

CG201 – ENGINEERING SURVEYING 2

CHAPTER 1

PRINCIPLES OF DISTANCE MEASUREMENT

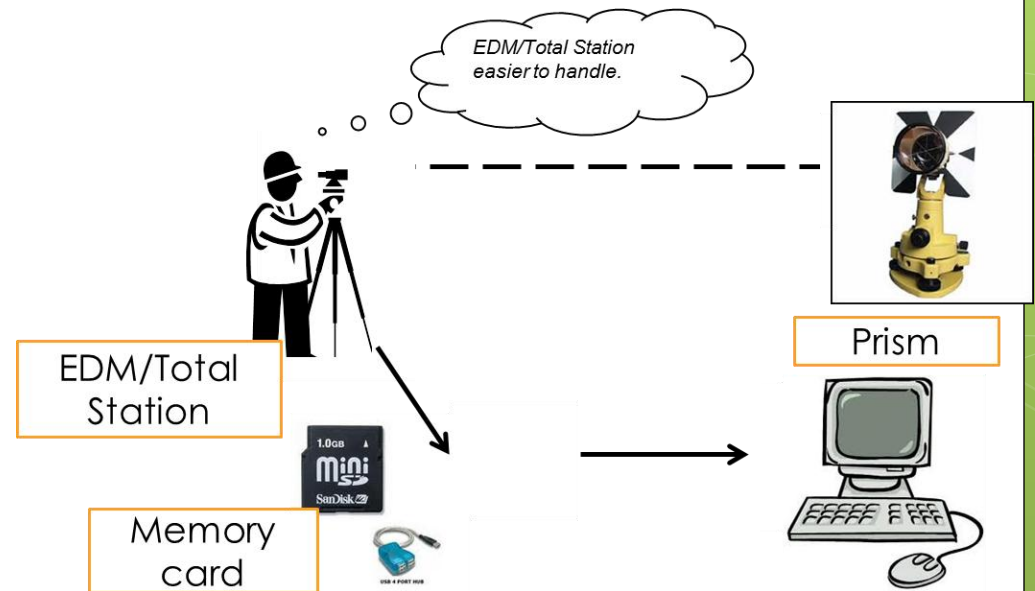
By : Pn Raihana binti Abdul Malek

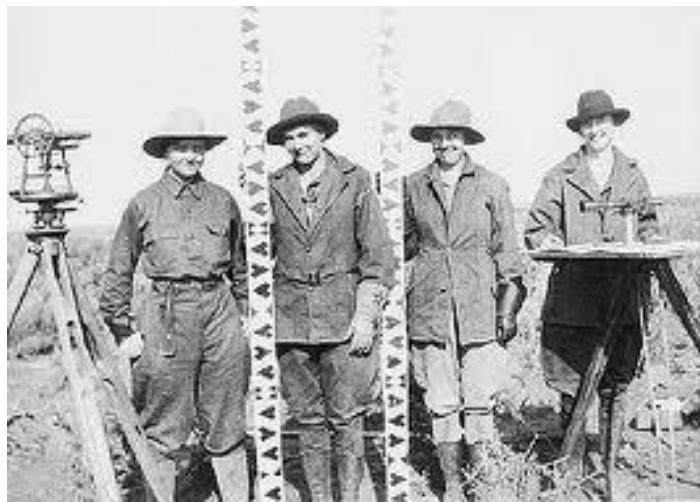


History of Distance Measurement

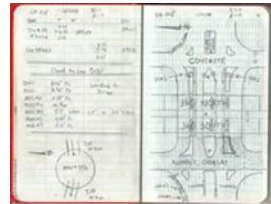
- Before computer and electronic technology exist, conventional equipment are used to get a distance. Example : Teodolite, chain survey and tape. All distances are booked in field book and after that adjusted distance will be obtained. Teodolite can give bearing and angle only.
- After computer technology existed, EDM was created. EDM is short name for '*Electronic Distance Measurement*'.

- Next development in computer technology created total station. Total station is a tool, where angle and distance observation are displayed simultaneously in digital form.
- This tool also has data storage combined with survey software.





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SURVEYING IN INDIA.



For Sokkia



*Distance Measurement
evolution*

Total Station Brand in Market Today...

- Sokkia
- Leica
- Nikon
- Topcon
- Pentax
- Trimble
- Etc

Basic Principle of EDM

- Basic principle electronic distance measurement use modulated infra-red wave with known frequency. The frequency send to reflector through transmitter, and reflector will return frequency to the transmitter.

Prinsip asas pengukuran jarak cara elektronik - menggunakan modulasi gelombang infra merah (infrared) yang diketahui frekuensinya dihantar kepada pemantul (reflektor) melalui pemancar dan pemantul akan mengembalikan semula frekuensi ke pemancar (Alat EDM)

- EDM can compute 'n' (number of wave) with accuracy 1 / 1000 part from long a wave

Dengan ini EDM dapat mengira nilai bilangan gelombang 'n' dengan ketepatan 1/1000 bahagian daripada panjang satu gelombang.

WAVE MODULATION



Measuring wave

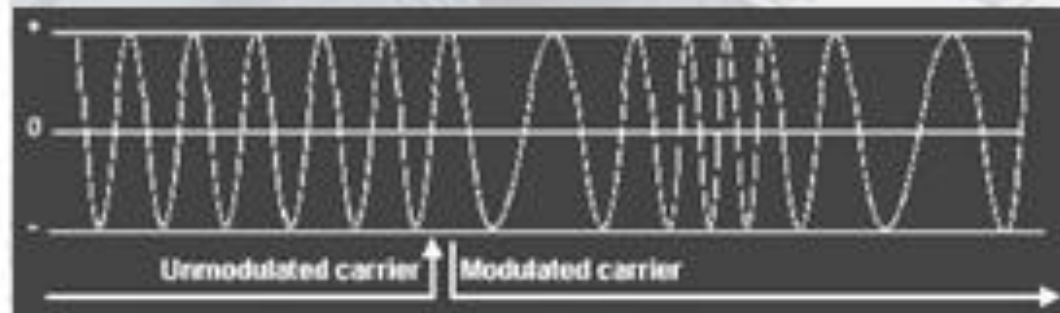


Carrier wave



Carrier wave modulated by measuring wave

"LOADING" THE VOICE ON A "CARRIER"



- n/f (n =number of wave, f = frequency) can be manually or automatically counted by EDM and multiply with standard velocity (v) through the atmosphere.

Nilai n/f (n = bilangan gelombang, f = frekuensi) dihitung secara manual atau secara otomatis oleh alat EDM dan didarabkan dengan halaju piawai (v) menerusi atmosfera.

- $D = v \times (n/f)$ (To obtain distance)
- **$D = vt$** (t = time between the point of wave motion with the other point)

QUESTION & ANSWER

- Waves moves with a frequency of 5Hz and velocity of 2.5m/s from station A. The calculations showed 10.5 waves occur when it approached the station B. **Calculate** the horizontal distance A to B.

Solution

$$\begin{aligned}\text{Number of wave } (n) &= 10.5 \\ \text{Frequency } (f) &= 5 \text{ Hz} \\ \text{Time } (t) &= n/f \\ &= 10.5 / 5 \\ &= 2.1 \text{ second} \\ \text{Velocity } (v) &= 2.5\end{aligned}$$

$$\begin{aligned}\text{From formula, } \quad \mathbf{D} &= \mathbf{vt} \\ &= 2.5 \times 2.1 \\ \text{Distance} &= \mathbf{\underline{5.25 \text{ meter}}}\end{aligned}$$

- Transmitter (EDM) and receiver (Prism) tools are placed at the end of the line to be measured. Wave is transmit from transmitter to receiver.



Figure 1.1: Basic principle measurement

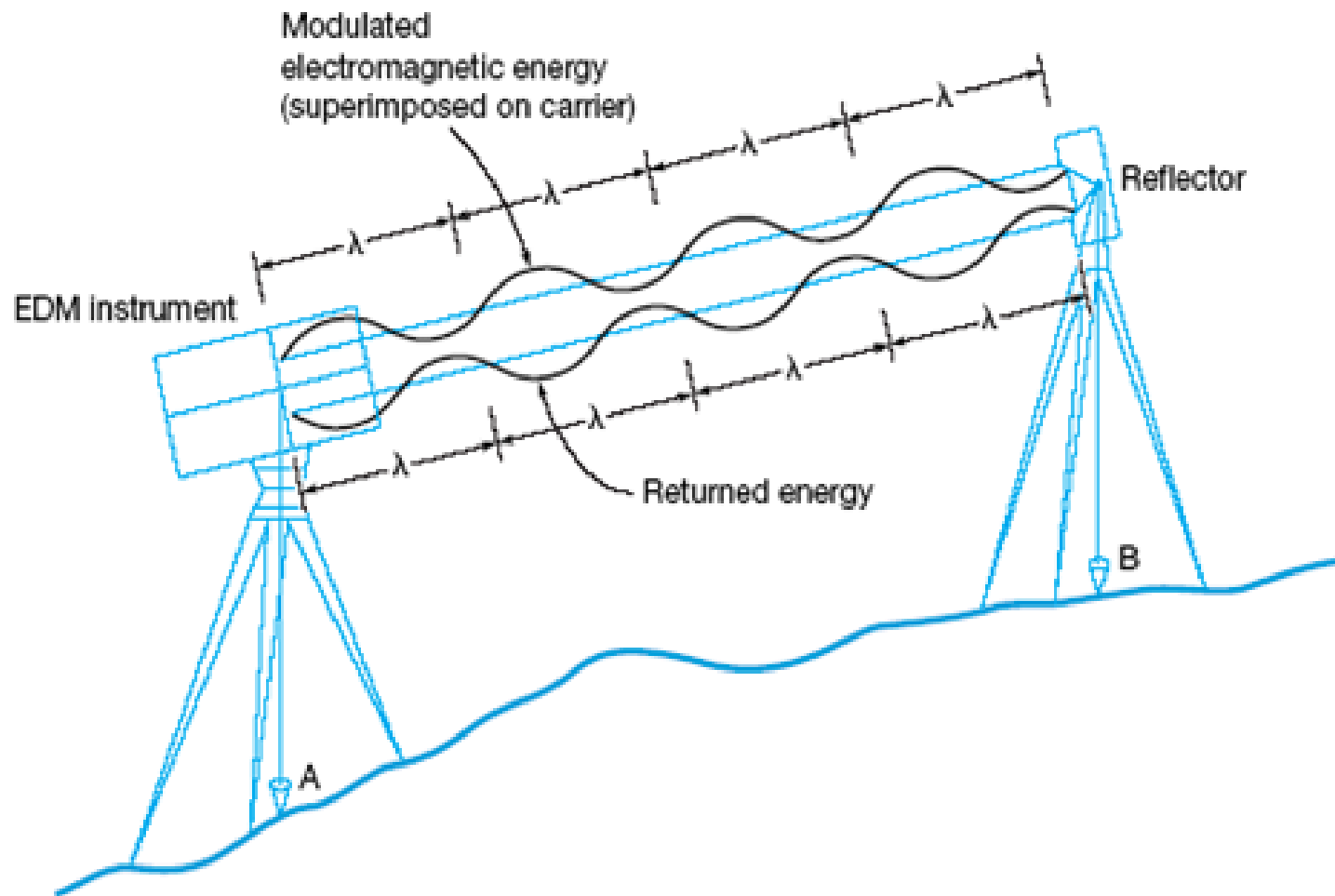
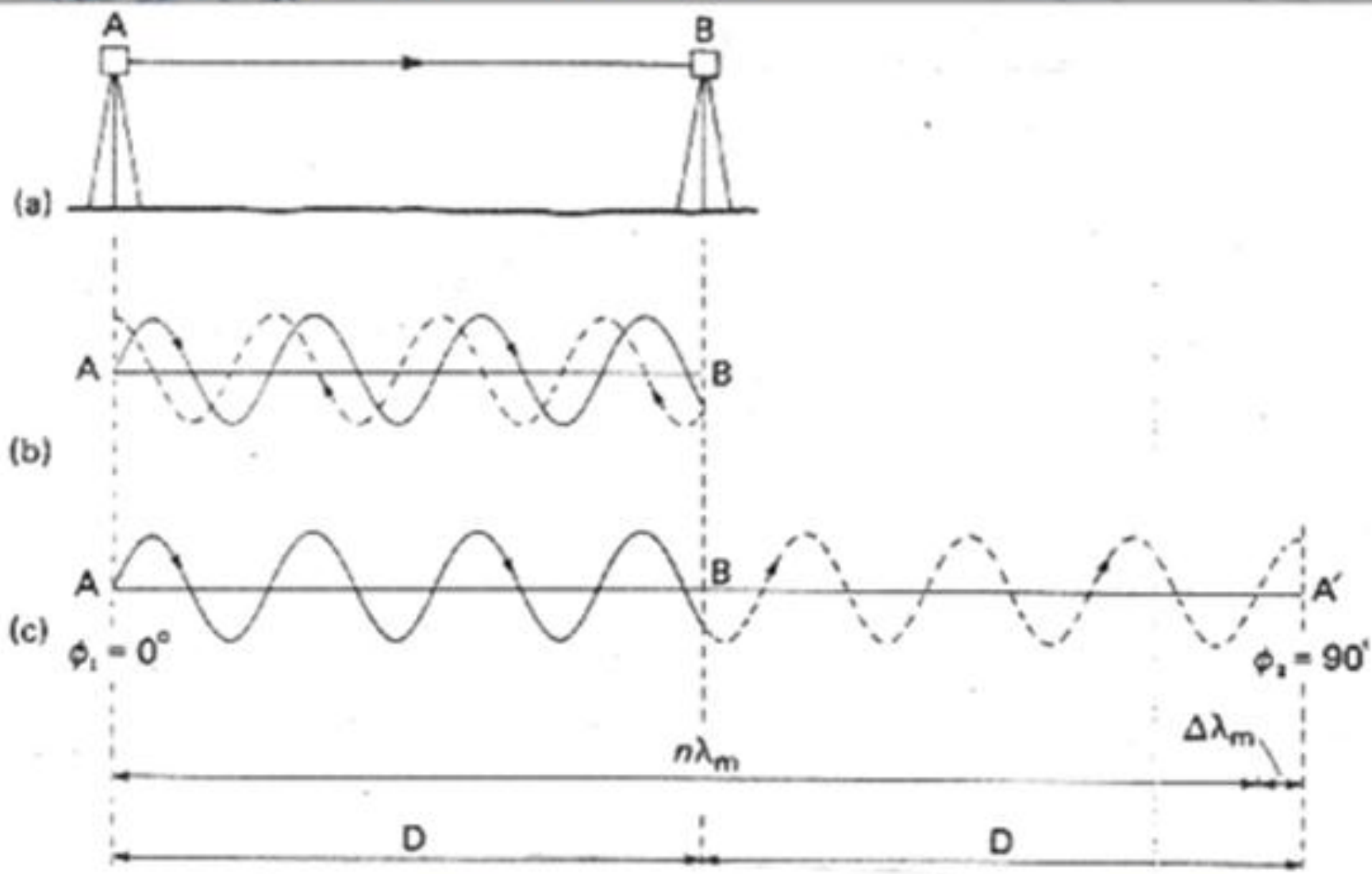


Figure 6-9 Generalized EDM procedure.

CONCEPT OF THE FRACTION

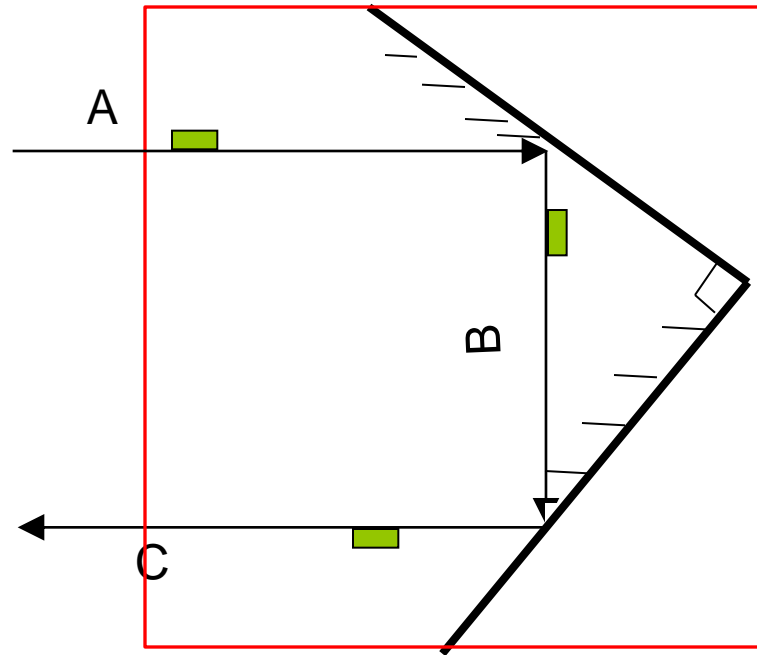


- Electromagnetic wave transmitted from transmitter in A to B. When wave transmit from A, time start in A to measure travel time of wave to the B. Distance can be compute if velocity of wave is known. Travel time of wave for EDM is 1×10^{-6} second.

Gelombang elektromagnetik dari pemancar di A diarah ke B, semasa gelombang mula dikeluarkan di A, jam dimulakan di A untuk mengukur masa perjalanan gelombang ke B. Jarak dapat dikira sekiranya halaju gelombang diketahui. Bagi EDM biasa, masa pergerakan gelombang adalah di dalam lingkungan 1×10^{-6} saat.

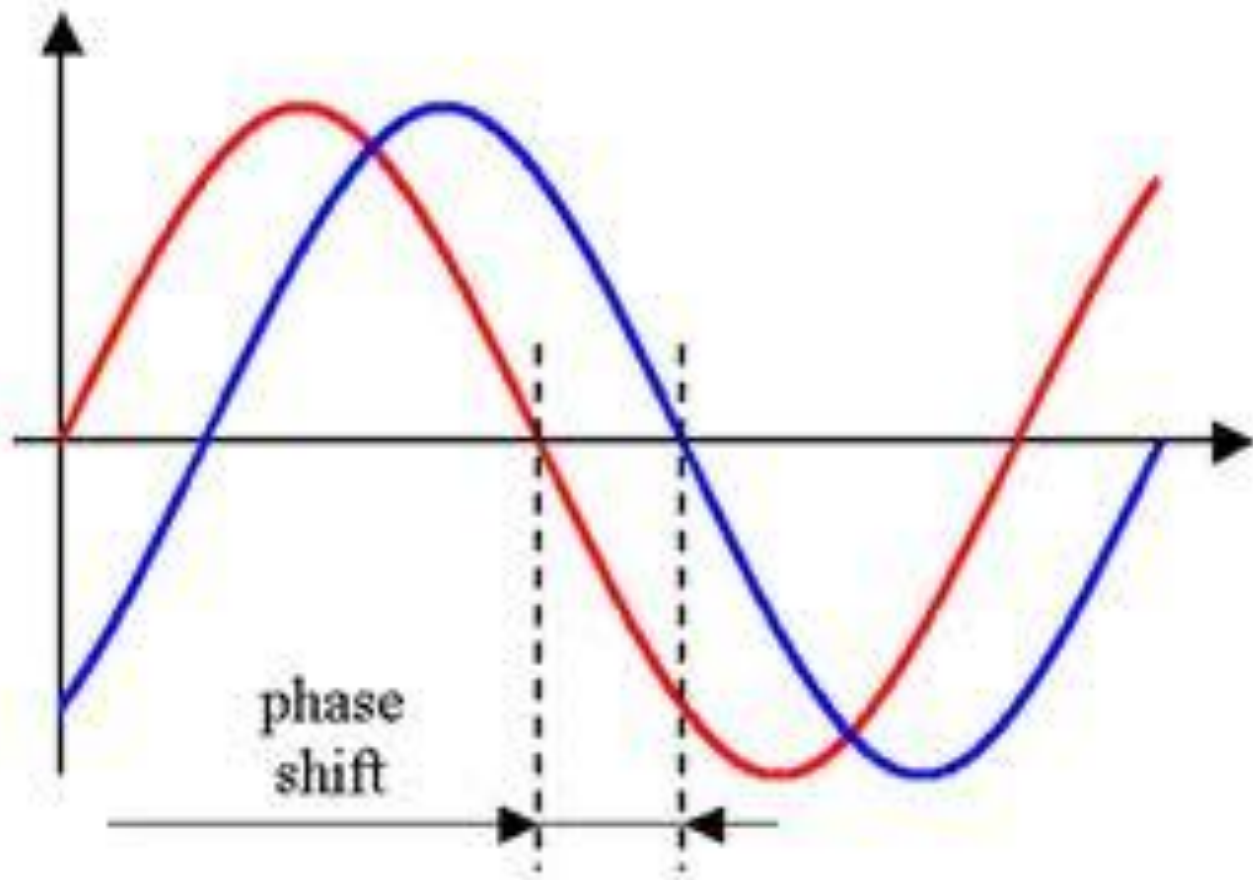
- Electromagnetic wave are reflected back from A to B. This mean, **A** act as a **transmitter and receiver**. Therefore, time can be measured more accurately in A, even though the time doubled.

Gelombang elektromagnetik dipatut semula ke arah A dari B, dengan ini alat di A bertindak sebagai pemancar dan juga penerima. Masa dapat diukur dengan lebih tepat di A walaupun masa ini berganda dua.



The angle between the rays A and C is double the angle between the two mirrors = $2 * 90^\circ = 180^\circ$

Notice that the objects will look upside down, notice the box at the tail of the arrow



- EDM system used phase difference calculation to get a distance. Phase difference is fraction of a round wave motion that may be converted into units of time or distance when frequency of wave is known. Conversion of phase difference to time or distance is made by the computer in transmitters.

Kebanyakan sistem EDM mengukur jarak dengan pengiraan selisih fasa (phase difference). Selisih fasa ialah pecahan dari satu pusingan pergerakan gelombang yang boleh ditukarkan kepada unit masa ataupun jarak apabila frekuensi gelombang diketahui. Penukaran selisih fasa kepada masa ataupun jarak dibuat oleh komputer di alat pemancar.

What is Electromagnetic Waves?

- Electrical energy is conveyed through the atmosphere. This creates an electrical disturbance in and around the aerial.

Tenaga elektrik dihantar melalui atmosfera. Jika arus elektrik dialirkan pada aerial, ini akan mewujudkan gangguan elektrik dalam dan sekitar aerial tersebut.

- The disturbance is not confined to the aerial but spreads out into space by varying the electric and magnetic fields in the medium surrounding the aerial.

Gangguan tersebut tidak tertumpu kepada aerial sahaja tetapi tersebar ke udara dengan mengubah-ubah medan elektrik dan magnet dalam media sekitar aerial.

Propagation of an Electromagnetic Wave

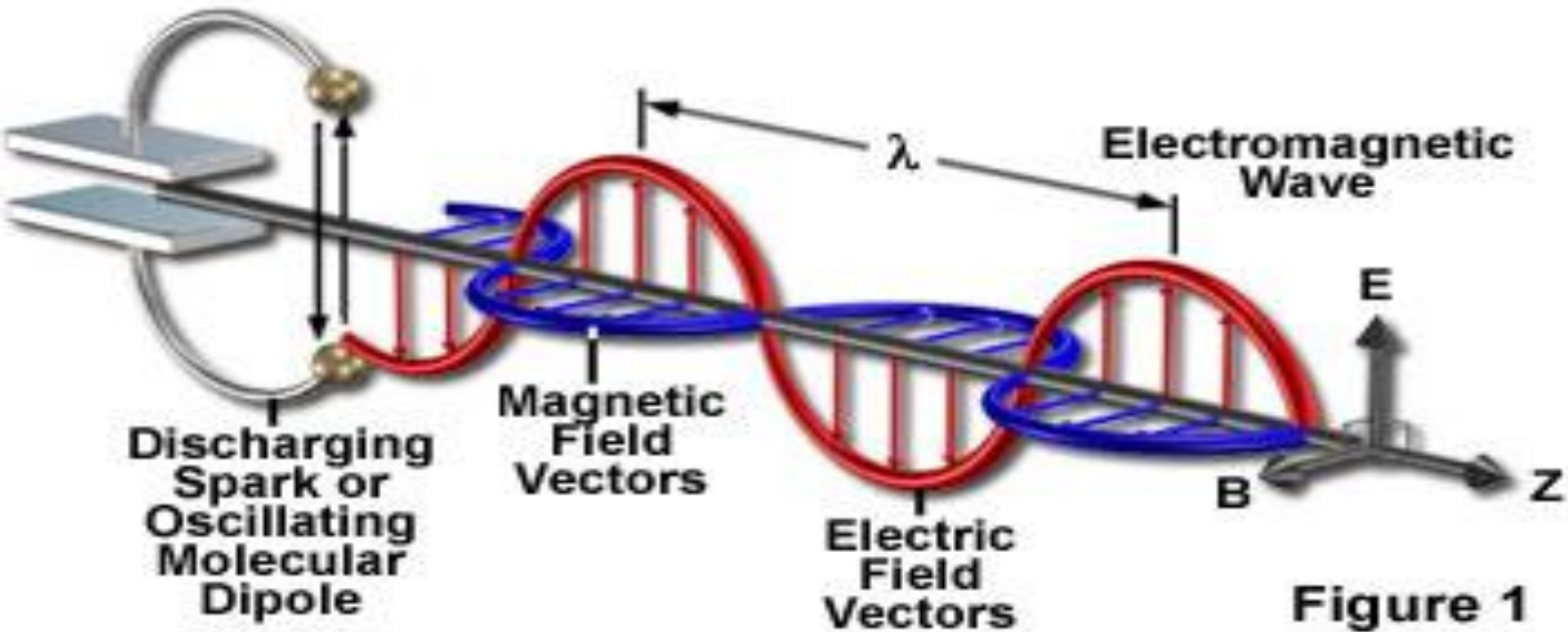
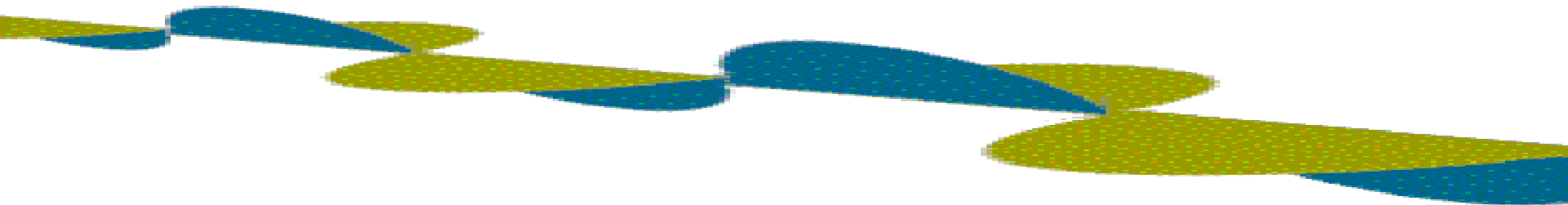


Figure 1



- Therefore, energy is propagated outwards and, since the energy is transmitted by varying electric and magnetic fields, the energy will be propagated by electromagnetic waves.

Oleh itu, tenaga dirambat keluar. Oleh kerana tenaga dihantar dengan medan elektrik dan magnet yang berbeza, maka tenaga dikatakan dirambat oleh gelombang electromagnet.

- Electromagnetic wave requires no material medium to support them and can be propagated in a vacuum or in the atmosphere.

Gelombang electromagnet yang wujud tidak memerlukan media bahan untuk menyokongnya dan boleh dirambat dalam hampagas atau atmosfera.

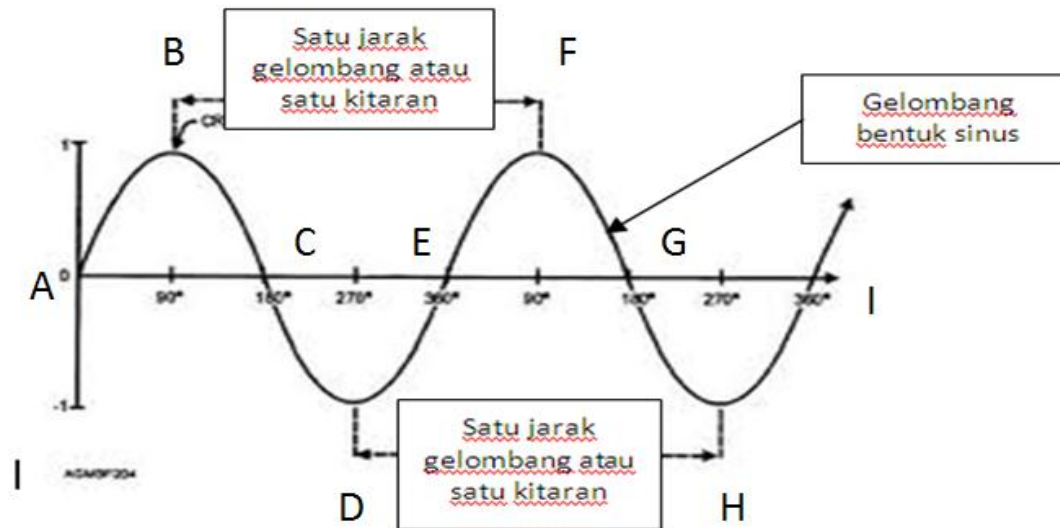
- The type of electromagnetic wave generated depends on many factors but, principally, on the nature of the electrical signal used to generate the waves.

Jenis gelombang electromagnet yang dijanakan bergantung kepada keadaan isyarat elektrik yang digunakan untuk menjana gelombang.

Type of Electromagnetic Wave

Ciri-ciri Gelombang Elektromagnet

- Extremely complex in nature
Sangat rumit dari segi keadaan dan bentuknya.
- It can be represented in their simplest form as periodic sinusoidal waves and therefore have predictable properties.
Digambarkan dalam bentuk sinus berkala dan mempunyai ciri-ciri yang boleh diramal.

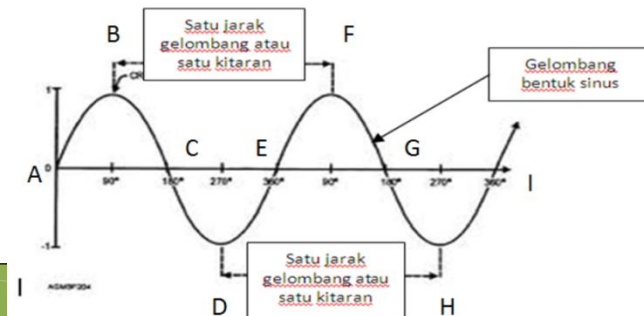


- Below figure shows a sinusoidal waveform which has the following properties.

Rajah di bawah menunjukkan gelombang sinus yang mempunyai ciri-ciri berikut :

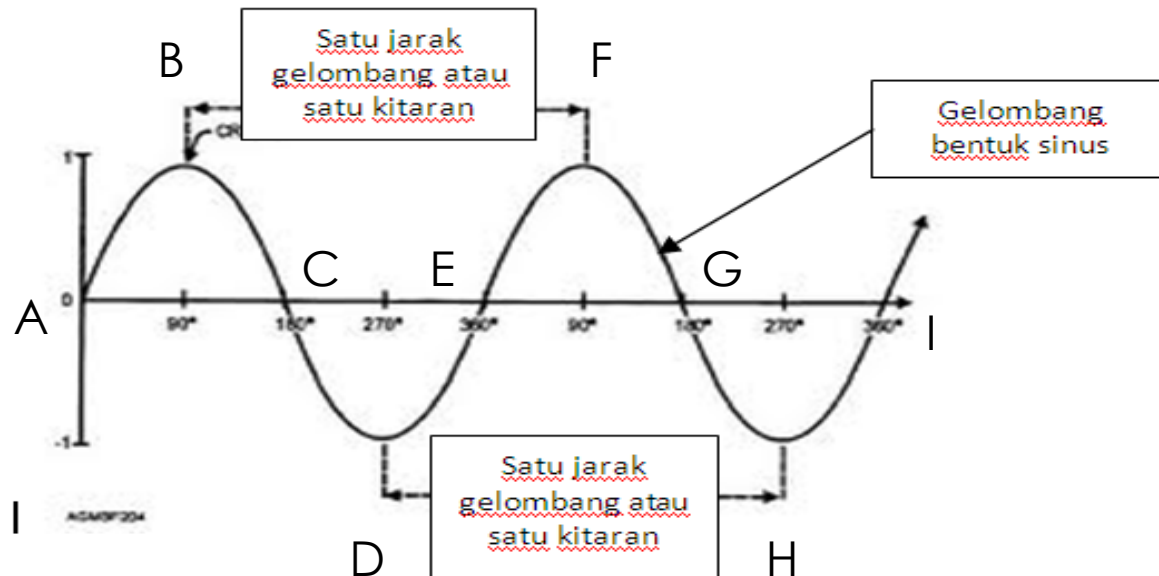
- The wave completes a cycle in moving from such identical points as A to E or D to H on the wave and the number of times in one second the wave completes a cycle is termed the frequency of the wave. Frequency is time taken for one complete wavelength

Gelombang melengkapkan satu kitaran dalam pergerakan dan titik-titik serupa di atas gelombang seperti A ke E atau D ke H. Beberapa kali dalam sesaat gelombang ini akan melengkapkan satu kitaran dinamakan frekuensi gelombang. Frekuensi gelombang adalah masa yang diambil untuk 1 gelombang yang lengkap.



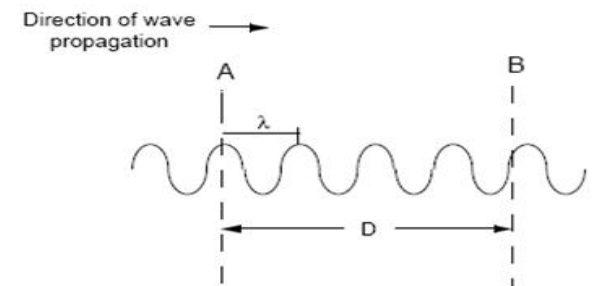
- ii. The wave length of a wave is the distance which separates two identical points on the wave or is that length traversed in one cycle by the wave and is denoted by λ metres.

Jarak gelombang (λ meter) - jarak yang memisahkan dua titik yang serupa di atas gelombang atau jarak yang dilalui oleh gelombang dalam satu kitaran.



- iii. The period is taken by the wave to travel through one cycle or one wavelength and it represented by T second
Masa (t saat) yang diambil oleh gelombang untuk bergerak melalui satu kitaran atau satu jarak gelombang.
- iv. The velocity of the wave is the remaining properties.
Halaju gelombang (v) adalah ciri selebihnya.
- v. Frequency wavelength and period can change according to the electrical disturbance.
Frekuensi (f), jarak gelombang (λ), dan tempoh (t) boleh berubah terhadap gangguan elektrik yang menghasilkan gelombang.

Relationship of Wavelength and Frequency of Electromagnetic Waves



- vi. The velocity of an electromagnetic wave in a vacuum is termed the *speed of light* and is given the symbol c . The value of c is 299 792 458 m/s.

Halaju gelombang (v) elektromagnet bergantung kepada media dimana gelombang itu bergerak. Dalam hampagas ia dipanggil laju cahaya (c).

$$\text{Speed of light} = \text{Wavelength} \times \text{Frequency}$$

$$\text{Wavelength} = \frac{\text{Speed of light}}{\text{Frequency}}$$

$$\text{Frequency} = \frac{\text{Speed of light}}{\text{Wavelength}}$$

$$c = \lambda f$$

System of Electronic Distance Measurement

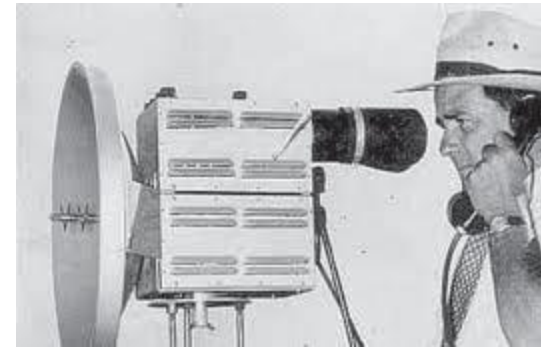
Have two systems :

- Micro wave system
- Electro optic system

Micro Wave System

- Carrier wave frequency used is 10 Ghz.
- Can measure distance until 100 km in bright weather condition.
- Required two instrument and two operator.
- All microwave tool required communicate between **Main** and **Remote** to help operator in conduct measurement.
- Brand tool using micro wave system in market :
Telluromter, Geodimeter, Macrometer and others.

Micro wave Tools



Tellurometer – model 1962-1970

Back and front of instrument (9kg with case)



Geodimeter in year 1966



Geodimeter Designed in 1959 by Weight of 50 kg.



Electro Optic System

- Use light and infra-red frequency. EDM with Infra-red frequency is cheap and easy to use. Many of EDM tools use Electro Optic System because the source of carrier wave is diode that transmit **infra red gallium arsenid (GaAs)**.

Lebih mendapat pasaran dalam EDM kerana menggunakan diod yang memancarkan infra merah gallium arsenaid (GaAs) sebagai punca gelombang pembawa.

- These diode can easier directly modulated the amplitude at high frequencies as EDM need.

Diod-diod ini boleh dimodulasikan amplitudnya secara langsung pada frekuensi-frekuensi tinggi spt yang diperlukan oleh EDM.

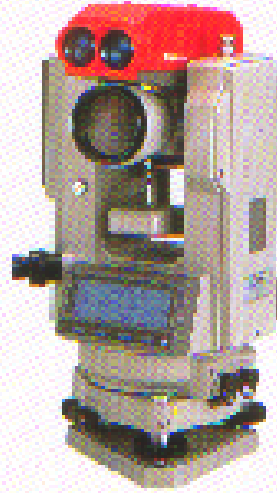
- Can measure short distance compare to micro wave system because power sent by using infra red carrier wave will decline quickly when the distance increased.

Boleh mengukur jarak pendek berbanding sistem gelombang mikro kerana tenaga yang dihantar menggunakan gelombang pembawa infra-red.

- Required reflecting mirror where infra red carrier wave will be reversed again to transmitter.

Memerlukan “cermin pembalik” dimana gelombang infa-red akan dibalikkan semula ke pemancar.

- Brand tool using Electro optic system in market Sokkia, Wild, Leica, Topcon and others.



EDM by SOKISSA

EDM by SOKISSA



Total Station by SOKISSA



Chain



Measurement tape



Prism

Edm / Total Station Errors and Effects

3 type of *Instrument Errors*:

- *Scale Error (or frequency shift)*
- *Zero error (or index error)*
- *Cyclic Error (or instrument nonlinearity)*

Total Station Errors and Effects

Scale Error (or frequency shift)

- Cause by variations in the **modulations frequency**, f , of the EDM instrument and the error therefore proportional to the distance measured.

Ini adalah disebabkan oleh perubahan frekuensi modulasi, f , pada alat EDM dan oleh itu selisih adalah berkadar dengan jarak yang diukur.

- The effect is much more noticeable on long lines and can usually be ignored for the short range.

Akibatnya, kesan lebih jelas ketara pada garisan jarak jauh dan biasanya boleh diabaikan untuk jarak pendek.

Zero error (or index error)

- Occurs if there are differences in the **mechanical, electrical and centers** of EDM instrument and reflector.

Wujud apabila ada perbezaan pada pusat mekanik, pusat elektrik dan pusat optik alat EDM dan pemantul-pemantulnya.

- Analogous to misscentring a EDM
Sama seperti ketidakpusatan alat EDM

- The error **not depends on range** and care must be taken to eliminate it.

Selisih ini tidak bergantung kepada julat jarak dan perhatian mesti diberi untuk menghapuskannya.

Cyclic Error (or Instrument Nonlinearity)

- Caused by **unwanted interference between electrical signals** generated in the EDM unit and can be investigated by measuring a series of known distances spread over the measuring wavelength of the instrument.

Selisih ini adalah disebabkan gangguan yang tidak dikehendaki antara isyarat-isyarat elektrik yang dijana dalam alat EDM. Selisih ini boleh diketahui dengan mengukur beberapa siri jarak yang telah diketahui.

- If calibration curve distance (observed – determined) is plotted against distance and a periodic wave is obtained, the EDM instrument has a cyclic error.

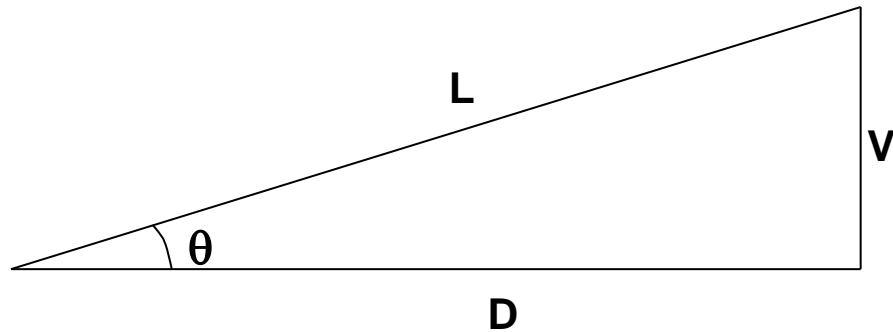
Jika jarak lengkung tentukan (dicerap – ditentukan) diplot melawan jarak dan satu gelombang berkala diperolehi, maka alat EDM tersebut mempunyai satu selisih berkitar.

- The effect- Can usually be ignored for ordinary engineering surveys but may have significance on longer lines or where a high precision is required.
Kesan ini biasanya boleh diabaikan untuk ukur kejuruteraan, tetapi boleh mempunyai kesan pada garisan-garisan jauh atau di mana kejituan tinggi diperlukan.

Accuracy and Correction of Slope Distance

- When use EDM for measurement, atmosphere and tool effect may cause the difference in displayed distance and therefore correction is needed.
- *Apabila pengukuran dibuat dengan menggunakan alat EDM, kesan-kesan atmosfera dan alat boleh menimbulkan selisih pada jarak yang dipamerkan dan oleh itu pembetulan diperlukan.*
- To obtained horizontal distance, slopes distance measured need to do geometric correction.
- Above figure show how to do slope distance correction.
- *Tambahan pula adalah menjadi kebiasaan untuk membuat pembetulan geometrik kepada jarak-jarak cerun yang diukur supaya jarak mendatar (ufuk) boleh diperolehi.*

$$\text{Slope correction (V)} = L(1 - \cos \theta)$$



$$\text{Horizontal Distance (D)} = L - \text{Slope Correction}$$

Where ;

L = Slope distance

D = Horizontal Distance

V = Vertical Distance

θ = Vertical Angle

Example Calculation in EDM Topic

- 1.) A measurement has been made from A to B with distance of 200m and vertical angle of $3^{\circ} 10' 05''$. B located at a hilly slopes. Calculate the Slope Correction
- A. 0.306
 - B. 0.330
 - C. 0.312
 - D. 0.388
- 2.) Based on above question, calculate the horizontal distance of A to B.
- A. 200.101
 - B. 198.510
 - C. 199.694
 - D. 199.999



3.) EDM equipment has been erected at the station A. The wave frequency is 11 Hz and velocity is 7.3 m/s. The number of wave is 13.8 from A to B. calculate the horizontal distance A to B.

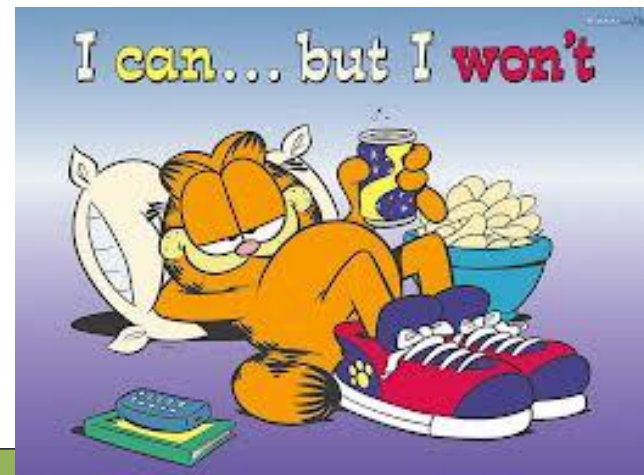
(6 Marks)

4.) At station A, the wave moves with a frequency of 5 Hz, the velocity of 3.0 m / s. The calculations showed 11.5 waves occur when it approached the station B. Calculate horizontal distances A to B.

- A. 7.5 m
- B. 6.9 m
- C. 6.0 m
- D. 5.0 m

5.) A measurement on a slope was performed using EDM. Calculate the horizontal distance of A to B if the distance between A (on the ground) and B (on the slope) is 300 meter and the vertical angle is $3^{\circ} 10' 05''$.

(4 marks)



List Types of Project

Engineering Survey

- Produce large-scale plan (<1:1000)
- Type of survey:
 - Routes survey, roads, rivers, drains, water pipes, and gas and so on.

Ukur laluan, jalanraya, sungai, perparitan, paip air, dan gas dan sebagainya

- Surveying the site, survey details, depth and other topographic features.

Ukur tapak, ukur butiran, ukur topografi dan lain-lain.





Setting-out Survey

- Marking of engineering construction such as buildings, bridges, ports and others.

Penandaan terhadap binaan kejuruteraan seperti bangunan, jambatan, pelabuhan dan lain-lain.

- Involve variety of EDM with the facility :

Melibatkan pelbagai jenis EDM dgn kemudahan :

- Tracking – measure distance to target which moves 10- 20mm
- Inter-com – One way relationship
- Visible guidance system
- LCD version of remote receiver guidance
- Tracking – ukur jarak ke sasaran yang bergerak 10-20mm*
- Inter-com – Perhubungan sehala*
- Sistem panduan tampak*
- LCD version of remote receiver guidance*

Engineering Survey Instrument



Engineering Survey Software

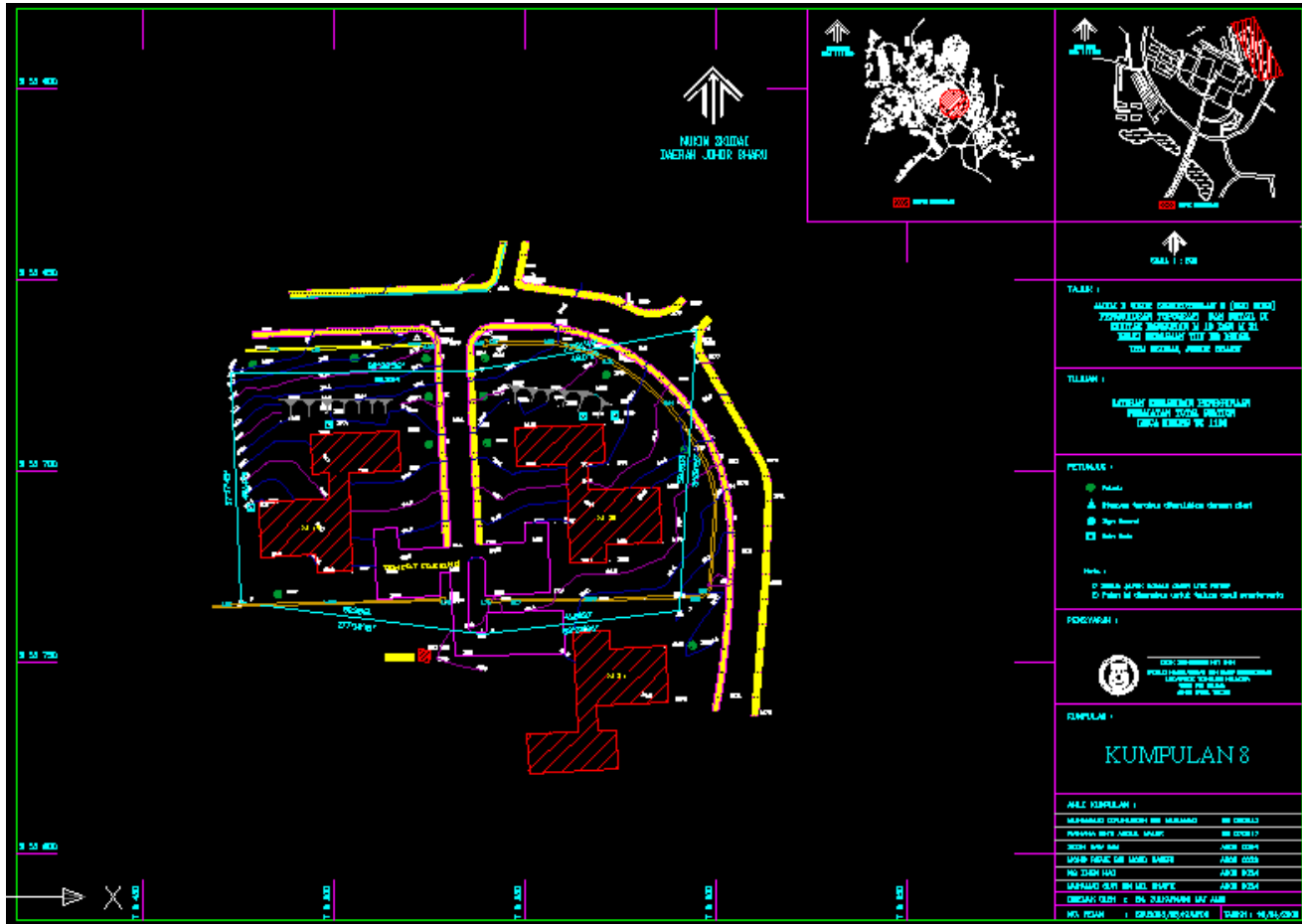
- ✍ Specific software for survey data
- ✍ To compute, editing, query & output data
- ✍ Example :



Autodesk®



- ✍ The development is increasingly and sophisticated.
- ✍ Generally it contain integrated module package to resolve comprehensively in all survey operation, engineering and design



Topography plan using AutoCAD

Latest development of Total Station instrument

- Previously surveyor and engineer only used tape method or optical method to measure distance
- Problem in field if using tape or optical method, e.g. measure a great distance can cause other problem for example :
 - calculate a distance without doing survey which demand time making the calculation
- The used of EDM has facilitated, accelerate (memudahkan, mempercepatkan)and give high precision on a job that carried out.
- EDM inventors has made modification from time to time to repair weakness in EDM equipment.

- EDM nowadays, have software to solve calculation in field. (e.g. total station – able to solve problems such as make a calculation, recording and storing data)
- The storing data can be downloaded to computer
- Therefore, survey equipment always change according to technology circulation.
- Total station have various brands such as Leica, Topcon, Geodimeter and so on.

Next Class.....

Tutorial 1....

Quiz 1.....

Prepare...

good luck!

