Geomatics Engineering Department

Second Year Geomatics

Geodesy 2 (GED209)

Lecture No: 1

INTRODUCTION

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Overview Of Previous Lecture

This is Lecture No 1.

Overview Of Today's Lecture

- Course Info.
- Scope
- Course Content
- Expected Learning Outcomes
- Course Assessment
- Teaching Members
- Lecture 1 – LOS Engineering
- Definition & Rationale
- Intervisibility Between Triangulation Stations
- Numerical Exercises
- Applications of LOS Engineering
- Software
- Summary

Your Subject

- **Name**: Geodesy 2 (Bylaw 2021), Geodesy 1B (Bylaw 2000).
- **Code**: GED209 (Bylaw 2021), SUR223(Bylaw 2000).
  - A bridging subject for geomatics students
  - Forms a basis for remaining study.
  - Promote an awareness of where some geospatial (2D and 3D) data used comes from and the factors that govern its creation and accuracy.
  - Class is scheduled every **Tuesday at 10:40 am**.
  - Lecture Venue: ***B7***
  - Tutorials Venue: ***Sections 1 and 3 @ B7; Section 2 @ Theatre.***
- ***References***

1. Hooijberg, M., 2007. Geometrical Geodesy: Using Information and Computer Technology. Spr verlag, Berlin, Germany.
2. Hooijberg, M., 2011. Practical Geodesy: Using Computers. Springer Ltd, London, UK
3. Hirt, C. and Buerki, B. 2006: Status of geodetic Astronomy at the beginning of 21st Century
4. Surveying and Geodetic Applications: Applications based on extensive field experience LAMBERT Academic Publishing (August 20, 2018)
5. Handbook of Geodetic astronomy Published by LAP LAMBERT Academic Publishing (July 28, 2011)

Scope

- Gain a comprehensive understanding of the basic principles of classical geodesy.
- Recognize the different coordinate systems used in geodesy.
- Distinguish between the actual and mathematical figure of the earth.
- Identify the applications of geodesy in surveying fields.
- Solve the major geodetic problems by relating them to mathematical theorems.
- Possess extensive knowledge of the theory of some geodetic instruments.
- Accomplish surveying missions using the methodology of traditional geodesy.

Content (w.r.t FENG Bylaw)

Geodesy 1B (SUR223)

- Introduction
- Figure of the earth
- Datums
- Geoid and its significance
- Coordinate systems in geodesy
- Gravimetric effect
- Triangulation, Trilateration, Hybrid Networks
- Two- and three-dimensional computations
- Geodesic line, LOS, and great circles.
- Direct and inverse problems.
- Intersection and resection
- Precise and trigonometric leveling
- GPS leveling
- Height systems

Geodesy 2 (GED209)

- Introduction, Celestial sphere, astronomic and geodetic coordinate systems
- Latitude, longitude, and azimuth determination
- Zenith determination
- Spherical triangles – Napier's rule
- Time – Methods to change time and its determination.
- History of the Egyptian Geodetic network
- Coordinate systems used in Geodesy
- Establishing of local and world best fitting ellipsoid
- Gravimetric effect on observations
- Coordinate transformations and datum shift
- Two and three-dimensional Geodesy
- Adjustment of three-dimensional geodetic networks.

Intended Lecture Series (A reasonable Merge of Content)

1) LOS Engineering (This lecture)
2) Overview of Celestial sphere, latitude, longitude, zenith, and azimuth determination
3) Datums, Geoid and its significance
4) Coordinate Systems in Geodesy
5) Gravimetric effect on observations
6) Establishing of local and world best fitting ellipsoid
7) Coordinate transformations and datum shift
8) Height systems
9) Intersection and resection
10) Two and three-dimensional Geodesy
11) Adjustment of three-dimensional geodetic networks.
12) History of the Egyptian Geodetic network

Expected Learning Outcomes

- Comprehend the concept of the celestial sphere and its role in geodetic measurements.
- Differentiate between astronomic and geodetic coordinate systems and their applications.
- Gain proficiency in determining latitude, longitude, azimuth, and zenith angles.
- Master the application of Napier's rule in solving problems related to spherical triangles.
- Explore different methods for changing and determining time in geodetic calculations.
- Acquire knowledge about the historical development and significance of the Egyptian Geodetic Network.
- Familiarize yourself with the various coordinate systems employed in geodesy.
- Understand the process of establishing local and global ellipsoids for geodetic measurements.
- Recognize the influence of gravity on geodetic observations and its correction.
- Learn how to perform coordinate transformations and handle datum shifts between different reference systems.
- Gain proficiency in geodetic calculations and measurements in both two and three-dimensional spaces.
- Understand the concept and methods of adjusting three-dimensional geodetic networks to improve accuracy and reliability.

Assessment

Geodesy 2 (GED209)

Code	Name	Lec.	Tut.	Lab.	Total	Sem. Work	Oral/Lab	Written Exam	Total	Dur. Of Final Exam
GED209	**Geodesy 2**	2	2	2	6	45	45	90	180	3 hrs.

Geodesy 1B (SUR223)

Code	Name	Lec.	Tut.	Lab.	Total	Sem. Work	Oral/Lab	Written Exam	Total	Dur. Of Final Exam
SUR223	**Geodesy 1B**	3	3	-	6	30	30	90	150	3 hrs.

Assessment Tool	Week	Weight
Midterm Examination	7	20 %
Final Examination	(As Scheduled)	50 %
Quizzes	3,5,9	10 %
Home assignments, and Reports	2,4,6,8,10,12	10%
Oral Exam	14	10%
Total		100 %

Your Teacher

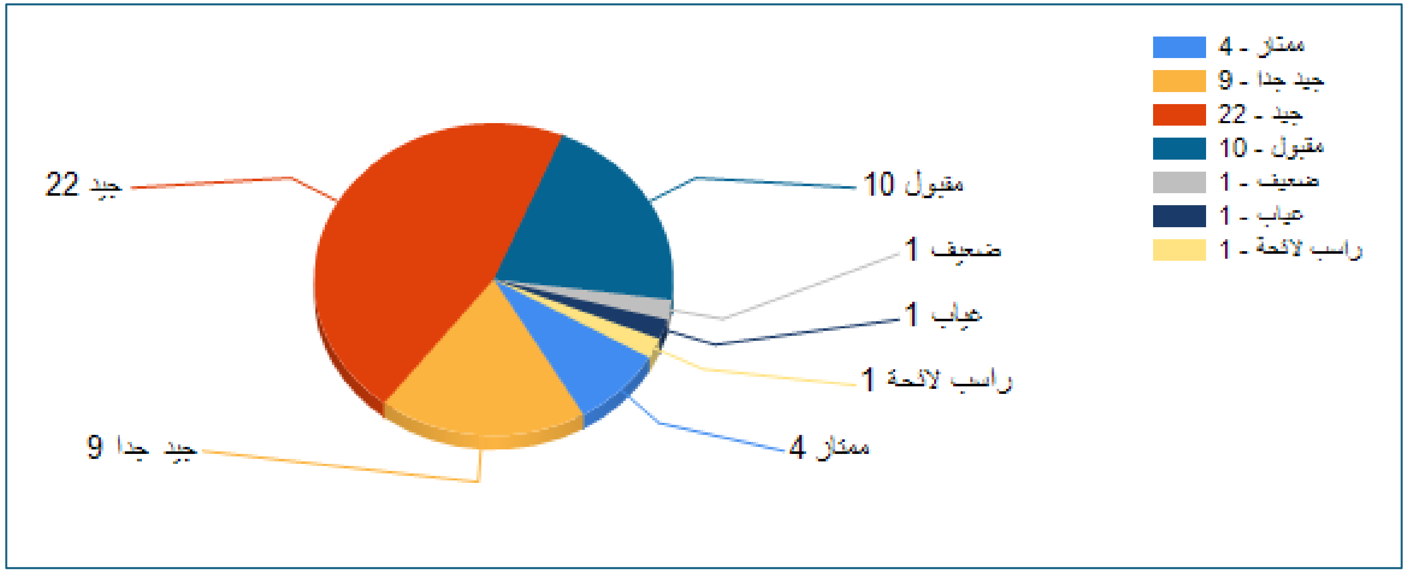
- **Name**
  - Dr. Eng. Reda Fekry
- **Research Interests**
  - Multi-modality 3D remote sensing.
  - Pattern recognition, and related environmental and industrial applications.
  - Sensor fusion for environmental informatics.
  - Deep learning for vision.
  - Object segmentation and classification
- **Teaching Areas**
  - Surveying and Geodesy.
  - Photogrammetry and Remote Sensing.
  - Geospatial computer vision and machine learning.
- **Room**
  - RCO-30
- **E-mail**
  - reda.abdelkawy@feng.bu.edu.eg
  - fekry.khaliel@connect.polyu.hk
  - rfekry@ecu.edu.eg

Your Tutors

- **Name**
  - Eng. Amina Nasser
- **Teaching Areas**
  - Surveying and Geodesy.
- **Room**
  - RCO-05
- **E-mail**
  - nasseramina06@gmail.com

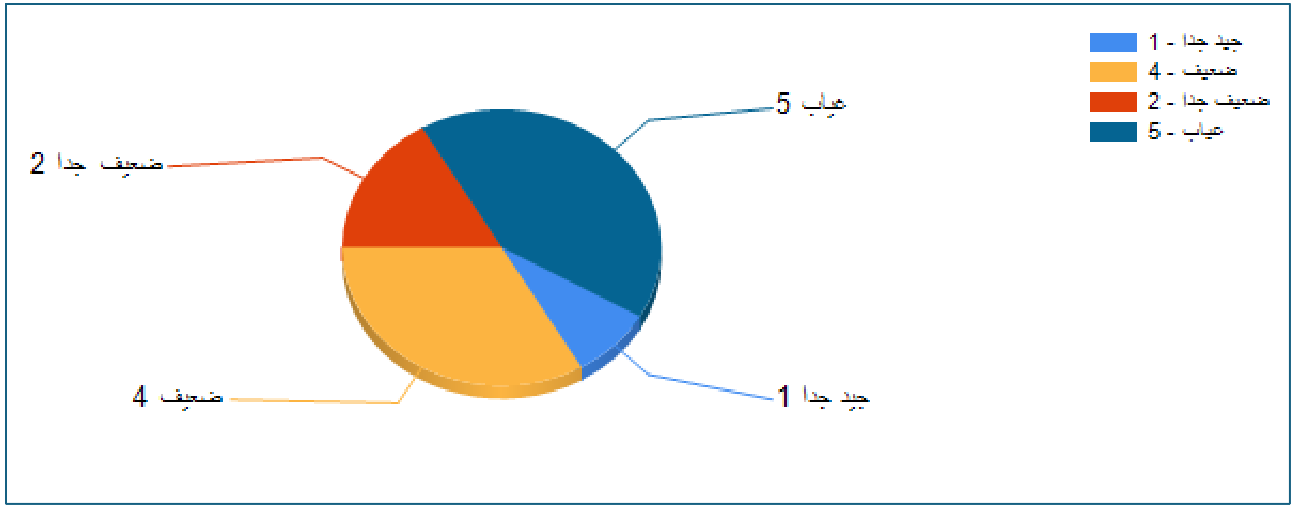
What Did We Achieve In Geodesy 1 & Geodesy 1A?

Success Rates



Geodesy 1 (GED203)

Geodesy 1A (SUR213)

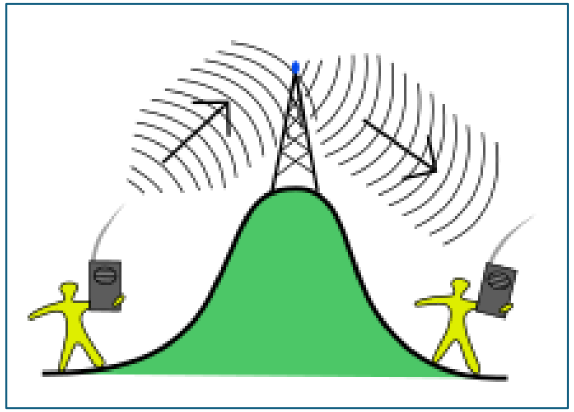


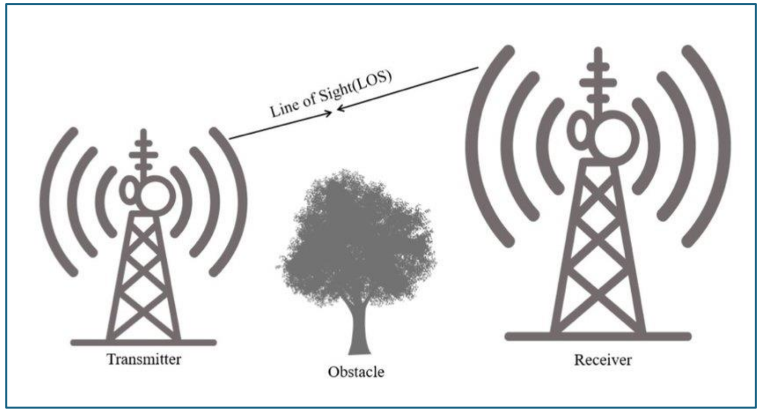
Lecture 1

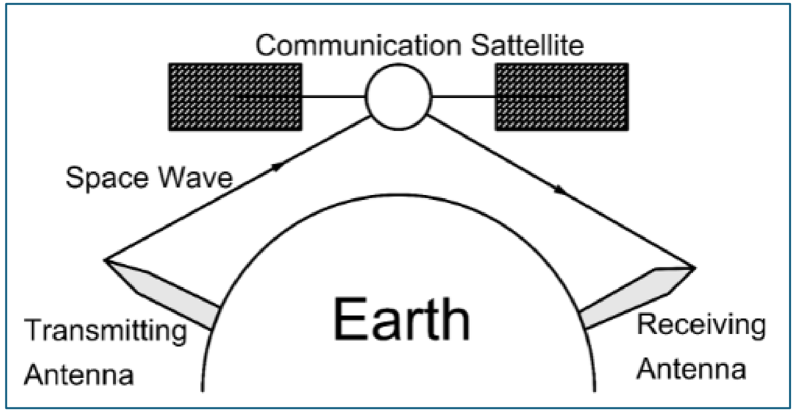
Line of Sight Engineering

DEFINITION

- **Line of Sight Engineering (LOS)** is a discipline within engineering that focuses on designing and analyzing systems where direct line-of-sight communication or observation is crucial.





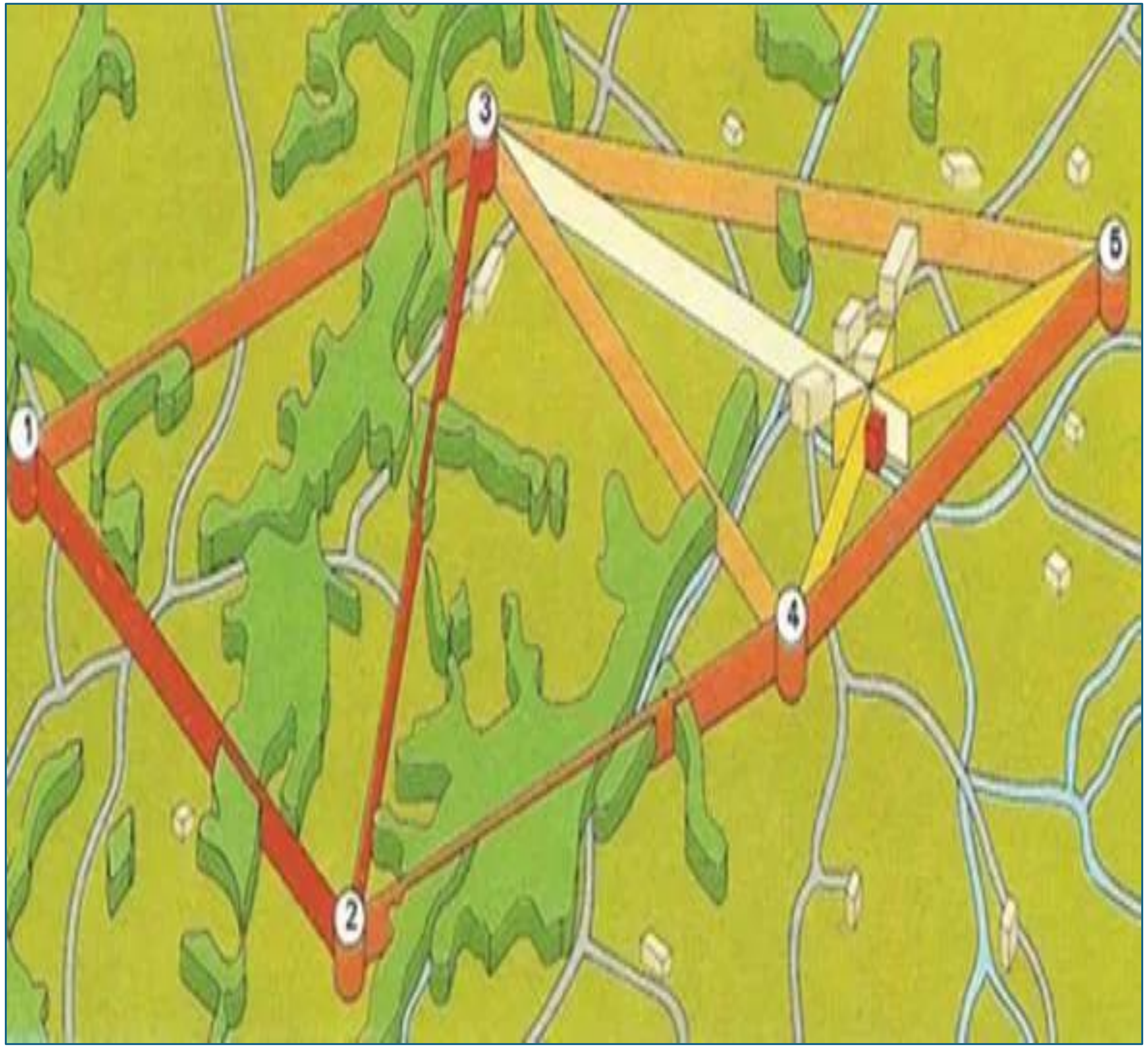


HOW DOES GEODESY ADDRESS LOS?

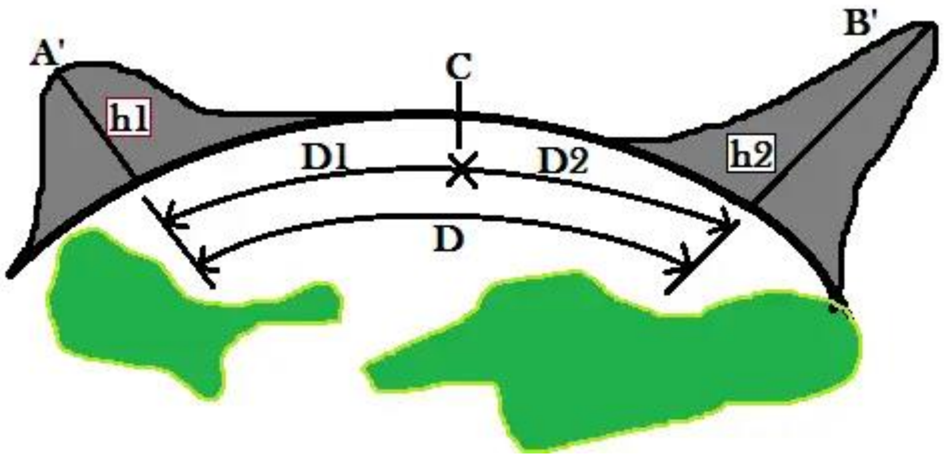
INTERVISIBILITY BETWEEN STATIONS, HOW!

Intervisibility Between Triangulation Stations

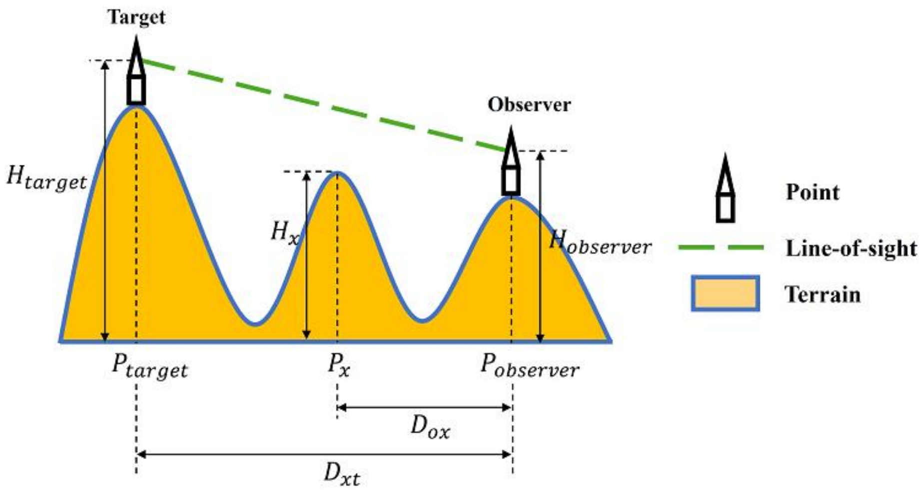
- Triangulation stations should be chosen on high ground so that all relevant stations are intervisible.
- For small distances, intervisibility can be ascertained during reconnaissance by *direct observation* with the aid of binocular, contoured map of the area, plane mirrors or heliotropes using reflected sun rays from either station.
- If the distance between stations is large, the intervisibility is ascertained by knowing the horizontal distance between the stations.



RATIONALE



Case I



Case II

* Images from Internet

RATIONALE – CASE I

(1) **Checking the obstruction of the intervening ground**

$h = \frac{D^2}{2R}(1 - 2m)$,

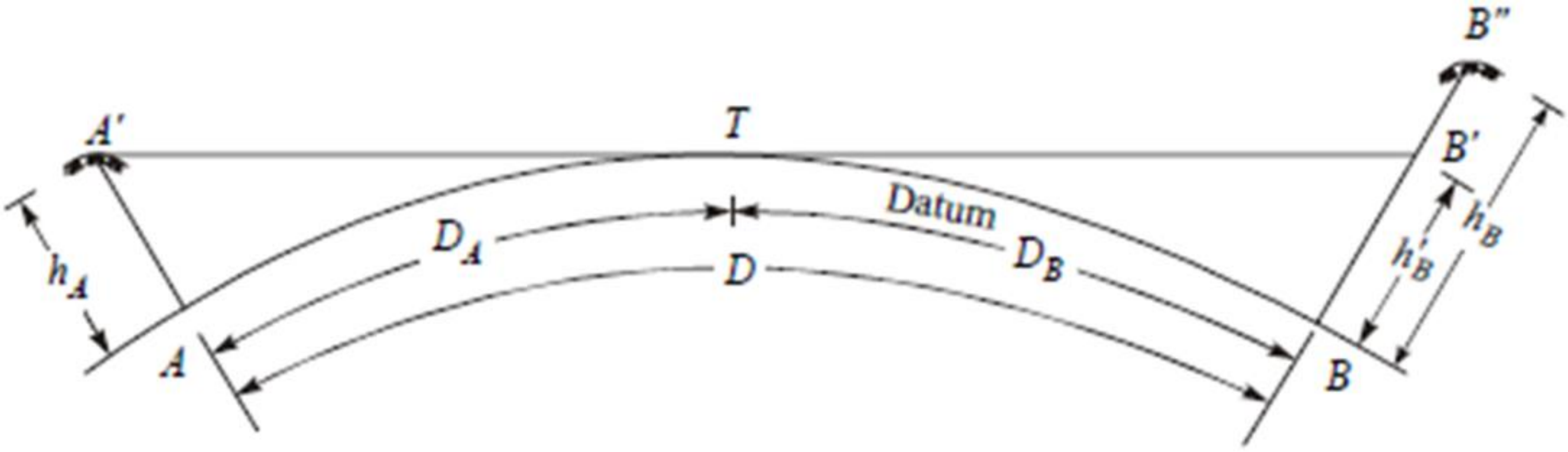
Such that: -

h: height of station above datum (i.e., elevation).

D: distance of visible horizon.

R: Earth's mean radius.

m: coefficient of refraction (m = 0.07 on land, and 0.08 on oceans).



RATIONALE – CASE I

(1) **Checking the obstruction of the intervening ground**

$$h = \frac{D^2}{2R}(1 - 2m),$$

To facilitate computations, substitute by values of R and m on land: -

$$h = 0.06735\, D^2,$$

Where h in meters, and D in kilometers.

N.B: The line of sight should be taken at least 3 m above the point of tangency T of the earth's surface to avoid grazing rays.

RATIONALE – CASE I

(1) **Checking the obstruction of the intervening ground**

The computed height of station B is compared to its known value as follows: -

$$If\ h_B \geq h'_B, the\ station\ B\ will\ be\ visiable\ from\ A.$$

$$If\ h_B < h'_B, the\ station\ B\ will\ NOT\ be\ visiable\ from\ A.$$

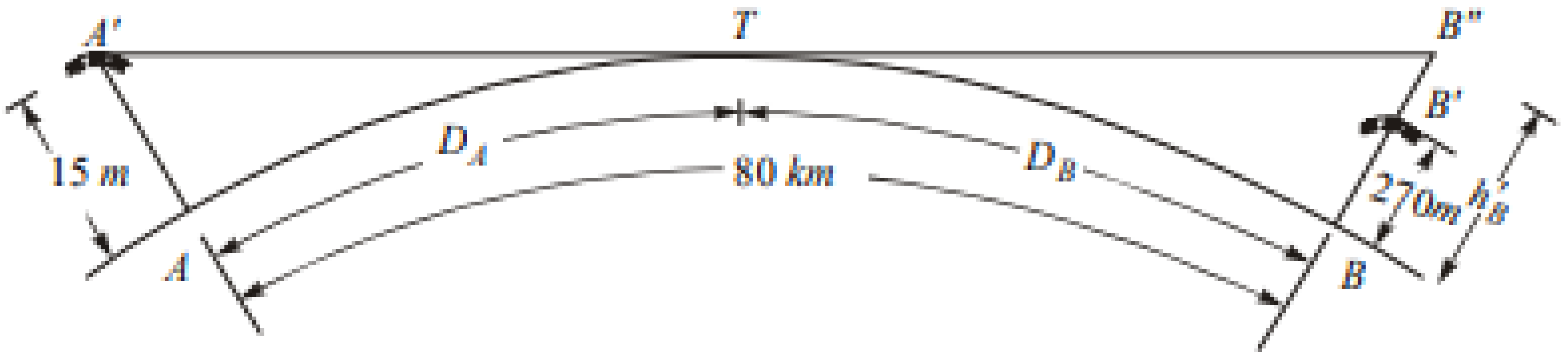
If B is NOT visible from A, then a tower should be erected at B while its height is: -

$$H_{tower} = h_B - h'_B$$

Rationale – Case I – Numerical Exercise

(1) **Checking the obstruction of the intervening ground**

Two stations A and B, 80 km apart, have elevations 15 m and 270 m above mean sea level, respectively. Check whether station B is visible from A, if NOT, Calculate the minimum height of the signal at B.



Rationale – Case I – Numerical Exercise

(1) **Checking the obstruction of the intervening ground**

Check whether station B is visible from A, if NOT, Calculate the minimum height of the signal at B.

$h = 0.06735\ D^2$

$$D_A = 3.853\sqrt{h_A} = 3.853 \times \sqrt{15} = 14.92\ \text{km}$$

or

$$D_B = D - D_A = 80 - 14.92 = 65.08\ \text{km}$$

Therefore

$$h'_B = 0.06735\ D_B^2 = 0.06735 \times 65.08^2 = 285.25\ \text{m}$$

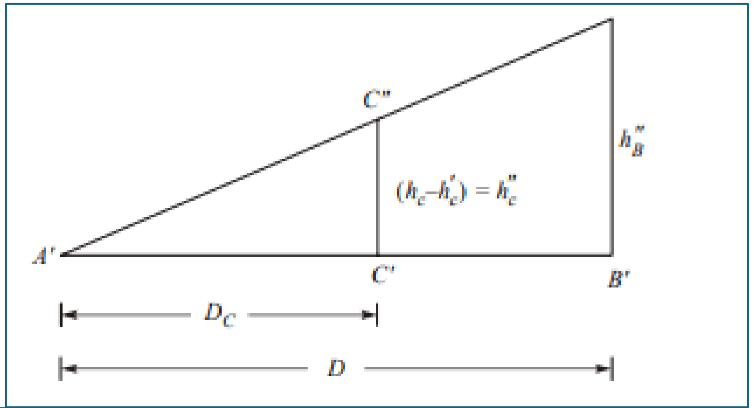
Hence, since the elevation of B is 270 m, the height of signal required at B, is

$$= 285.25 - 270 = 15.25 \simeq \mathbf{15.5\ m.}$$

Rationale – Case II - Numerical Exercise

- **(2) Intervisibility obstructed by intervening ground**

From Captain McCaw's formula, the height of sight can be computed as: -



$$h = \frac{1}{2}(h_B + h_A) + \frac{1}{2}(h_B - h_A)\frac{x}{S} - (S^2 - x^2)\operatorname{cosec}^2 \xi \frac{(1-2m)}{2R},$$

h_A: elevation of station A

h_B: elevation of station B

h_C: elevation of station C

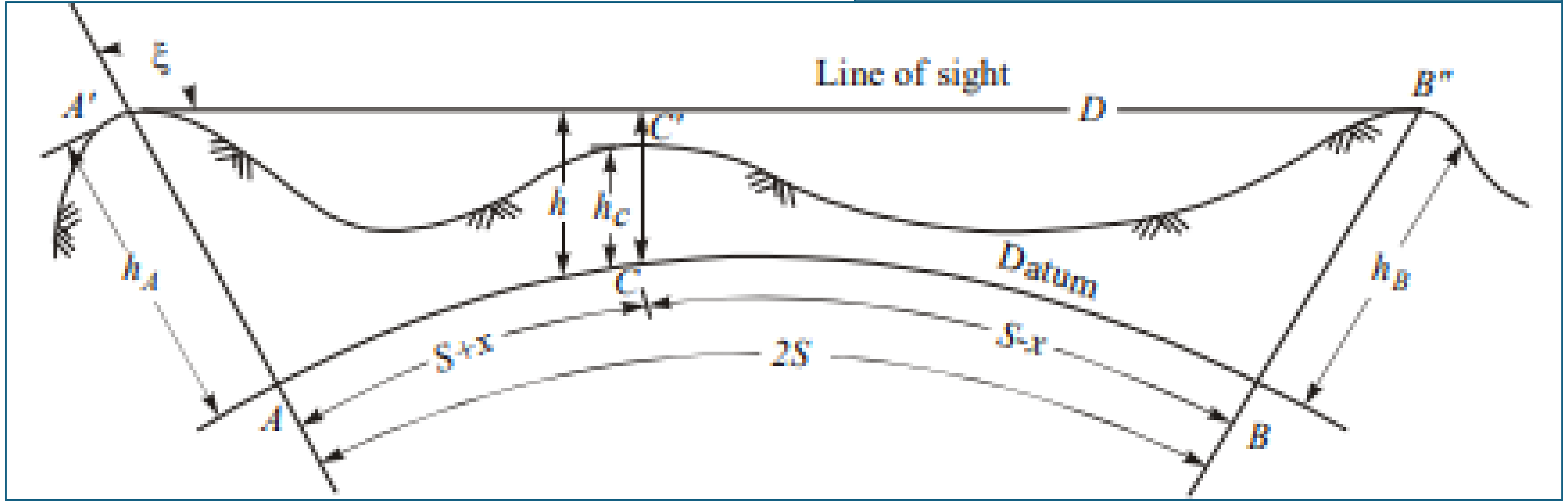
$2S$: distance between A and B

$(S + x)$: distance between A and C

$(S - x)$: distance between C and B

h : elevation of the line of sight at C

ξ: zenith distance from A to B $(90° - vertical)$.



* Images from Internet

Rationale – Case II - Numerical Exercise

- **(2) Intervisibility obstructed by intervening ground**

A. There are two stations P and Q at elevations of 200 m and 995 m, respectively. The distance of Q from P is 105 km. If the elevation of a peak M at a distance 38 km from P is 301 m, determine whether Q is visible from P or not. IF NOT, what would be the height of scaffolding required at Q so that Q becomes visible

from P ?

Rationale – Case II - Numerical Exercise

- **(2) Intervisibility obstructed by intervening ground**

A. Determine whether Q is visible from P or not. IF NOT, what would be the height of scaffolding required at Q so that Q becomes visible from P ?

It is given that

$$h_P = 200\text{ m}$$
$$h_Q = 995\text{ m}$$
$$h_M = 301\text{ m}$$
$$2S = 105\text{ km or } S = 52.5\text{ km}$$
$$S + x = 38\text{ km or } x = -14.5\text{ km}$$

Therefore

$$h = \frac{1}{2}\times(995+200) + \frac{1}{2}\times(995-200)\times\frac{(-14.5)}{52.5} - (52.5^2 - 14.5^2)\times 0.06735 = \mathbf{316.24\ m}.$$

The elevation of the line of sight at M is 316.24 m, and the elevation of the peak is 301 m, therefore, the line of sight is clear of obstruction

RATIONALE – CASE II - NUMERICAL EXERCISE

- **(2) Intervisibility obstructed by intervening ground**

B. In a triangulation survey, the altitudes of two proposed stations A and B, 100 km apart, are respectively 425 m and 750 m. The intervening ground situated at C, 60 km from A, has an elevation of 435 m. Ascertain if A and B are intervisible, and if necessary find by how much B should be raised so that the line of sight must nowhere be less than 3 m above the surface of the ground. Take R = 6400 km and m = 0.07.

$$h_A = 425\text{ m},\ h_B = 750\text{ m},\ h_C = 435\text{ m},\ R = 6400\text{ km},\ m = 0.07$$

$$2S = 100\text{ km, or } S = 50\text{ km}$$

$$S + x = 60\text{ km or } x = 10\text{ km}$$

$$h'_C = \frac{1}{2}(h_B + h_A) + \frac{1}{2}(h_B - h_A)\frac{x}{S} - (S^2 - x^2)\operatorname{cosec}^2\xi\,\frac{(1-2m)}{2R}$$

Taking $\operatorname{cosec}^2\xi = 1$, and substituting the values of the given data in the above equation, we have

$$h = \frac{1}{2}\times(705+425) + \frac{1}{2}\times(705-425)\times\frac{10}{50} - (50^2 - 10^2)$$

$$\times\ 1\times\frac{(1-2\times0.07)}{2\times6400}\times1000 = 431.75\text{ m}$$

Geodesy 2 - Dr. Eng. Reda Fekry

RATIONALE – CASE II - NUMERICAL EXERCISE

- **(2) Intervisibility obstructed by intervening ground**

B. ….

As the elevation of the line of sight at C is less than the elevation of C, the line of sight fails to clear C by

435 – 431.75 = 3.25 m

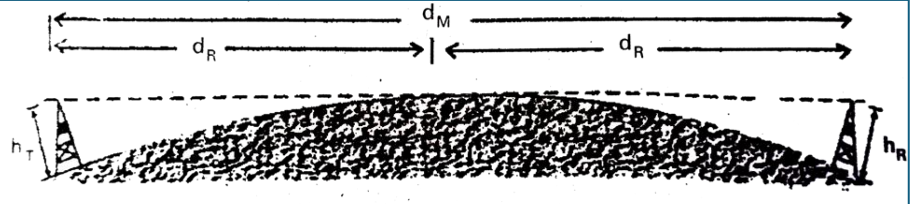
To avoid grazing rays, the line of should be at least 3m above the ground. Therefore, the line of sight should be raised to 3.25 + 3 = 6.25 m at C.

Hence, the minimum height of signal to be erected at *B*

$$= \frac{6.25}{60} \times 100 = \mathbf{10.42\ m.}$$

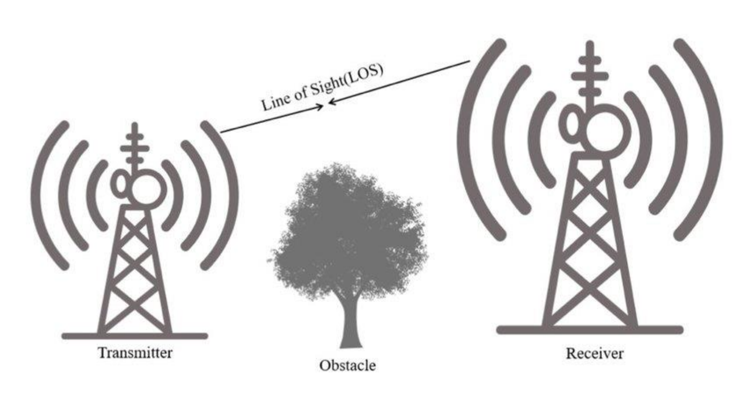
* Images from Internet

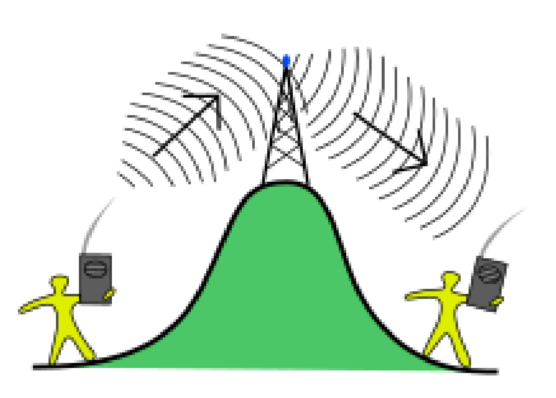
Applications of LOS Engineering



Line of sight communication by space waves

1. Wireless Communication Networks
2. GNSS CORS
3. Radio and Television Broadcasting
4. Remote Sensing and Satellite Imaging
5. Unmanned Aerial Vehicles (UAVs)
6. Laser Communication
7. Industrial Wireless Control Systems
8. ……





LOS Software

1. Radio Mobile - RF propagation simulation software: http://radiomobile.pe1mew.nl/
2. Pathloss: https://www.pathloss.com/
3. HeyWhatsThat! Coverage Prediction Software: https://www.vk3bq.com/2014/08/24/heywhatsthat-and-radio-mobile/
4. Cell Tower Coverage Planning: https://teragence.com/teragence-cell-coverage/
5. Google Earth Pro: https://earth.google.com/web/

End Of Presentation

Thank You For Attention!