CHAPTER-8
TOPOGRAPHIC SURVEYING AND MAPPING

Topographic Survey:

- Determine position of natural and man made features
- Features drawn to scale on plan or map
- Determine ground elevations (contours, cross-sections and profiles)
- Vast majority done by aerial survey

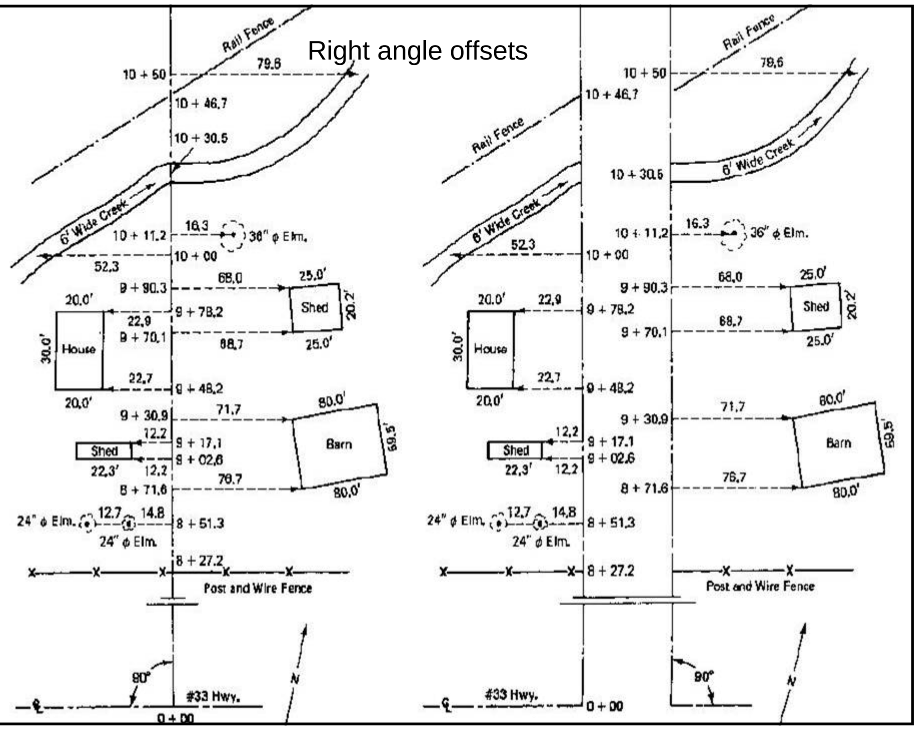
- EDM and total station (x-y zonal location) and vertical location (elevation) by one sighting
- Rectangular and polar surveying techniques Rectangular technique:

- Right angle offsets for location detail

- Polar technique use stadia or electronic techniques

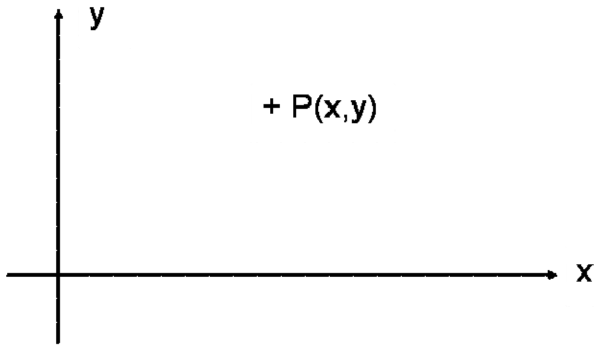
- Elevation for profiles and cross section

Right angle offsets



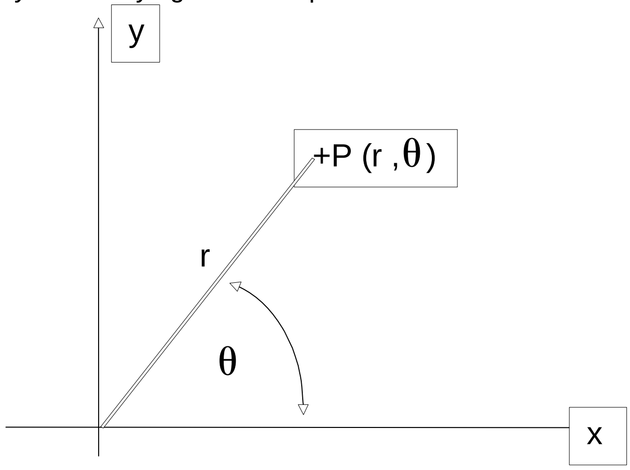
Coordinates.

You are all familiar with the following way of identifying a point P



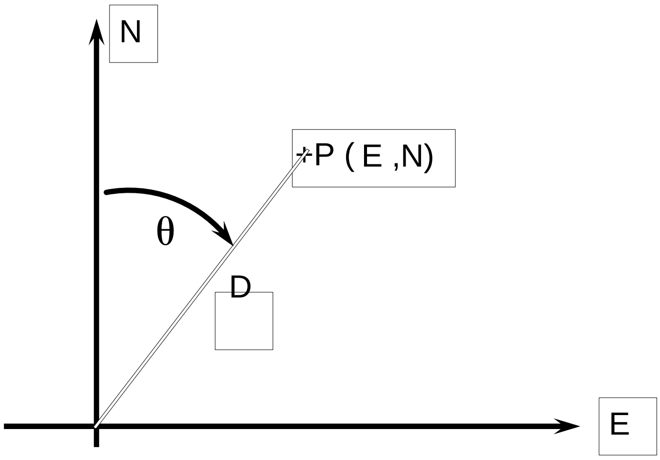
This is known as a RECTANGULAR Coordinate System.

Another way of identifying the same point P is



This is known as a **POLAR Coordinate System.**

FOR SURVEYING we use a slightly different form of notation ...
instead of x,y we use E,N (Easting, Northing)



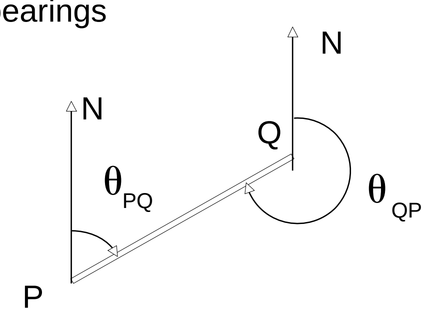
Easting is always quoted first and then **Northing**.

θ is always measured in a **CLOCKWISE** direction from **North.**

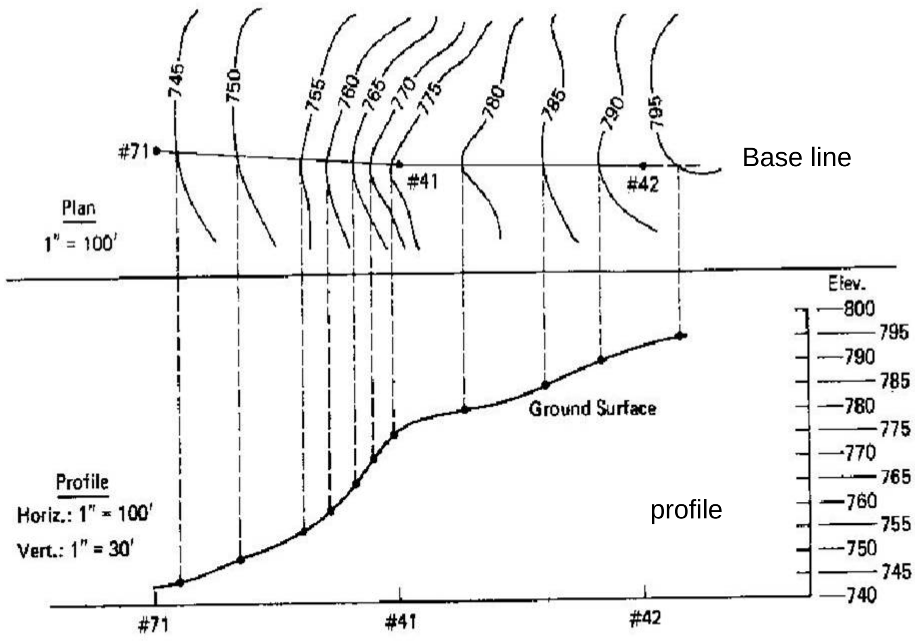
θ is known as the **WHOLE CIRCLE BEARING. (WCB)**

We MUST be able to Convert from Rectangular to Polar VERY QUICKLY. (and from Polar to Rectangular)

Any line has two bearings



We consider that the **line PQ** ***is a different line to*** **line QP**

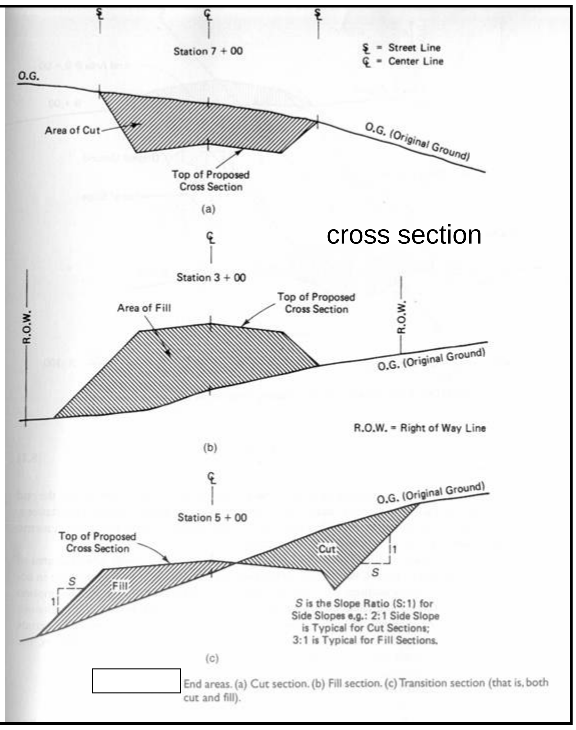


Plan and profile [from Figure 8.8(b)].

$$V = \frac{(A1+A2)\,L}{2}$$

$$V = \frac{(A1+4\,Am+A2)\,L}{6}$$

Other Rules



Scales and Precision:

Scale: Ratio between plan distance and ground distance
Consistent through the plan
Equivalences e.g. 1” = 50’
Fractions e.g. 1 : 500
Table 8.1
Small scale and intermediate scale done by aerial survey

Precision

- If points to be plotted on at scale 1:500 → precision 0.25 m
- If points to be plotted on at scale 1:20,000 → precision 10 m

- Some details can be precisely determined → e.g. bldg corner
- Some details cannot precisely determined → e.g. stream banks
- Some details can be determined with moderate precision → e.g. single large tree

Details that can be well defined is located with more precision than required just for plotting because:

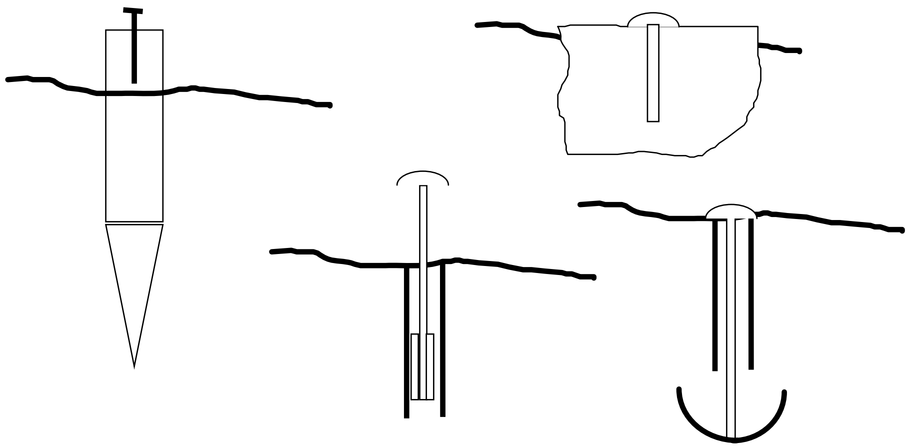
- o It take little effort
- o Uniform practice
- o Some details are shown as layout dimensions

- If area contain only natural feature, stadia is used
- All topographic surveys are tied into both horizontal and vertical control (Benchmark)
- Horizontal control could be:
  - Closed transverse
  - Transverse from coordinate grid monuments
  - Close to another coordinate grid monuments
  - Route centerline
  - Assumed baseline

Horizontal Control

•Horizontal control is required for initial survey work (detail surveys) and for setting out.

CONTROL or TRAVERSE STATIONS.



-Measurement taken to establish control are more precise than other measurements

-Control should be accurate and well references

-Control should be used for additional work (e.g. layout)

Location by Right Angle Offset

-Used in all topographic survey except mapping

-Provide location of details and area elevation taken by X-section

-Measure distance to base line and station on baseline

-Baseline laid by stakes (nails),

-Sketch in note book

-Tape can be laid on baseline if terrain is smooth

-Details on both sides of baseline or make split baselines

-Penta prism or (swing-arm technique (Appx.)

-SAT good result for short of test 15 m otherwise use penta prism or transit

Cross Section and Profile

-Cross section to the baseline

-Profile along the baseline

-Elevation plotted as spot elevation, contours or end area for construction quantity estimation

-Intervals 20/30 in. – in changing terrain 10-15 m + any sudden change in terrain (top, bottom of slops)

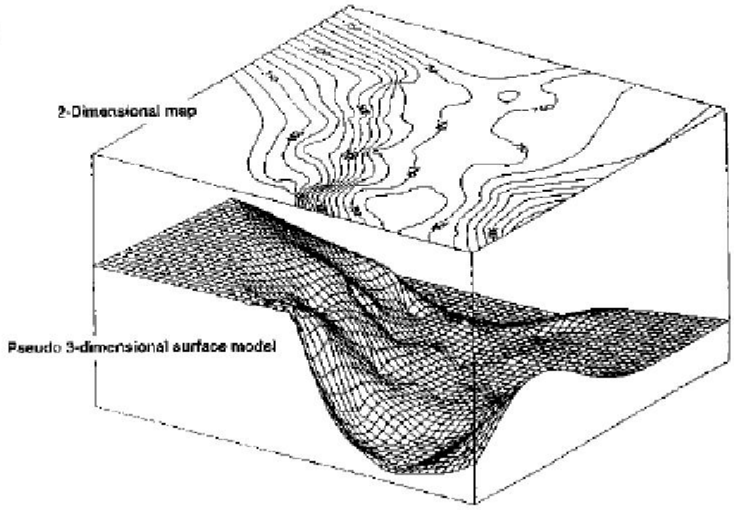
Mapping Survey

Introduction

- Mapping surveys are made
  - to determine the locations of **natural**, and **cultural** features on the earth's surface, and
  - to define the configuration of that surface.
- **Natural features** on the maps include
  - vegetation,
  - rivers,
  - lakes,
  - oceans, etc.

Topographic Survey

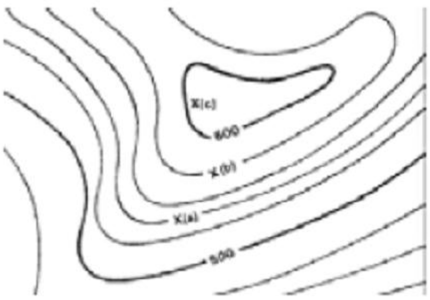
Contours



Topographic Survey

Contours

- The most common method of representing the topography of an area is to use ***contour lines***



- A ***contour line*** is an imaginary level line that connects points of equal elevation

Introduction

- **Cultural features** on the maps are the products of people, and include
  - roads,
  - railroads,
  - buildings,
  - bridges,
  - canals,
  - boundary lines, etc.

Introduction

- Type of maps
  - **planimetric**; include natural and cultural features in the plan view only, and
  - **topographic**; include planimetric features and show the configuration of the earth's surface.

Basic Methods for Performing Mapping Surveys

- **Aerial** (photogrammetric) techniques, and
- **Ground** (field) techniques.
- Often combination both are employed.

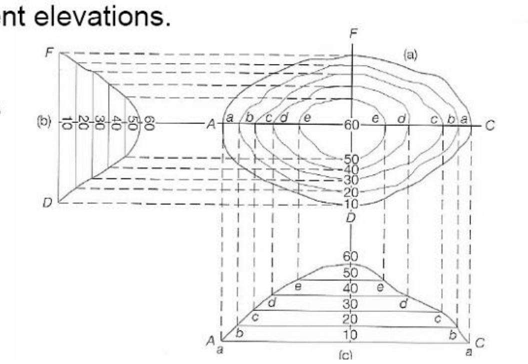
Map Scale

- The ratio of the length of an object or feature on a map to the true length of the object or feature.
- Map scales are given in three ways:
  - by ratio or representative fraction, such as 1:2000 or 1/2000
  - by an equivalence, for example 1 in. = 200 ft.
  - graphically using either a bar scale or labeled grid lines spaced.

Contours

- A contour is a line connecting points of equal elevations.
- Contours cannot be seen in nature.
- On maps, contours represent the planimetric locations of the traces of level surfaces for different elevations.

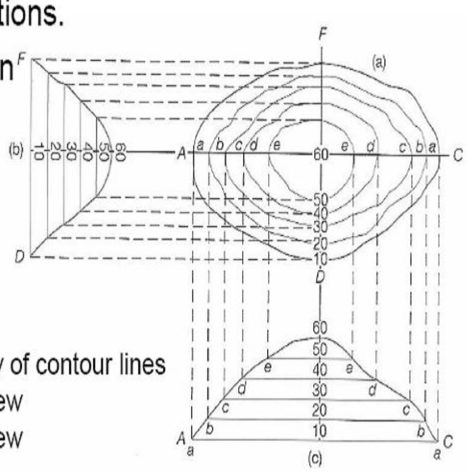
(a) Plan view of contour lines
(b) Profile view
(c) Profile view



Contours

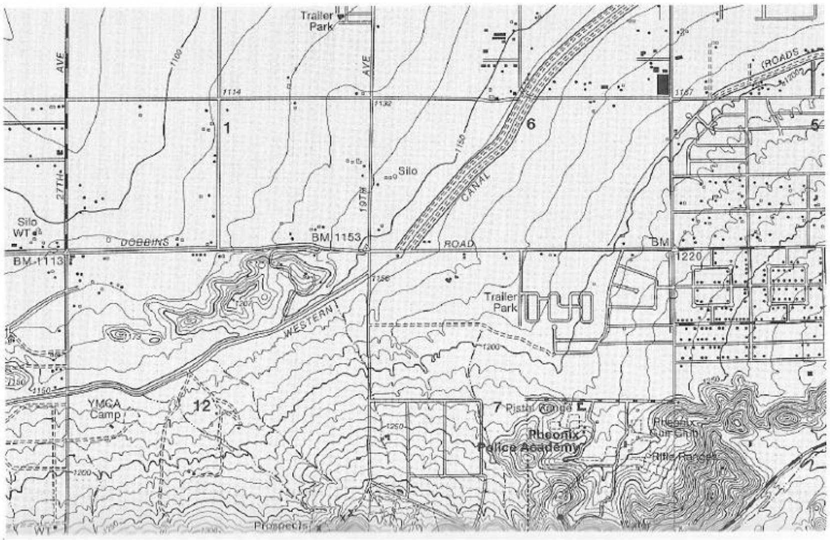
- A contour is a line connecting points of equal elevations.
- Contours cannot be seen in nature.
- On maps, contours represent the planimetric locations of the traces of level surfaces for different elevations.

- The elevation difference between the adjacent contours is called the ***contour interval***.
- The contour interval depends on a map's purpose and scale.



(a) Plan view of contour lines
(b) Profile view
(c) Profile view

Contours



Topographic Survey

Characteristics of Contours

- Closely spaced contours indicate steep slopes
- Widely spaced contours indicate moderate slopes
- Contours should be labeled to the elevation value
- Contours are not shown going through buildings
- Contour line do not cross

Topographic Survey

Characteristics of Contours

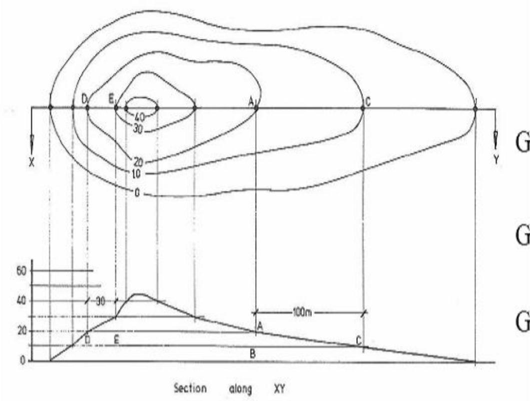
- Depression and hill look the same; note the contour value to distinguish the terrain
- Important points can be further defined by including a "spot" elevation
- Contour lines tend to parallel each other on uniform slopes

Characteristics of Contours

- Contour lines must close on themselves, either on or off a map. They cannot dead-end.
- Contours are perpendicular to the direction of maximum slope.
- The slope between adjacent contour lines is assumed to be uniform.
- The distance between contours indicates the steepness on a slope.
  Wide separation → Gentle slopes
  Close spacing → Steep slope
  Even and parallel spacing → Uniform slope
- Irregular contours: rough, rugged country
- Smooth lines: more uniformly rolling terrain.
- Concentric closed contours that increase in elevation represent hills.

Characteristics of Contours

- Contours of different elevations never meet except on a vertical surface such as a wall, cliff, or natural bridge.
- A contour cannot branch into two contours of the same elevation.
- Contour lines crossing a stream point upstream and form V's

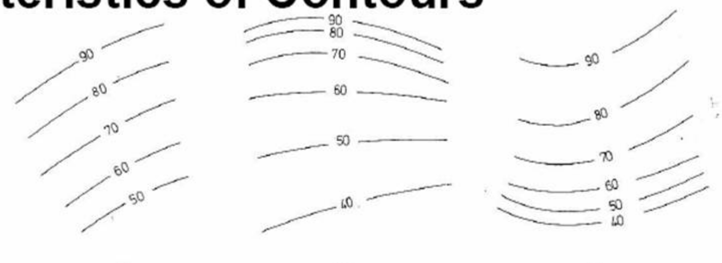


$$\text{Gradient} = \frac{AB}{BC} = \frac{\text{Vertical interval}}{\text{Horizontal equivalent}}$$

$$\text{Gradient along AC} = \frac{10}{100} = \frac{1}{10} = 1 \text{ in } 10$$

$$\text{Gradient along DE} = \frac{10}{30} = \frac{1}{3} = 1 \text{ in } 3$$

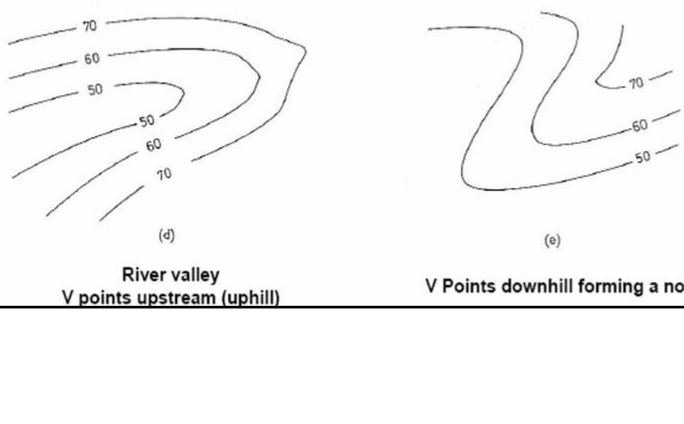
Characteristics of Contours



(a)
Regular Gradient

(b)
Concave Slope

(c)
Convex Slope



(d)
River valley
V points upstream (uphill)

(e)
V Points downhill forming a nose

Topographic Survey

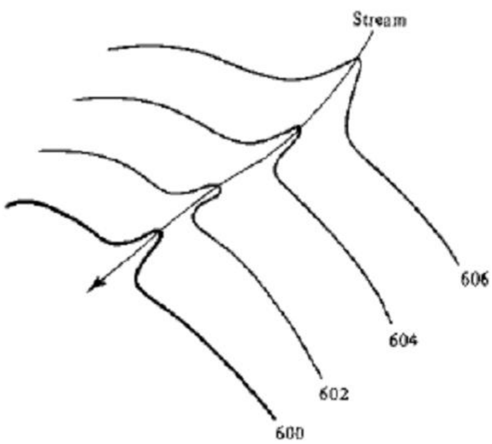
Contours

There are several rules to note when viewing topographic maps:

- **The rule of Vs:** sharp-pointed V usually are in stream valleys, with the drainage channel passing through the point of the V, with the V pointing upstream.
- **The rule of Os:** closed loops are normally uphill on the inside and downhill on the outside, and the innermost loop is the highest area.
- **Spacing of contours:** close contours indicate a steep slope; distant contours a shallow slope. Two or more contour lines merging indicates a cliff.

Topographic Survey

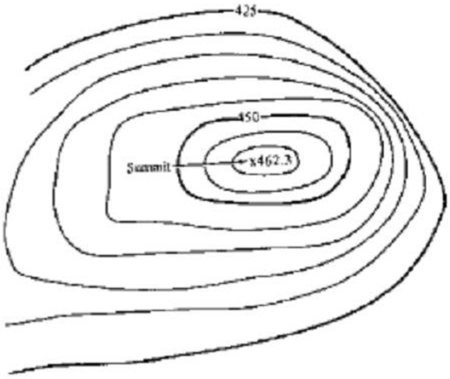
Contours



- Contours that point up hill can indicate a valley or stream

Topographic Survey

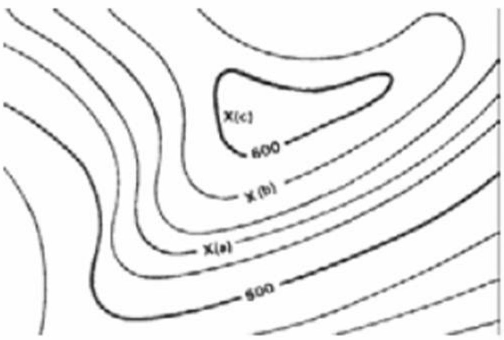
Contours



- Imagine a hill that has its top sliced off with a really big knife

Topographic Survey

Contours



- When is the steepest part of this terrain?
- The shallowest part?

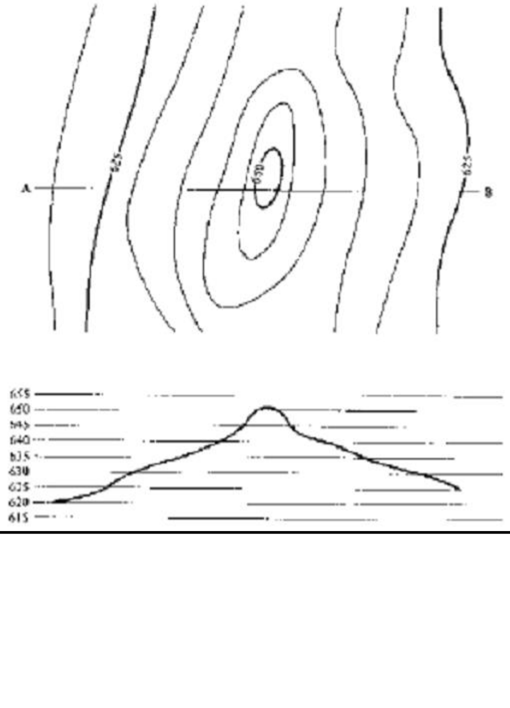
Topographic Survey

Contours

- The selection of the contour is important
- The contour interval should be small enough to give the desired topographic detail while remaining economic
- Usually every fifth contour line is shown in a heavy, wider line, this is called a ***index line***

Topographic Survey

Contours



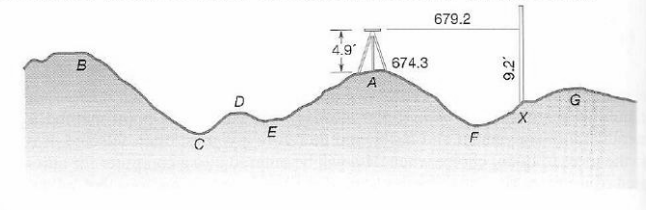
Locating Contours

- Direct Method
- Indirect Method

- **Direct Method**: In this method, the contour lines are physically followed on the ground using a total station.
  - After the instrument set up, the HI is established, and the telescope oriented horizontally.
  - Then for the existing HI, the rod reading (FS) that must be subtracted to give a specific contour elevation is determined.
  - The rod person selects trial points expected to give this minus sight, and is directed uphill or downhill by the instrument operator until the required reading is actually secured.

Locating Contours

- **Direct Method**:
  - For example: The instrument set up at point A, elevation 674.3 ft, hi 4.9 ft, and HI 679.2 ft. If the 5-ft contours are being located, a reading of 4.2 or 9.2 with the telescope level will place the rod on a contour point.
  - The 9.2-ft rod reading means that point X lies on the 670-ft contour.
  - After the point which gives the required rod reading has been located by trial, the horizontal position of the point is determined by measuring the horizontal distance and direction from the instrument.

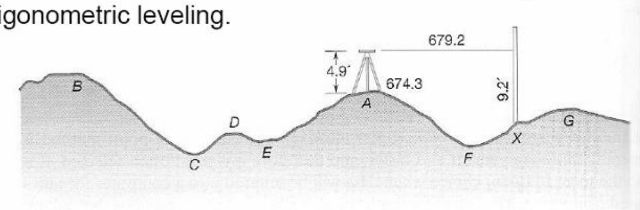


Locating Contours

- **Direct Method**
  - This method is not practical in rough terrain.
  - Neither is it convenient for observing data to be used in computer-driven automated contouring systems.

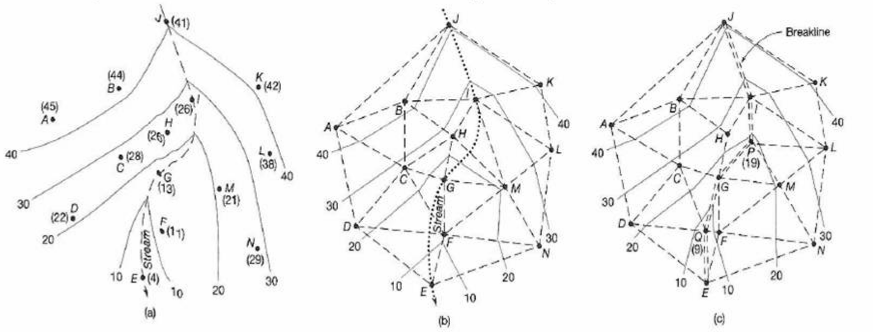
Locating Contours

- **Indirect Method**:
  - No attempt is made to follow the contour lines.
  - Instead a series of spot levels is taken at readily identifiable locations (controlling points) that are critical to the proper definition of the topography such as B, C, D, E, F, and G.
  - Trees, manholes, and intersections of walls and fences are also included.
  - Elevations are determined on these points using total station by employing trigonometric leveling.



Locating Contours

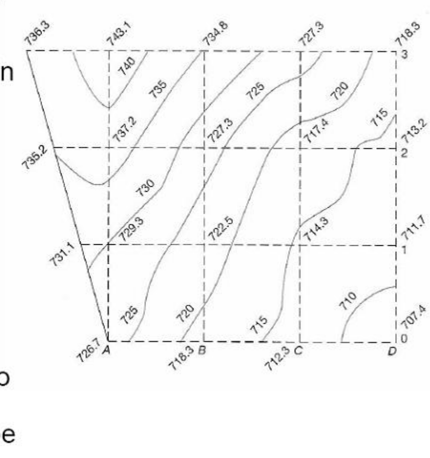
- **Indirect Method**:
  - Horizontal distance and azimuth are also measured to locate the points.
  - The position of controlling points are then plotted, and contours interpolated between elevations of adjacent points.



Contours compiled by hand　　Contours compiled by Model

Locating Contours

- **Coordinate Squares or "Grid" Methods**
  - The area to be surveyed is staked in squares 5, 10 20, or 40 m (10, 20, 50, or 100 ft) on a side.
  - Elevations of the corners can be obtained by differential or trigonometric leveling .
  - Contours are interpolated between the corner elevations by estimation or by calculated proportional distances.
  - A drawback of the method is that no matter how dense the grid, critical points (high and low spots and slope changes) will not generally identify.



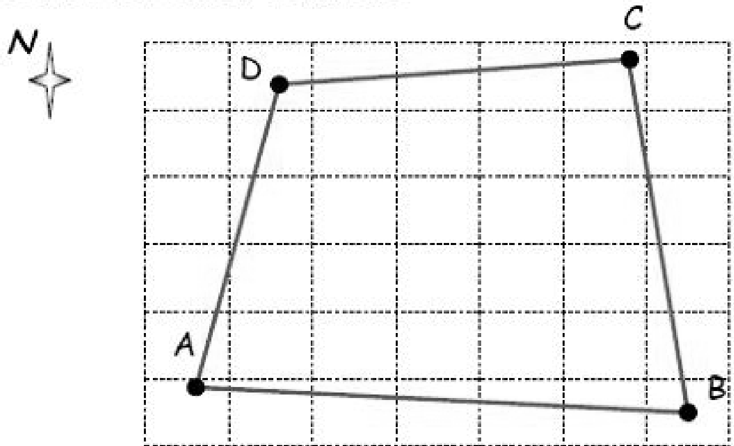
Topographic Survey

Construction of Contours

- The first step in developing a contour map is measuring the elevations of a group of points
- It will be easier for us to establish a rectangular grid of points (marked with flags) and measure the elevation
- The location of the flag points can be established by taping and checked by pacing or the odometer

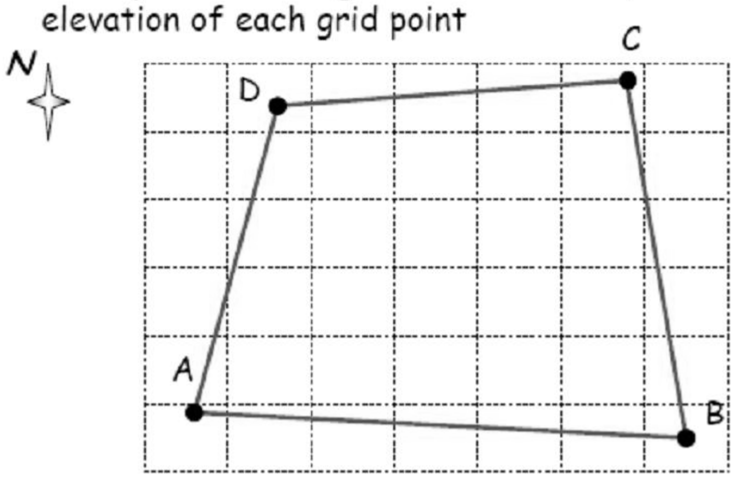
Topographic Survey

Construction of Contours

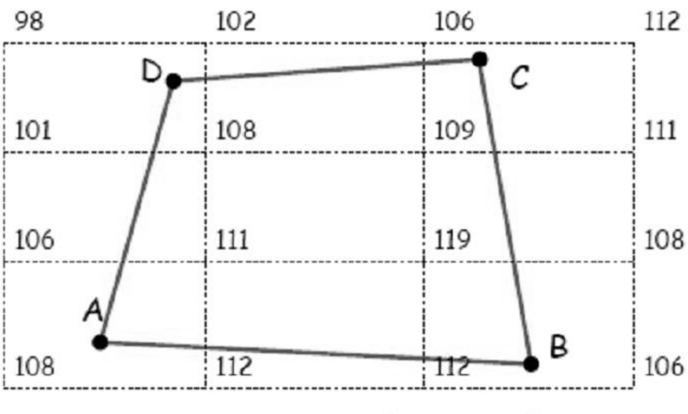


Topographic Survey

- Once your contour grid is established, measure the elevation of each grid point



Topographic Survey



- We want a contour map on 5 ft intervals
- The grid is rectangular, the dimensions of the sides are 80 ft (north) and 100 ft (east)

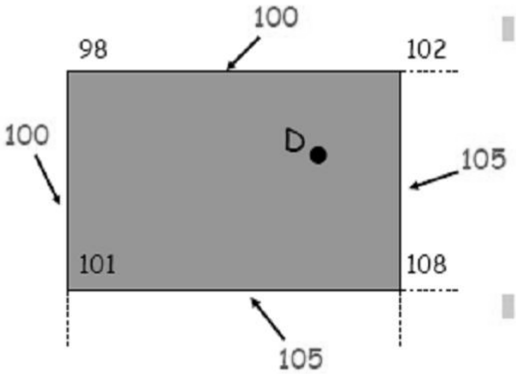
Topographic Survey

Construction of Contours

- The basic method for estimating contour is applied to each grid cell individually
- Use ***linear interpolation*** to find the location of the desired contour interval
- Let consider the cell in the upper left-hand corner - remember the contour interval is 5 ft

Topographic Survey

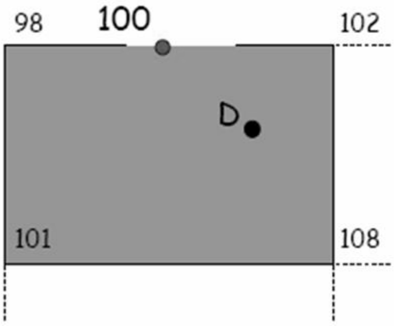
Construction of Contours

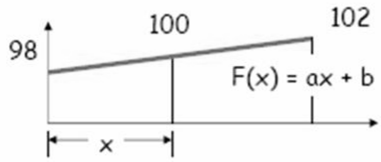


- First see if a contour interval exist between nodes of the grid cell; if so, estimate where along the side the contour interval would be located
- Apply simple linear interpolation to each side to locate the contour interval

Topographic Survey

- Let's look at the top edge of the grid cell





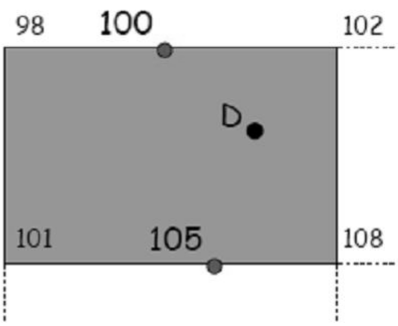
$$a = slope = \frac{102 - 98}{100}$$

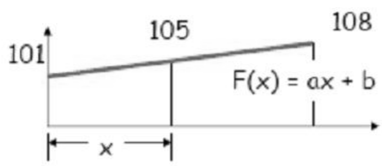
$$b = \text{intercept} = 98$$

$$x = \frac{2(100)}{4} = \boxed{50ft} \quad \longleftarrow \quad 100 = \frac{4}{100}x + 98$$

Topographic Survey

- Let's look at the bottom edge of the grid cell





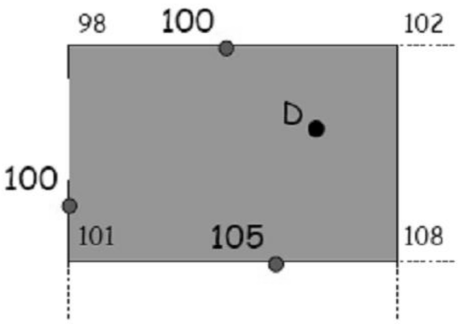
$$a = slope = \frac{108 - 101}{100}$$

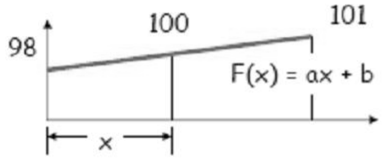
$$b = \text{intercept} = 101$$

$$x = \frac{4(100)}{7} = \boxed{57ft} \quad \longleftarrow \quad 105 = \frac{7}{100}x + 101$$

Topographic Survey

- Let's look at the left edge of the grid cell





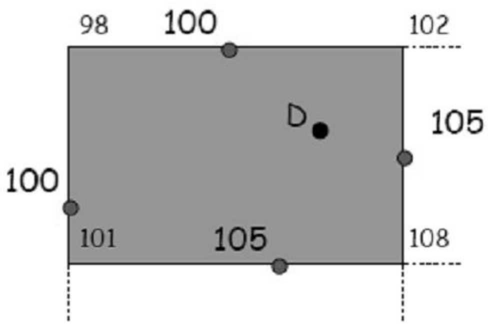
$$a = slope = \frac{101-98}{80}$$

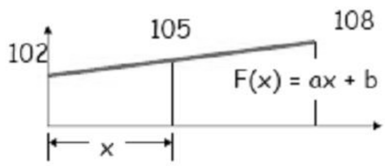
$$b = \text{intercept} = 98$$

$$x = \frac{2(80)}{3} = \boxed{53ft} \leftarrow 100 = \frac{3}{80}x + 98$$

Topographic Survey

- Let's look at the right edge of the grid cell





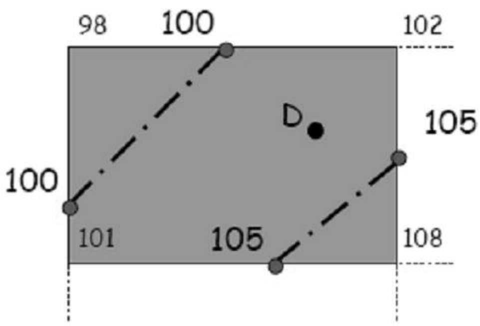
$$a = slope = \frac{108-102}{80}$$

$$b = \text{intercept} = 102$$

$$x = \frac{3(80)}{6} = \boxed{40ft} \leftarrow 105 = \frac{6}{80}x + 102$$

Topographic Survey

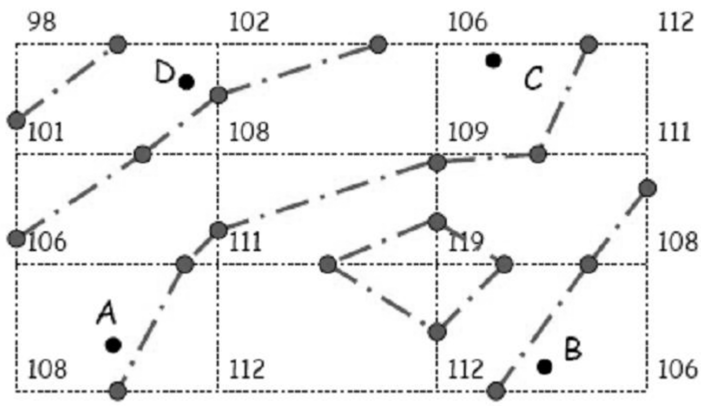
- Locate the contour intervals locations on the grid cell



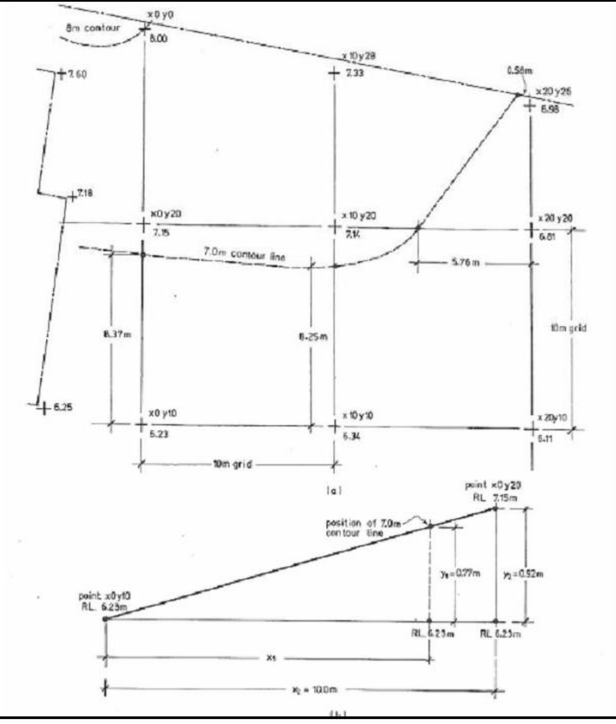
- Next, simply connect points of equal contour intervals
- One grid cell down, eight to go . . .

Topographic Survey

- Repeating the linear interpolation for each of the remaining grid cell gives:

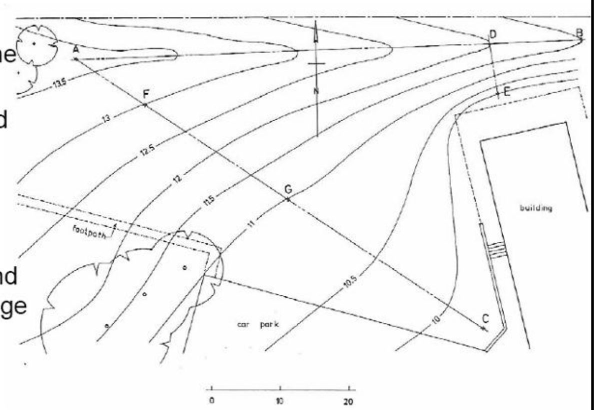


Exercise



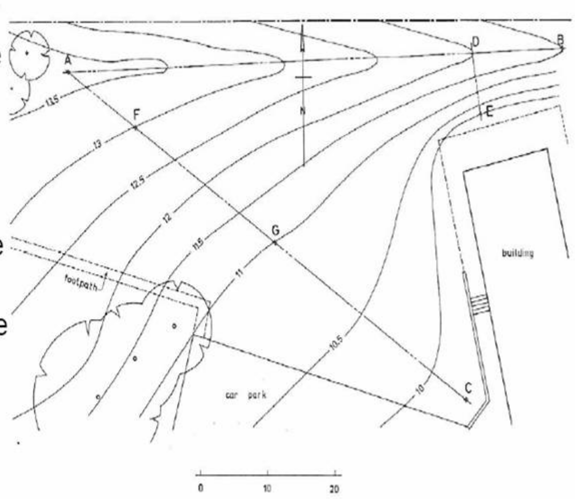
Exercise

- Describe the terrain along the line AB:
  - From point A, the ground falls on a fairly regular slope, towards B.
  - Line AB is the line of a ridge, where the ground falls, both northwards and southwards, from the ridge line.



Exercise

- Describe the terrain along the line AC:
  - On line AC, the ground falls in the form of a concave slope, slope being steeper towards the north end of the line.
  - The whole area is the side of a hill.



Exercise

- Calculate the gradient between
  - Points D and E:
    - Fall = 2 m
    - Horizontal distance = 8.0 m
    - Gradient = 1 in 4
  - Points F and G
    - Fall = 2 m,
    - Horizontal distance = 25 m.
    - Gradient = 1 in 12.5