

**CE200 SURVEYING**

Lecture 4.0  
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**ANGULAR MEASUREMENTS and  
ANGLE MEASURING INSTRUMENTS  
(Tacheometers and Theodolites)**

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- ❖ An *angle* is defined as the difference in direction between two convergent lines.
- ❖ A *horizontal angle* is formed by the directions to two objects in a horizontal plane.
- ❖ A *vertical angle* is formed by two intersecting lines in a vertical plane, one of these lines horizontal.
- ❖ A *zenith angle* is the complementary angle to the vertical angle and is formed by two intersecting lines in a vertical plane, one of these lines directed toward the zenith.

Horizontal angles are the same

But Vertical angles vary with elevation (height) of instrument

Horizontal Angle

Vertical Angle

Vertical Angle

Zenith

Zenith

Level Surface

Plumb Line

Plumb Line

Nadir

Zenith Angle

Vertical Angle

Angle instruments called tacheometers or theodolites, depending on their precision in measuring angles.

Internal Focus (For sighting object)

Eyepiece Focus (For cross hairs)

Slow motion target screw (up / down)

Slow motion target screw (left / right)

Telescope clamp (up / down)

Upper plate clamp (left / right)

CC : Collimation Axis  
SS : Standing Axis  
PP : Plate Bubble Axis  
TT : Trunnion Axis

CC  $\perp$  TT  
PP // TT  
SS  $\perp$  PP  
SS  $\perp$  TT

CC

SS

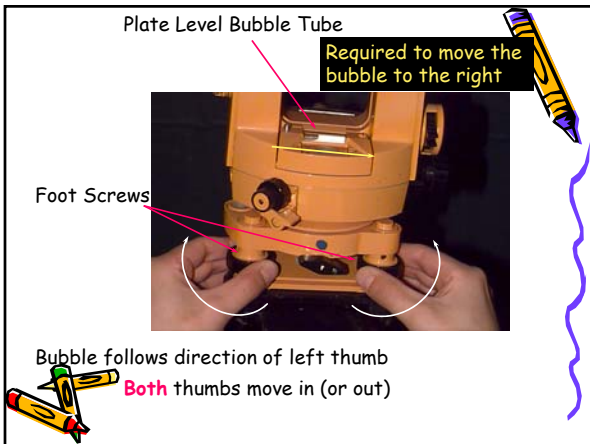
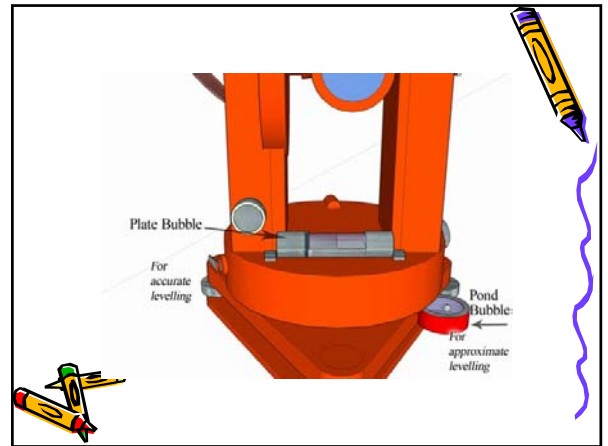
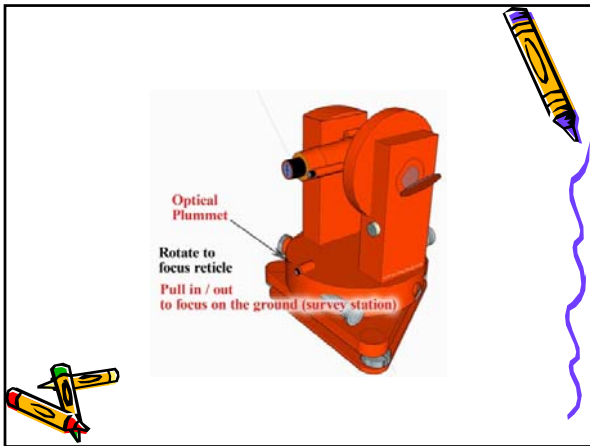
TT

PP

CC

PP

SS

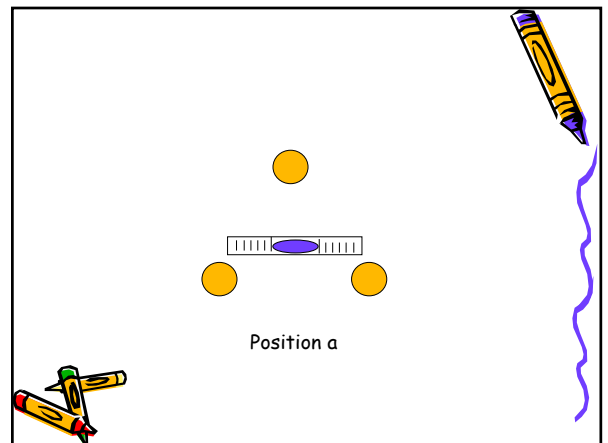
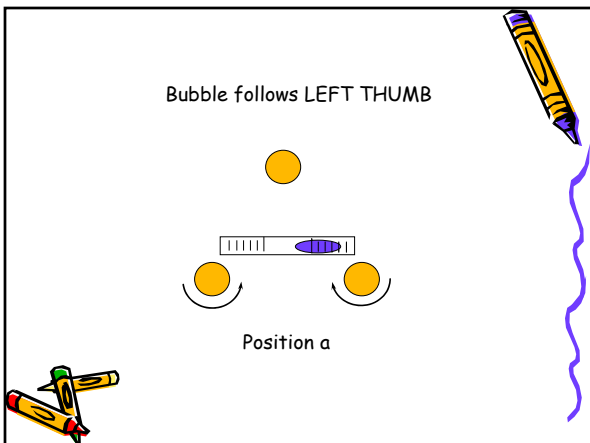


**Recommendation for Setting up a Theodolite**

Fine level the theodolite using the PLATE level bubble tube and foot **SCREWS**

Position a) align the plate level bubble tube with two foot screws.  
Centre the bubble by rotating the two foot screws in opposite directions.  
The bubble follows the **LEFT** thumb.

Position b) align the plate level bubble tube with the third foot screw.  
Centre the bubble by rotating the the third foot screw (only). The bubble follows the **LEFT** thumb.



Bubble still follows LEFT THUMB

Position b  
90° to position a

**SUMMARY OF ERRORS IN ANGLE MEASUREMENTS**

Instrumental Errors

1. Plate bubble's out of adjustment
2. Horizontal Axis not perpendicular to vertical axis
3. Axis of Sight not perpendicular to vertical axis (Collimation error)
4. Vertical Circle Index Error
5. Eccentricity of Circle Centres
6. Circle Graduation Errors
7. Worn components and peripherals

Solution

1. Keep bubbles in adjustment and level instr. carefully (especially with varying elevations)
2. Observe on both faces (i.e. Direct and Reverse)
3. Be careful when plunging for line extensions etc.
4. Determine  $i$  from direct and reverse and apply
5. Read Circle on opposite sides
6. Change circle orientation between positions
7. Pay attention to adjustments, maintenance and storage conditions

Natural Errors

1. Wind causes vibrations (difficult sightings)
2. Temperature variations cause bubbles to run
3. Refraction
4. Tripod settlement

Solution

1. Shield Instrument from Wind, weigh down tripod
2. Use umbrella to shade instrument
3. Avoid excessive heat and turbulent air
4. Pay attention to centering and bubbles during observations - set tripod up firmly

Personal Errors

Centering incorrectly  
Bubbles not centered  
Poor focusing  
Leaning targets

Solution

Check tribrachs - take care in centering  
Re-adjust bubbles between positions only  
Focus eye-piece as well as objective  
Use staff levels

Common Mistakes

Point or Target misidentifications  
Incorrect recordings  
Improper focusing

Officework 1: