

- F-number
- Nadir point
- Principle distance
- Flying height
- Fiducial marks
- Brightness factor

b) The image distance for a photograph of an object, which is located 4.5 meters from the camera, is 76.5mm. What image distance is required for perfect focus if the object is in infinity?

c) An aerial camera makes an exposure at a shutter speed of 1/1,000 sec. If the aircraft speed is 500 miles per hour, how far will the aircraft travel during the exposure?

(12+4+4) marks

Question 2

a. Name the instrument usually employed to measure the position of a point in a photograph.

b. Define the x- and y-parallaxes.

c. What are the systematic errors contained in the measured photo-coordinates that disturb the ideal linear relation between the perspective center, the image point and the ground point?

(2+4+14) marks

Question 3

a) What is meant by a vertical photograph?

b) What are the effects of tilt and relief displacement on a photo?

c) A vertical photograph captured at a flight height of 2000' above sea level shows a radio tower with a base elevation 540' above the same datum. The image of the tower has a relief displacement of 1.33". The distance from the photograph' s principal point to the top of the tower is 5.97". What is the height of the tower?

(4+8+8) marks

Question 4

a) Describe the meaning of photosensitivity and spectral sensitivity of photographic material.

b) What are the relationships between?

- F-number and shutter speed
- Film speed and emulsion grain size
- Resolution and emulsion grain size

c) Mention and explain one of the methods of camera calibration.

(4+6+10) marks

SECTION B

Question 5

The figure below shows an overlapping pair of truly vertical aerial photographs taken at equal flying height H above mean sea level (MSL) and having equal focal lenths f. The corresponding images of the ground point P are P_L on the left photo and P_R on the right photograph, respectively. The ground coordinate system XYZ has its origin at the MSL level location O of the left photo camera exposure station, i.e. the **X** and **Y** axes are parallel to the x and y axes of the photo system.

a) Derive the basic parallax equations for the ground coordinates of point P based on the illustrated geometry of the overlapping truly vertical photos.

b) Compute the ground coordinates $\mathbf{X_p Y_p Z_p}$ of point **P** using the previously derived parallax equations for the photo stereo pair, whose
focal length **f**=152mm, the air base **B**=1815m and the flying height **H**=3000m;
and the photo-coordinates of point **P** are:
for the left photo: x_L = +80.00mm y_L = -50.00mm, and
for the right photo: x_R = -20.00mm, y_R = -50.00

SECTION A

Question 1 (25 marks)

a) A vertical aerial photograph was taken with a 152.4-mm-focal-length camera from a flying height of 1385 m above datum. Images *a* and *b* of two ground points A and B appear on the photograph, and their measured photo coordinates are x_a = -52.35 mm, y_a = 48.27 mm, x_b = 40.64 mm and y_b = 43.88 mm. Determine the horizontal length of line AB if elevations of points A and B are 204 and 148 m above datum, respectively.

b) A distance *ab* on a vertical photograph is 65.0 mm, and the corresponding ground distance *AB* is 1150 m. If the camera focal length is 152.4 mm, what is the flying height above the terrain upon which line *AB* is located?

Assume that the values given for focal length, photo distance and ground length contain random errors of ± 0.005 mm, ±0.50 mm, and ±0.30 m respectively. What is the expected error in the computed flying height?

Question 2 (25 marks)

a) Discuss and give examples of the terms:

i) Active Remote and
ii) Passive Remote sensor systems

b) Mention three (3) most common bands of the electromagnetic spectrum used for remote sensing.

c) When electromagnetic radiation strikes matter, it interacts with it in possibly four main ways; Name the four (4) processes involved?

d) Three main types of scattering important to remote sensing are: Explain their effects.
- Rayleigh scattering
- Mia scattering
- Nonselective scattering

Question 3 (25 marks)

a) Spatial and non-spatial data are the two types of data to be entered in a GIS. Give a brief description of Spatial and non-spatial data?

b) Briefly describe what the terms digitizing and scanning mean in GIS data entry?

c) What are the two main types of data formats used in GIS?

d) Give three (3) advantages and disadvantages of Vector Data?

e) What does the term "Georeferencing" mean?

2. a) Describe two different conditions that are commonly enforced in analytical photogrammetry.

b) Distinguish between **Space Resection by** collinearity and **Space Intersection by** collinearity.

c) Aerial photography is to be taken from a flying height of 1830 m above average ground with a camera having a 152.4-mm focal length and a 23cm format. End lap will be 60 percent, and side lap will be 30 percent. What is the ground area covered by a single photograph and by the stereoscopic neat model?

(6+8+11 marks)

3. a) Mention Three (3) basic sensor hardware for laser mapping systems.

b) A laser mounted on an airplane emits a pulse that reflects off a target and returns to the sensor in 0.0066000 millisecond. Assume that the pulse is aimed directly down to the datum surface, that the speed of light is 299,792,458 m/s, and that the laser is at exactly 1 km above the datum. What is the object's height above datum?

c) Evaluate the contrasts between airborne laser scanning and (stereo-) photogrammetry from an application perspective.

(6+7+12 marks)

SECTION B

4. a) Briefly, explain what is meant by aerial triangulation.

b) Outline at least three (3) advantages of control extension by aerial triangulation

c) Mention at least five (5) sources of errors that are normally taken into account in aerial triangulation

d) Why is the similarity (conformal) transformation used in the Block adjustment by independent models?

(6+9+5+5 marks)

5. a) The relationship of between density and exposure of a photographic emulsion can be described by the characteristic curve called *D-log(H)* curve. With the help of a sketch diagram, explain the main components of the curve.

b) State the difference between contact printing and projection printing

c) Explain the five steps involved in processing black and white emulsion.

(10+6+9 marks)

STOP: GO BACK AND CHECK YOUR WORK!

The University of Zambia

School of Engineering

Department of Geomatic Engineering

2018/2019 Academic Year

Second-Half Year Final Examinations

GEE 3622: Principles of Data Acquisition and Processing

Time: Three (3) Hours

Instructions

1. This Examination is **Closed Book**
2. Calculators are permitted
3. Time allowed is **Three (3) Hours**
4. **Answer ALL QUESTIONS FROM SECTION (A) AND ONE FROM SECTION (B)**
5. Show all the work leading to the solution
6. Total marks for this Examination paper is 100

Please! Do Not Turn This Page Until Instructed By The Invigilator

Section B

Question Four

a) White light is made up of all the components of colour.

(i) Within what wavelength range does a human eye detect colour and what is this range called?

(ii) List and explain the three (3) visual variables of colour. - colour hue - colour value - colour saturation

(iii) Draw and explain the additive colour mixture on a colour model used for computer display.

b) The role of a picture in computer graphics is described as:

(i) An end in itself and

(ii) A means to an end

Explain these two (2) concepts clearly giving appropriate examples.

c) Map projections are used to transform the curved surface of the Earth onto a flat plane of the map.

(i) Give and fully explain one (1) characteristic of map projections.

(ii) Give and fully explain one (1) property of map projections.

(iii) On which four (4) things is the selection of a map projection based?

distance direction angles shape size scale

cylindrical - Angles plane conic

[2 + 6 + 5 + 2 + 2 + 2 + 2 + 4] Marks

Question Five

Data visualisation is some form of visual communication that involves creation and ... its main goal is to communicate information

The University of Zambia
School of Engineering
Department of Geomatic Engineering
2015/6 ACADEMIC YEAR
MID-TERM TEST - JULY 2016

COURSE NAME: **PRINCIPLES OF DATA ACQUISITION AND PROCESSING**
COURSE CODE: GEE 3622
TIME: TWO (2) HOURS
TOTAL MARKS: 100
INSTRUCTIONS

1. **Answer: ALL THREE (3) QUESTIONS from SECTION A and ONE QUESTION from SECTION B**
2. This TEST is Closed Book
3. Calculators are permitted
4. Show all the work leading to the solution

SECTION A

1. a) Explain the following terms:

   i. **Depth of field of a lens**

   ii. **Illuminance of any photographic exposure**

   iii. **Panchromatic emulsion**

   iv. **Crab angle**

   v. **Y-Pallax**

b) A vertical aerial photograph was taken with a 152.4-mm-focal-length camera from a flying height of 1385 m above datum. Images *a* and *b* of two ground points A and B appear on the photograph, and their measured photo coordinates (corrected for shrinkage and distortions) are x_a=-52.35 mm, y_a=-48.27 mm, x_b=40.64 mm, and y_b=43.88 mm. Determine the horizontal length of line AB if the elevations of points A and B are 204 and 148 m above datum, respectively.

(2+2+2+2+2+15 marks)

Electromagnetic Radiation (EMR) is light energy detected when it comes into contact with an object (False. Ans EM)

The visible portion of the EM Spectrum ranges from 4 · m to 7 · m (False. Ans. 0.4 · m to 0.7 · m)

The most common bands of the EM spectrum used for remote sensing are cosmic, gamma and x-rays. (false. Ans. ultraviolet (UV), visible, infrared (IR) and microwave.

Remote sensing depends upon operation in wavelength regions of spectrum where spectral signatures occur for identification purposes. (true)

GROUP 2

$H_A = H - \frac{Bf}{p_a}$

The figure below shows an overlapping pair of truly vertical aerial photographs taken at equal flying height H above mean sea level (MSL) and having equal focal lenths f. The corresponding images of the ground point P are P_L on the left photo and P_R on the right photograph, respectively. The ground coordinate system XYZ has its origin at the MSL level location O of the left photo camera exposure station, i.e. the **X** and **Y** axes are parallel to the x and y axes of the photo system.

a) Derive the basic parallax equations for the ground coordinates of point P based on the illustrated geometry of the overlapping truly vertical photos.

b) Compute the ground coordinates $X_pY_pZ_p$ of point **P** using the previously derived parallax equations for the photo stereo pair, whose

focal length f=152mm, the air base B=1815m and the flying height H=3000m;

and the photo-coordinates of point **P** are:

for the left photo: x_L = +80.00mm y_L = -50.00mm, and

for the right photo: x_R = -20.00mm, y_R = -50.00

left − right

$p_a = x_a - x'_a$

$p_a = 100$

$H_A = H - \frac{Bf}{p_a}$

$X_p = B \frac{x_a}{p_a}$

$= 1815 \left(\frac{80.00}{100}\right)$

... Two (10+4+5 marks)

... the following terms:

Collinearity
Principal Point
Nadir
Isocenter

...efly, state the main difference between a vertical photograph and a tilted photograph.

...e distance between two points, measured on a vertical photograph, is 8.21 cm. The distance between these same two points, measured on a 1:5000 map, was found to be 1.43 cm. The average ground elevation between the two points is 300 m above mean sea level. Find the flying height at which the photograph was taken if the focal length used is 152.4 mm.

...stion Three (15+10 marks)

a) Given the following 3x3 rotation matrices around the x-axis, y-axis and z-axis, respectively, derive the rotation matrix $R(\omega,\phi,\kappa)$ which converts the measured image coordinate system(camera coordinate system) x,y,-f to the camera system x'y'z' parallel to the reference system. Assume that ω,ϕ,κ are clockwise rotation angles around x,y,z, respectively.

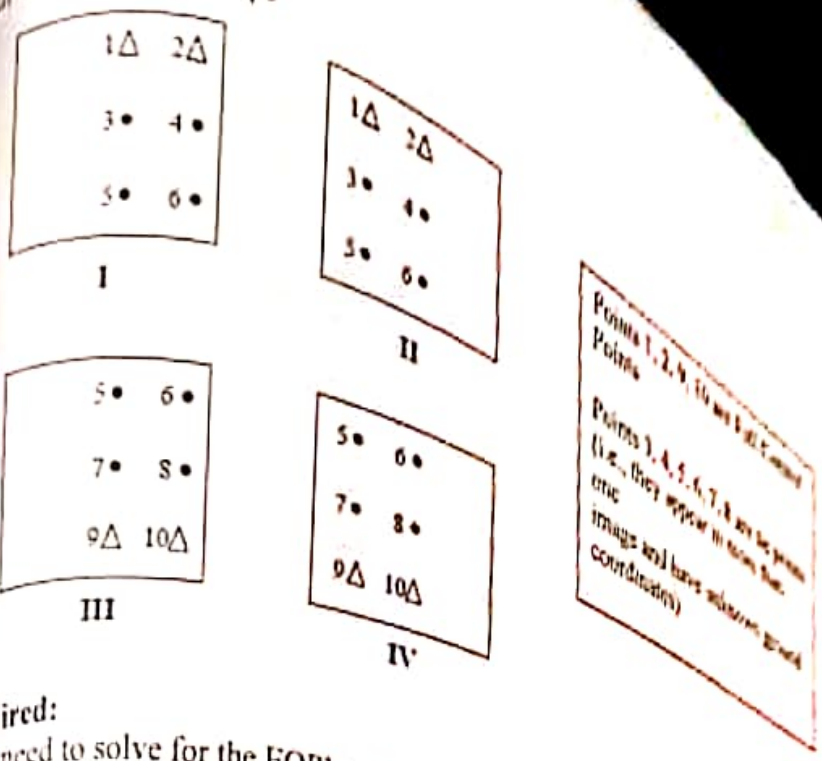
$$R(\omega) = \begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos\omega & \sin\omega \\ 0 & -\sin\omega & \cos\omega \end{pmatrix}, \quad R(\phi) = \begin{pmatrix} \cos\phi & 0 & -\sin\phi \\ 0 & 1 & 0 \\ \sin\phi & 0 & \cos\phi \end{pmatrix}, \quad R(\kappa) = \begin{pmatrix} \cos\kappa & \sin\kappa & 0 \\ -\sin\kappa & \cos\kappa & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

Hint:

$$R(\omega,\phi,\kappa) = R(\kappa)R(\phi)R(\omega) = \begin{pmatrix} r_{11} & r_{12} & r_{13} \\ r_{21} & r_{22} & r_{23} \\ r_{31} & r_{32} & r_{33} \end{pmatrix}$$

b) Calculate the elements of the rotation matrix R, when ω= -0.0396 gon, ϕ=0.3070 gon and κ= -102.1708 gon.

Given:
Four images in two strips



Required:
If we need to solve for the EOP's of the four images and the ground coordinates of the points assuming known/errorless IOP's and ground coordinates of control points, analyze the observations-parameters and show the structure of each component of the Gauss-Markov model required to perform a least squares adjustment procedure;

$y = A\xi + e.$

Determine the following:

Observation-parameters analysis:
a) The observations

The measured image coordinates of points 1,2,3,4,5,6 on image I ? 6×2 = 12
The measured image coordinates of points 1,2,3,4,5,6 on image II ? 6×2 = 12
The measured image coordinates of points 5,6,7,8,9,10 on image III ? 6×2 = 12
The measured image coordinates of points 5,6,7,8,9,10 on image III? 6×2 = 12
Total n = 48

b) The parameters/unknowns

Known interior orientation parameters for the camera: xp, yp, c — 0 (errorless)
Exterior orientation parameters: Xo, Yo, Zo, ω, φ, κ for images I,II,III,IV — 4×6 = 24
The ground coordinates of the control points 1,2,9,10 — 0 (errorless)
The ground coordinates of the tie points 3,4,5,6,7,8 — 6×3 = 18
Total m = 42

n – m = 48 − 42 = 6

c) Redundancy

Due to this redundancy, the unknown parameters are determined through a least squares adjustment procedure.

(3+3+3+3+2+3+3+2+3) marks

The University of Zambia
School of Engineering
Department of Geomatic Engineering
2015/6 ACADEMIC YEAR
MID-TERM TEST - JULY 2016

COURSE NAME: PRINCIPLES OF DATA ACQUISITION AND PROCESSING
COURSE CODE: GEE 3622
TIME: TWO (2) HOURS
TOTAL MARKS: 100
INSTRUCTIONS

1. **Answer: ALL THREE (3) QUESTIONS from SECTION A and ONE QUESTION from SECTION B**
2. **This TEST is Closed Book**
3. **Calculators are permitted**
4. **Show all the work leading to the solution**

SECTION A

1. a) **Explain the following terms:**

   i. **Depth of field of a lens**

   ii. **Illuminance of any photographic exposure**

   iii. **Panchromatic emulsion**

   iv. **Crab angle**

   v. **Y-Pallax**

b) **A vertical aerial photograph was taken with a 152.4-mm-focal-length camera from a flying height of 1385 m above datum. Images *a* and *b* of two ground points A and B appear on the photograph, and their measured photo coordinates (corrected for shrinkage and distortions) are x_a=-52.35 mm, y_a=-48.27 mm, x_b=40.64 mm, and y_b=43.88 mm. Determine the horizontal length of line AB if the elevations of points A and B are 204 and 148 m above datum, respectively.**

(2+2+2+2+2+15 marks)

UNIVERSITY OF ZAMBIA

MID-SECOND SEMESTER TEST
MARCH 2012
GE 332
Photogrammetry I

Instructions:
Time: THREE (2) hours
Answer **ALL** questions from section A and **ONE** from section B

SECTION A

Question ONE(1)

a) Define briefly, the following photographic terms:
- Aperture - lens opening
- F-number - the ratio of the focal length to the diameter of the lens opening
- Illuminance - the amount of light received per unit area on an image plane surface during exposure
- Nadir point -
- Principle distance -
- Flying height - altitude of the camera
- Over lap - adjacent flight strips overlap

b) An aerial camera makes an exposure at a shutter speed of 1/1,000 sec. If the aircraft speed is 500 miles per hour, how far will the aircraft travel during the exposure?

c) What are the causes of radial lens distortion? List two of its characteristics. Use sketches to illustrate your answer
Radial lens distortion is caused from faulty grinding of the lens.
d) What are the relationships between?
- F-number and shutter speed
- Film speed and emulsion grain size
- Resolution and emulsion grain size

(6+7+6+6) marks

QUESTION 2

a) What is meant by exterior orientation? What parameters are involved?

b) What are the alternative methodologies for determining the exterior orientation parameters of an imaging system?

c) What is the difference between establishing the exterior orientation and the relative orientation for a stereo-pair?

d) What is the difference between relative and absolute orientation of a stereopair? What parameters are involved in these orientation procedures?

e) Can you use relative orientation to reconstruct the real object space? Why?

f) Do we need ground control points to establish the relative orientation of a stereopair? Why?

g) Do we need ground control points to establish the absolute orientation of a photogrammetric model? Why?

(4+4+4+4+3+2+4 marks)

QUESTION 3

The image-to-ground coordinate relationship is established through the collinearity model and is represented by the collinearity equations:

$$x = x_p - c\frac{r_{11}\cdot(X-X_o)+r_{21}\cdot(Y-Y_o)+r_{31}\cdot(Z-Z_o)}{r_{13}\cdot(X-X_o)+r_{23}\cdot(Y-Y_o)+r_{33}\cdot(Z-Z_o)}$$

$$y = y_p - c\frac{r_{12}\cdot(X-X_o)+r_{22}\cdot(Y-Y_o)+r_{32}\cdot(Z-Z_o)}{r_{13}\cdot(X-X_o)+r_{23}\cdot(Y-Y_o)+r_{33}\cdot(Z-Z_o)}$$

The above equations involve the following quantities:

- The measured image point coordinates: x, y
- Interior orientation parameters of the camera: xp, yp, c
- Exterior orientation parameters of the image under consideration: $Xo, Yo, Zo, \omega, \varphi, \kappa$ where ω, φ, κ are embedded in the rotation matrix components:

r11 = cos φ cos κ	r12 = -cos φ sin κ	r13 = sin φ
r21 = cos ω sin κ + sin ω sin φ cos κ	r22 = cos ω cos κ - sin ω sin φ sin κ	r23 = -sin ω cos φ
r31 = sin ω sin κ - cos ω sin φ cos κ	r32 = sin ω cos κ + cos ω sin φ sin κ	r33 = cos ω cos φ

- The ground coordinates of point: X, Y, Z.

SECTION B

Question FOUR (4)

a) Discuss briefly,

i. The principle difference between a 'map' and a 'photo'

ii. Virtual and Real Image formation

b) What is meant by exterior orientation? What parameters are involved?

c) An aerial camera with IMC (Image Motion Compensation) is used to acquire photography at a flying height of 5200 m above ground. The focal length is 153.15 mm. The aircraft is flying at 325 km/hr and an exposure time of 1/250 second is used. How far across the focal plane must film travel during the exposure in order to obtain an image with no image motion blurring?

(10+8+7) marks

Question FIVE (5)

a) Describe the meaning of photosensitivity and spectral sensitivity of photographic material.

b) What is a diapositive and give one example?

c) Define the following photographic terms:

- Nodal points
- focal points
- focal length **Focal length is defined as the distance from the focal plane to the center of the lens when focused at infinity (figure 6.4).**

II. Engineering

III. Automotive, machines and shipbuilding industries

IV. Medicine and Physiology

V. Forensic including Police work

GROUP 5

a) In analytical photogrammetry, we often deal with matrix rotations in a plane for image points that must satisfy the orthogonality conditions. Given the following transformation:

$$\begin{pmatrix} X \\ Y \end{pmatrix} = \begin{pmatrix} 0.36 & 0.69 \\ 0.19 & 0.27 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix}$$

With the help of unit vectors

$$\mathrm{I} = \begin{pmatrix} \cos\alpha \\ \sin\alpha \end{pmatrix}, \qquad \mathrm{J} = \begin{pmatrix} -\sin\alpha \\ \cos\alpha \end{pmatrix}$$

State three (3) orthogonality conditions that must be satisfied for an orthogonal matrix and prove that the above transformation does not represent a rotation.

The figure below shows four models (1-4) which are observed

Independently

Question TWO (2)

a) What is meant by a vertical photograph? What is meant by a nearly vertical photography?

b) A vertical photograph captured at a flight height of 2000' above sea level shows a radio tower with a base elevation 540' above the same datum. The image of the tower has a relief displacement of 1.33". The distance from the photograph's principal point to the top of the tower is 5.97". What is the height of the tower?

c) Mention and explain one of the methods of camera calibration.

d) The line lies on fairly level terrain. Find the approximate flying height above terrain if the camera focal length = 90mm and the section line ab = 100mm (on photo) and on terrain AB = 1000m.

(7+5+8+5) marks

Question THREE (3)

(a) Discuss the darkroom procedure for black and white emulsion. Explain when and why a 'safe' light can be used in a darkroom

(b) Discuss the characteristic curve H and D, or D-log- E curve.

(c) Define the following terms:

- Filter
- Density
- Contrast
- Resolution

(d) Explain briefly,

- 'Depth of field'
- What are the effects of tilt and relief displacement on a photo?

(7+5+8+5) marks

Briefly, define the adjustment involved in these models?

The models are:

displaced (two translations, Xu,Yu)

rotated (rotation angle, k) and

scaled (scale factor,m)

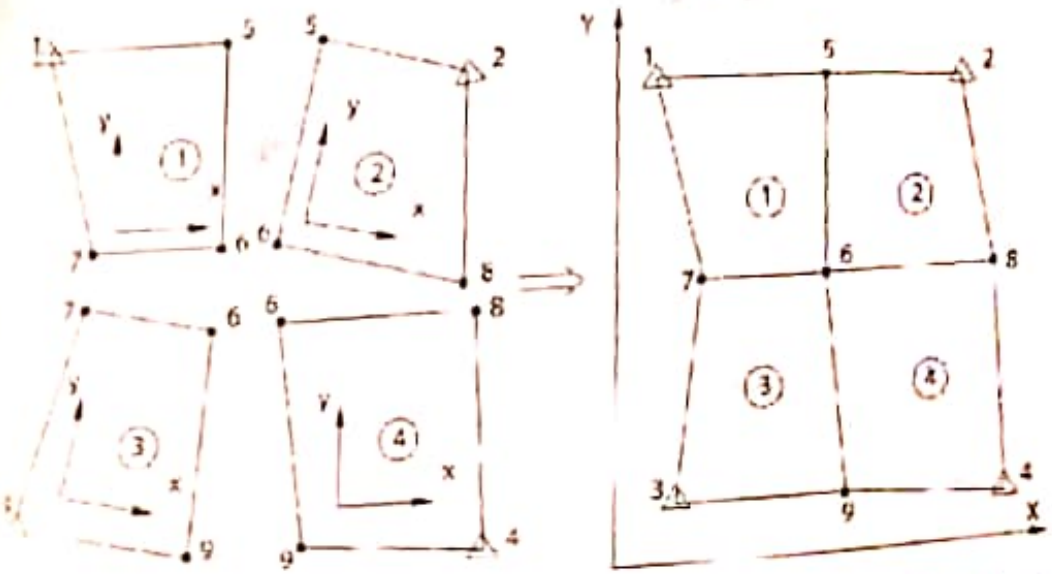
So that:

the tie points fit together as well as possible and

the residual discrepancies at the control points are as small as possible.

Why is the similarity (conformal) transformation used in the Block adjustment by independent models?

- The scale, position and orientation of the models may be changed but not its shape



SECTION A

Question 1

a) Provide the definition of space resection
i. How many and which are the unknown parameters for space resection
ii. What mathematical expression is used to determine the unknown parameters of the space resection
iii. What is required to be known to solve for the unknown parameters?

b) A project area is 16 km wide in east-west direction and 10.4 km long in north-south direction. It is to be covered with photos in scale 1:12000. The nominal end-lap and side-lap are to be 60% and 30%, respectively. A camera having a 152.4-mm focal length lens and a 230-mm square format is to be used.

Compute

i. Ground coverage
ii. The distance between two successive axes of the strips.
iii. Base in the strip
iv. Number of photos per strip (assuming two extra photos at each end of the strip to ensure coverage)
v. The intervalometer setting necessary to obtain the desired end-lap, assuming the aircraft flies at a velocity of 192km/h.

[13+10] marks

Question 2

a) Provide the definition of collinearity condition and give its mathematical expression. Explain the terms used in the mathematical expression

b) The figure below shows the angular field of view of a camera. Calculate the angular field of view for a nominal 152-mm focal-length camera with a 23cm square format. State whether this is a wide angle, normal angle or super-wide angle type of a single-lens frame camera.

Focal Plane

α=Angular field of View

Rear Nodal point of lens

$$\alpha = 2\tan^{-1}\left(\frac{d}{2f}\right)$$

UNIVERSITY OF ZAMBIA

SECOND SEMESTER EXAMINATIONS - MAY 2011

GE 332 - PHOTOGRAMMETRY I

Instructions:

Time: THREE (3) hours

Answer ALL questions from section A and ONE from section B

Chilombo Chipeta Steven

SECTION A

QUESTION 1

(a) Define the following photographic terms:

- Aperture
- F-number
- Illuminance
- Front nodal and Rear Nodal Points of an aerial camera
- Isocenter
- Principle point
- Ground nodal point
- Swing and Tilt angle

(b) What are the relationships between?

- F-number and shutter speed
- Film speed and emulsion grain size
- Resolution and emulsion grain size

(c) What are the causes and characteristics of radial lens distortions? Use a representative sketch to explain two different types of radial lens distortion.

(8+9+8) marks

i. A pair of overlapping vertical photographs was taken from a flying height of 1,231 m above ... with a 154.4-mm-focal-length camera. The air base was 330 m. With the photos ... oriented, parallax bar readings of 12.57 mm and 13.04 mm were obtained with the ... set on the principle points O_1 and O_2, respectively. On the left photo b was measured as 93.73 mm and on the right photo b' was measured as 93.30 mm. Parallax bar ... of 10.96 mm and 15.27 mm were taken on points A and B. Also, the x and y photo ... of points A and B measured with respect to the flight axes on the left photo ... 53.41 mm, y_a = 50.84 mm, x_b=88.92mm, and y_b = -46.69 mm. Calculate the ... of points A and B and the horizontal length of line AB.

ii. Name the instrument usually employed to measure the position of a point in a photograph.

iii. What are the systematic errors contained in the measured photo-coordinates that disturb the ideal linear relation between the perspective centre, the image point and the ground point?

(15+2+8) marks

SECTION B

Section 4

i. Assuming the principle point to be at the intersection of lines joining opposite corner fiducial points, calculate the coordinates of those fiducial points in the conventional xy coordinate system if their comparator coordinates XY are as in the table below.

Fiducial points	X(mm)	Y(mm)
A	87.294	210.223
B	199.826	96.996
C	313.054	209.555
D	200.512	322.768

b) Define the following photogrammetric terms, give the number of the corresponding parameter elements required for their determination and name them.

i. Basic interior orientation

ii. Relative orientation

iii. Absolute orientation

iv. Exterior orientation

(13+12) marks

QUESTION 4

SECTION B

a) Define x-parallax and show with a figure how it depends on the elevation of terrain

b) Derive parallax equations for any point A(x,y) assuming that two overlapping photos are taken from the same height above datum

c) The length of line AB and the elevation of its endpoints A and B, are to be determined from a stereopair containing images a and b. The camera used to take the photographs has a 152.4-mm lens. The flying height was 1200m. The measured photo coordinates of the two photos) and the airbase was 600m. The measured photo coordinates are xa=54.61mm, points A and B in the "flight line" coordinate system are xa=54.61mm, xb=98.67mm,ya=50.80mm,yb= -25.40mm, x'a=-59.45, y'a=27.35mm. Find the length of line AB and elevation of A and B.

QUESTION 5

(5+10+10) marks

a) Discuss vertical, tilted and oblique type of photographs.

b) Briefly, distinguish between a map and a photo.

c) Assume a vertical photograph was taken at a flying height of 5000m above mean sea level using a camera with a 152-mm-focal-lenght lens. (a) Determine the photo scale at points A and B, which lie at elevations of 1200 and 1960 m. (b) What ground distance corresponds to a 20.1 mm photo distance measured at each of these elevations?

d) What is relief displacement? With the help of sketch diagrams, derive the formula for relief displacement.

e) Assume that the relief displacement for a tower appearing on a photo is 2.01mm, and the radial distance from the centre of the photo to the top of the tower is 56.43mm. If the flying height is 1220m above the base of the tower, find the height of the tower.

(5+5+5+5+5) marks

$$h = \frac{dH}{r}$$

$$d = \frac{rh}{H}$$

The nearer the object the greater the parallactic angle and vice versa. The depth between object A and B (DB-DA) is perceived as the difference in their parallactic angles (QA-QB)

a) Given that the shortest distance of clear stereoscopic depth perception for an average eye base of 65mm is 250mm, calculate the maximum Parallactic angle.

Stereoscopic Depth Perception

NB.

① Shortest distance of clear Stereoscopic depth perception for the average eye base of 65mm is 250mm

∴ Max parallactic angle will be

$$\phi(max) = 2\tan^{-1}\frac{32.5mm}{250mm} \approx 15°$$

b) Given that the maximum distance at which the stereoscopic depth perception is possible is approximately 600m, calculate the minimum Parallactic angle.

$$= 2\tan^{-1}\frac{32.5}{600m}$$

$$= 0°0'22''$$

② Maximum distance at which the stereoscopic depth perception is possible is approx 600 m

$$\phi(min) = 22''$$

List at least three examples of close range photogrammetry in each of the following applications

1. Information System – Image database, building facility management. project planning

Building information system

Question Two (14+4+7 marks)

a. Briefly, define the following photogrammetric terms:
   - Pallaras
   - Principal Point
   - Illuminance
   - Exposure Station
   - Interior orientation parameters
   - Exterior orientation parameters
   - Fiducial Marks

b. Briefly, state the main difference between a map and a photograph.

c. State briefly, the relationships between?
   - f-number and shutter speed
   - Film speed and emulsion grain size
   - Resolution and emulsion grain size

Question Three (20+5 marks)

a. Assuming the principle point to be at the intersection of lines joining opposite corner fiducial points, calculate the coordinates of those fiducial points in the conventional xy coordinate system if their comparator coordinates XY are as in the table below.

Fiducial points	X(mm)	Y(mm)
A	87.294	210.223
B	199.826	96.996
C	313.054	209.555
D	200.512	322.768

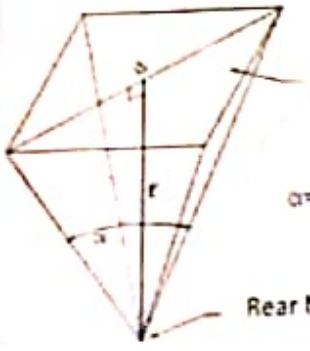
$(y_2 - y_1) = m(x_2 - x_1)$

$y = mx + c$

$y = mx + c$

$A = A' - O'$

b. The figure below shows the angular field of view of a camera. Calculate the angular field of view for a nominal 152-mm focal-length camera with a 23cm square format. State whether this is a wide angle, normal angle or super-wide angle type of a single-lens frame camera.



Question 5

a) Given the following 3x3 rotation matrix

$$R(\omega) = \begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos\omega & \sin\omega \\ 0 & -\sin\omega & \cos\omega \end{pmatrix}$$

$$R(\phi) = \begin{pmatrix} \cos\phi & 0 & -\sin\phi \\ 0 & 1 & 0 \\ \sin\phi & 0 & \cos\phi \end{pmatrix}$$

$$R(\kappa) = \begin{pmatrix} \cos\kappa & \sin\kappa & 0 \\ -\sin\kappa & \cos\kappa & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

Derive the rotation matrix R (ω,φ,κ) that rotates the coordinate system of tilted photograph to the coordinate system parallel to the reference ground system.

Determine the rotation angles (ω,φ,κ) if R has the following form:

$$R = \begin{pmatrix} 0.999910 & 0.013319 & 0.001635 \\ -0.013351 & 0.999671 & 0.021907 \\ -0.001343 & -0.021927 & 0.999759 \end{pmatrix}$$

(Formulas: sin φ= r13, tan κ= -r12/r11, tan ω=-r23/r33)

b) Provide the definitions of the independent and the dependent methods of relative orientation. Name the projector elements used in each of them.

(15+10) marks

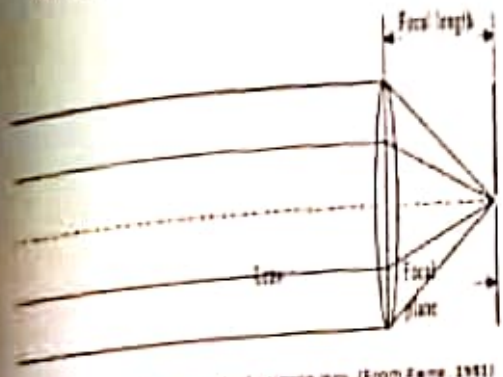


Figure 6.4. Focal length of a simple lens. (From Kemp, 1981)

d) The image distance for a photograph of an object, which is located 4.5 meters from the camera, is 76.5mm. What image distance is required for perfect focus if the object is in infinity?

(10+3+6+6) marks

SECTION B

...four (5+5+5+5+5 marks)

...With the help of sketches, show how stereoscopic coverage is lost due to:

i) Tilt
ii) Unequal flying heights
iii) Terrain variations

...Air base of a stereopair is 1400m and flying height above ground is 2400m. Camera has a 152.4 mm focal length and 23-cm format.

i) What is the percent *endlap*?
ii) Assuming spacing between adjacent lines is 2500m, what is the percent *side lap*?

...estion Five (3+18+4 marks)

In an *ideal* optical system, all rays of light from a point in the object plane would converge to the same point in the image plane, forming a clear image.

a) What term is used for the *influences* which cause different rays to converge to different points?

b) Mention and briefly explain **six (6)** types of the *influences* mentioned in (a). Support your answer with sketches of the aberration types.

c) Draw ray diagrams for a typical convex lens for a real and virtual image formation.

SECTION B

Question Four (15+10 marks)

a. With the help of sketches, show how stereoscopic coverage is lost due to
   i) Tilt
   ii) Unequal flying heights
   iii) Terrain variations

b. Air base of a stereopair is 1400m and flying height above ground is 2400m. Camera has a 152.4 mm focal length and 23-cm format.
   i) What is the percent end lap?
   ii) Assuming spacing between adjacent lines is 2500m, what is the percent side lap?

c. An aerial camera with IMC (Image Motion Compensation) is used to acquire photography at a flying height of 5200 m above ground. The focal length is 153.15 mm. The aircraft is flying at 325 km/hr and an exposure time of 1/250 second is used. How far across the focal plane must film travel during the exposure in order to obtain an image with no image motion blurring?

Question Five (4+6+15 marks)

a. What is relief displacement?

b. A vertical photo is taken from a height of 535 m above the datum. The elevation of the base of tower is 259m and the relief displacement'd' is measured as 54.1 mm. The radial distance to the top of the tower is 121.7 mm. What is the height of the tower?

c. The length of line AB and the elevation of its endpoints, A and B, are to be determined from a stereopair containing images a and b. The camera used to take the photographs has a 152.4-mm lens. The flying height was 1200 m (average for the two photos) and the air base was 600 m. The measured photographic coordinates of points A and B in the "flight line" coordinate system are x_a = 54.61 mm, x_b = 98.67 mm, y_a = 50.80 mm, y_b = -25.40 mm, x'_a = -59.45 mm, and x'_b = -27.39 mm. Find the length of line AB and the elevations of A and B.

REVISION QUESTIONS AUGUST 2017

GEE 3622-PRINCIPLES OF DATA ACQUISITION & PROCESSING

GROUP 1

Figure 1 of reflectance curves; show the spectral response patterns of deciduous and coniferous trees.

(a) Which range of the wavelength is the visible portion of the electromagnetic spectrum?

(b) Which range is the near-infrared (NIR) portion?

(c) Explain why it would be difficult to distinguish the two types of trees in the visible portion.

(d) Explain why it would easier to distinguish the two types of trees in the NIR portion.

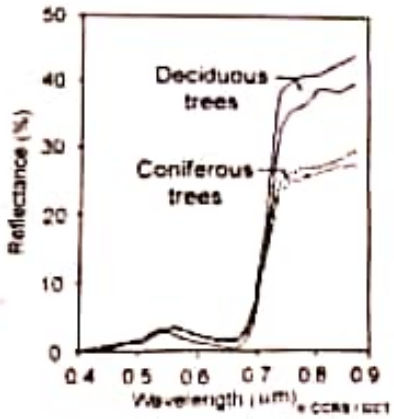


Figure 1: Reflectance curves for Deciduous trees and Coniferous trees

(a) Visible: 0.4 – 0.7 μm

(b) NIR: 0.7 – 0.9 μm

(c) The reflectance in the visible portion for both trees is low, and not clearly separable

(d) In the near-infrared, although both types reflect a significant portion of the incident radiation, they are clearly separable.

2. a) Describe two different conditions that are commonly enforced in analytical photogrammetry.

b) Distinguish between **Space Resection** by collinearity and **Space intersection** by collinearity.

c) Aerial photography is to be taken from a flying height of 1830 m above average ground with a camera having a 152.4-mm focal length and a 23cm format. End lap will be 60 percent, and side lap will be 30 percent. What is the ground area covered by a single photograph and by the stereoscopic neat model?

(6+8+11 marks)

3. a) Mention **Three** (3) basic sensor hardware for laser mapping systems.

b) A laser mounted on an airplane emits a pulse that reflects off a target and returns to the sensor in 0.0066000 millisecond. Assume that the pulse is aimed directly down to the datum surface, that the speed of light is 299,792,458 m/s, and that the laser is at exactly 1 km above the datum. What is the object's height above datum?

c) Evaluate the contrasts between airborne laser scanning and (stereo-) photogrammetry from an application perspective.

(6+7+12 marks)

SECTION B

4. a) Briefly, explain what is meant by aerial triangulation.

b) Outline at least three (3) advantages of control extension by aerial triangulation

c) Mention at least five (5) sources of errors that are normally taken into account in aerial triangulation

d) Why is the similarity (conformal) transformation used in the Block adjustment by independent models?

(6+9+5+5 marks)

5. a) The relationship of between density and exposure of a photographic emulsion can be described by the characteristic curve called *D-log(H)* curve. With the help of a sketch diagram, explain the main components of the curve.

b) State the difference between contact printing and projection printing

c) Explain the five steps involved in processing black and white emulsion.

(10+6+9 marks)

STOP: GO BACK AND CHECK YOUR WORK!

Sharon Chelimbo Chepsm

GEE 3622

Example: **Flight Planning**

A study area is 10 km wide in the east-west direction and 16 km long in the north-south direction. A camera having a 152.4-mm-focal-length lens and a 230-mm format is to be used. The desired photo scale is 1:25, 000 and the nominal endlap and sidelap are to be 60 and 30 percent. Beginning and ending flight lines are to be positioned along the boundaries of the study area. The only map available for the area is at a scale of 1: 62,500. This map indicates that the average terrain elevation is 300 m above datum. Perform the computations necessary to develop a flight plan and draw a flight map.

SOLUTION

a) Use north-south flight lines. Note that using north-south flight lines minimizes the number of lines required and consequently the number of aircraft turns and realignments necessary. (Also , flying in a cardinal direction often facilitates the identification of roads, section lines, and other features that can be used for aligning the flight lines.)

b) Find the flying height above terrain (H' =f/S) and add the mean site elevation to find flying height above mean sea level:

$H = f/S + h_{avg} = (0.1524\ m)/(1/25{,}000) + 300\ m = 4110\ m$

c) Determine ground coverage per image from film format size and photo scale:

Coverage per photo = 0.23m/(1/25,000) = 5750 m on a side

d) Determine ground separation between photos on a line for 40 percent advance per photo (i.e., 60 percent endlap):

0.40 x 5750 m = 2300 m between photo centers

e) Assuming an aircraft speed of 160 km/hr, the time between exposures is

(2300m/photo)/160 km/hr x (3600 sec/hr)/ 1000m/km = 51.75 sec (use 51 sec)

f) Because the intervalometer can only be set in even seconds (this varies between models), the number is rounded off. By rounding down, at least 60 percent coverage is ensured. Recalculate the distance between photo centers using the reverse of the above equation:

51 sec/photo x 160 km/hr x (1000 m/km)/ 3600 sec/hr = 2267 m

g) Compute the average number of photos per 16-km line by dividing this length by the photo advance. Add one photo to each end and round the number up to ensure coverage:

(16,000 m/line)/2267 m/photo + 1 + 1 = 9.1 photos/line (use 10)

h) If the flight lines are to have a sidelap of 30 percent of the coverage, they must be separated by 70 percent of the coverage:

0.70 x 5750 m coverage = 4025 m between flight lines

i) Find the number of flight lines required to cover the 10-km study area width by dividing this width by distance between flight lines (note: this division gives number of spaces between flight lines; add 1 to arrive at the number of lines):

(10,000 m width)/ 4025 m/flight line + 1 = 3.48 (use 4)

The adjusted spacing between lines for using four lines is

10,000 m/(4-1 spaces) = 3333 m/space

j) Find the spacing of flight lines on the map (1: 62,500 scale):

3333 m x 1/62500 = 53.3 mm

k) Find the total number of photos needed:

10 photos/line x 4 lines = 40 photos

(NOTE: The first and last flight lines in this example were positioned coincident with the boundaries of the study area. This provision ensures complete coverage of the area under the "better safe than sorry" philosophy. Often, a savings in film, flight lines, and money is realized by experienced flight crews by moving the first and last lines in toward the middle of the study area.)

The University of Zambia
School of Engineering
Department of Geomatic Engineering
2015/6 ACADEMIC YEAR
MID-TERM TEST - JULY 2016

COURSE NAME: **PRINCIPLES OF DATA ACQUISITION AND PROCESSING**
COURSE CODE: GEE 3622
TIME: TWO (2) HOURS
TOTAL MARKS: 100
INSTRUCTIONS

1. **Answer: ALL THREE** (3) QUESTIONS from SECTION A and **ONE** QUESTION from SECTION B
2. This TEST is Closed Book
3. Calculators are permitted
4. Show all the work leading to the solution

SECTION A

1. a) Explain the following terms:
   i. **Depth of field** of a lens
   ii. **Illuminance** of any photographic exposure
   iii. **Panchromatic** emulsion
   iv. **Crab** angle
   v. **Y-Pallax**

b) A vertical aerial photograph was taken with a 152.4-mm-focal-length camera from a flying height of 1385 m above datum. Images *a* and *b* of two ground points A and B appear on the photograph, and their measured photo coordinates (corrected for shrinkage and distortions) are x_a=-52.35 mm, y_a=-48.27 mm, x_b=40.64 mm, and y_b=43.88 mm. Determine the horizontal length of line AB if the elevations of points A and B are 204 and 148 m above datum, respectively.

(2+2+2+2+2+15 marks)

PART B

5. a) Outline briefly atleast **ten (10)** steps involved in the map compilation procedure

b) What range in map scales is possible for a wild A-8 stereoplotter for photography taken with 152 mm focal length camera at a flying height of 3040 meters above mean terrain? Assume that the A-8 is equipped with a coordinatograph capable of 4X reduction or enlargement from model scale and that a projection distance range of A-8 is from 175mm to 350mm.

c) Discuss two (2) main categories of *automation* in photogrammetric instruments.

(10+7+8)

6. a) What kind of viewing systems are used in different types of stereoplotters?

b) What is the purpose of using aerial triangulation?

c) Describe the procedure of aerial triangulation by the independent models method, in two cases:
i) - using a full analytical approach
ii)- using a semi analytical approach

d) Describe the main principles of image correlation.

e) What are the main differences between electronic and digital image correlators?

(4+2+8+6+5)

PART B1-CIVIL ENGINEERING STUDENTS

Question 1

(A) Given a project area of a proposed dam construction for which mapping by aerial photogrammetry is required for feasibility study and preliminary design at a photo scale of 1:30,000 using a 150mm camera focal length and camera format of 230mm (15/23), calculate the following;

-The airbase and photo base
- Flying height
- Distance between strips (runs)

Given that end and side overlaps are 60% and 20% respectively.

(10)

(B) -Define stereoscopic perception as used in photogrammetric observations
-Describe the principle of height measurements by using a parallax bar

(5)

(C) Briefly describe the use of remote sensing in the following civil engineering applications [motivate your answer].

(10)

-highway planning (feasibility study)
-water resources investigations

Section B – Photogrammetry-Answer only one question from this section

Question 3 (5+12+8)

a. Define the following terms: (2+2+1)

i. Vertical photograph
ii. Low oblique photograph
iii. High oblique photograph

b. Points A and B are at elevations 223 m and 162 m above datum respectively. The photographic coordinates of their images on a vertical photograph are

	X (mm)	Y (mm)
A	-52.35	-48.27
B	40.64	43.88

What is the horizontal length of the line AB if the photo was taken from a height of 1510m above datum with a 152.4mm focal length camera?

c. Mention and describe any four products of aerial photogrammetry.

Question 4 (3+5+4+5+3+5)

a. Name three major components of an aerial camera. (3)

b. Aerial photos of a project area were taken at scale 1:24,000 with a 153mm focal length camera. The end lap was 65% while the side lap was 30%.

Calculate:

(i) The flying height of the place was 1584m above mean sea level,

(ii) Ground dimensions covered by a 230mm by 230 mm picturformat.

(iii) The ground spacing between exposure stations,

(iv) The ground spacing between the flight lines,

(v) The total ground area expressed in hectares covered by a pair of overlapping photographs.