

A large, solid brown curved shape on the left side of the page, resembling a quarter of a circle or a large arc, extending from the top to the bottom.

Graphic Expression

ORTHOGRAPHIC SYSTEM

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APUNTES

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Collection notes

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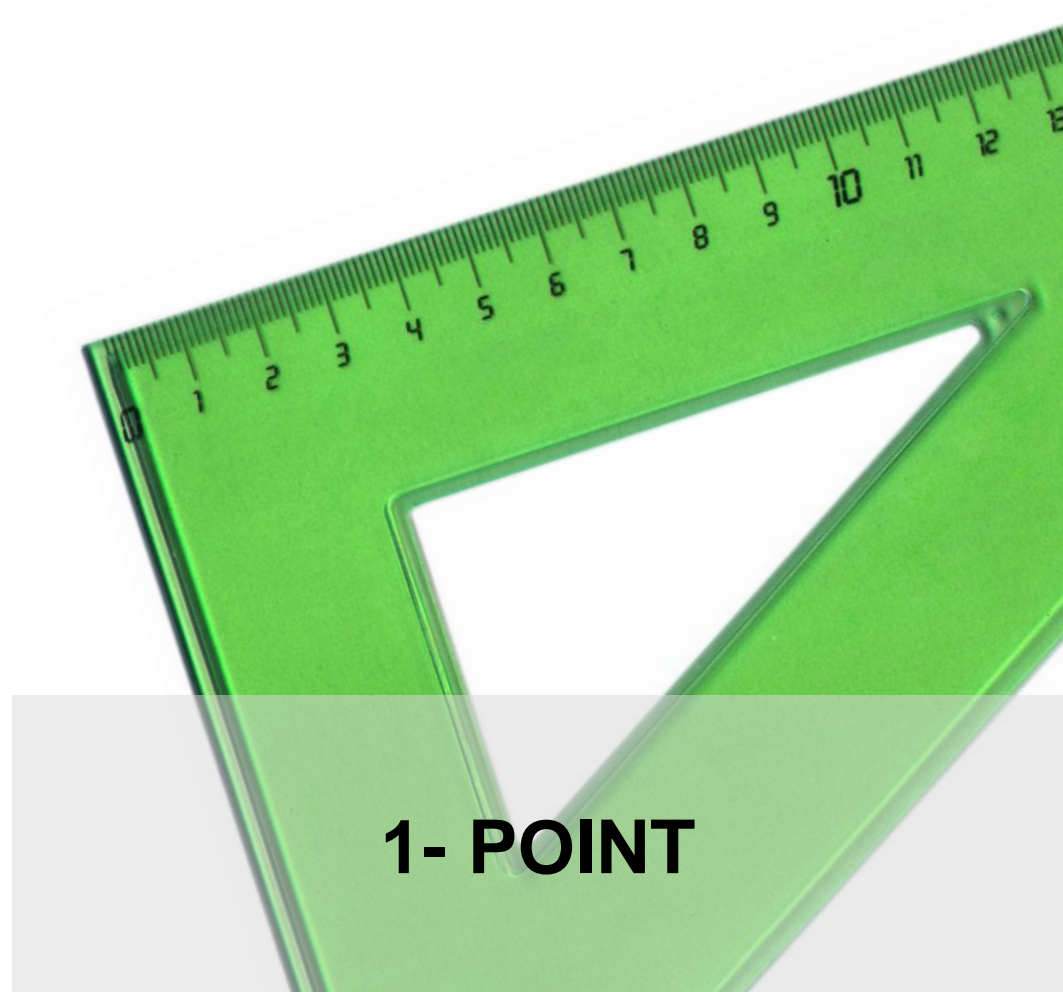
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ORTHOGRAPHIC SYSTEM



1- POINT

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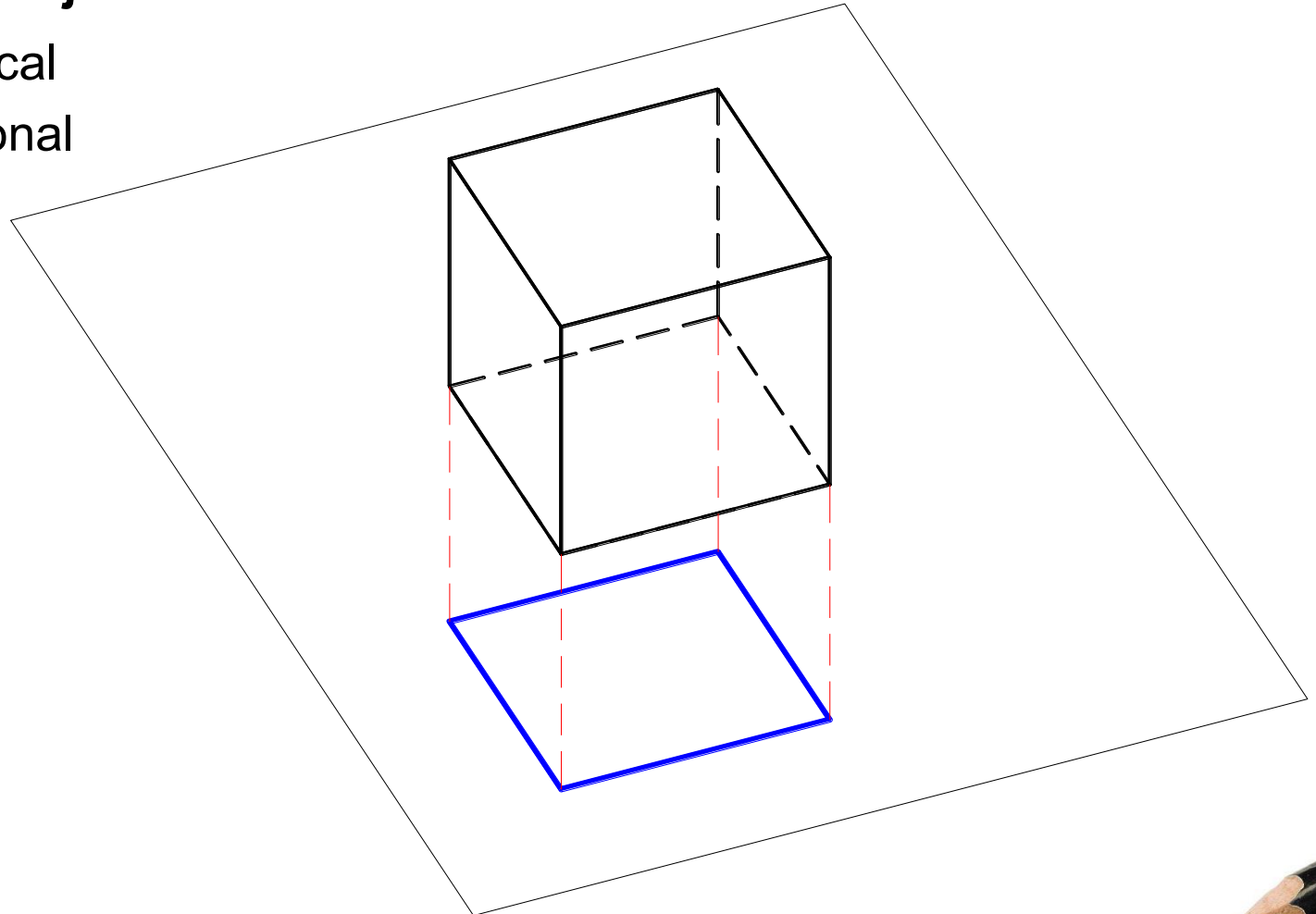
2. POINT REPRESENTATION

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 4. DISTANCE TO THE EARTH LINE
2. POINT TYPICAL LOCATIONS
3. POINT MEMBERSHIP TO THE BISECTORS



PREVIOUS CONCEPTS

- **ORTHOGRAPHIC SYSTEM: representation systems that uses projections**
 - Cylindrical
 - Orthogonal



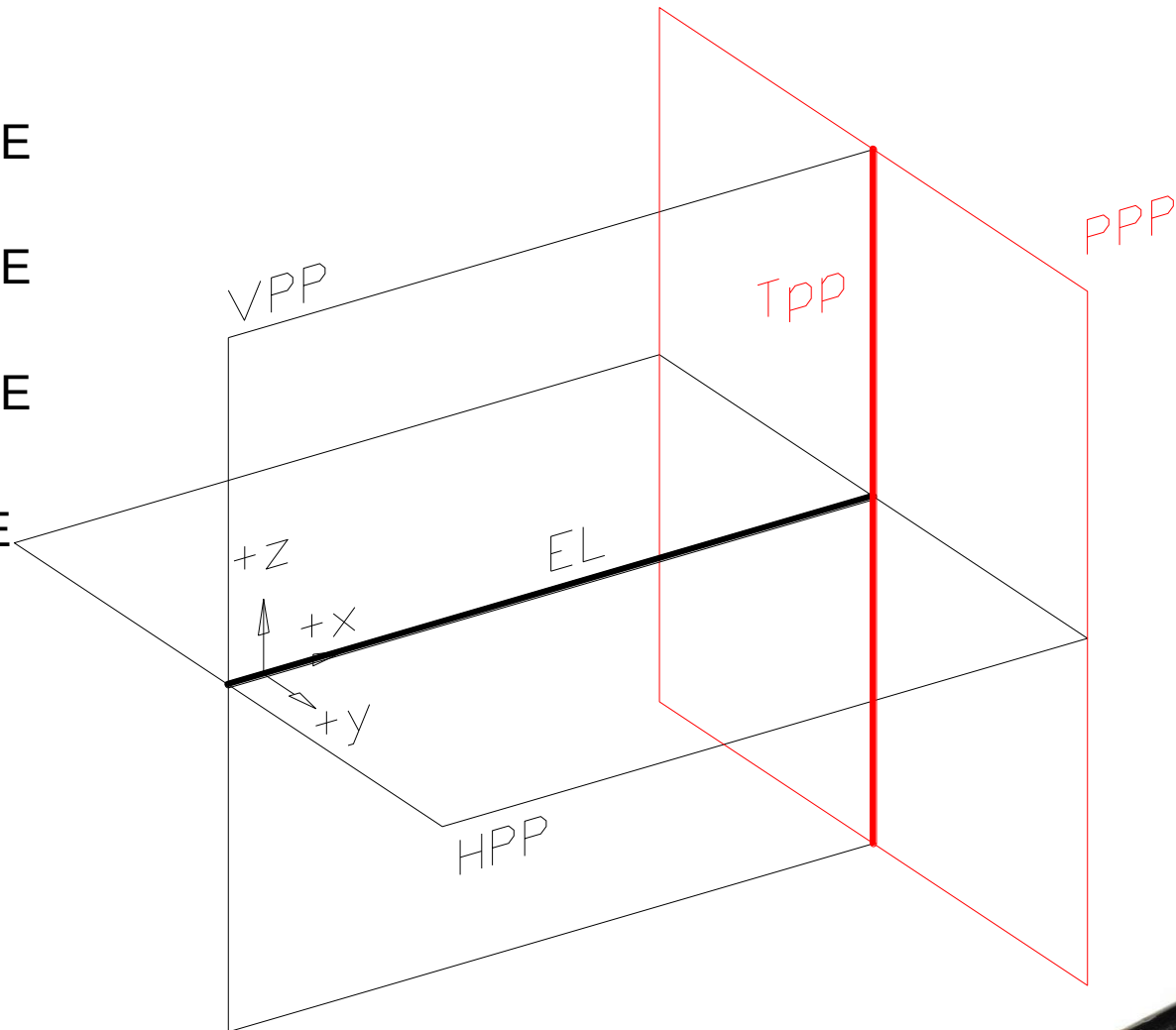
PROJECTION PLANES

- **Projection system**

- VPP: VERTICAL PROJECTION PLANE
- HPP: HORIZONTAL PROJECTION PLANE
- PPP: PROFILE PROJECTION PLANE
- EL: EARTH LINE
- Tpp: TRACE OF THE PP

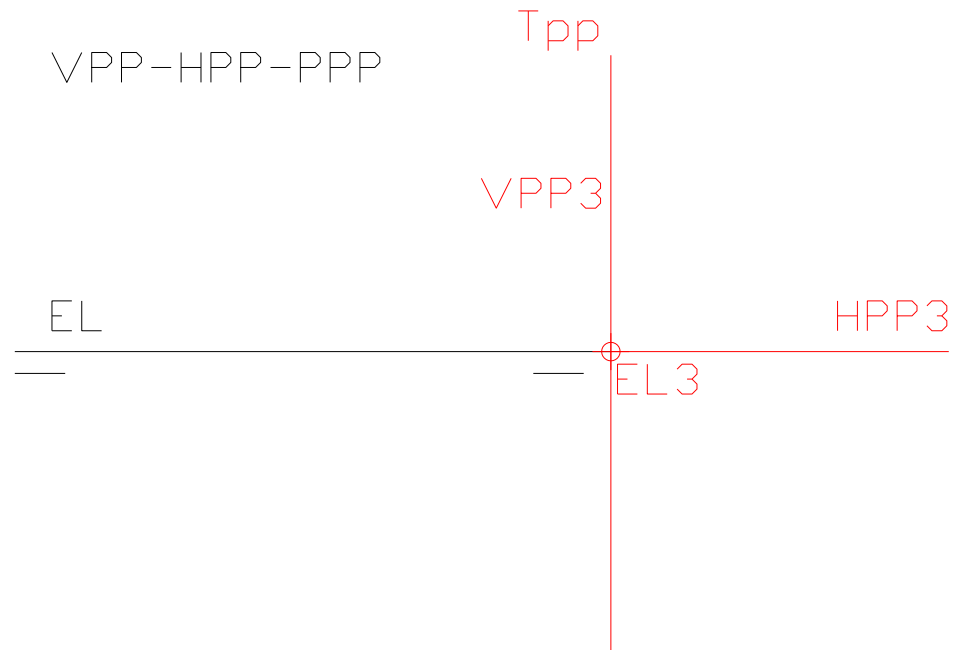
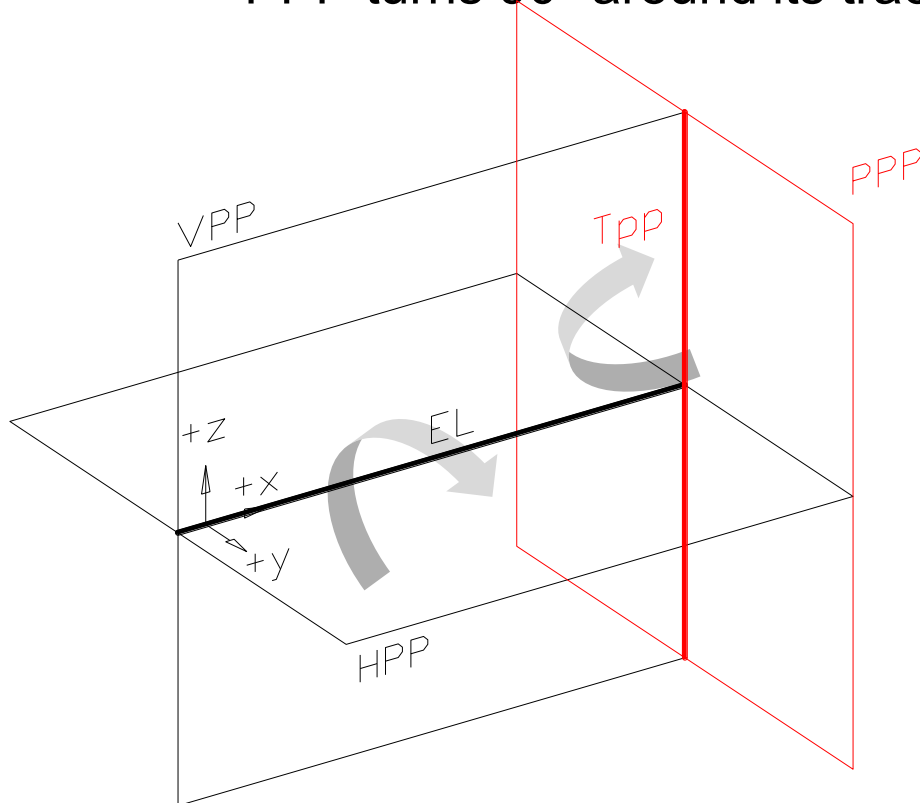
- **Coordinates system**

- X: DISTANCE TO ORIGIN
- Y: REMOTENESS
- Z: HEIGHT



PROJECTION PLANES: FROM 3D TO 2D

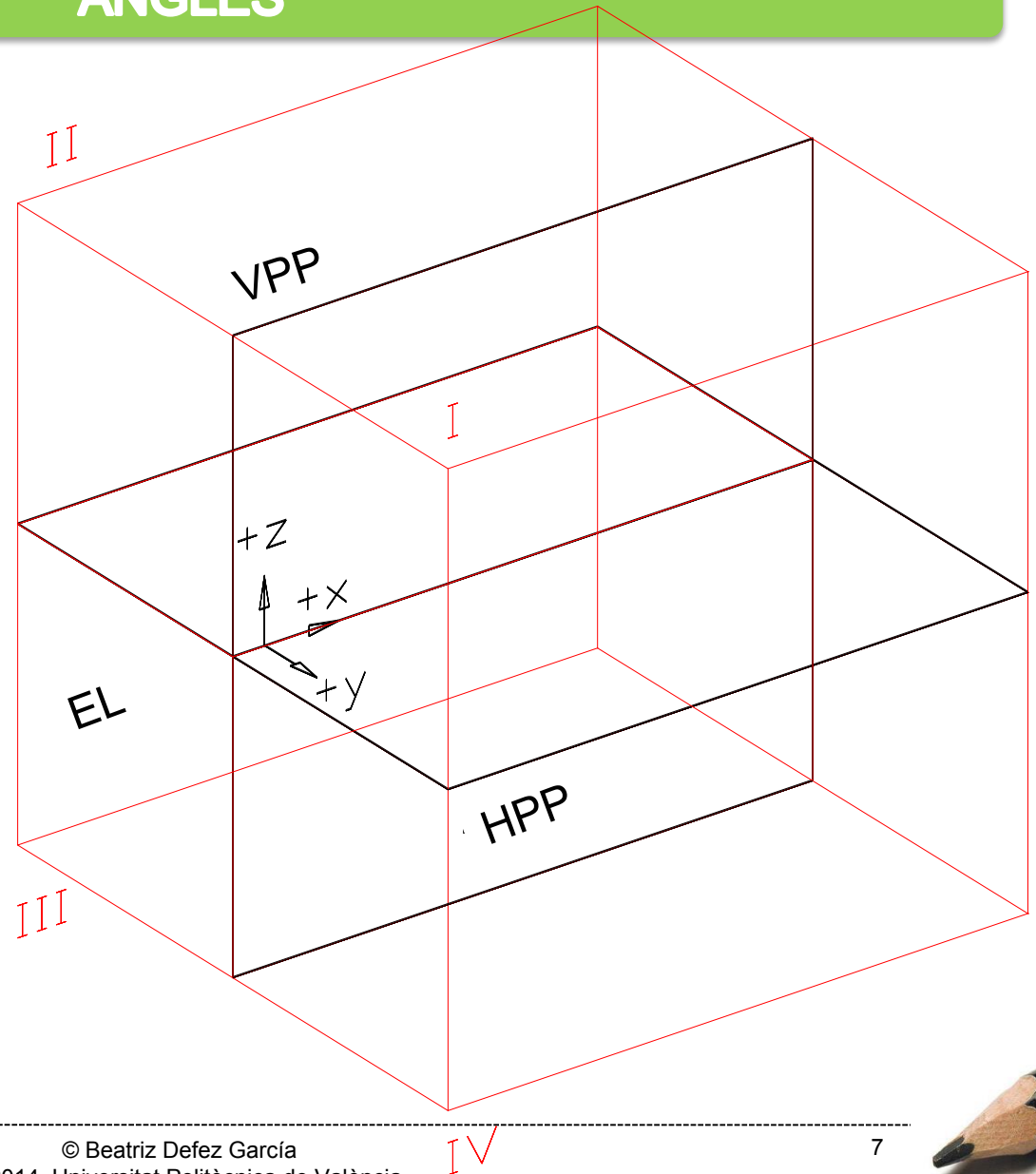
- **Conversion from 3d to 2d**
 - VPP invariant
 - HPP turns 90° around EL to meet VPP
 - PPP turns 90° around its trace to meet VPP



ANGLES

- **Four angles (or quadrants):**

I, II, III and IV



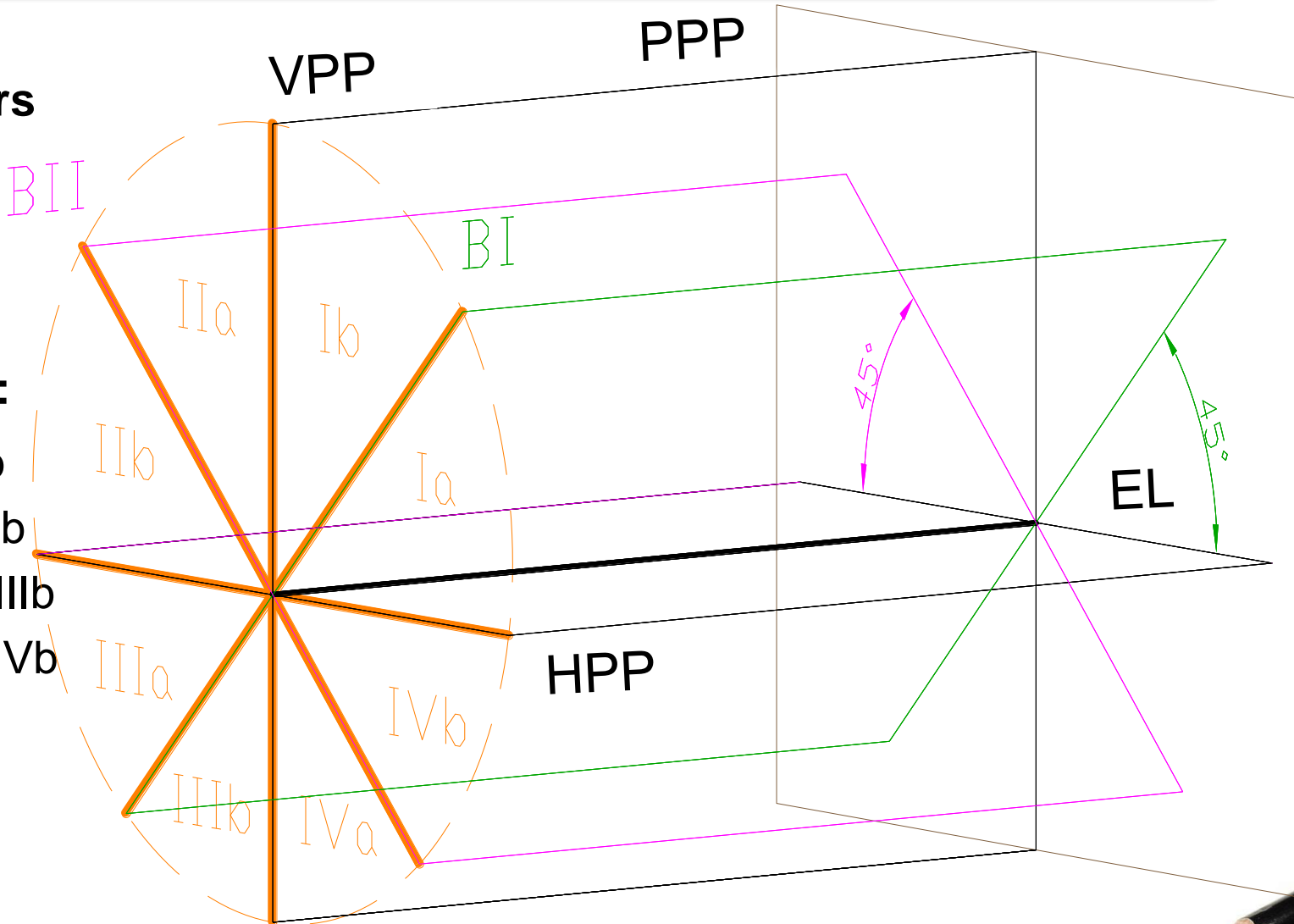
BISECTORS

- **Two bisectors**

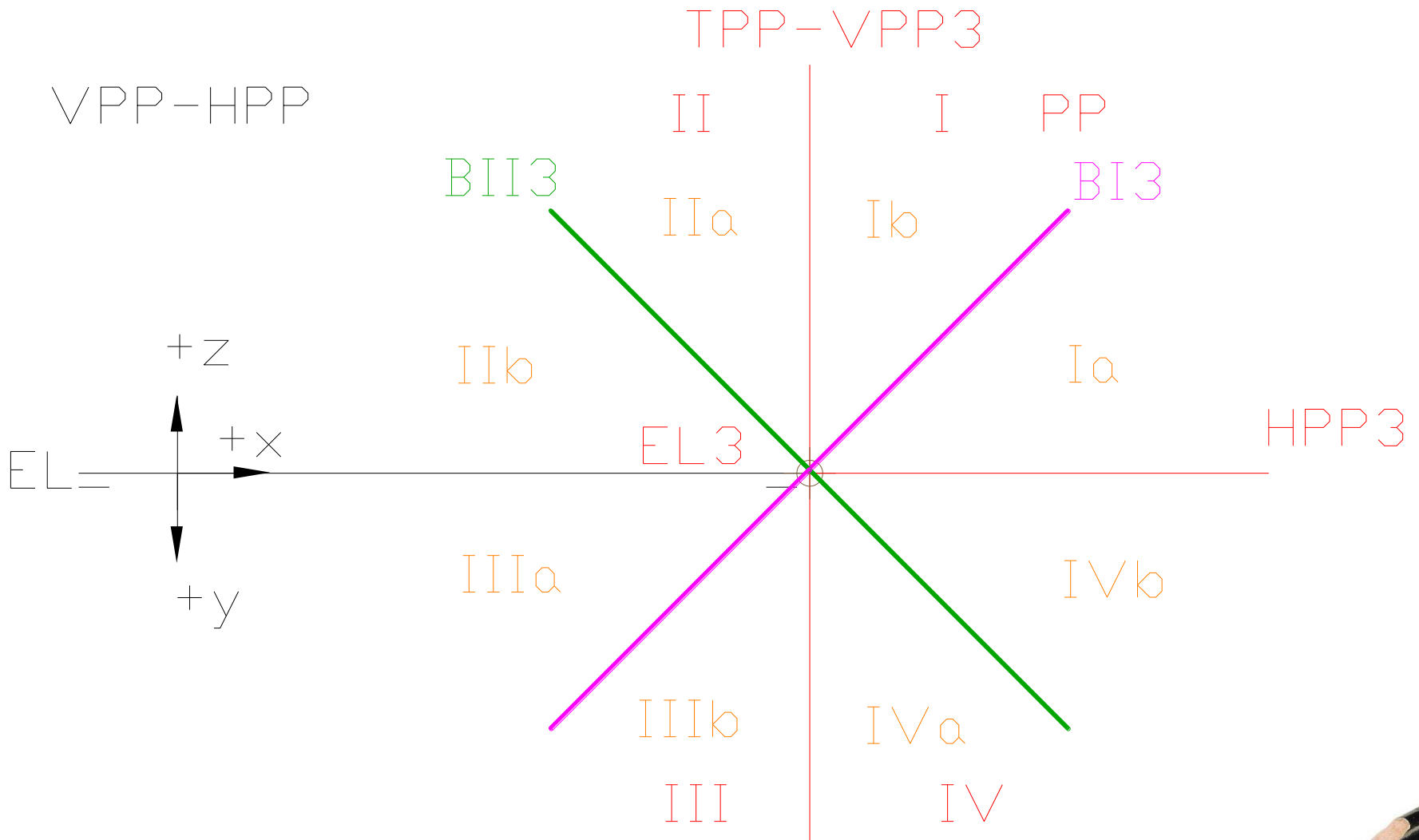
- BI
- BII

- **Eight octants:**

- Ia, Ib
- Iia, Iib
- IIIa, IIIb
- Iva, IVb



BISECTORS 2D



POINT NOTATION

- **POINT NOTATION**

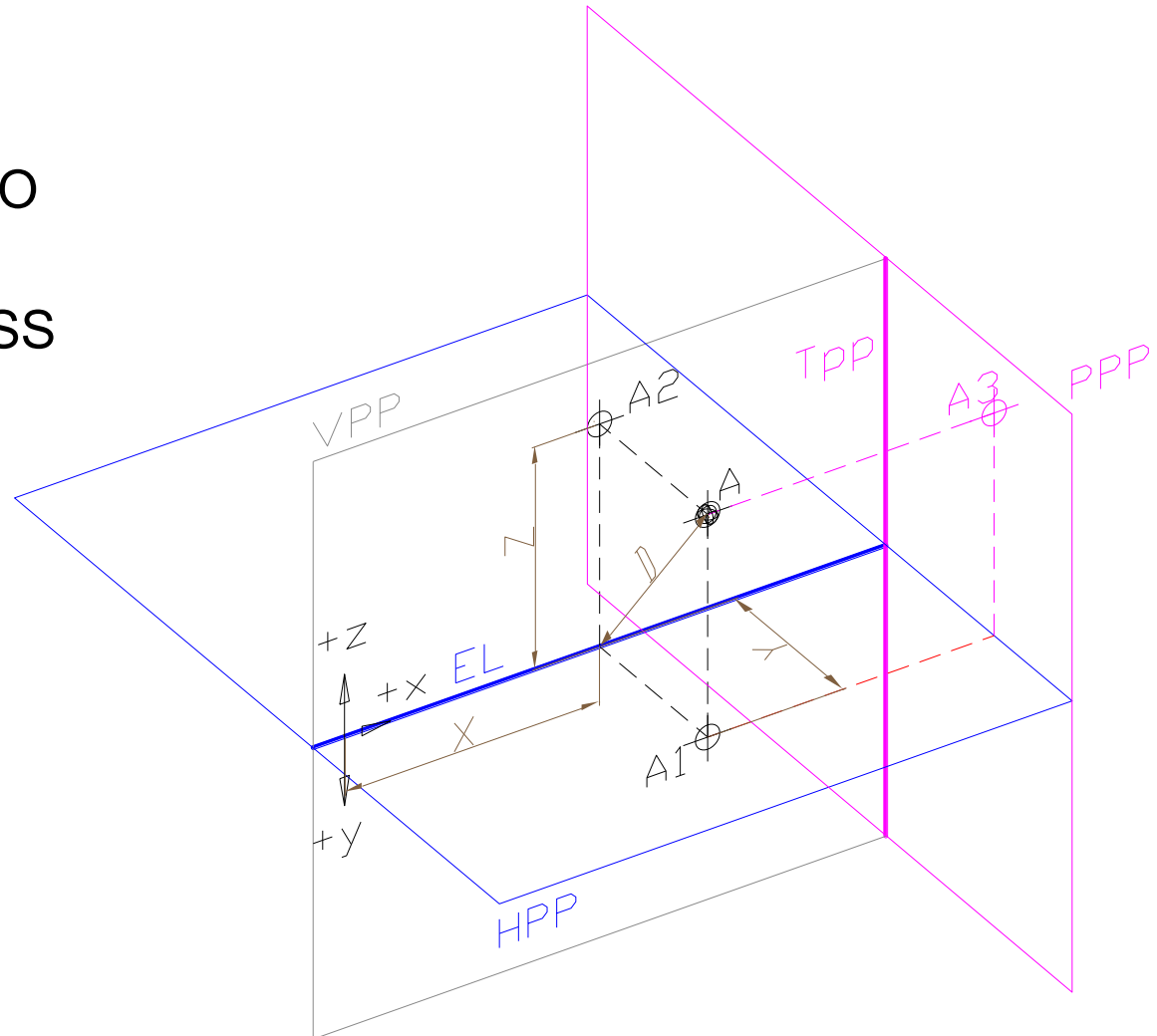
$A(x,y,z)$

X: DISTANCE TO
ORIGIN

Y: REMOTENESS

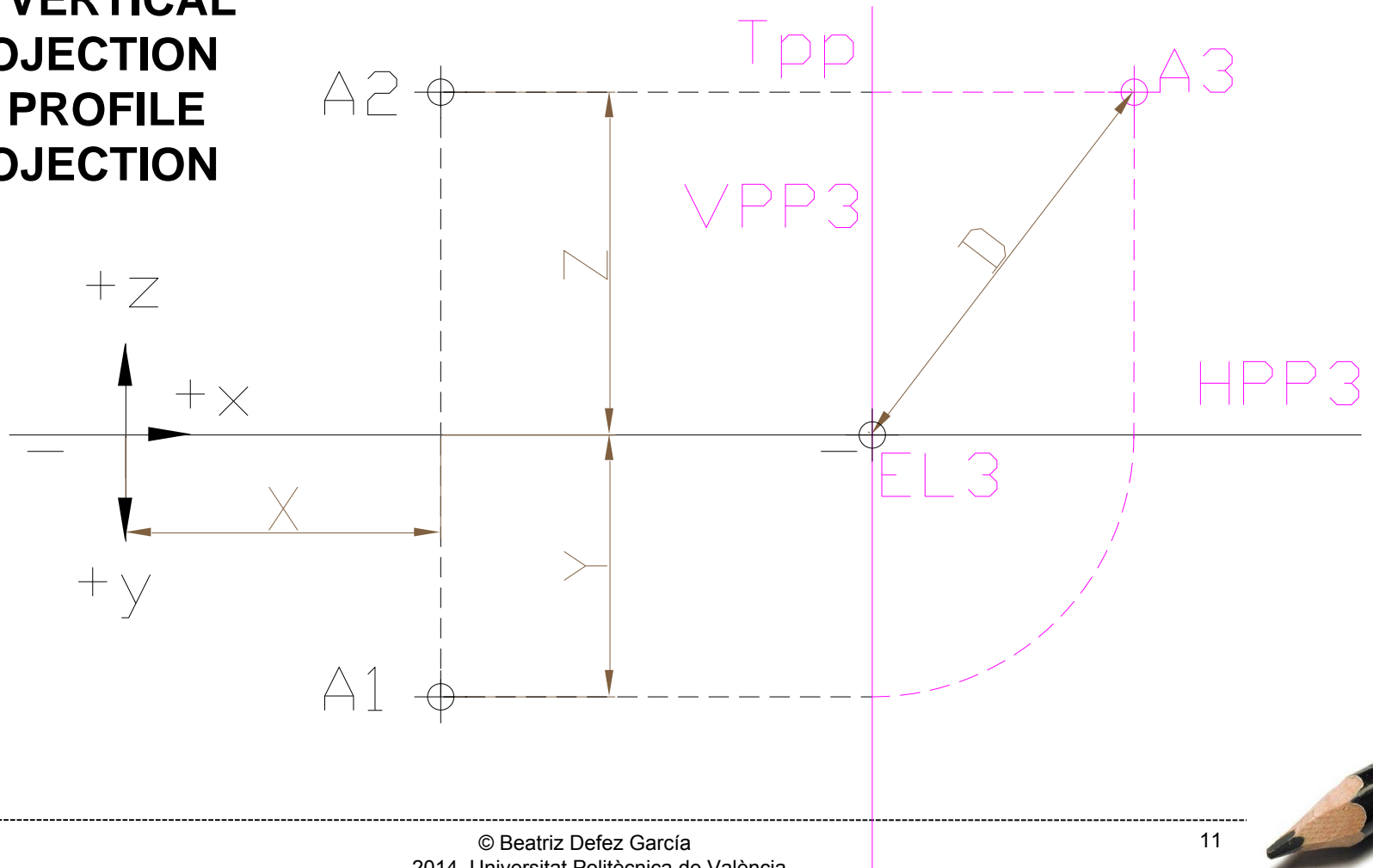
Z: HEIGHT

- **D: DISTANCE TO
THE EL**

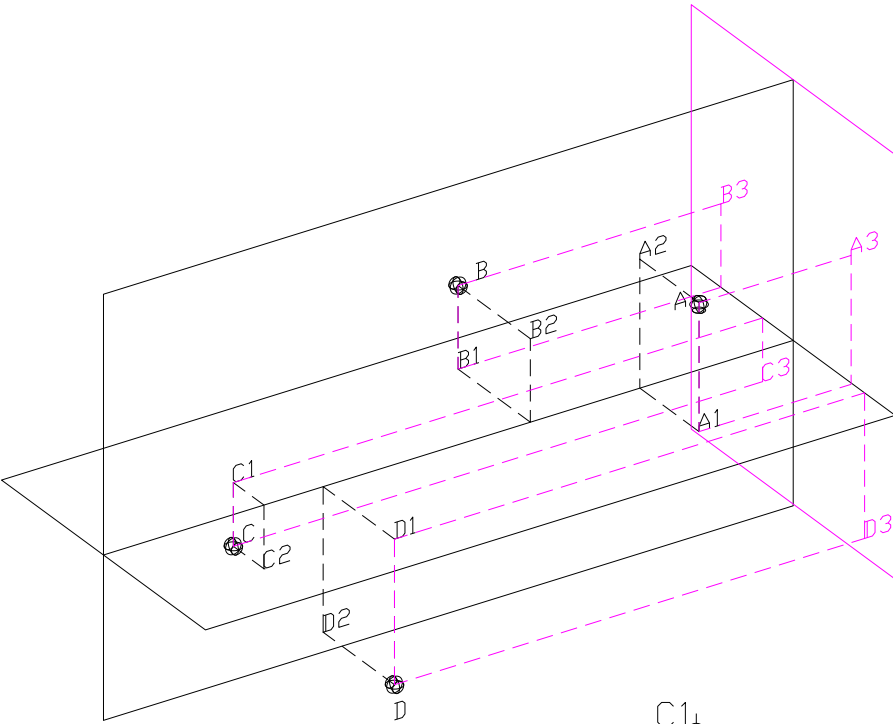


POINT NOTATION 2D

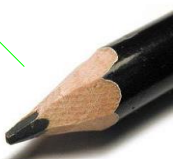
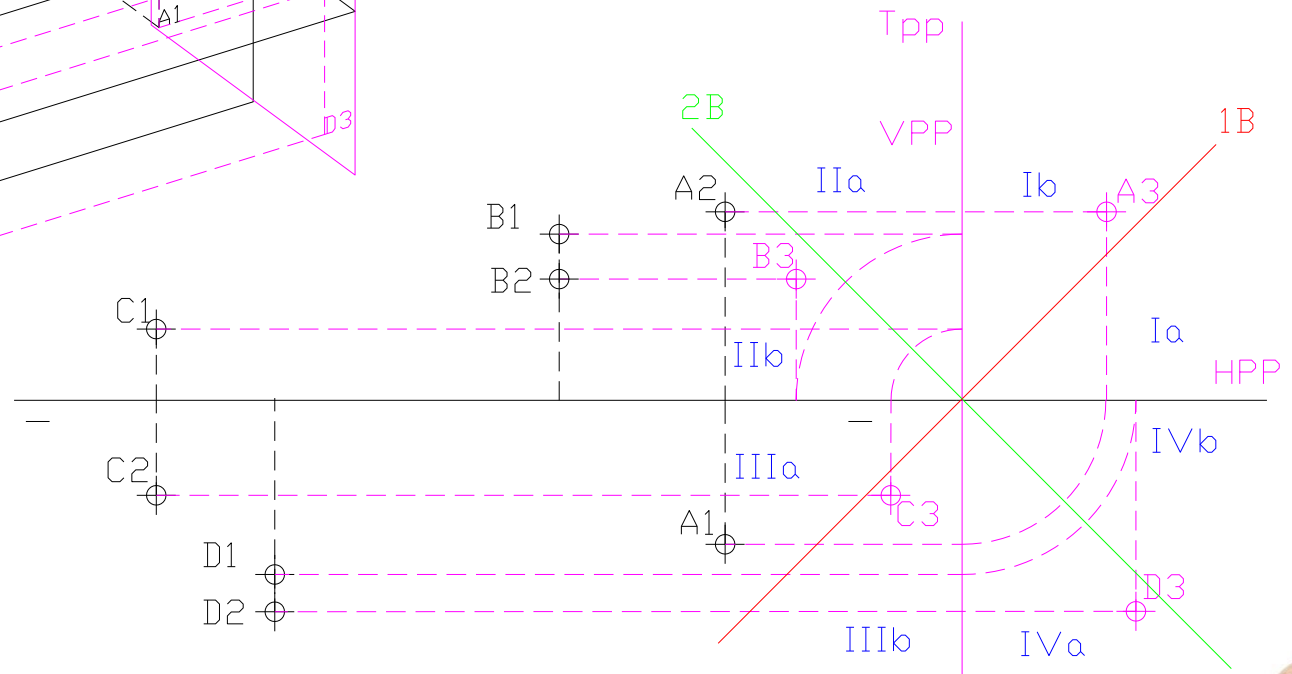
- **A1: HORIZONTAL PROJECTION**
- **A2: VERTICAL PROJECTION**
- **A3: PROFILE PROJECTION**



POINT TYPICAL LOCATIONS



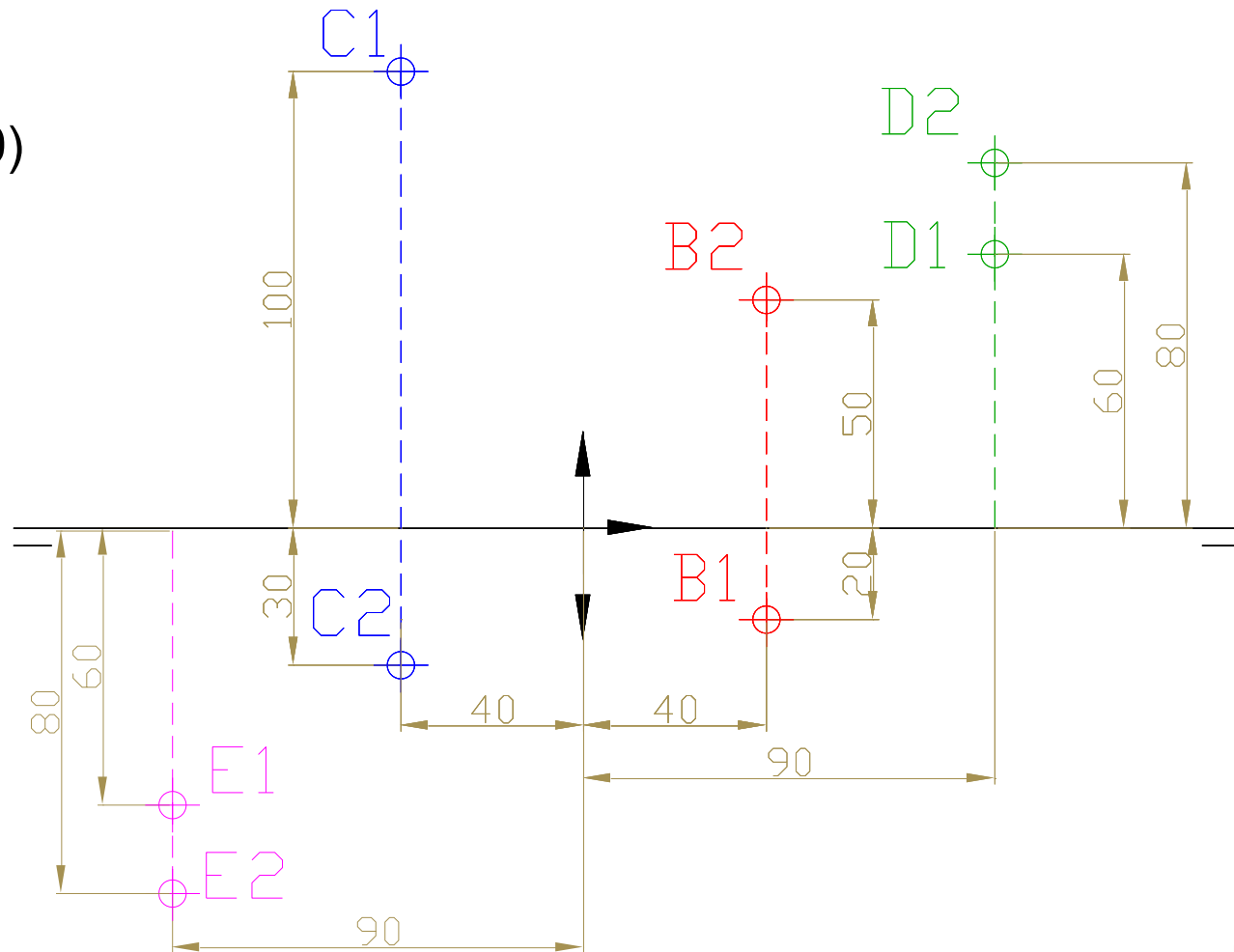
- ✓ **A BELONGS TO ANGLE I**
- ✓ **B BELONGS TO ANGLE II**
- ✓ **C BELONGS TO ANGLE III**
- ✓ **D BELONGS TO ANGLE IV**



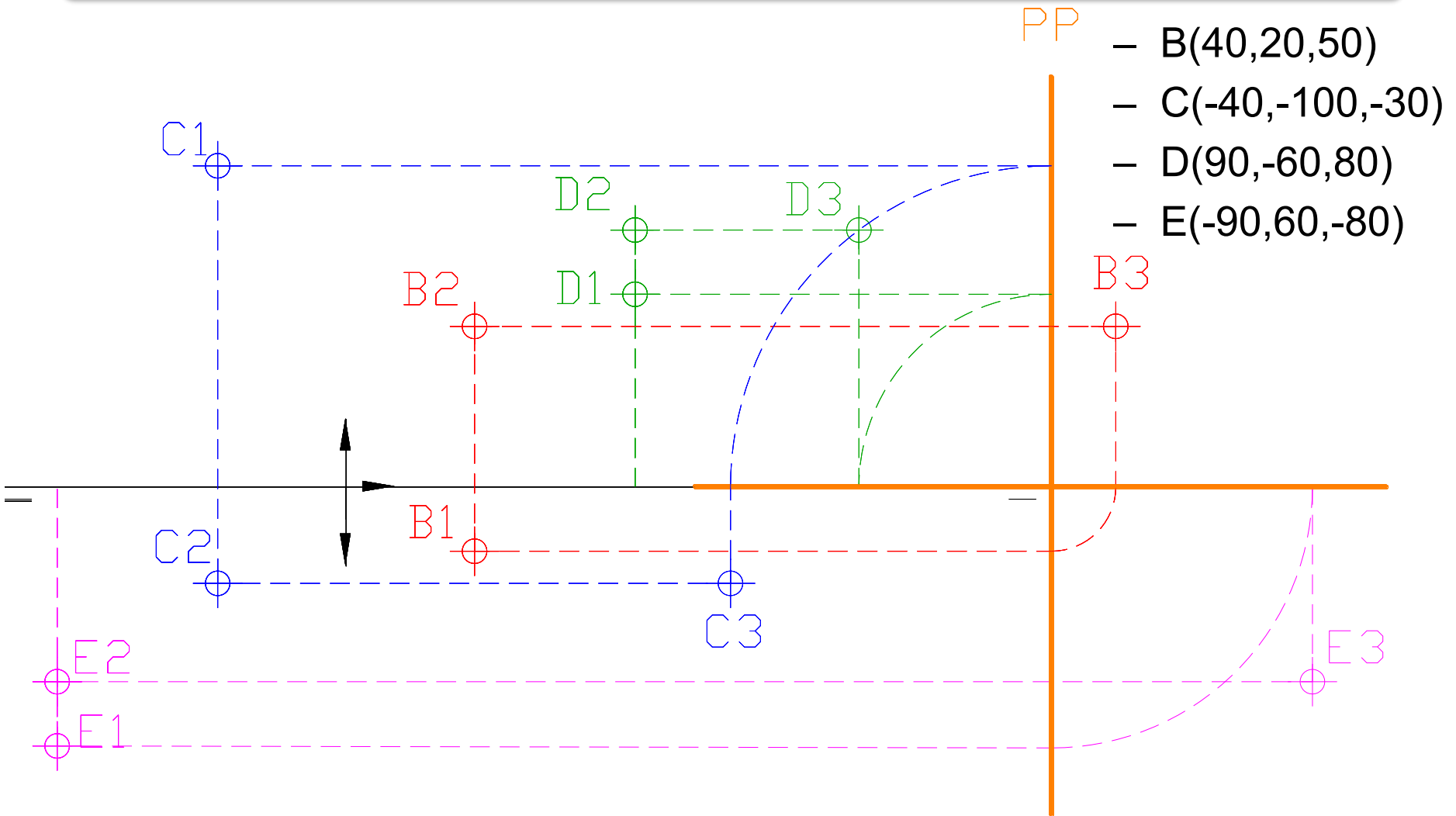
EXAMPLES OF VERTICAL AND HORIZONTAL PROJECTIONS

- **Represent:**

- B(40,20,50)
- C(-40,-100,-30)
- D(90,-60,80)
- E(-90,60,-80)

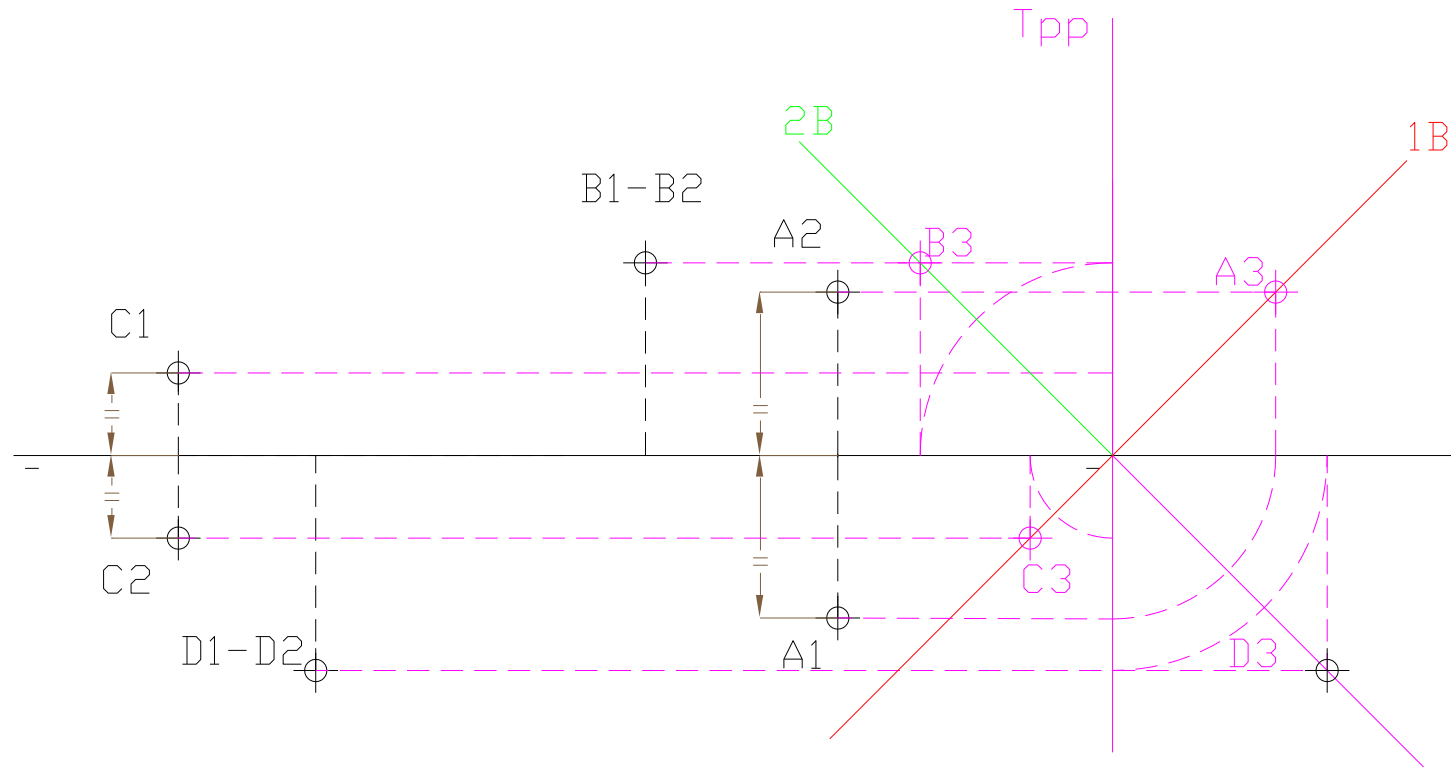


EXAMPLES OF 3RD PROJECTION



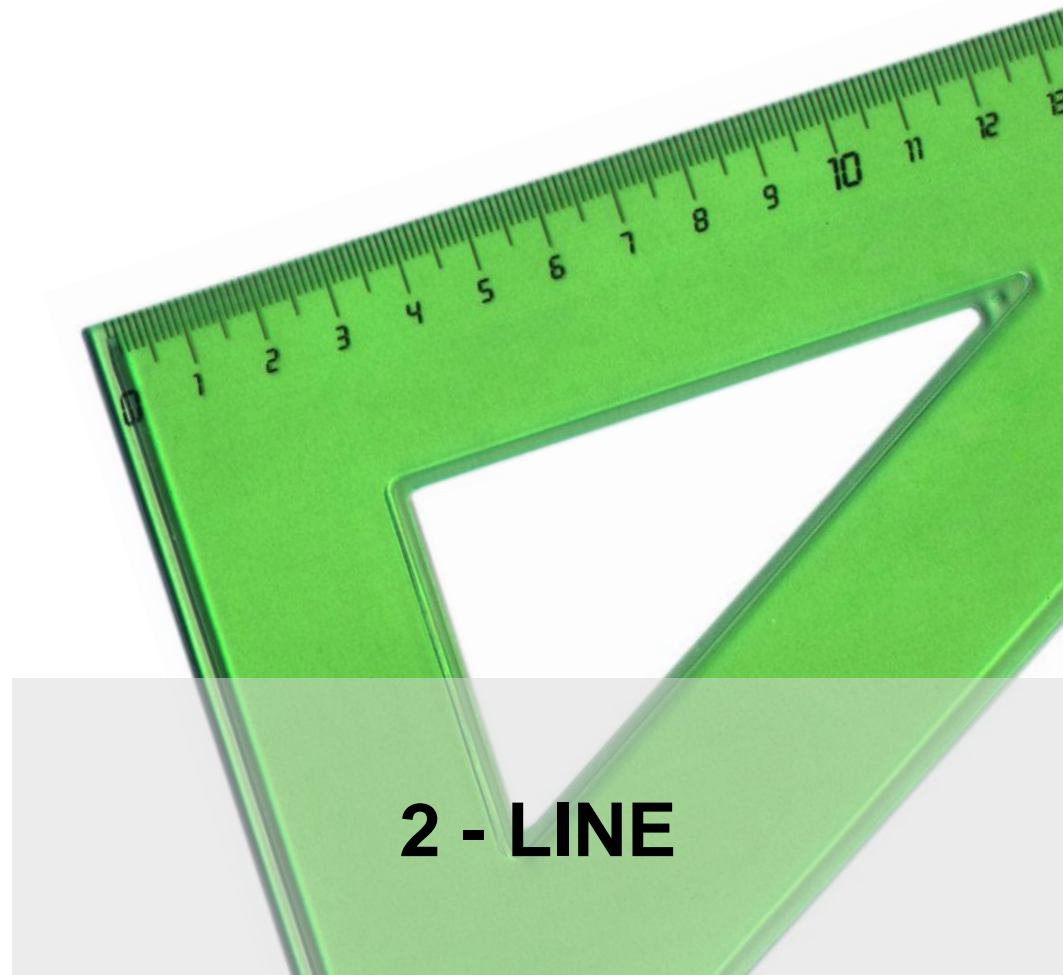
POINT MEMBERSHIP TO BISECTORS

- ✓ A BELONGS TO B1, ANGLE I
- ✓ B BELONGS TO B2, ANGLE II
- ✓ C BELONGS TO B1, ANGLE III
- ✓ D BELONGS TO B2, ANGLE IV



Graphic Expression

ORTHOGRAPHIC SYSTEM



2 - LINE

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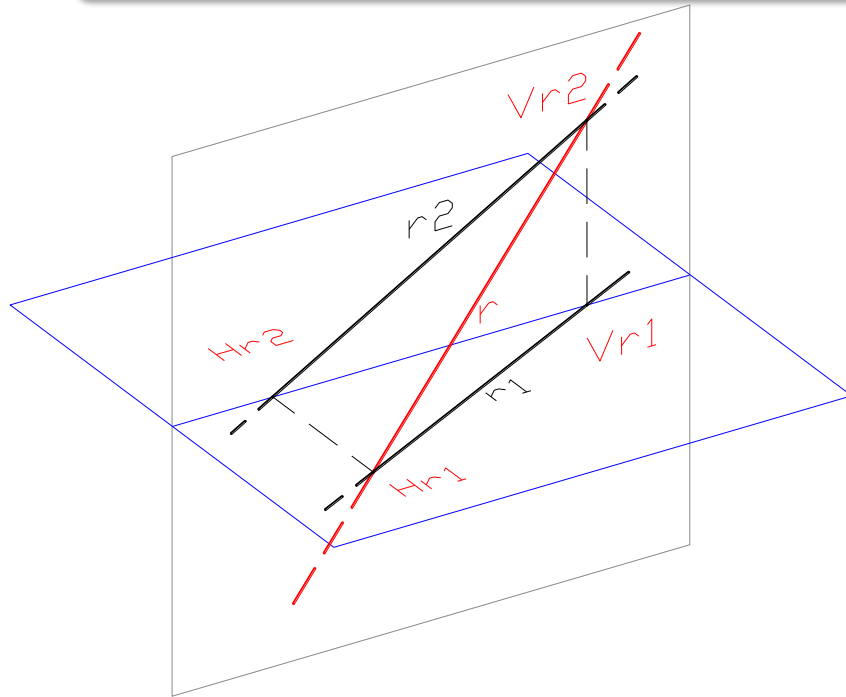
1. LINE PROJECTIONS, TRACES, CROSSING ANGLES, VIEWED AND HIDDEN PARTS
2. 3RD PROJECTION
3. BISECTORS' INTERSECTIONS

2. REMARKABLE LINES

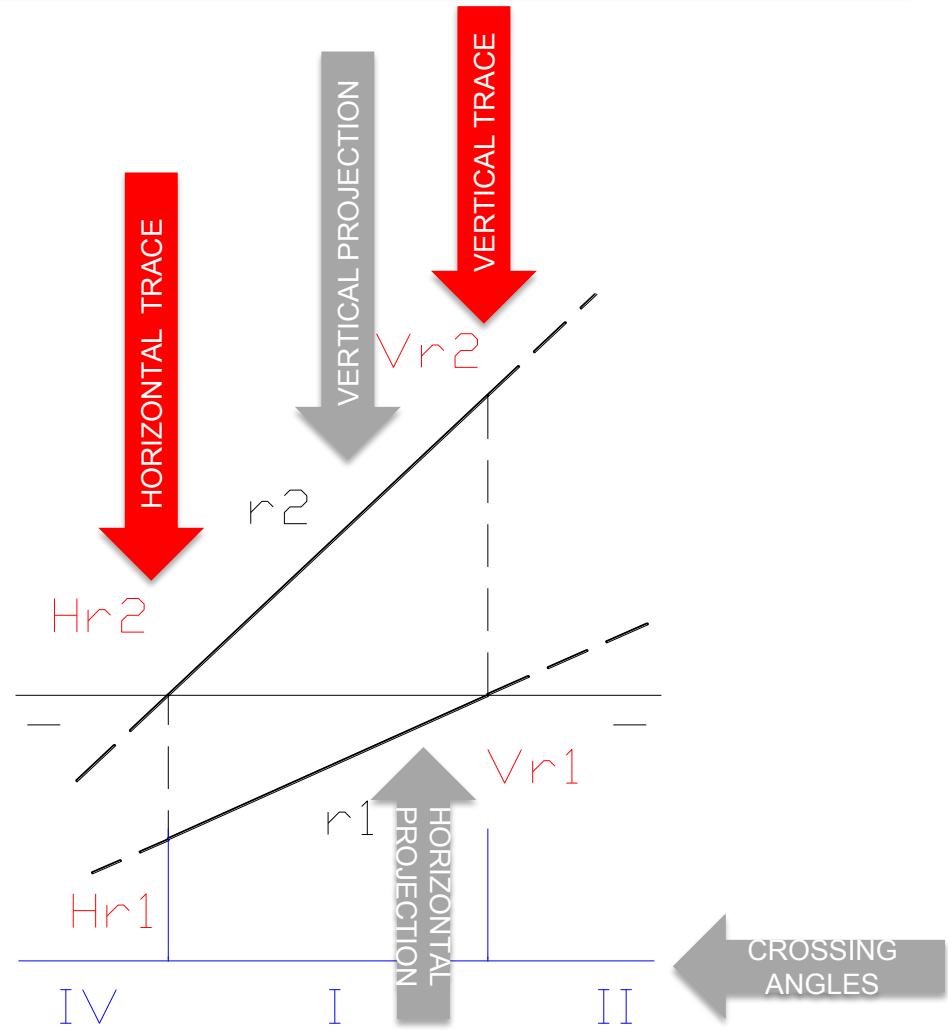
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5. PROFILE LINE



LINE PROJECTIONS, TRACES, CROSSING ANGLES, VIEWED AND HIDDEN PARTS

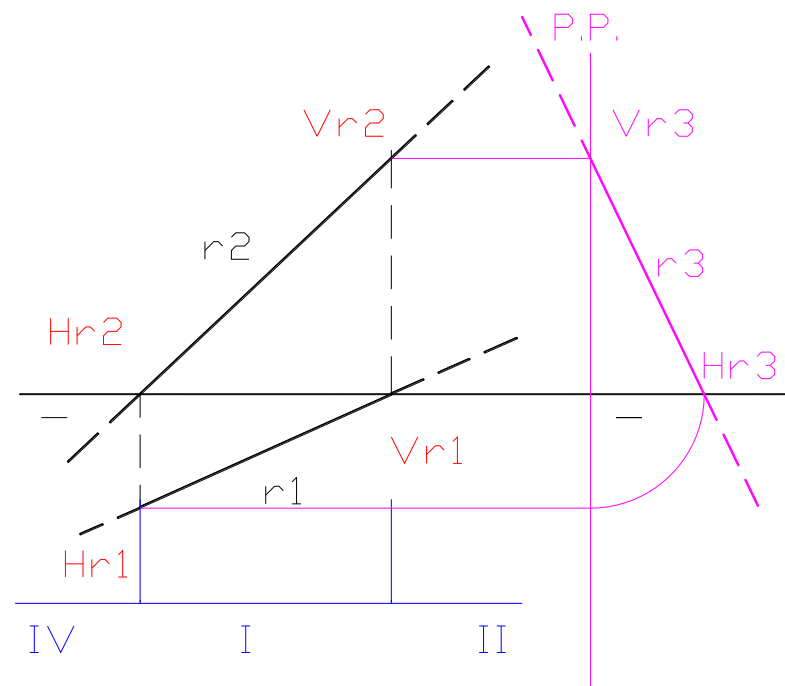
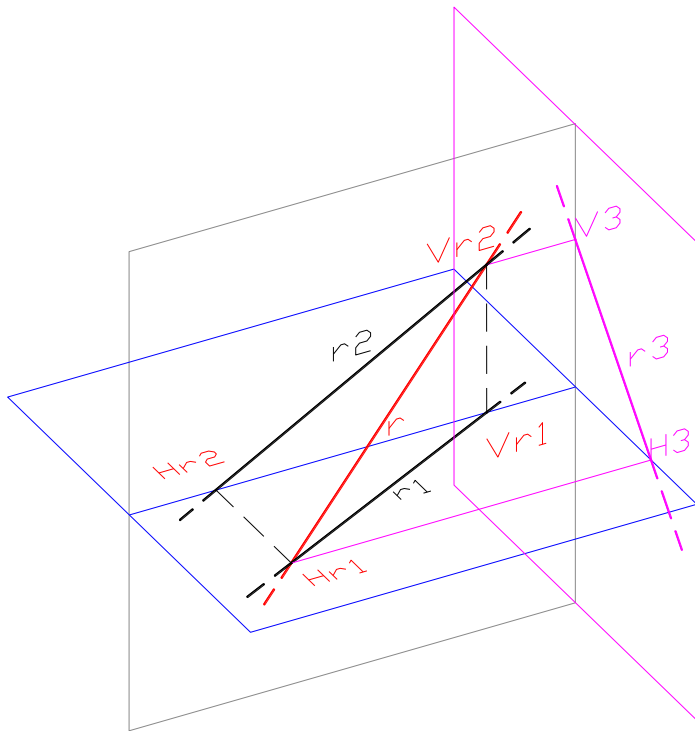


- Only the part of the line along the 1st angle is viewed. In the rest of the angles, the line is hidden

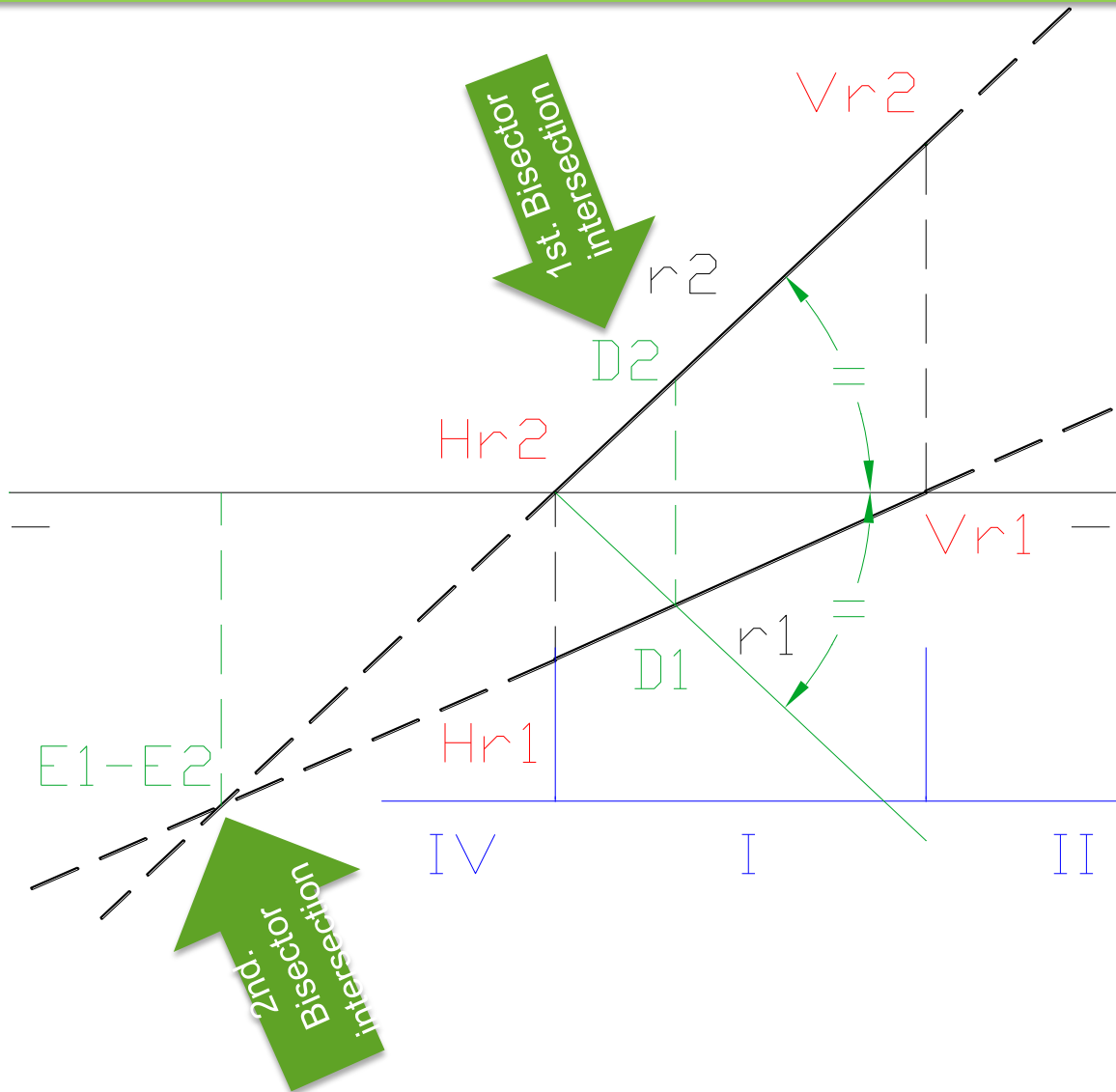


3RD PROJECTION OF A GENERIC STRAIGHT LINE

- Obtained by finding the 3rd projection of two of its points and joining them
- It is useful to locate traces and intersections with other elements also represented in 3rd projection
- The 3rd projection of a generic line does not show the true magnitude of the line
- Straight lines are represented with thick line, continuous only along the 1st angle

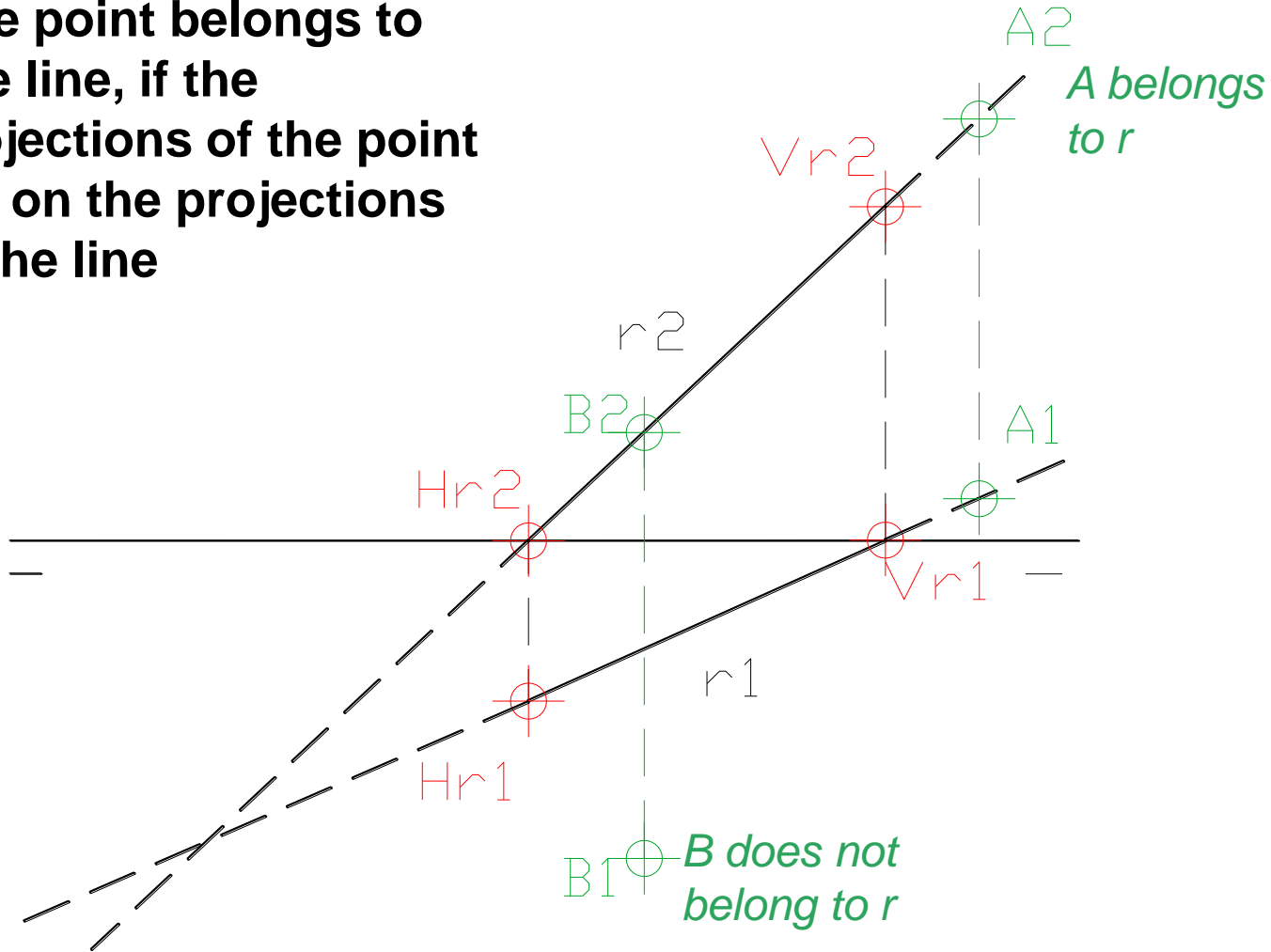


BISECTORS' INTERSECTION

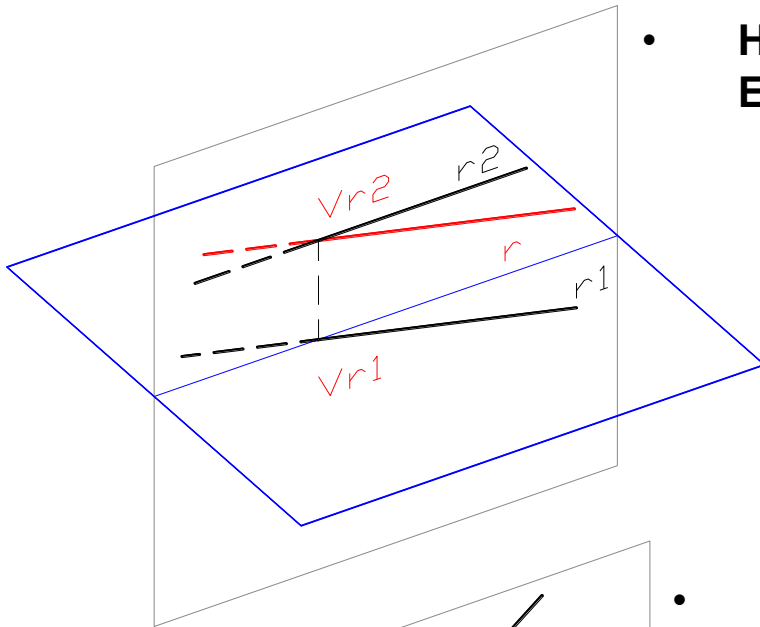


POINT MEMBERSHIP TO THE LINE

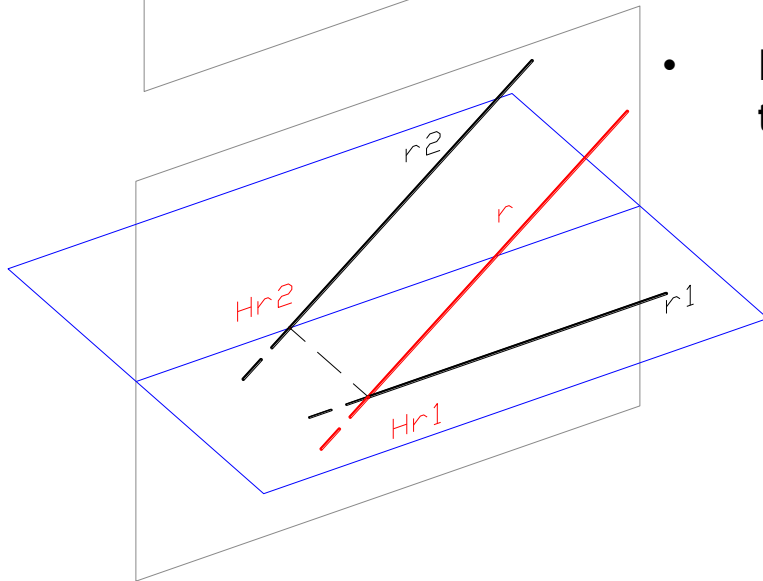
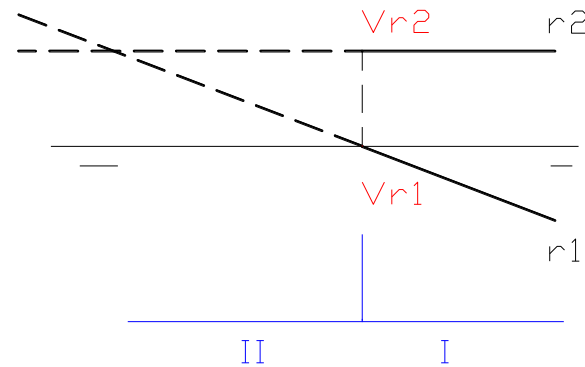
- One point belongs to one line, if the projections of the point are on the projections of the line



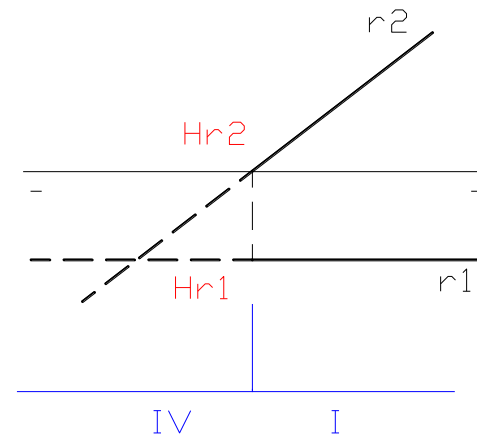
HORIZONTAL AND FRONTAL LINES



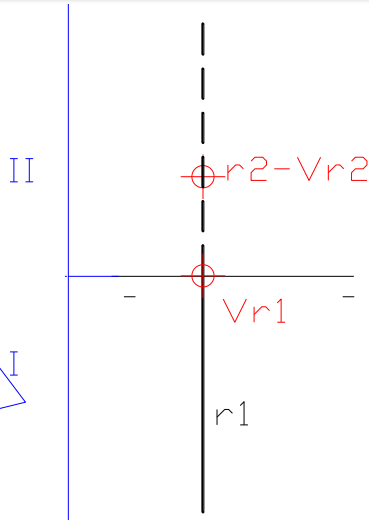
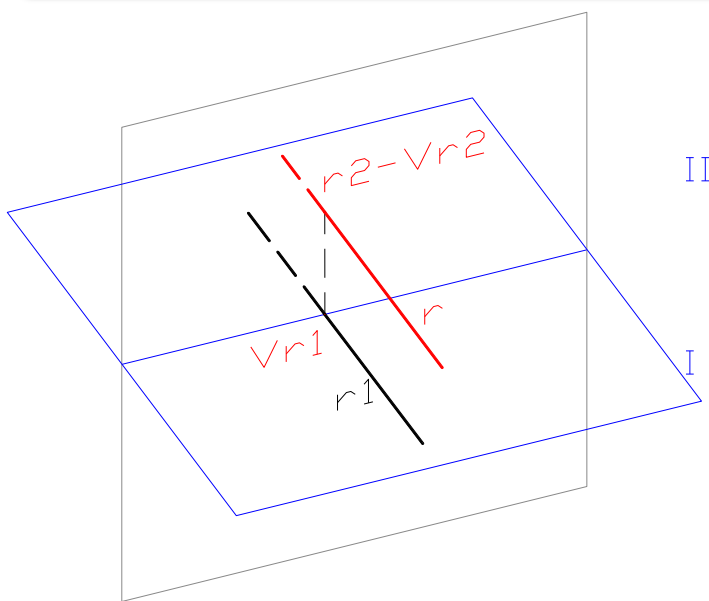
- **H. LINE:** The vertical projection is parallel to the E.L. and only the vertical trace exits



- **F. LINE:** The horizontal projection is parallel to the E.L. and only the horizontal trace exits

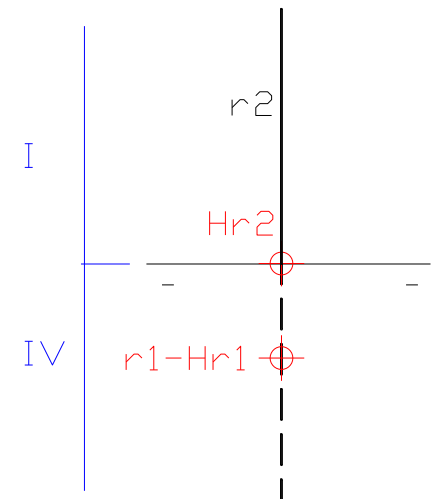
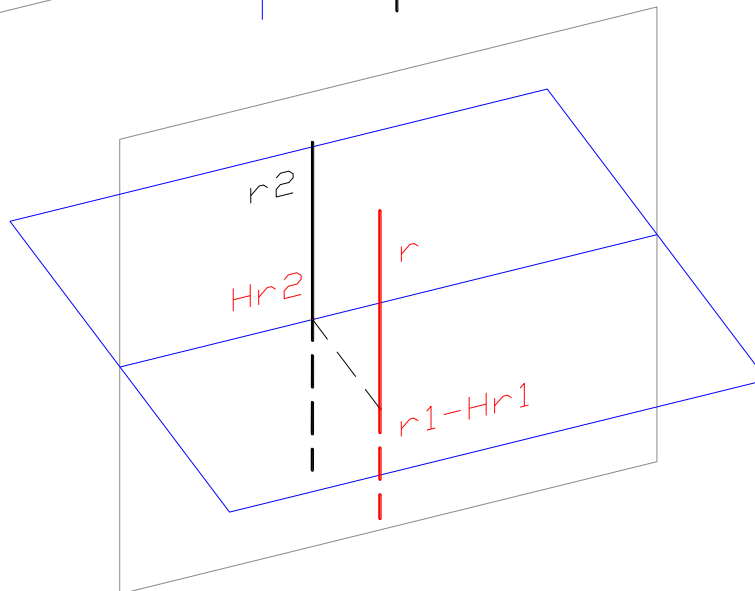


EXTREME AND VERTICAL LINES



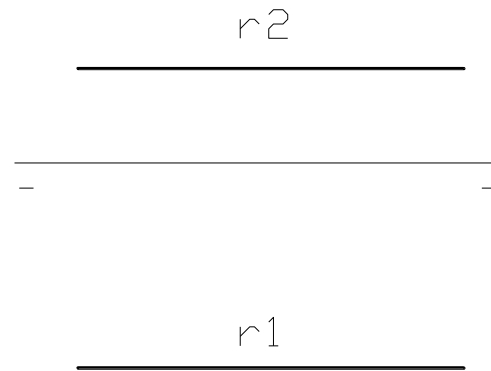
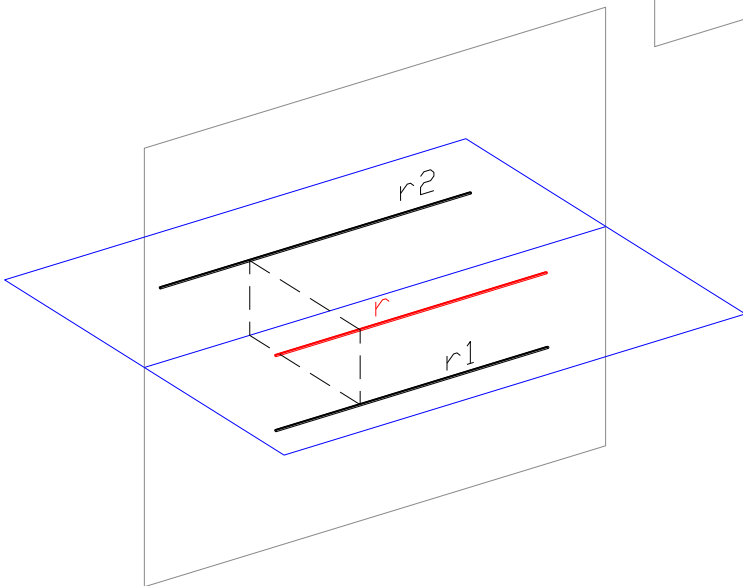
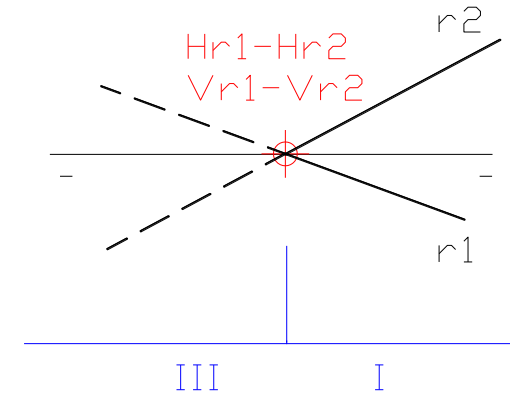
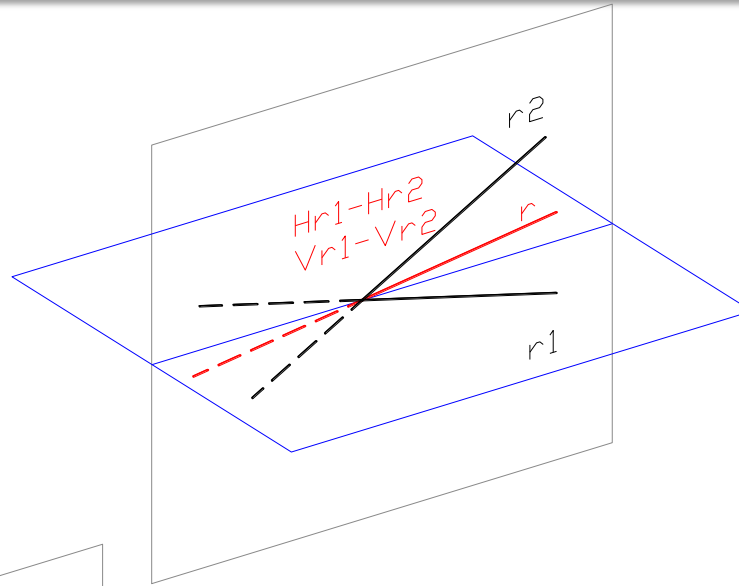
- **E. LINE:** Only the horizontal projection and the vertical trace exist

- **V. LINE:** Only the vertical projection and the horizontal trace exist



LINE CUTTING THE EARTH LINE AND LINE PARALLEL TO THE EARTH LINE

LINE CUTTING THE E.L.: Both projections cut the E.L. on the same point

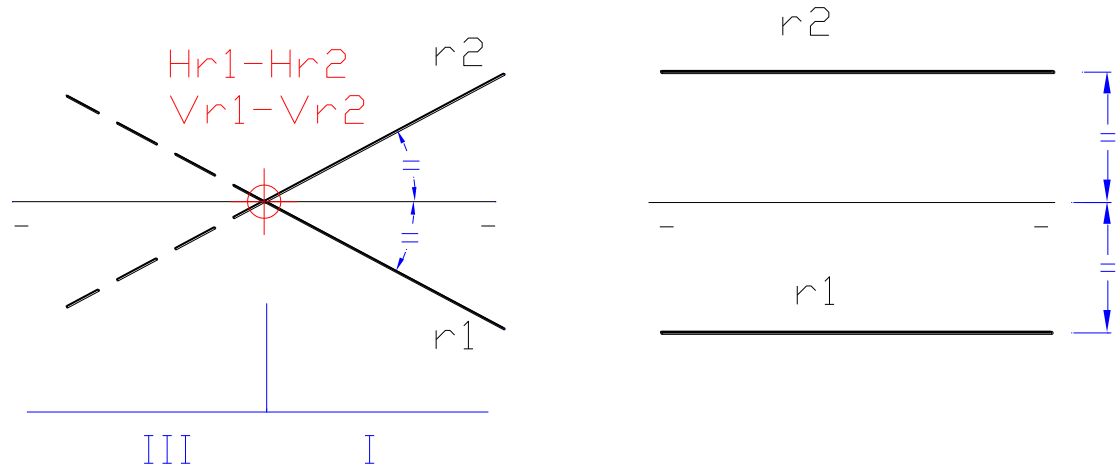


LINE // TO THE E.L.: Both projections are parallel to the E.L.

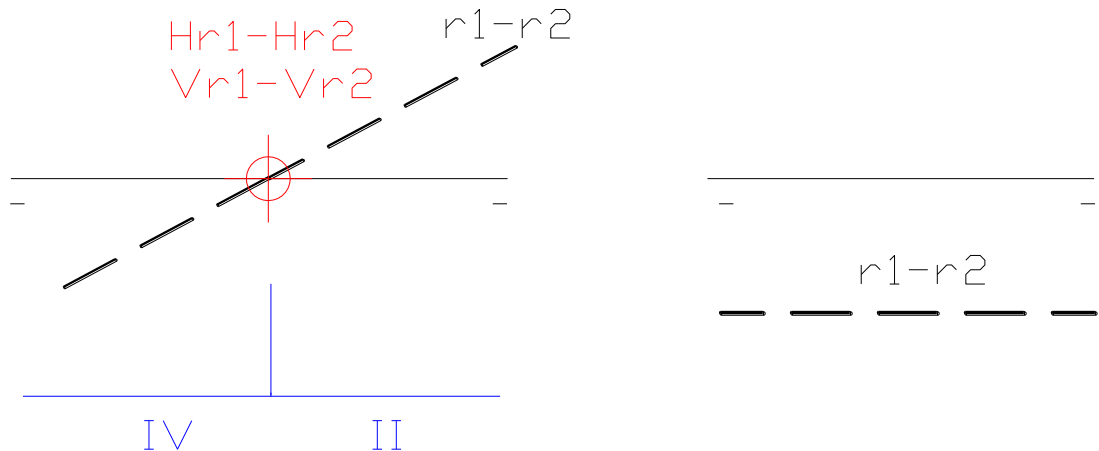


LINE LOCATED ON THE 1ST. BISECTOR AND LINE LOCATED ON THE 2ND. BISECTOR

- **LINE ON B1:**
Projections are symmetric with respect to the E.L.

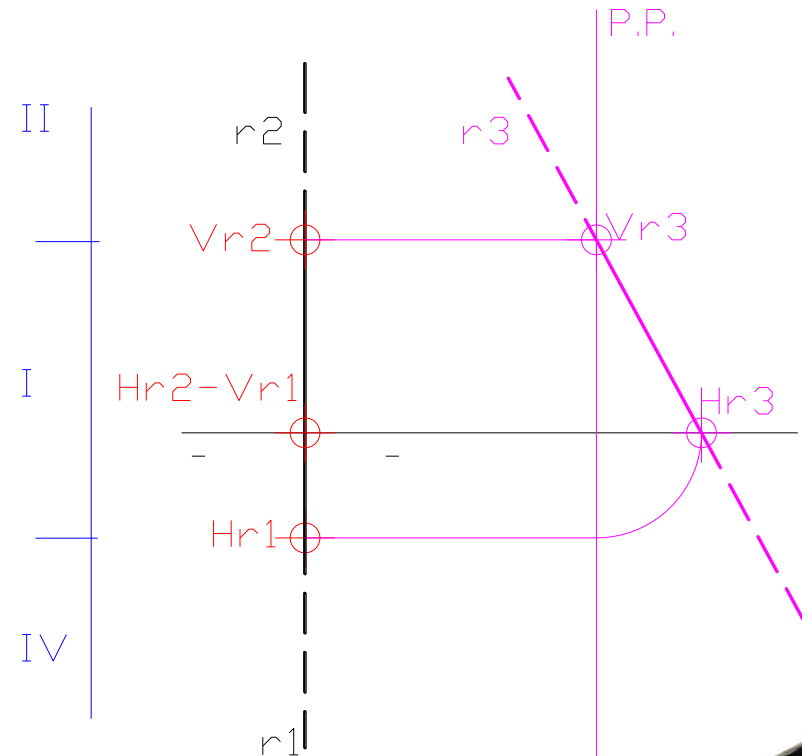
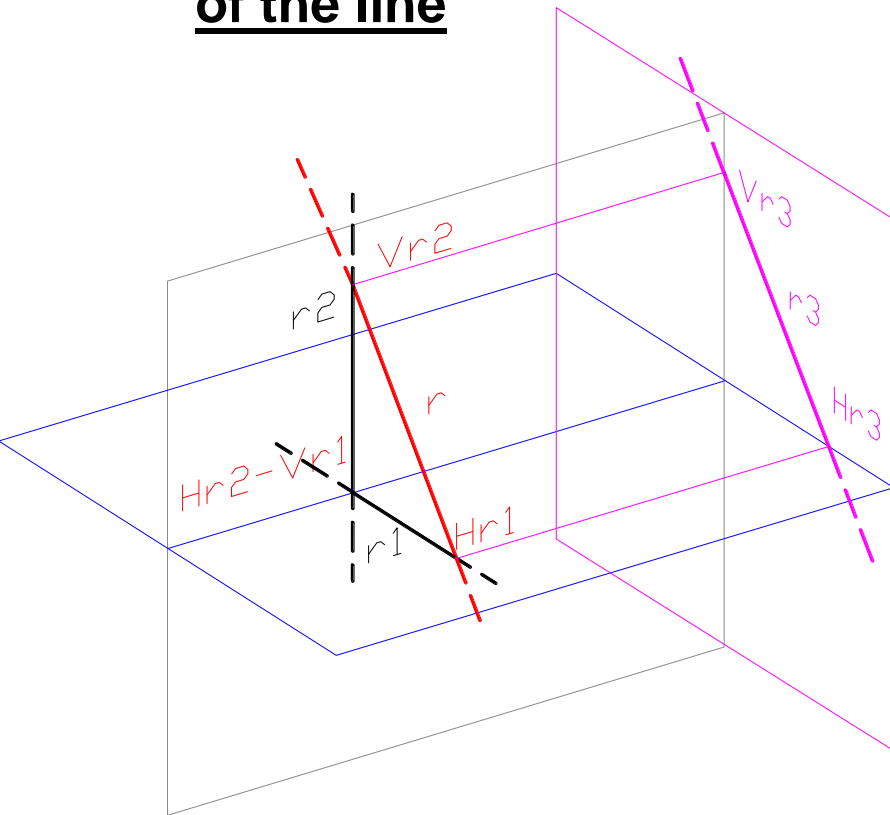


- **LINE ON B2:**
Projections are superimposed



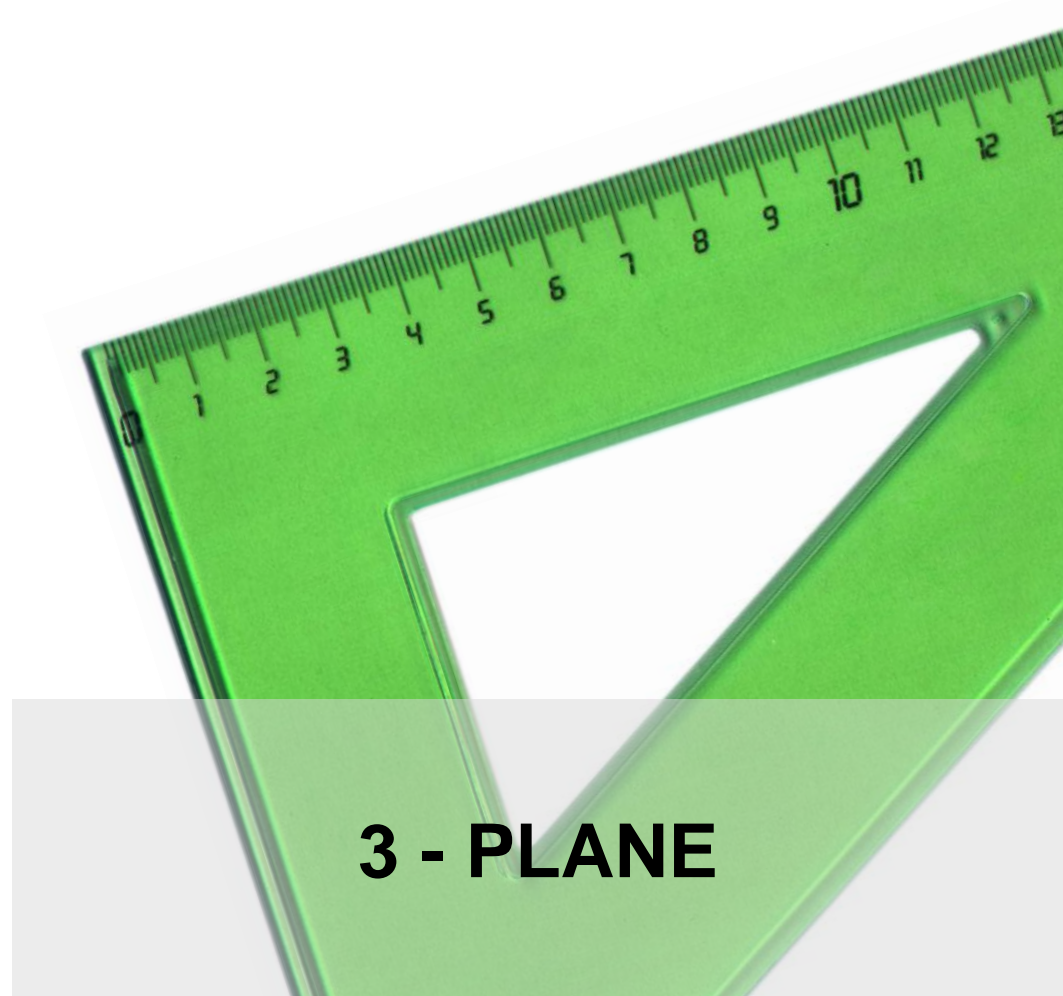
PROFILE LINE

- To determine a profile line, it is necessary to find its 3rd projection (profile projection), using two given points.
- For a profile line, the 3rd projection shows the true magnitude of the line



Graphic Expression

ORTHOGRAPHIC SYSTEM



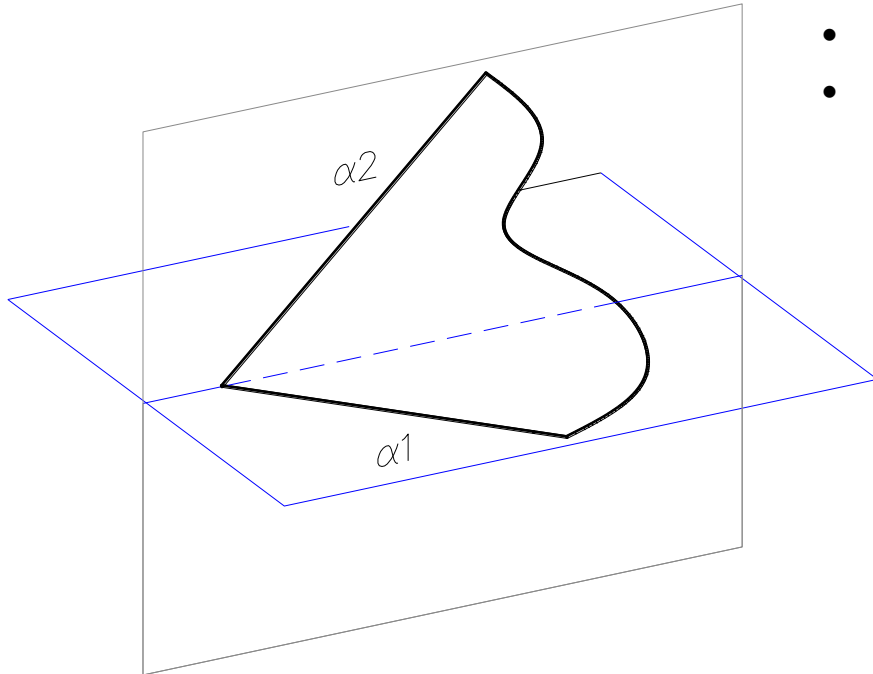
3 - PLANE

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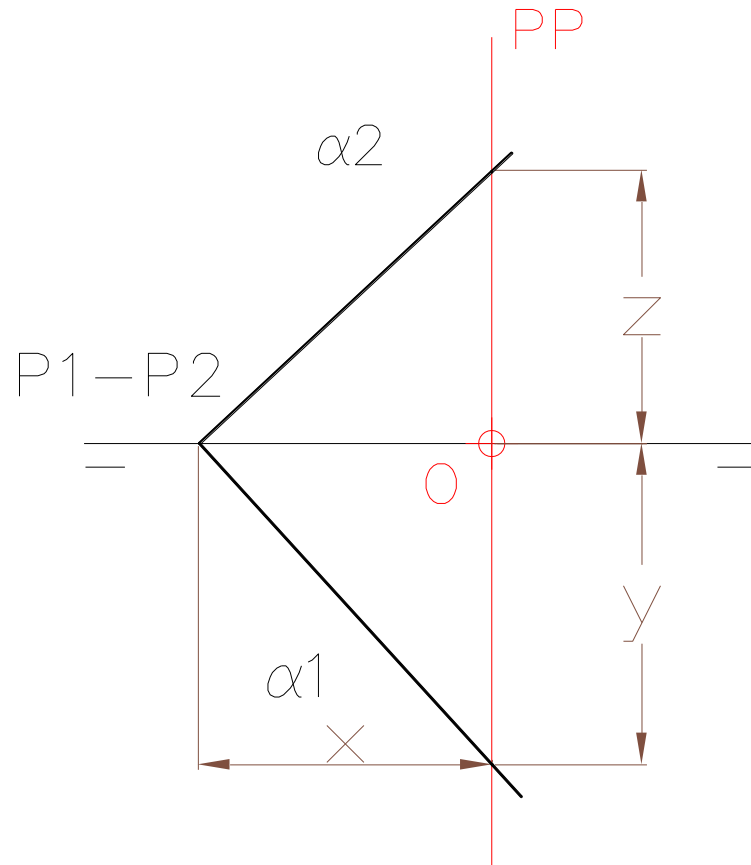
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 3. MAXIMAL TILT LINES
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GENERIC PLANE REPRESENTATION: TRACES, VIEWED AND HIDDEN PARTS AND NOTATION



- Traces are viewed along the 1st. angle.
- Plane traces are represented with thick line, continuous only along the 1st angle.



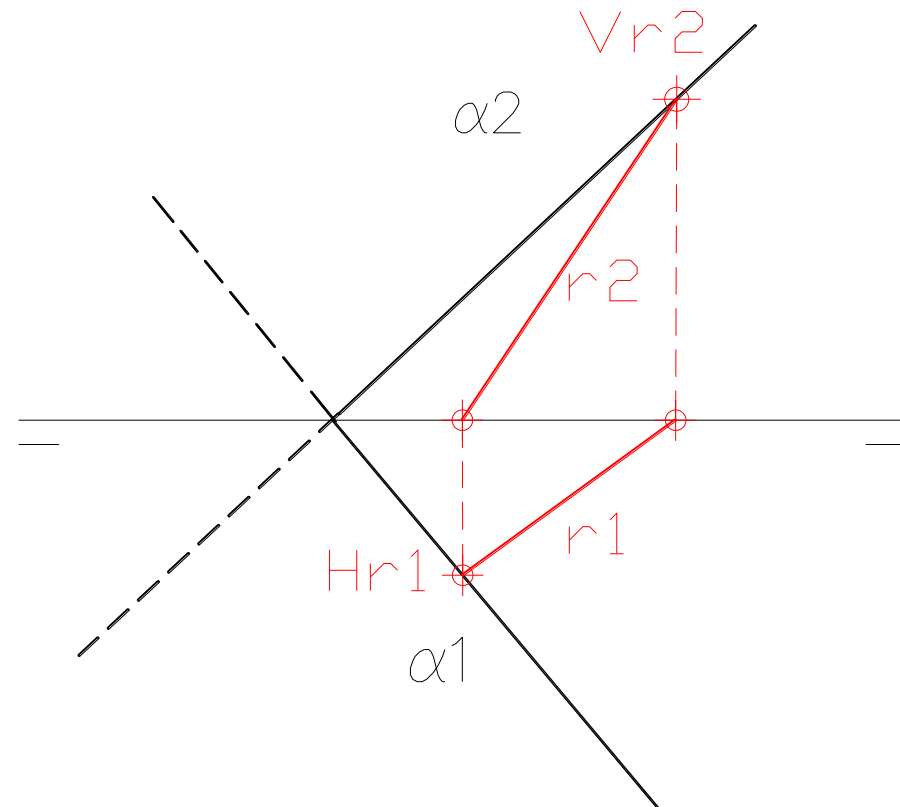
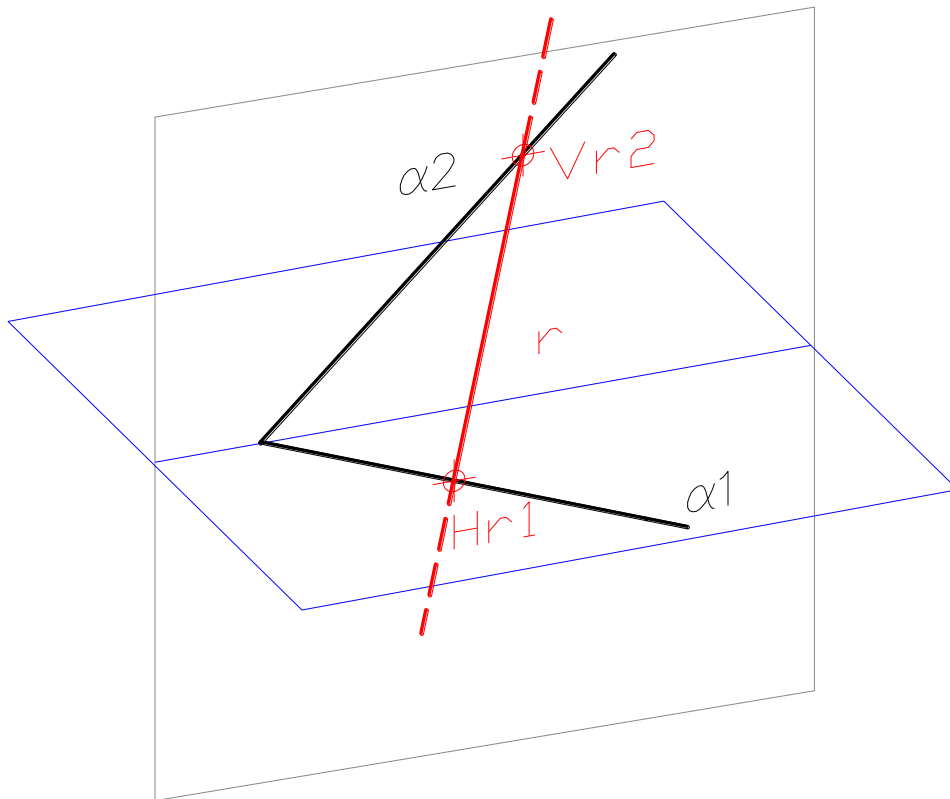
• NOTATION: distance from the plane end to the origin; remoteness and height of the interesection of the plane traces with a profile plane crossing the origin of coordiantes

$\alpha (x,y,z)$



LINE MEMBERSHIP TO A PLANE

- A straight line belongs to a plane if its traces are located on the traces of the plane



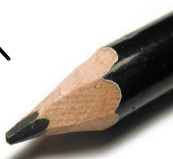
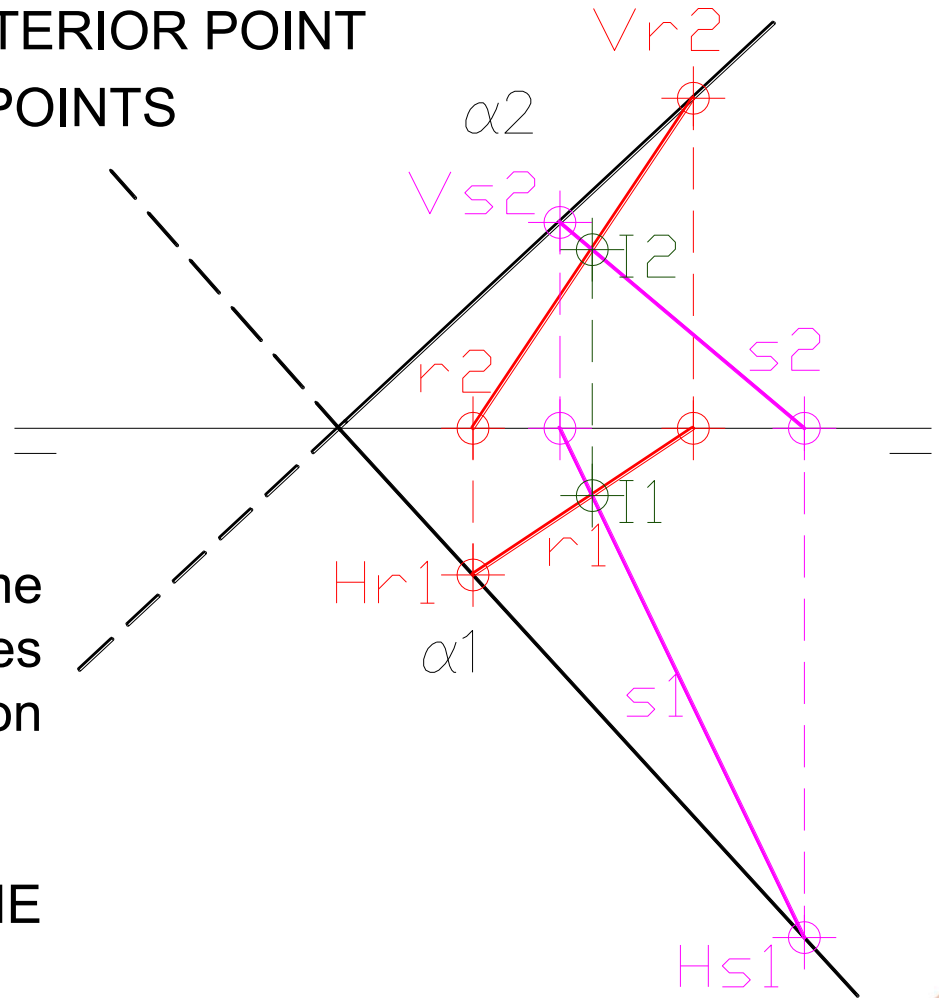
PLANE GIVEN BY...

1. 2 CUTTING LINES
2. ONE LINE AND ONE EXTERIOR POINT
3. THREE NON-ALIGNED POINTS

In any case:

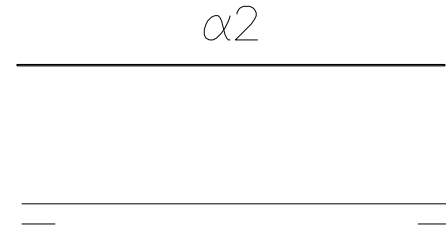
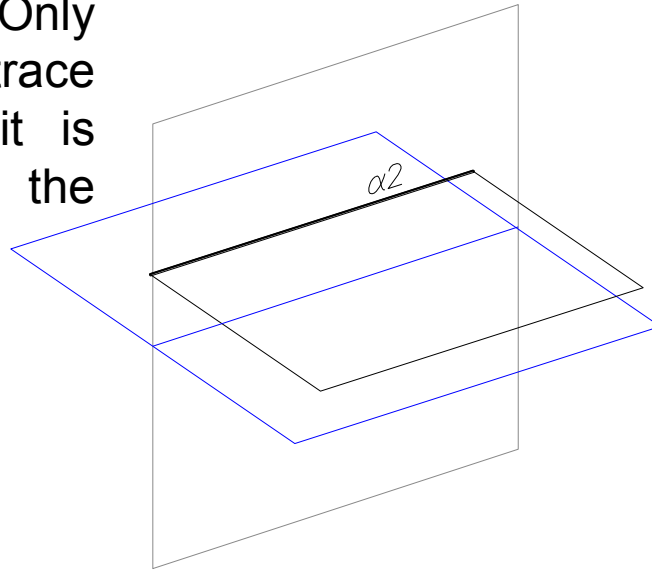
- ✓ Build two lines
- ✓ Find their traces
- ✓ Join the traces of the same projection plane. These lines are the traces of the solution plane

THE TRACES OF THE PLANE
SHOULD MEET AT THE E.L.

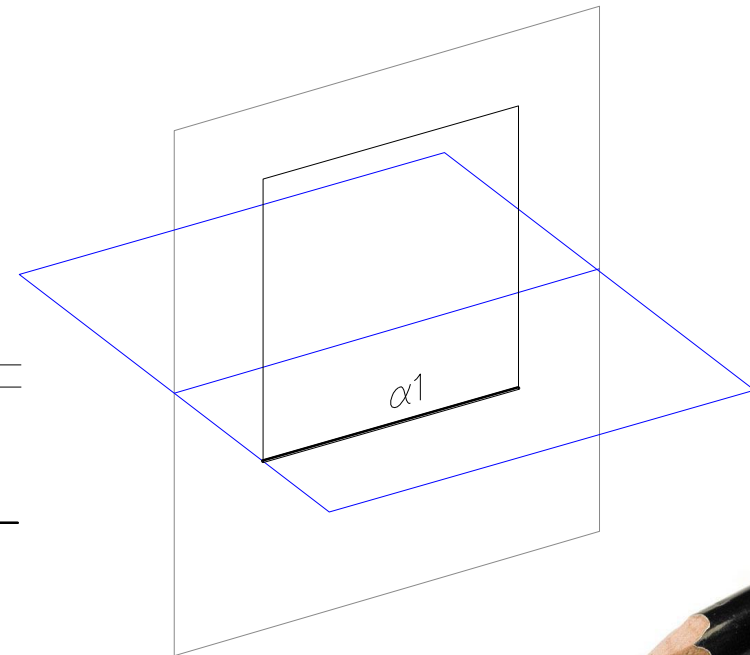


HORIZONTAL AND VERTICAL (or frontal) PLANES

- H. PLANE: Only the vertical trace exists and it is parallel to the E.L.
 $\alpha(\infty, \infty, z)$



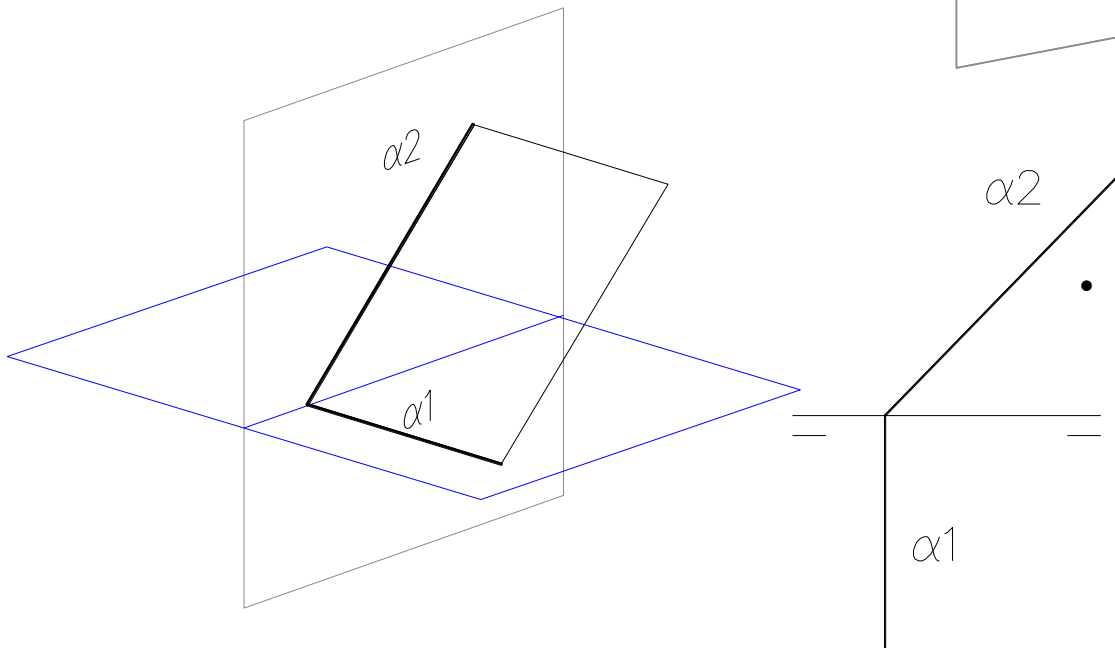
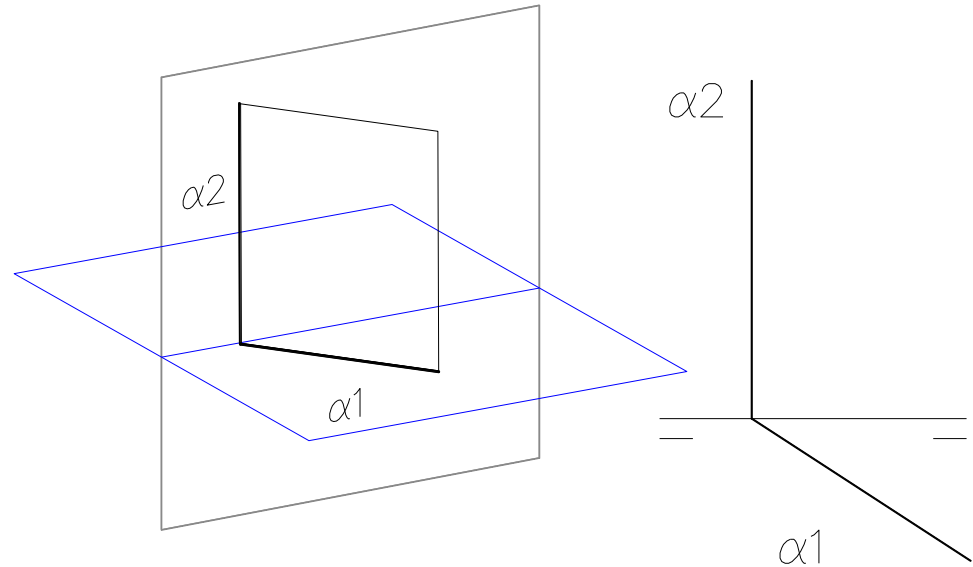
- V. PLANE: Only the horizontal trace exists and it is parallel to the E.L.
 $\alpha(\infty, y, \infty)$



HORIZONTAL AND VERTICAL (or frontal) PROJECTING PLANES

H. PROJECTING PLANE: The vertical trace is perpendicular to the E.L. All its elements have their horizontal projection on its horizontal trace

$\alpha(x, y, \infty)$



V. PROJECTING PLANE: The horizontal trace is perpendicular to the E.L. All its elements have their vertical projection on its vertical trace

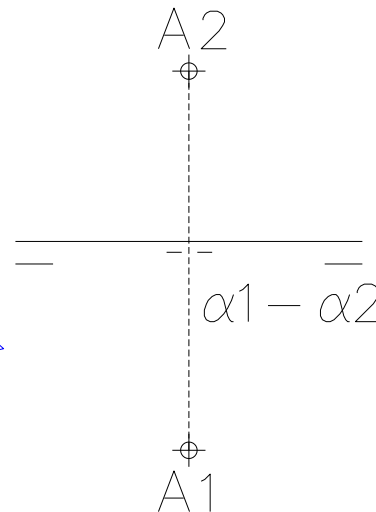
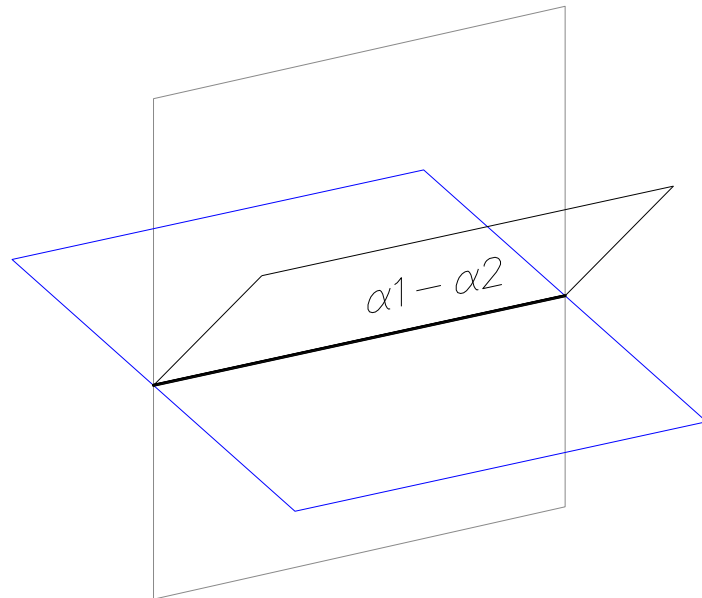
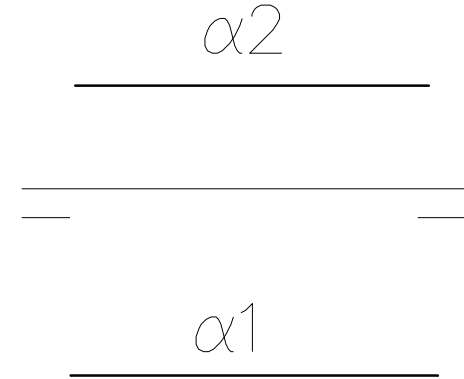
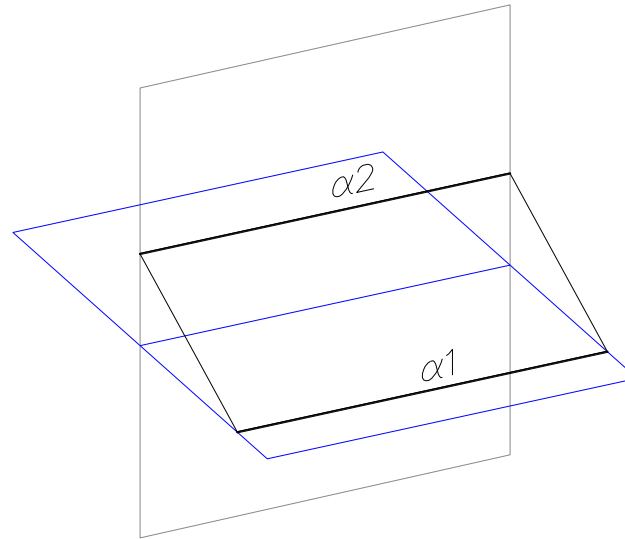
$\alpha(x, \infty, z)$



PLANE PARALLEL TO THE E.L AND PLANE CONTAINING THE E.L.

PLANE PARALLEL TO
E.L.: It has their traces
parallel to the E.L.

$\alpha(\infty, y, z)$

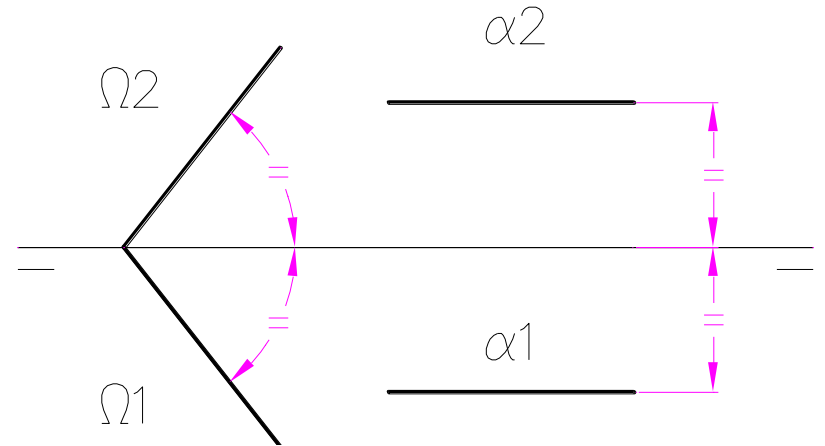


- PLANE CONTAINING
THE E.L.: It has its traces
coincident with the E.L.
One single point defines
the plane

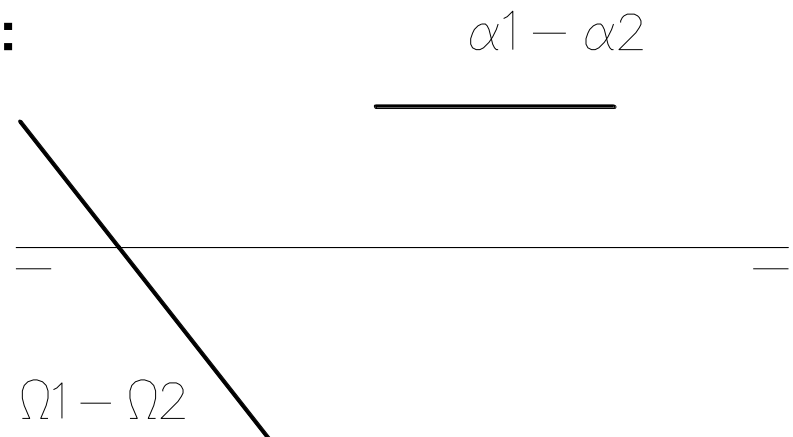


PLANE PERPENDICULAR TO THE 1ST BISECTOR AND PLANE PERPENDICULAR TO THE 2ND BISECTOR

- **PLANE PERPENDICULAR TO B1:**
It has symmetrical traces with respect to the E.L.

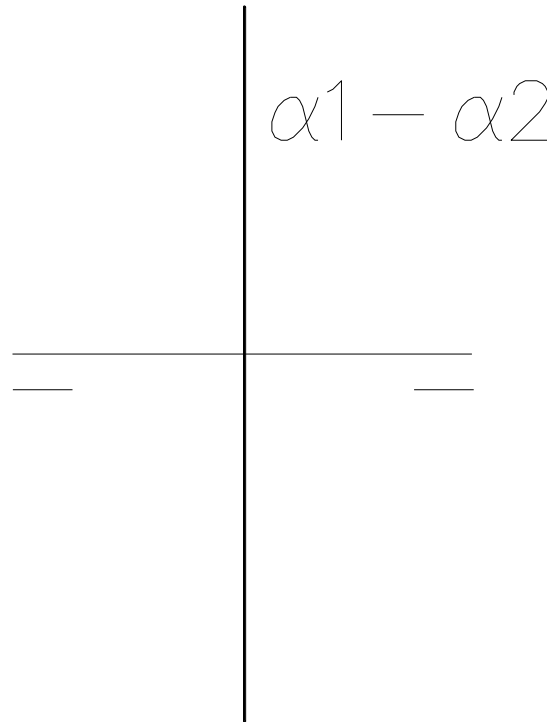
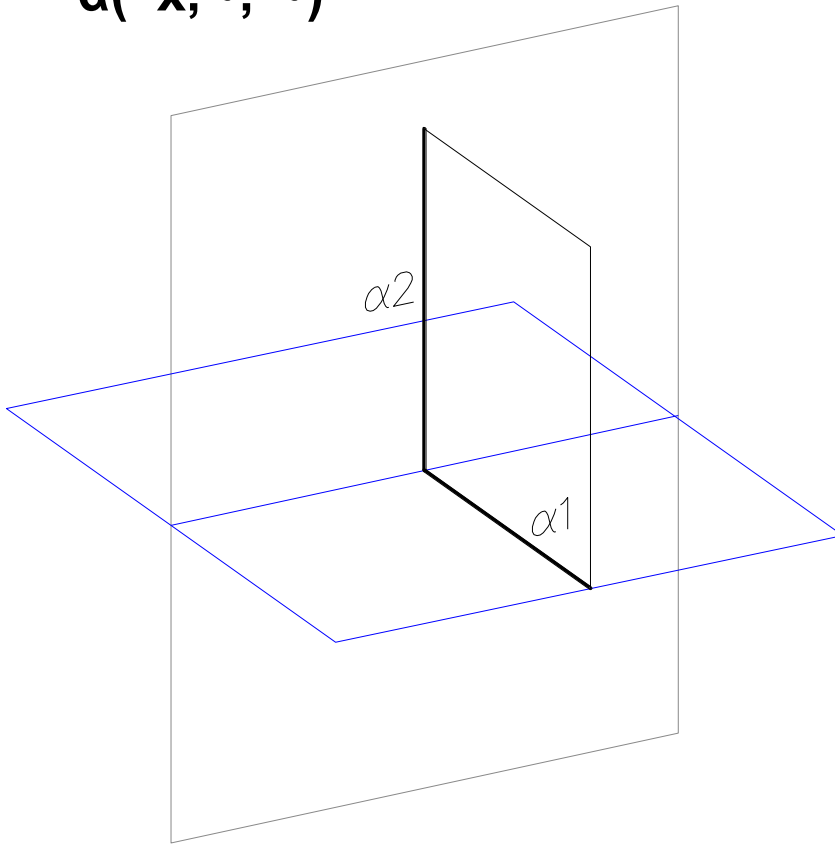


- **PLANE PERPENDICULAR TO B2:**
It has coincident traces



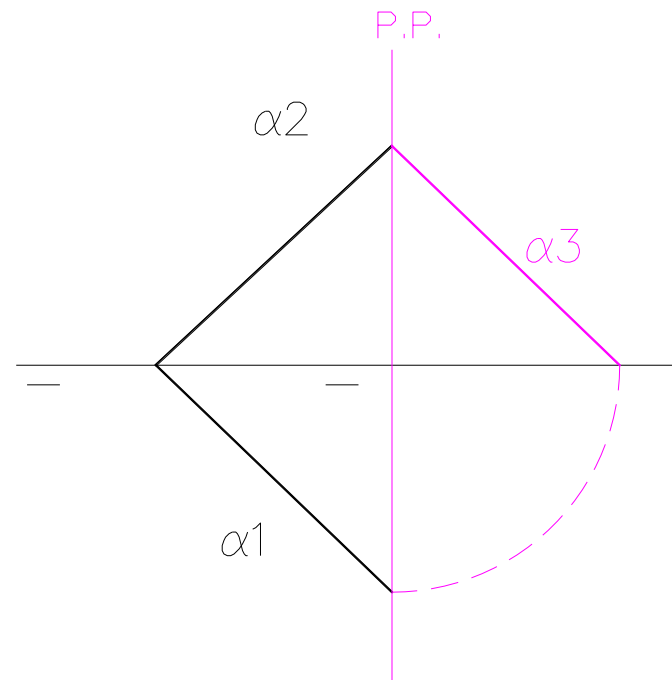
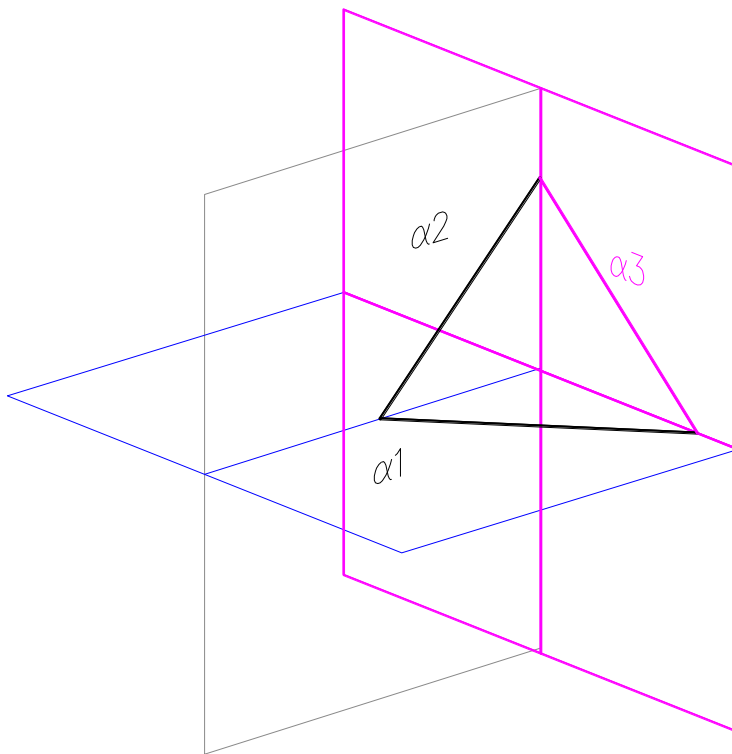
PROFILE PLANES

- **P. PLANE:** Its traces are both perpendicular to the E.L.
Are usually used to help defining other elements
 $\alpha(x, \infty, \infty)$

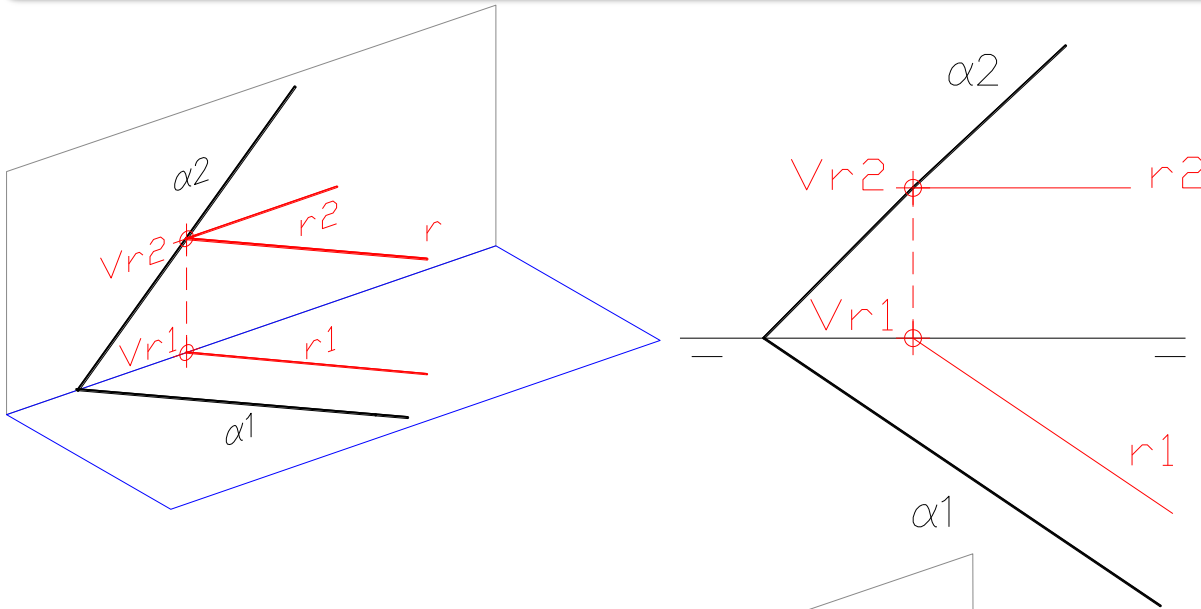


3RD TRACE

- The 3rd trace of a plane is its intersection with the Profile Projection Plane (P.P)
- It is obtained by joining the intersection of the horizontal and vertical traces of the plane on the P.P
- It is useful for the managing of particular planes, like those parallel or cutting the Earth Line.

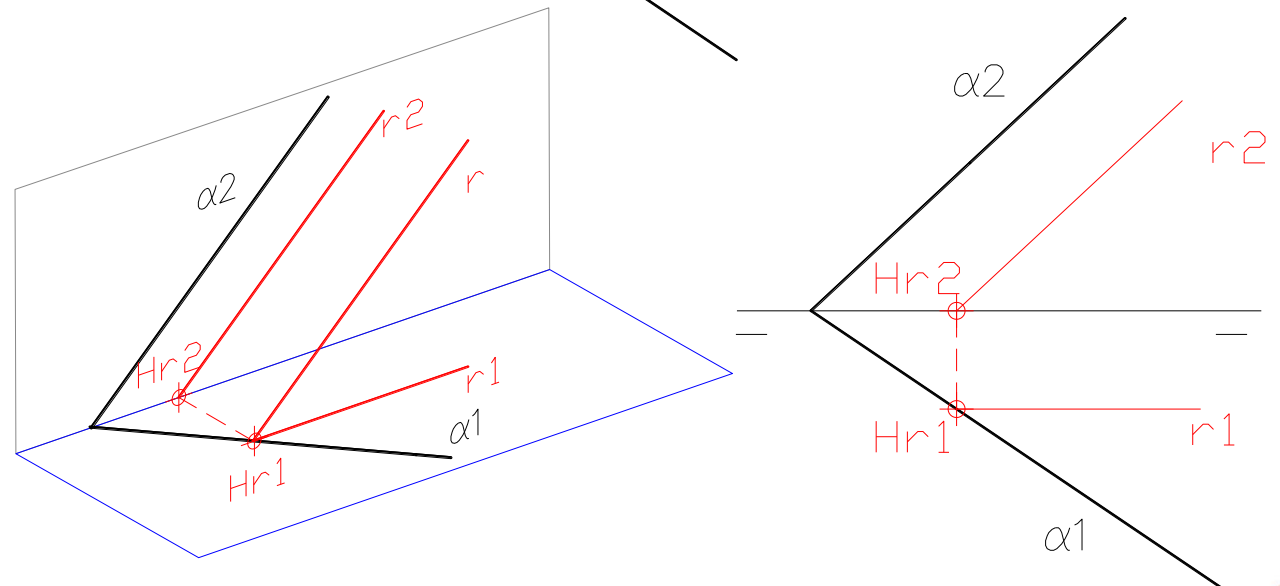


HORIZONTAL AND FRONTAL PLANE LINES



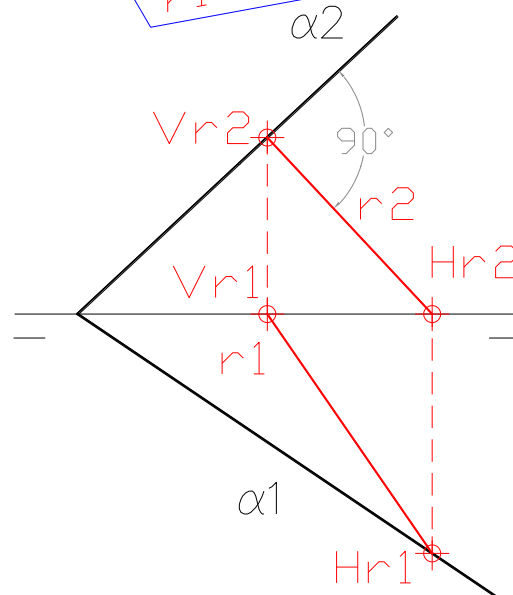
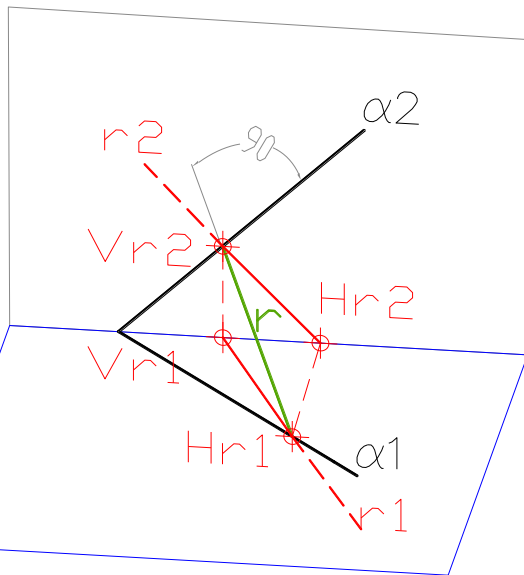
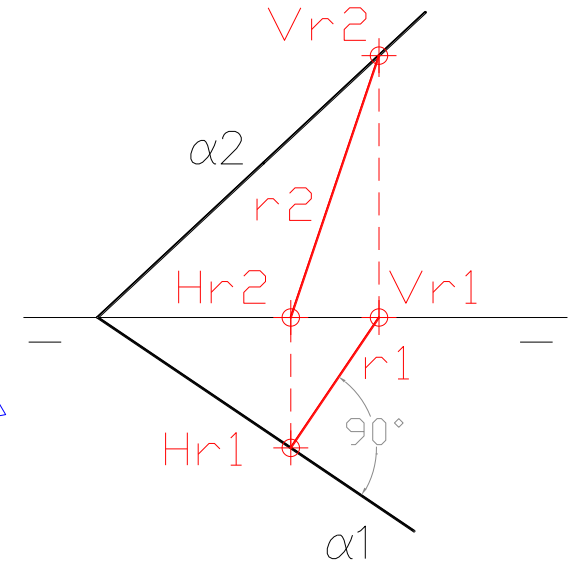
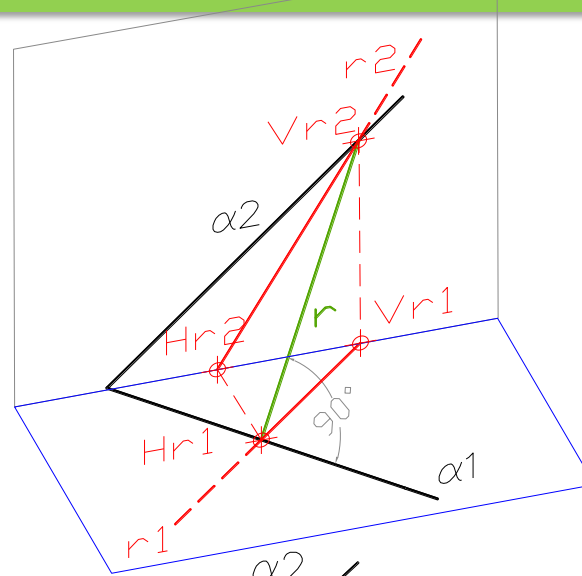
- **H. PLANE LINE:** The horizontal projection of the line is parallel to the horizontal trace of the plane

- **F. PLANE LINE:** The vertical projection of the line is parallel to the vertical trace of the plane



MAXIMAL SLOPE AND MAXIMAL TILT PLANE LINES

- MAX. SLOPE LINE: Its horizontal projection is perpendicular to the horizontal trace of the plane

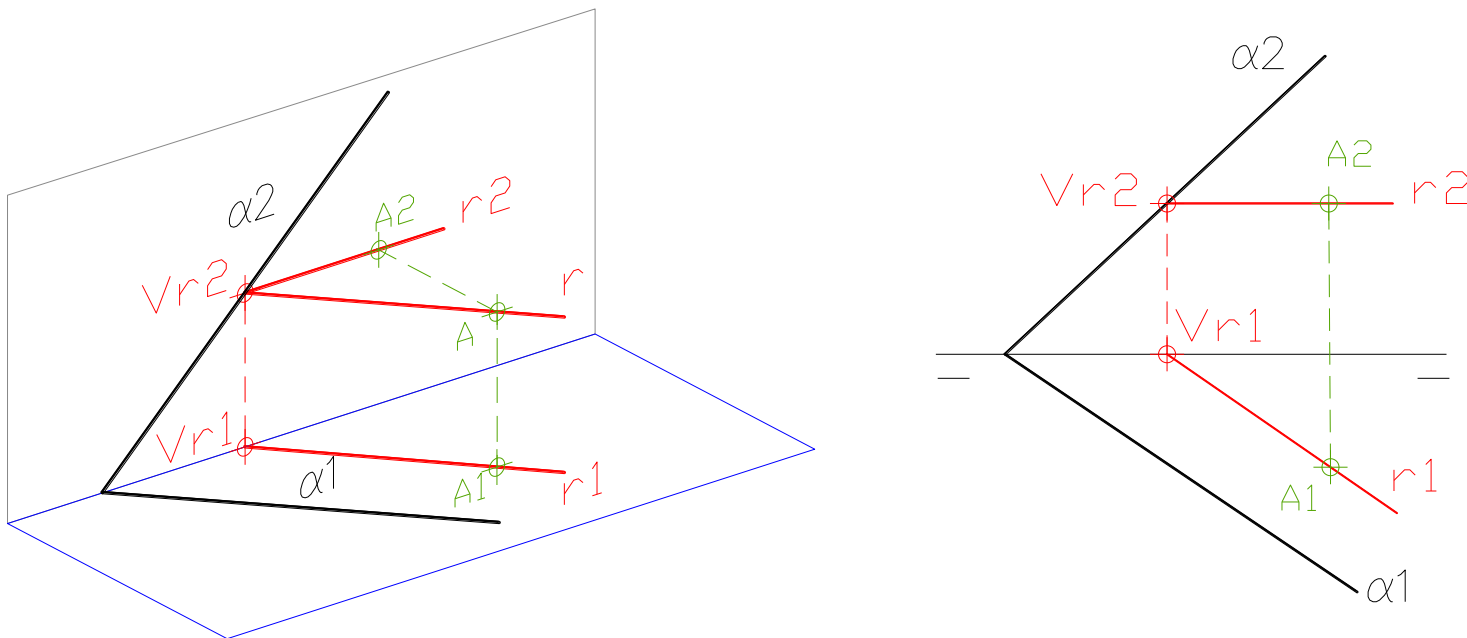


- MAX. TILT LINE: Its vertical projection is perpendicular to the vertical trace of the plane



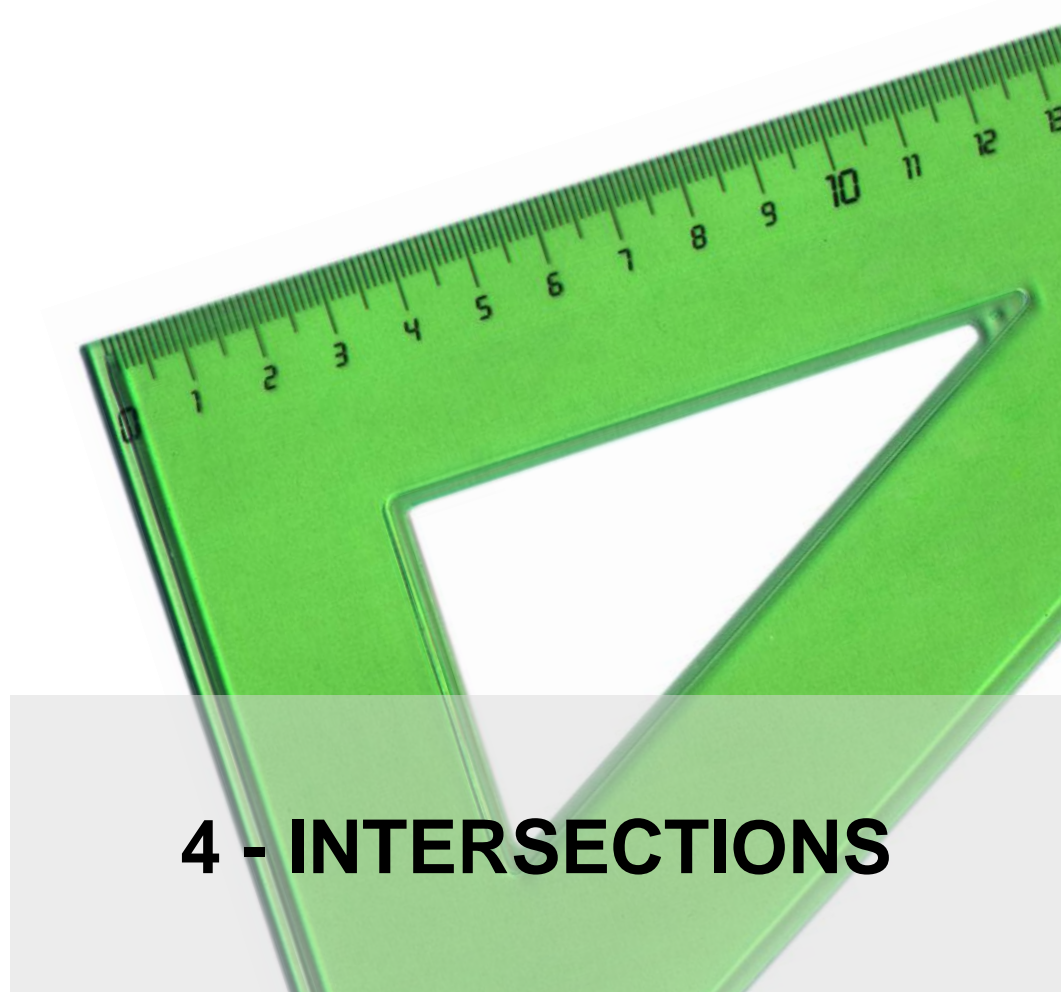
POINT MEMBERSHIP TO A PLANE

- A point belongs to a plane, if the point could be located on any of the lines that belong to that plane
- In practice, horizontal or frontal lines are used to check the point membership to a plane, or to locate a point onto a plane



Graphic Expression

ORTHOGRAPHIC SYSTEM



4 - INTERSECTIONS

TABLE OF CONTENTS

1. LINES INTERSECTION

2. PLANES INTERSECTION

1. GENERIC CASE
2. TRACES DO NOT MEET IN THE LIMITS OF THE PAPER FORMAT
3. INTERSECTIONS WITH THE BISECTORS
4. INTERSECTIONS OF PLANES PARALLEL OR CUTTING THE EARTH LINE: USE OF THE 3RD TRACE

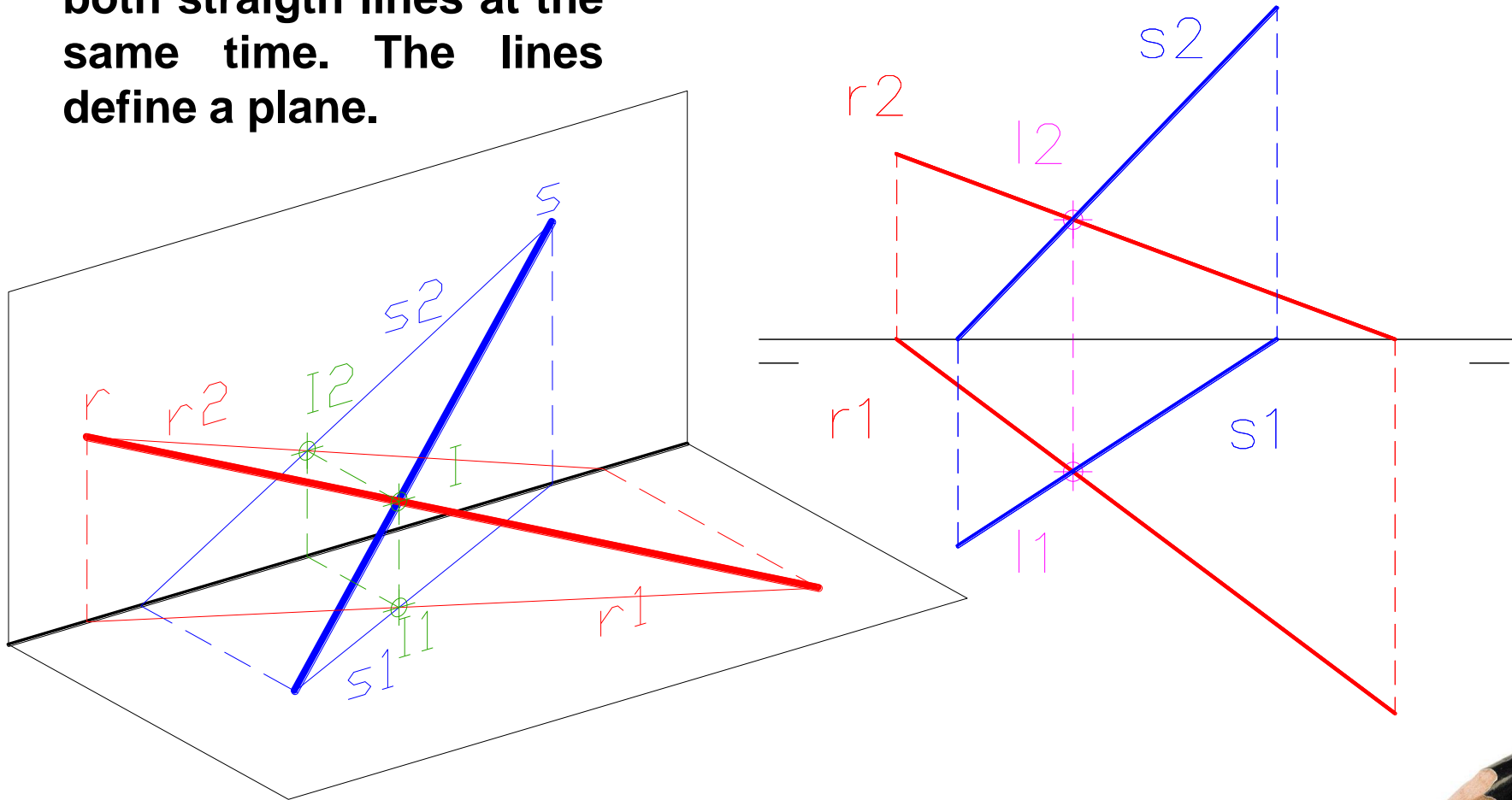
3. LINE AND PLANE INTERSECTION

1. GENERIC CASE
2. INTERSECCION OF A PROFILE LINE WITH A PLANE



LINES INTERSECTION

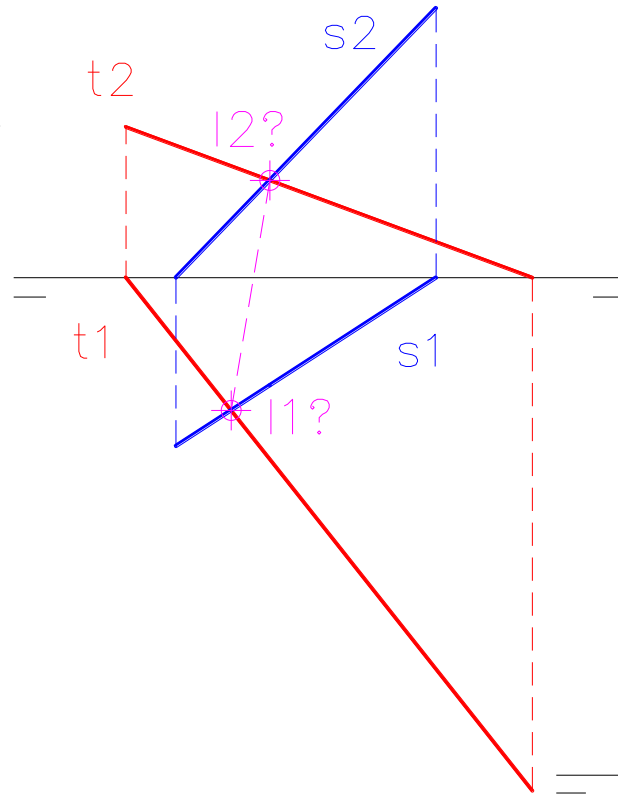
- The intersection is the point which belongs to both straight lines at the same time. The lines define a plane.



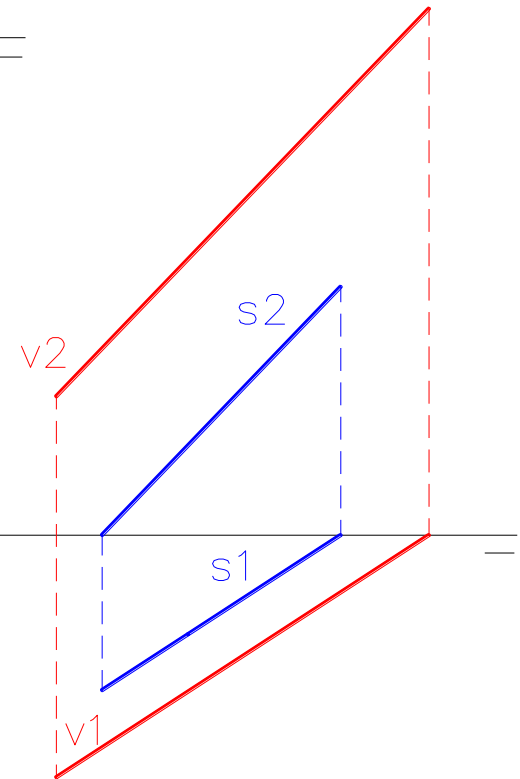
LINES INTERSECTION

- Lines do not intersect if they:

- Cross each other

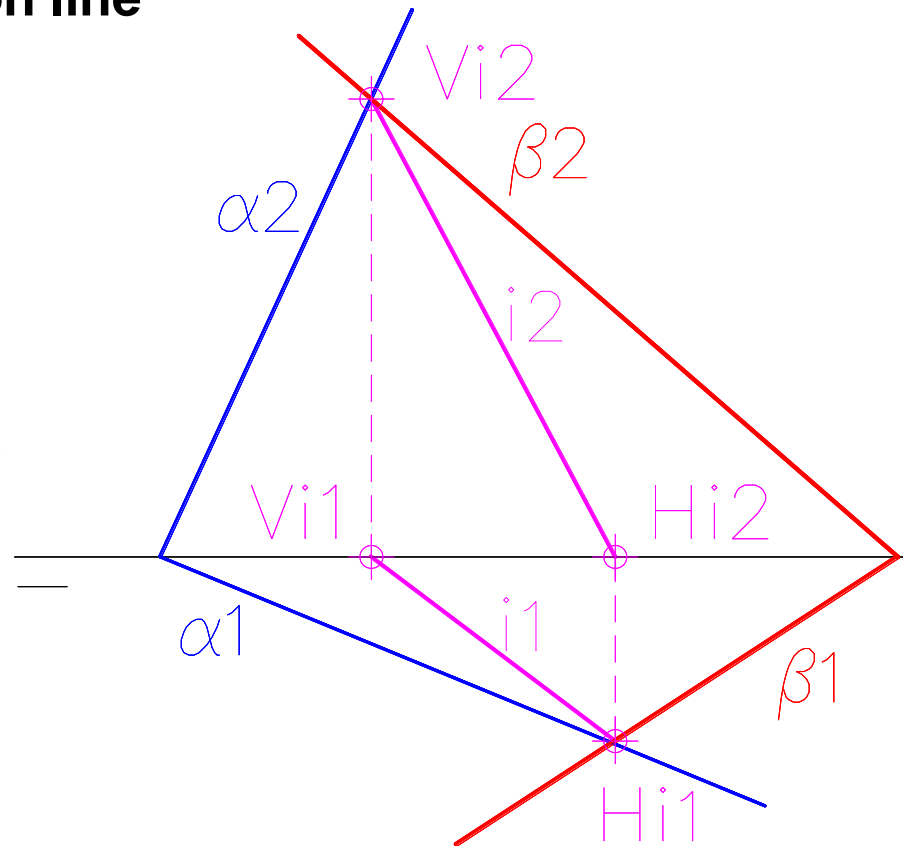
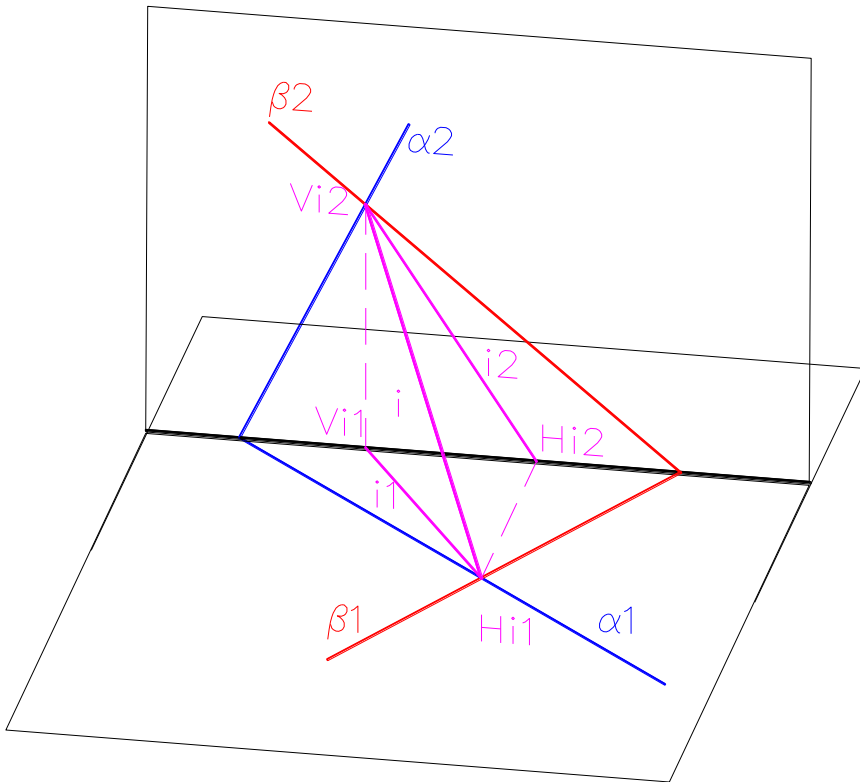


- Are parallel to each other



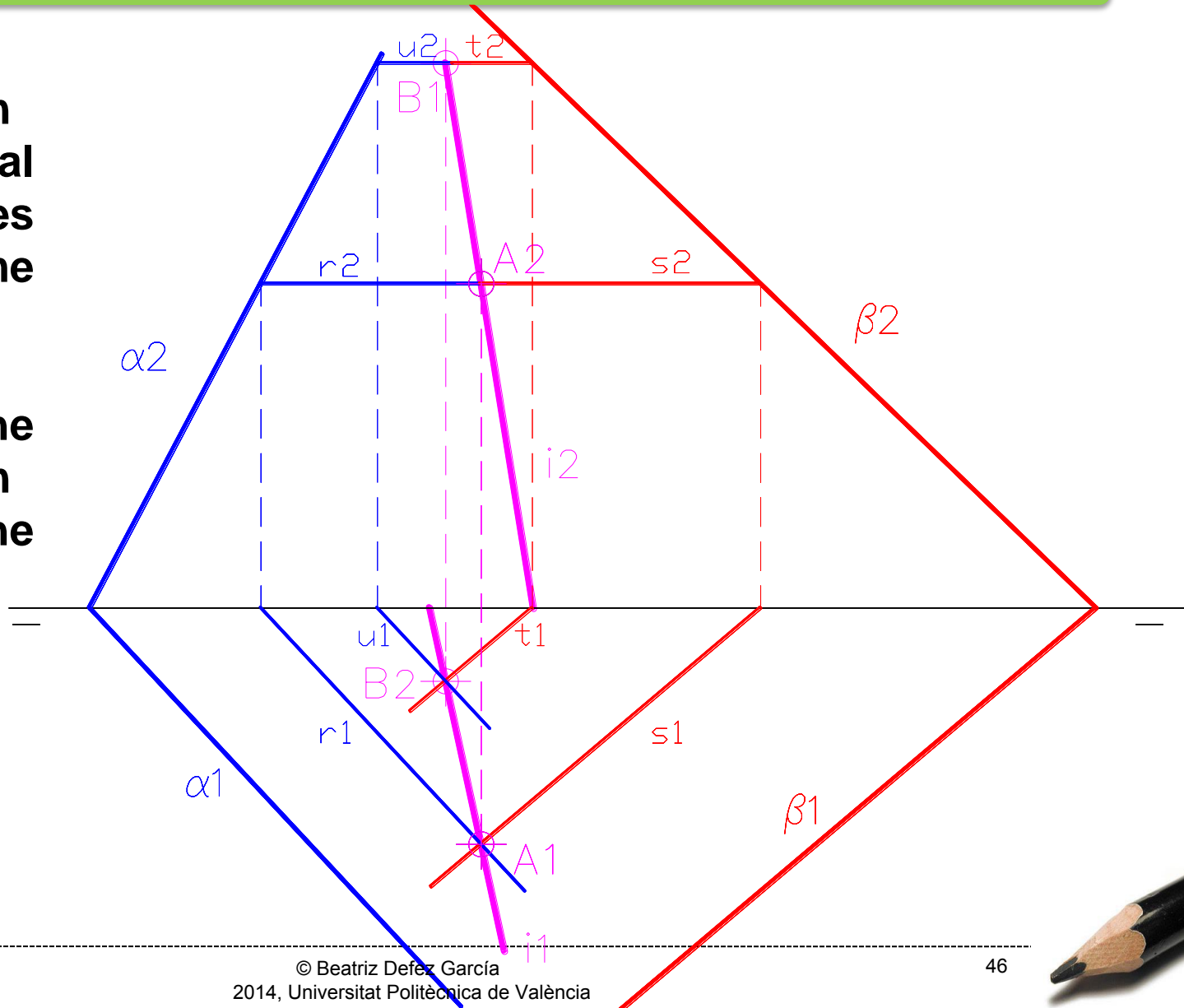
PLANES INTERSECTION. GENERIC CASE

- The intersection is the line that joins the intersection points of the horizontal and vertical traces of the planes. Such points are the traces of the intersection line

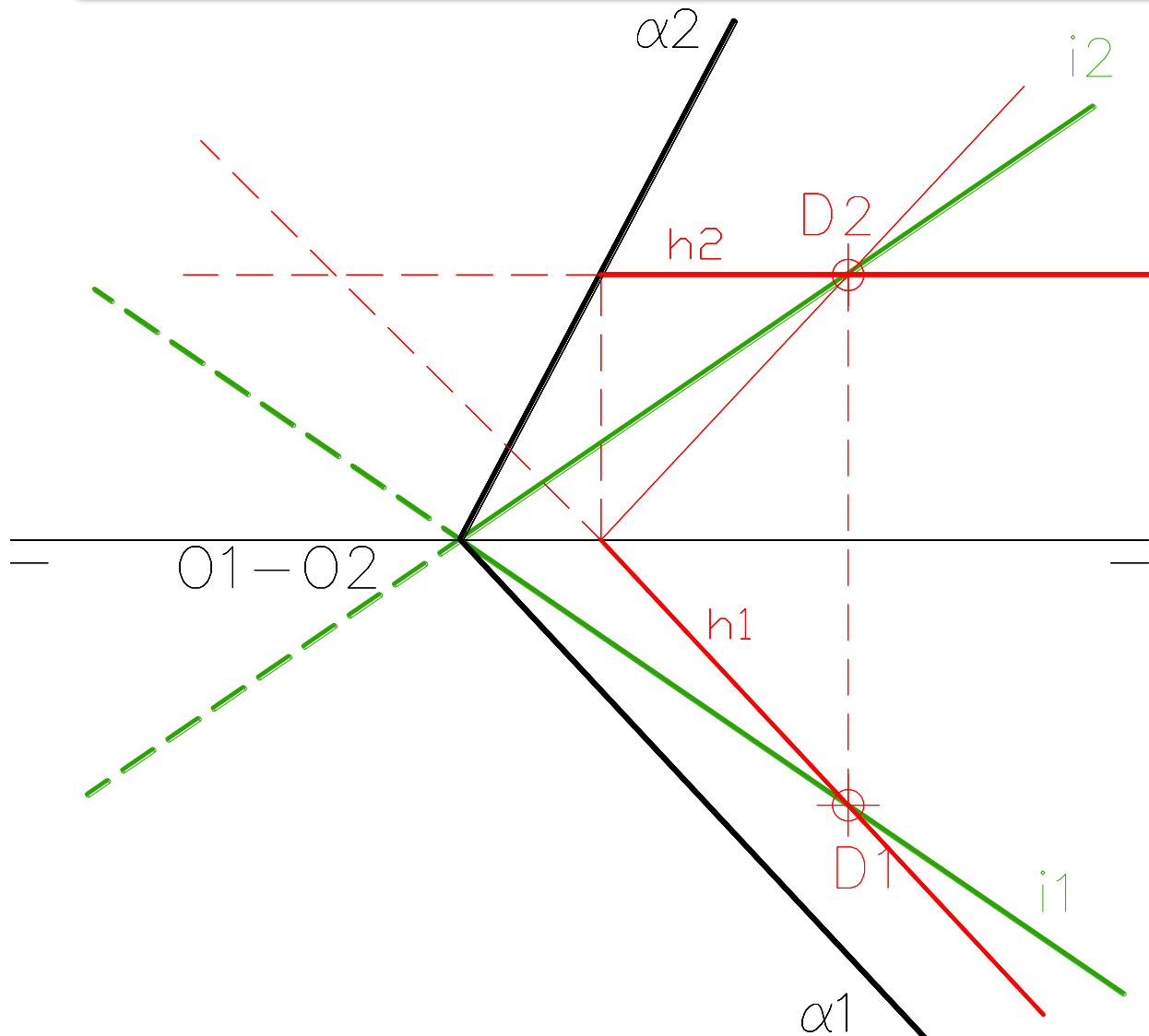


PLANES INTERSECTION. TRACES DO NOT MEET ON THE PAPER

- The intersection of horizontal plane lines at the same height provide points of the intersection line of the planes



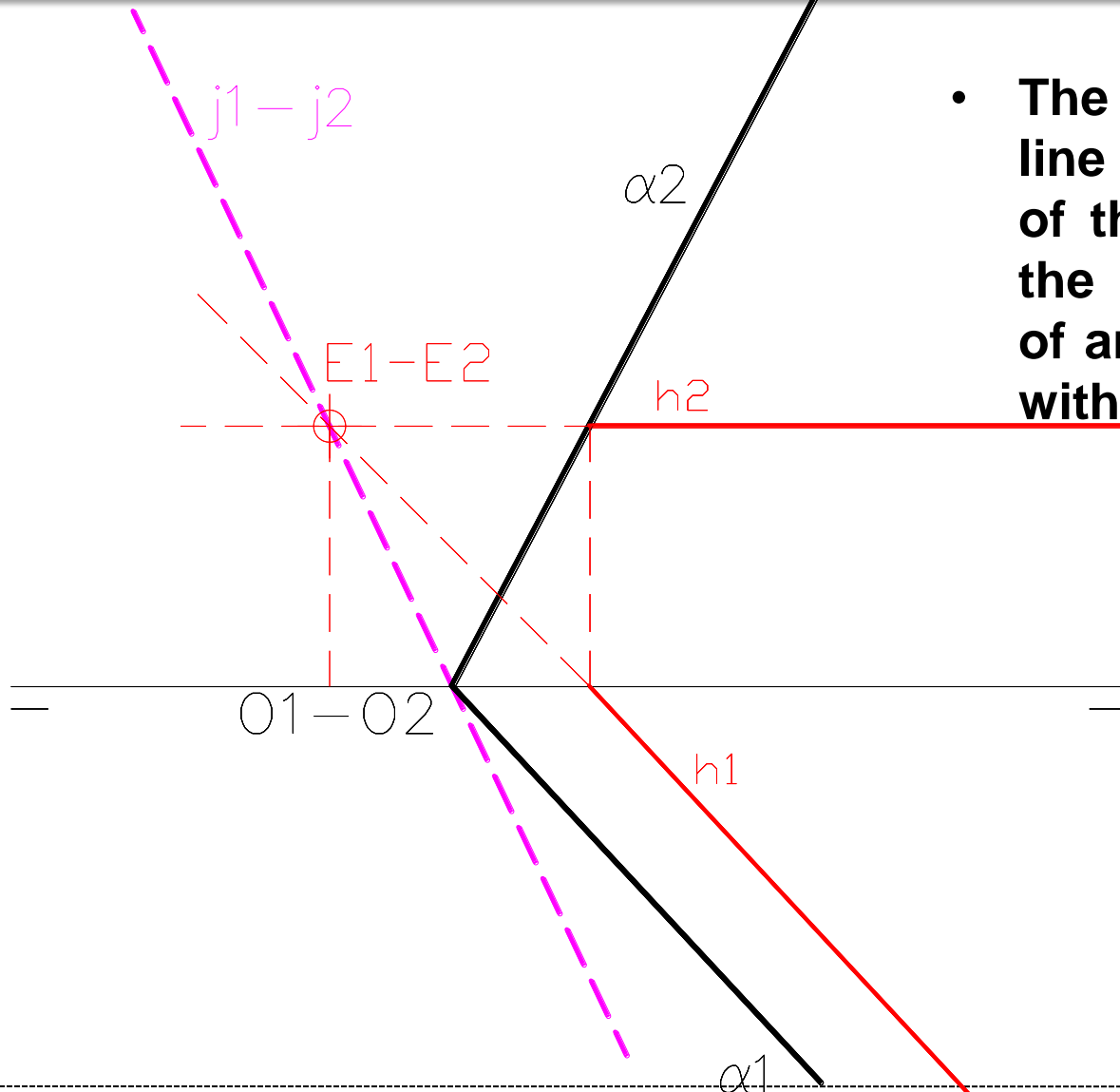
PLANES INTERSECTION. INTESECON WITH B1



- The intersection line joins the end of the plane with the intersection of any of its lines with B_1



PLANES INTERSECTION. INTERSESECTION WITH B2

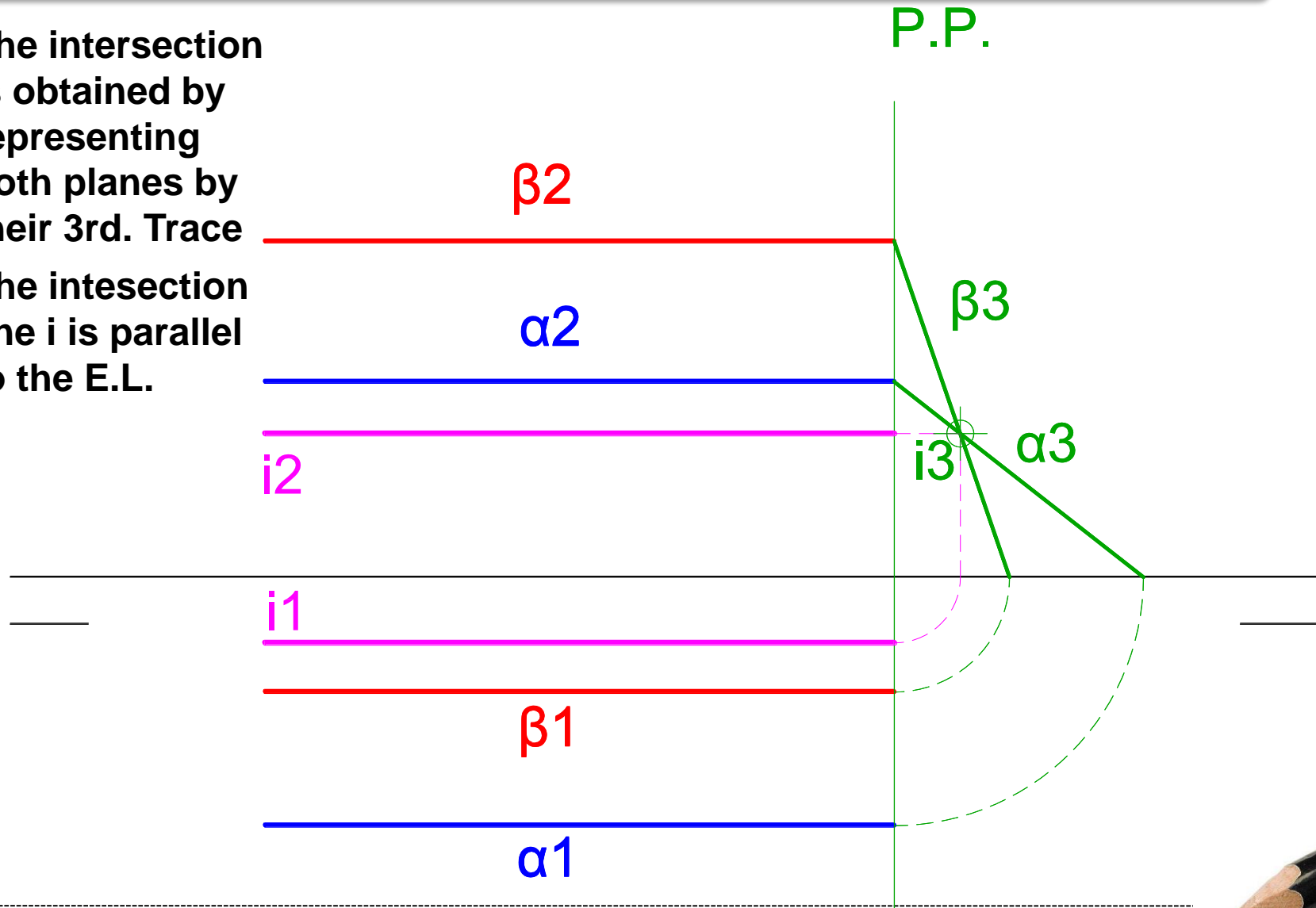


- The intersection line joins the end of the plane with the intersection of any of its lines with B_2



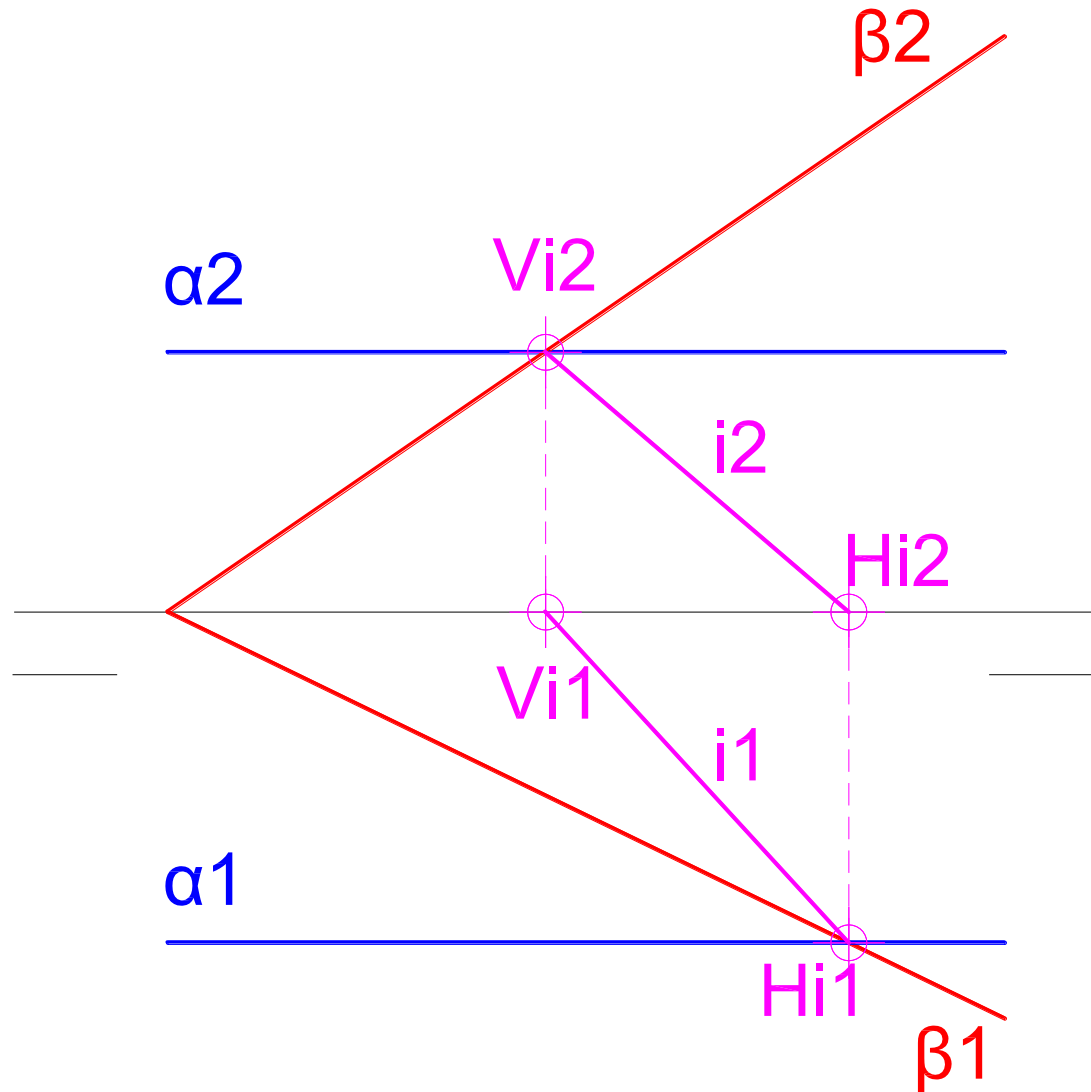
INTERSECTIONS OF PLANES PARALLEL TO THE E.L.

- The intersection is obtained by representing both planes by their 3rd. Trace
- The intersection line i is parallel to the E.L.



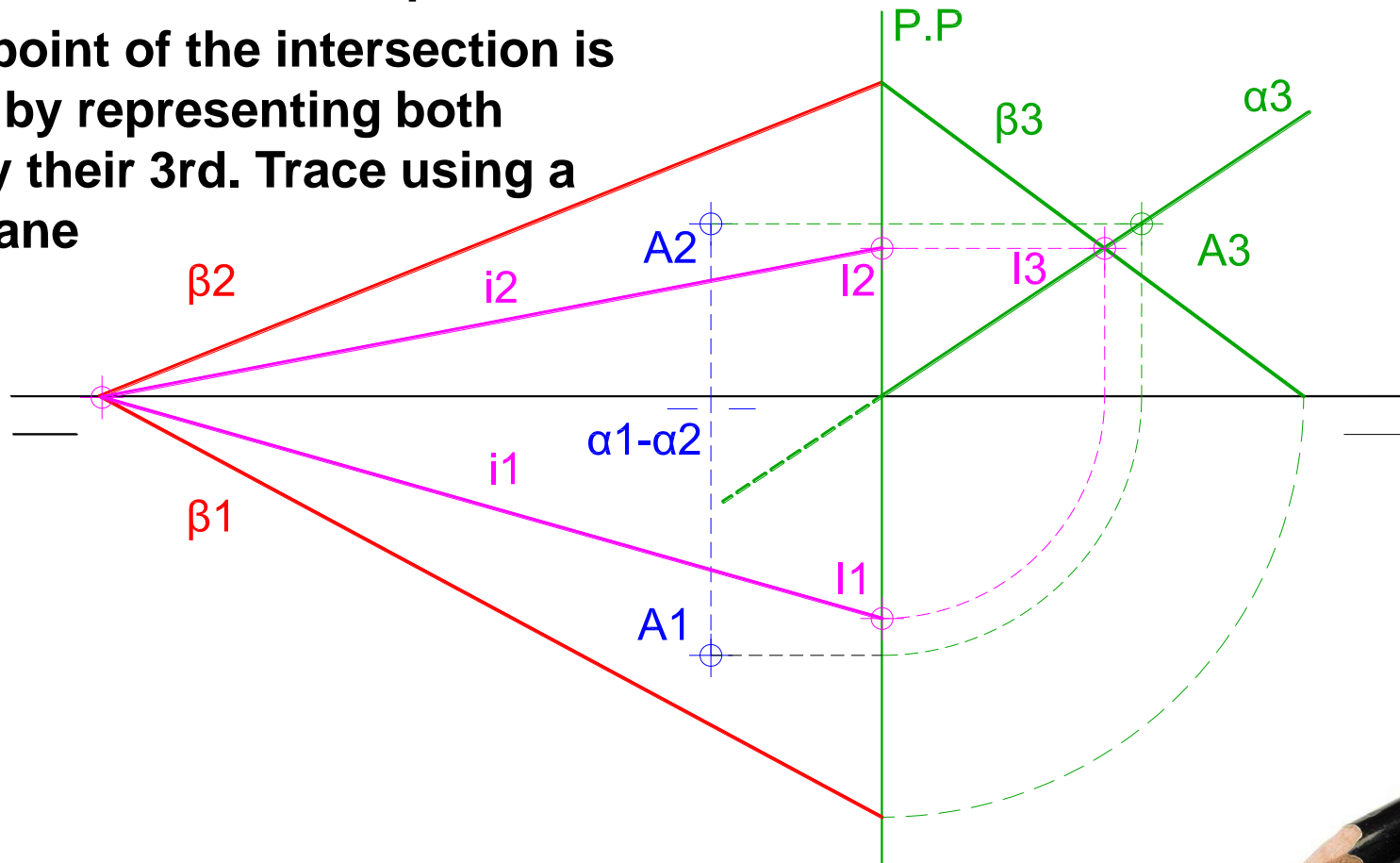
INTERSECTIONS OF PLANES PARALLEL TO THE E.L. AND COMMON PLANES

- The intersection is obtained by representing both planes by their 3rd. Trace
- The intersection line i is parallel to the E.L.



INTERSECTIONS OF PLANES CONTAINING THE E.L. AND COMMON PLANES

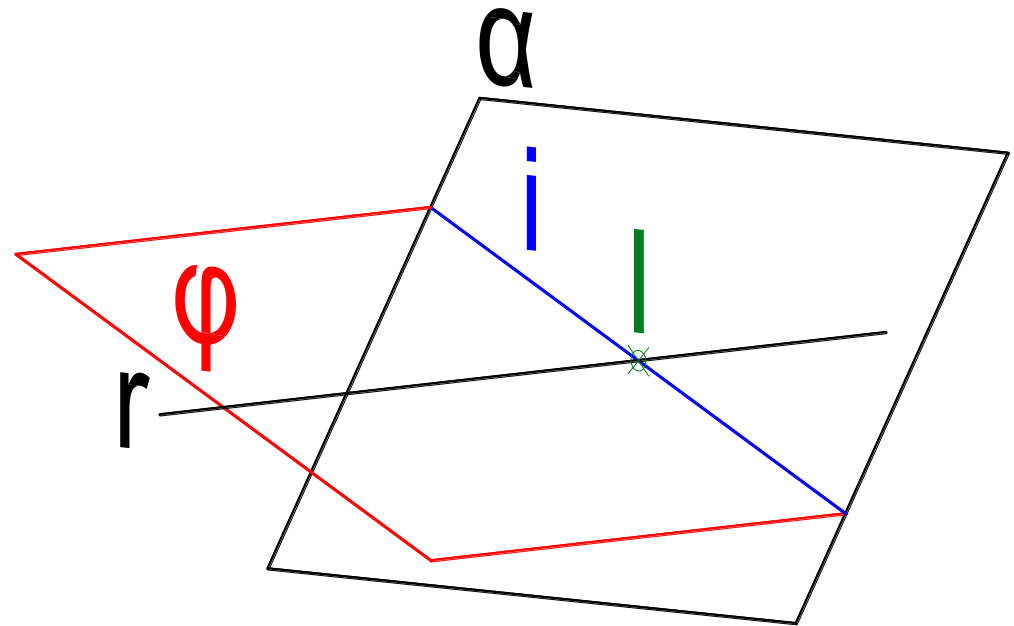
- The intersection line contains the EL. Therefore its traces are located at the end of the common plane
- Another point of the intersection is obtained by representing both planes by their 3rd. Trace using a profile plane



LINE AND PLANE INTERSECTION. GENERIC CASE. 3D APPROACH

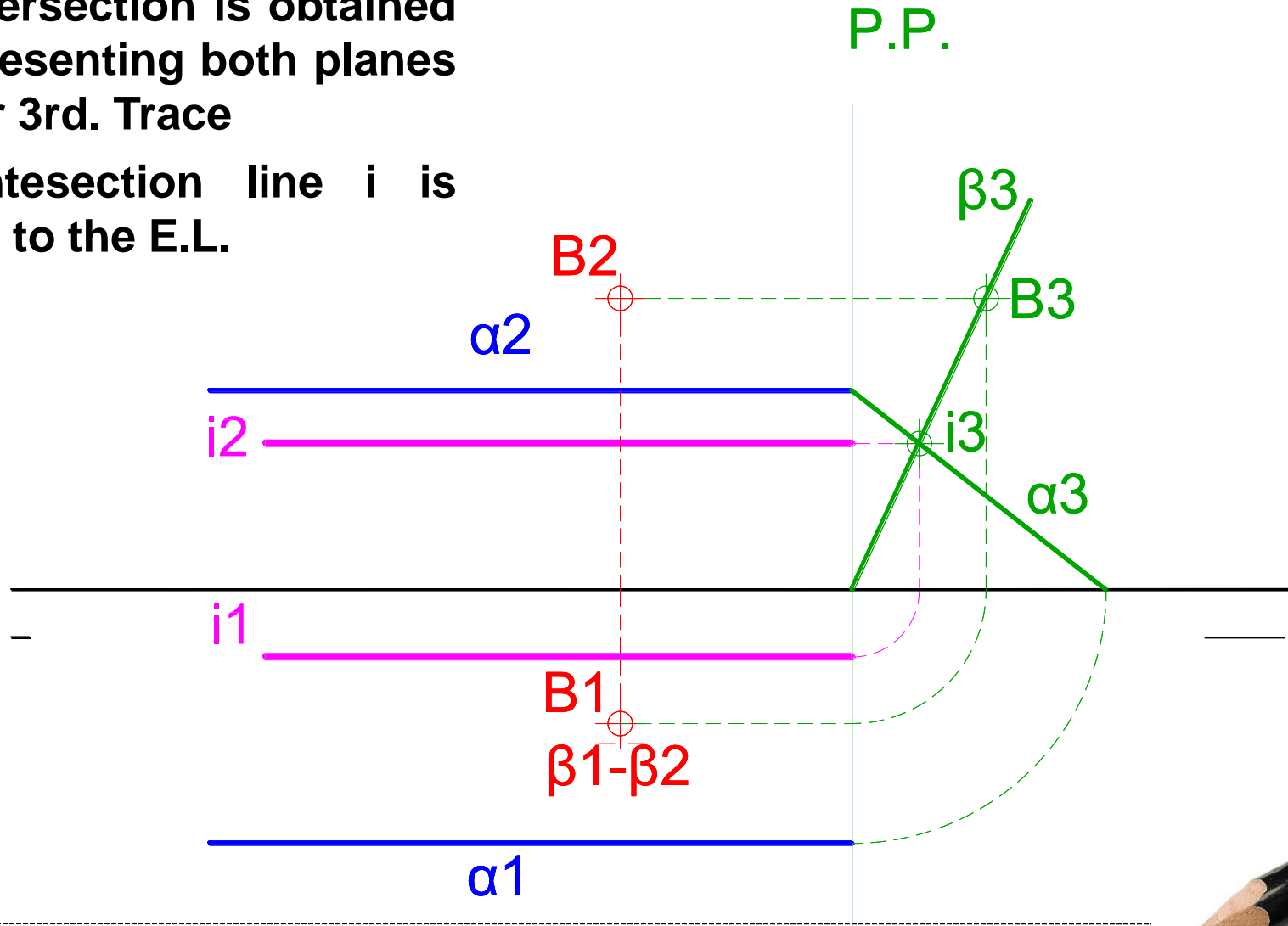
- **GENERIC METHOD:**
intersection between
plane α and line r

- Build an auxiliar plane φ containing the line r
- Find the intersection line i between planes α and φ
- Find the intersection point I between lines r and i . THIS IS THE INTERSECTION POINT



INTERSECTIONS OF PLANES CONTAINING THE E.L.

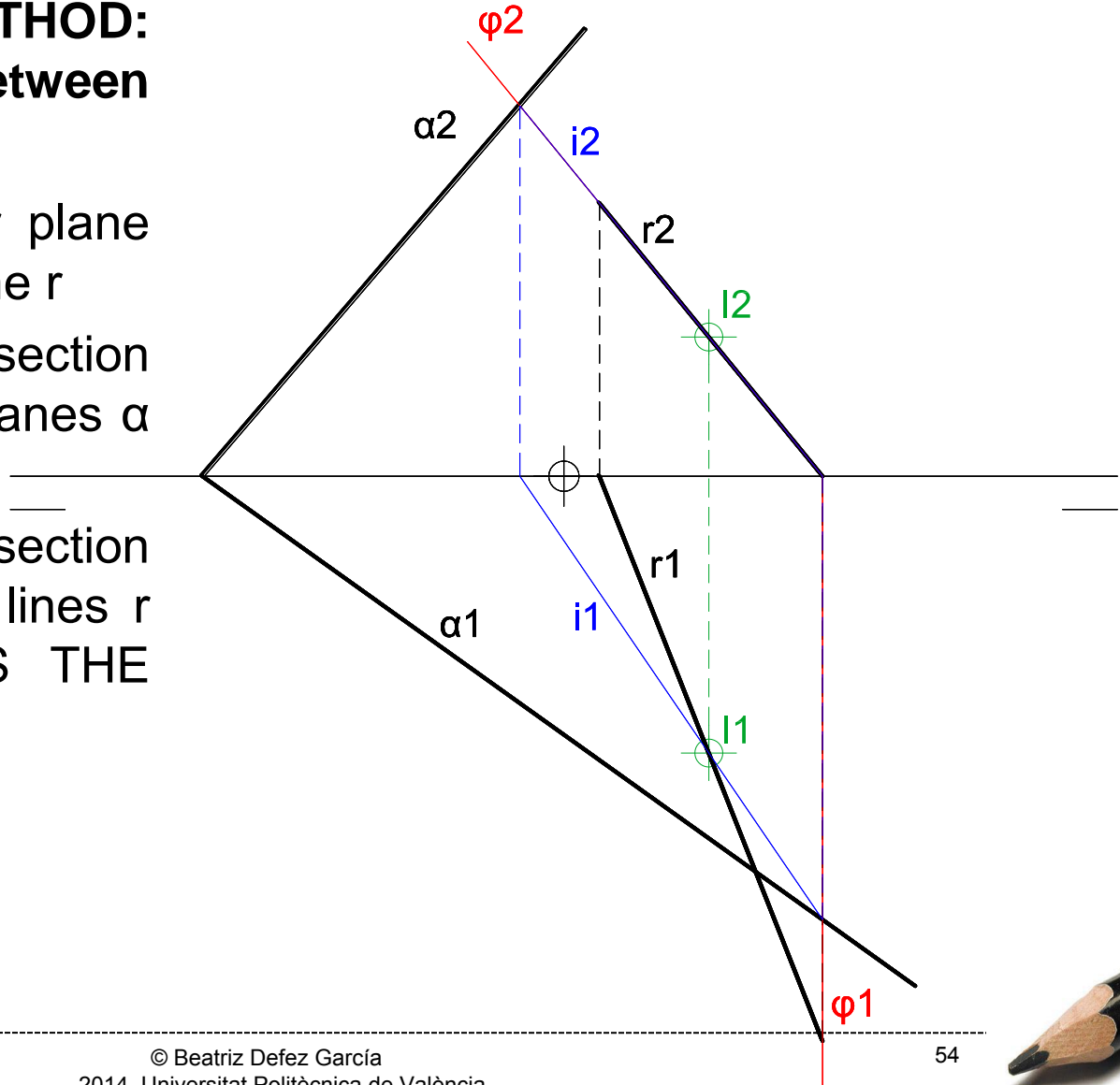
- The intersection is obtained by representing both planes by their 3rd. Trace
- The intersection line i is parallel to the E.L.



LINE AND PLANE INTERSECTION. GENERIC CASE

• **GENERIC METHOD:**
intersection between
plane α and line r

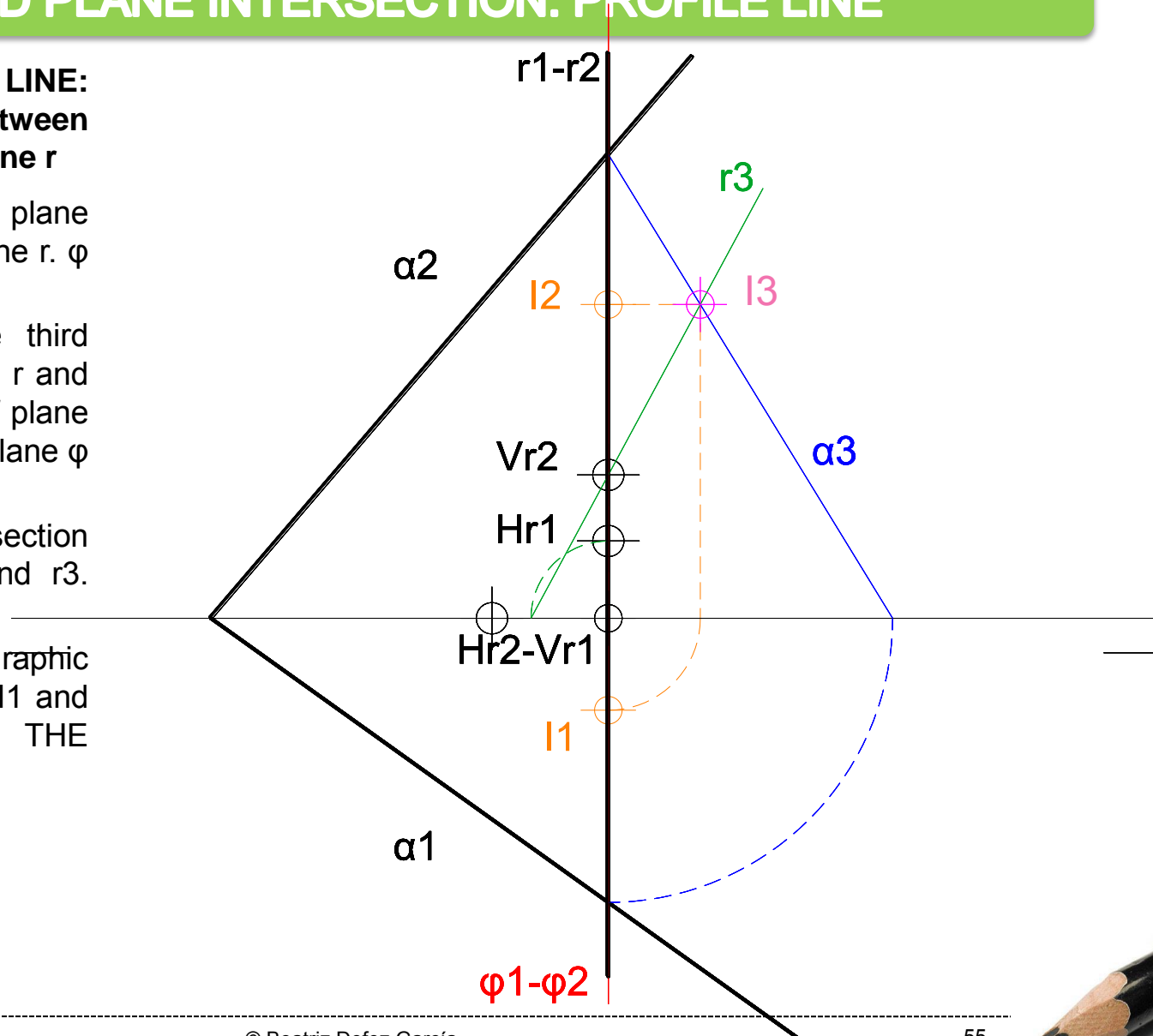
- Build an auxiliar plane φ containing the line r
- Find the intersection line i between planes α and φ
- Find the intersection point I between lines r and i . **THIS IS THE INTERSECTION POINT**



LINE AND PLANE INTERSECTION. PROFILE LINE

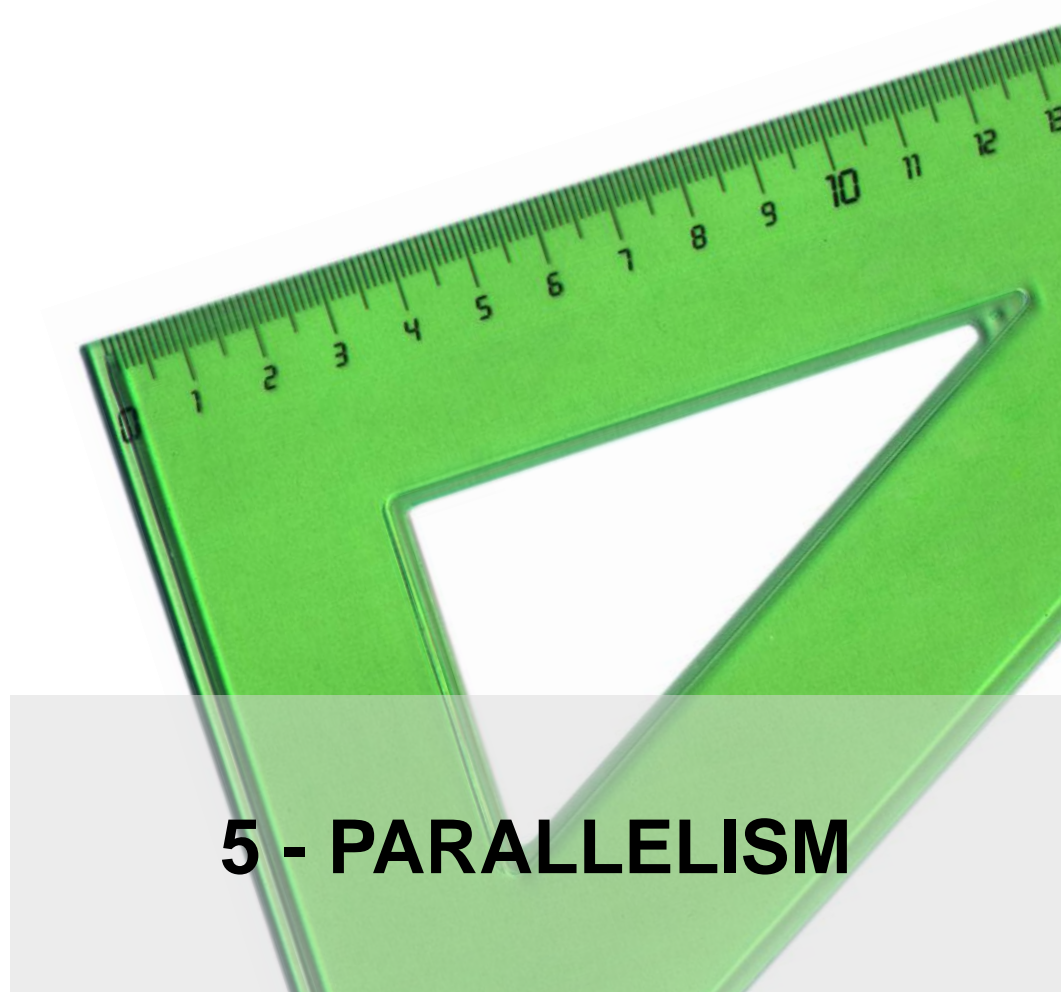
• **PROFILE LINE:**
intersection between plane α and profile line r

- Build an auxiliar plane φ containing the line r . φ is a profile plane
- Represent the third projection of line r and the third trace of plane α according to plane φ : α_3 and r_3
- Find the intersection between α_3 and r_3 . This point is I_3 .
- Find the orthographic projections of I : I_1 and I_2 . **THIS IS THE INTERSECTION POINT**



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5 - PARALLELISM

TABLE OF CONTENTS

- 1. LINES PARALLELISM**
 1. PROFILE LINES

- 2. PLANES PARALLELISM**
 1. SPECIAL PLANES

- 3. LINE AND PLANE PARALLELISM**

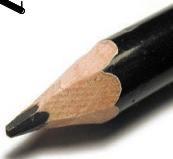
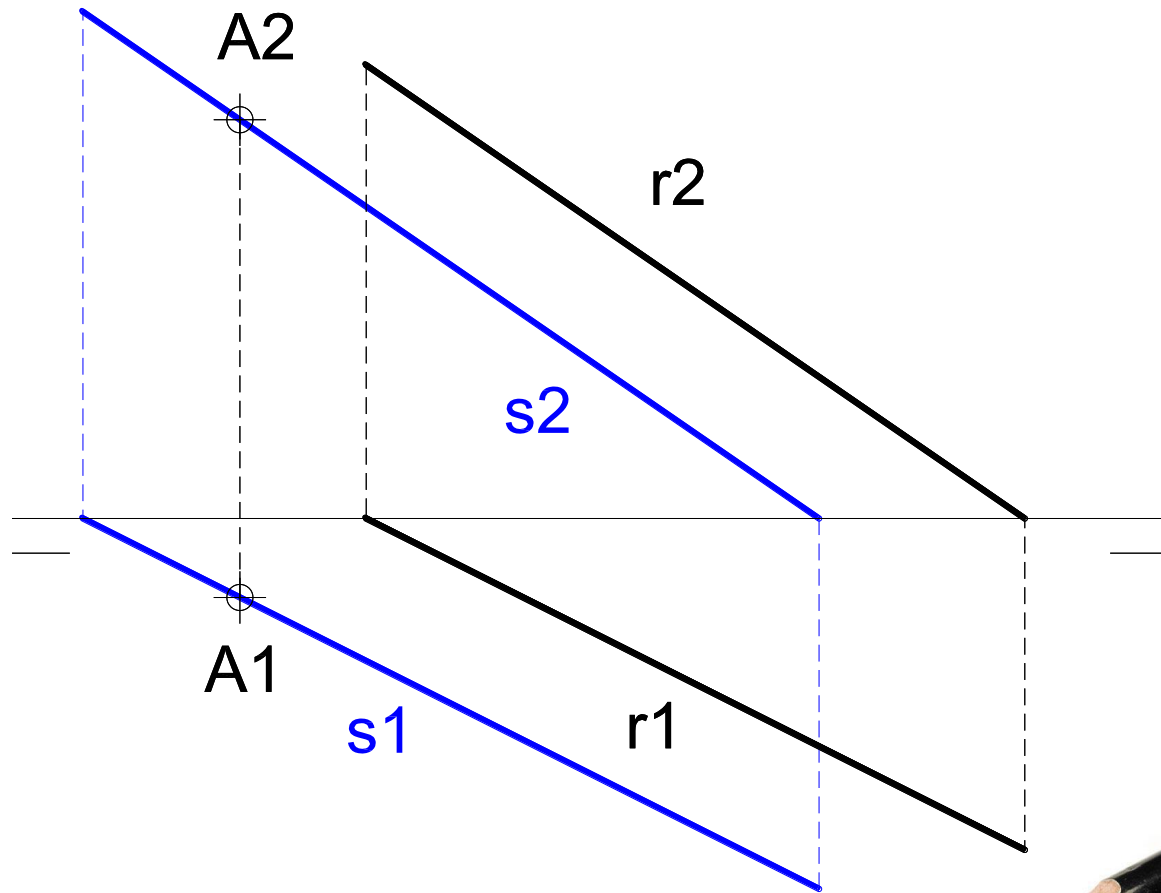


LINES PARALLELISM

- Two straight lines are parallel if their projections on the same projection plane are parallel to each other

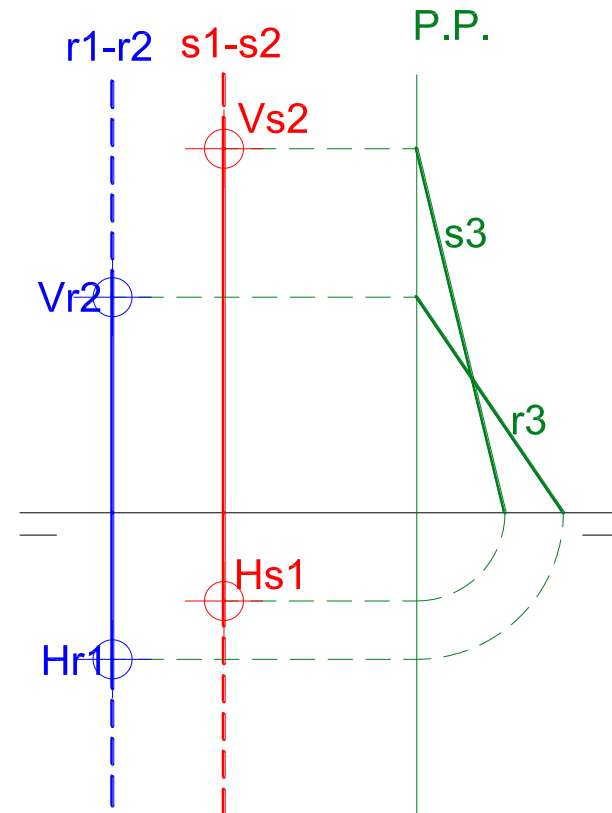
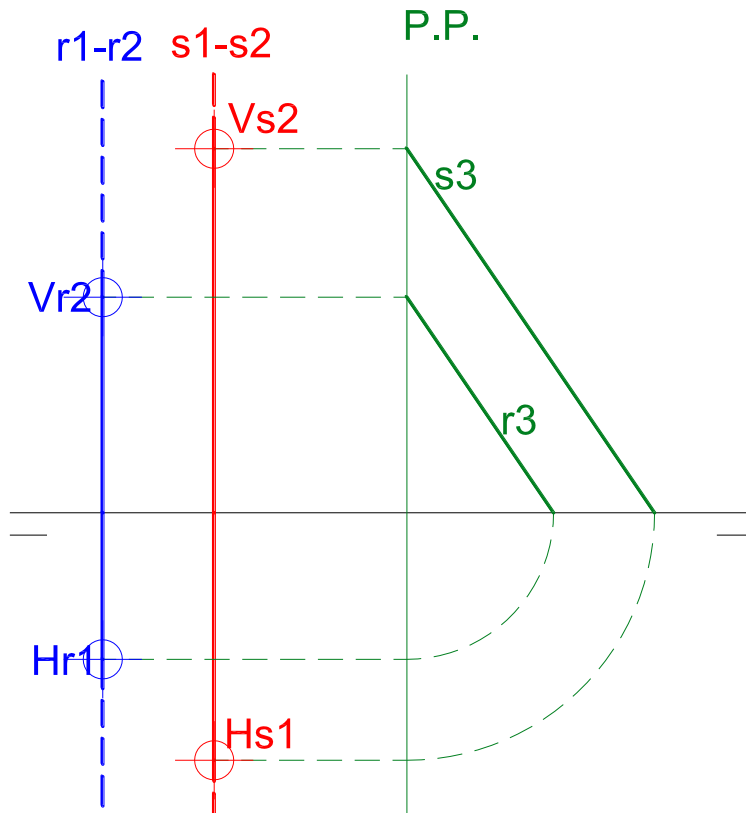
- $s1 // r1$
- $s2 // r2$
- $s3 // r3$

- Case: drawing s parallel to r by point A



LINES PARALLELISM. PROFILE LINE

- For profile lines, it is necessary to work with their the 3rd projection

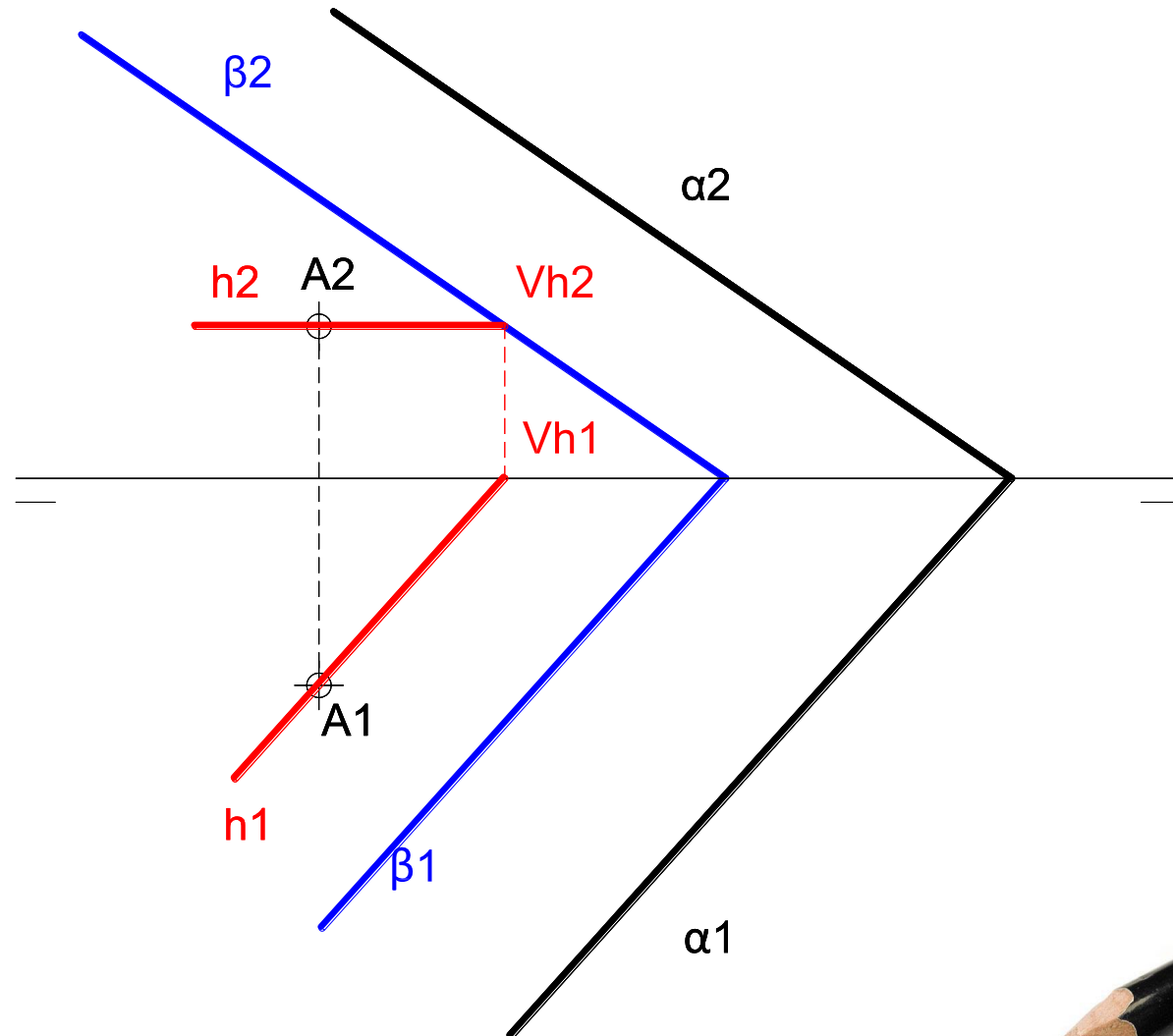


PLANES PARALLELISM

- Two planes are parallel if their traces on the same projection plane are parallel to each other

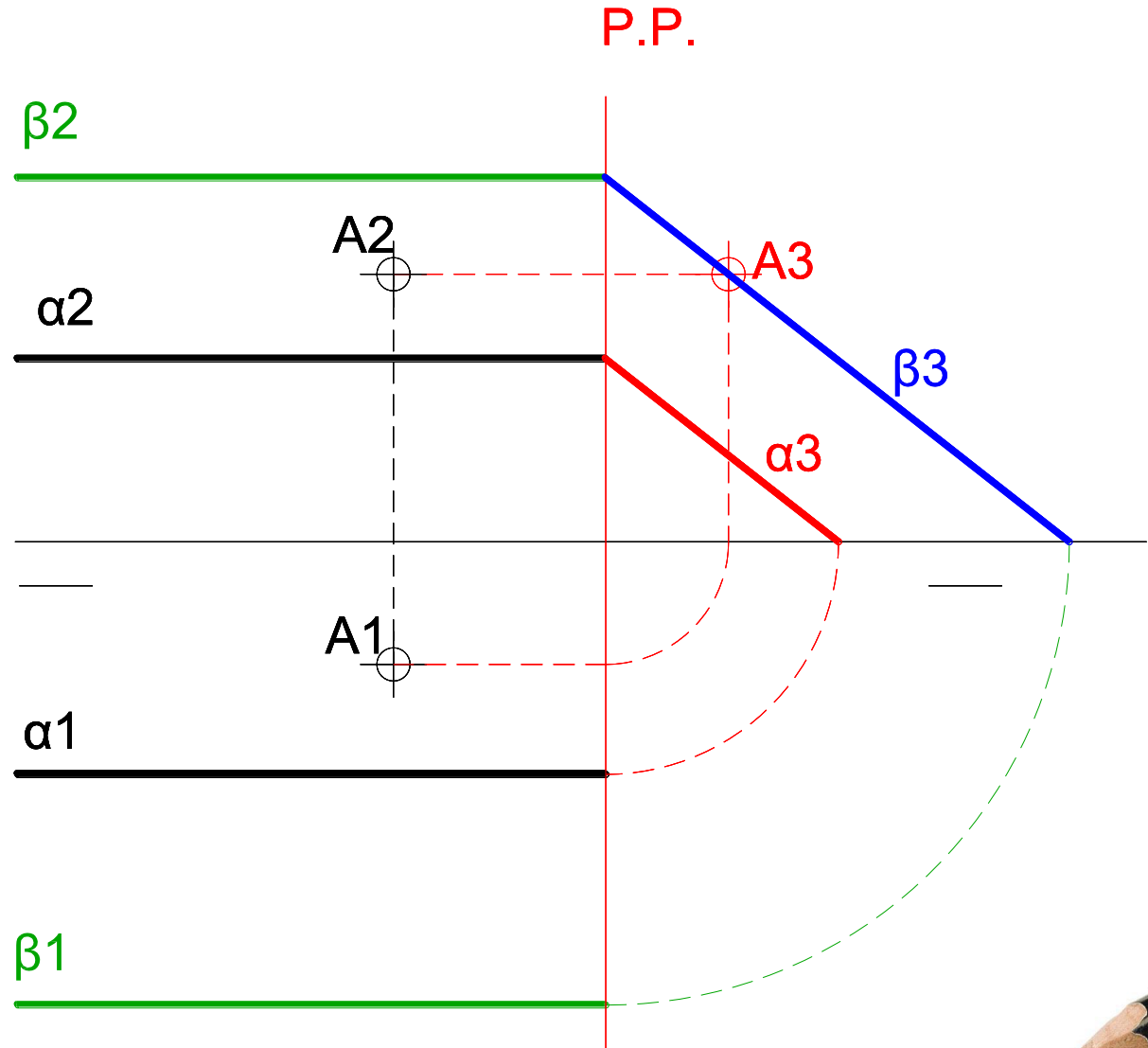
- $\alpha_1 // \beta_1$
- $\alpha_2 // \beta_2$
- $\alpha_3 // \beta_3$

- Case: drawing β parallel to α by point A



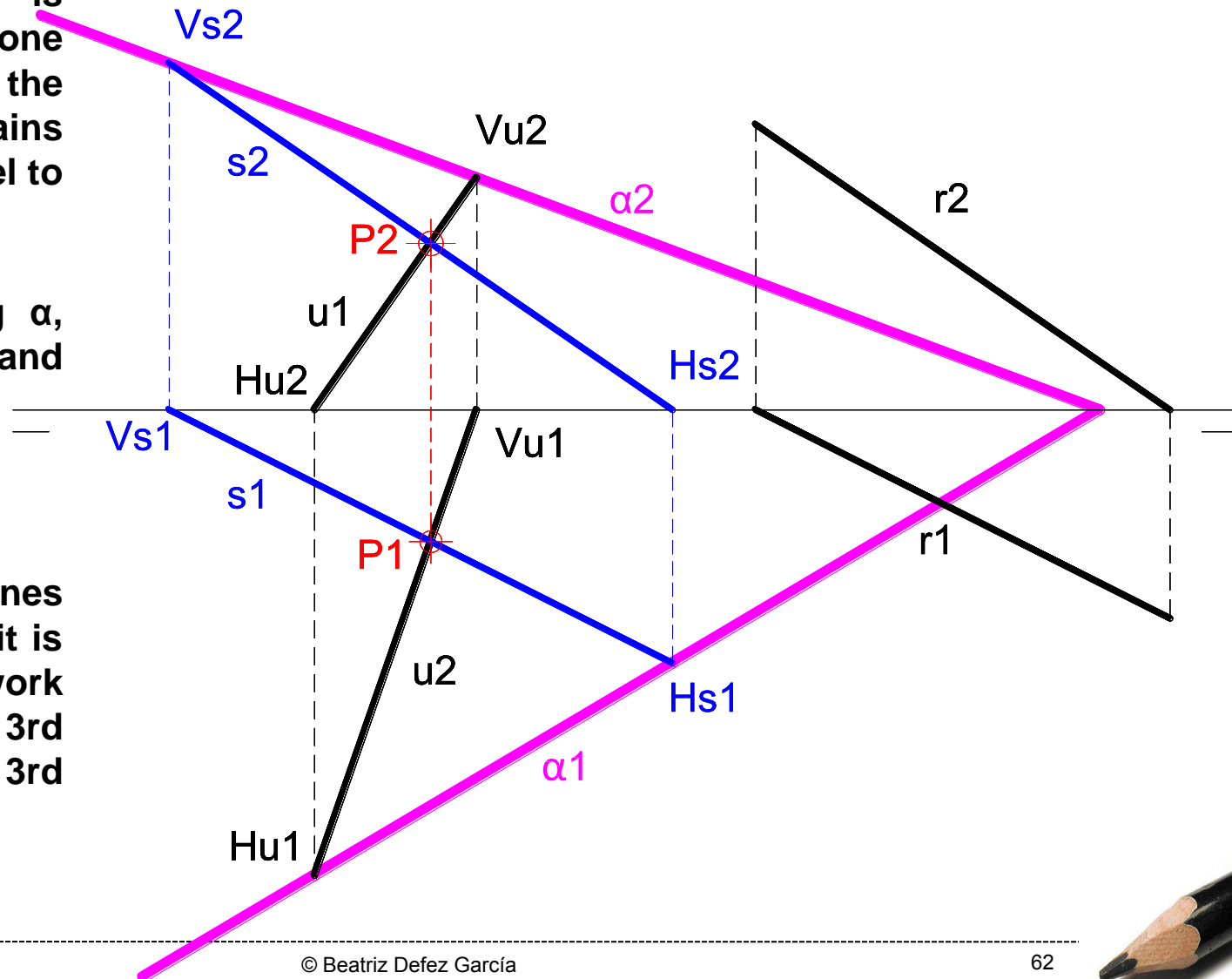
PLANES PARALLELISM. SPECIAL PLANES

- For planes parallel to the E.L., or containing the E.L., it is necessary to work with their 3rd trace



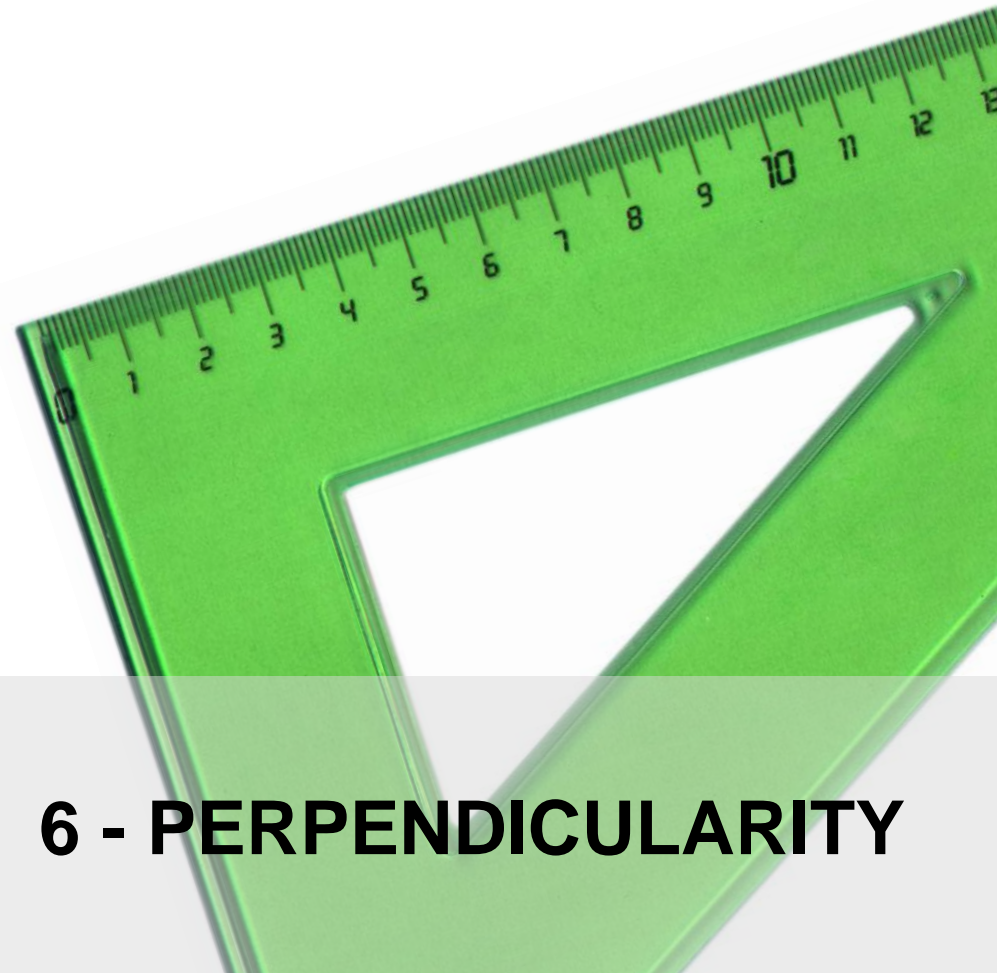
LINE AND PLANE PARALLELISM

- One plane is parallel to one straight line if the plane contains one line parallel to the first one
- Case: drawing α , parallel to r and containing u
- For special lines and/or planes it is necessary to work with their 3rd projection or 3rd trace



Graphic Expression

ORTHOGRAPHIC SYSTEM



6 - PERPENDICULARITY

TABLE OF CONTENTS

1. LINE AND PLANE PERPENDICULARITY

1. Line perpendicular to a plane by a given point
2. Plane perpendicular to a line by a given point

2. PLANES PERPENDICULARITY

1. Plane perpendicular to another plane, by a given line
2. Plane perpendicular to another plane, by a given point

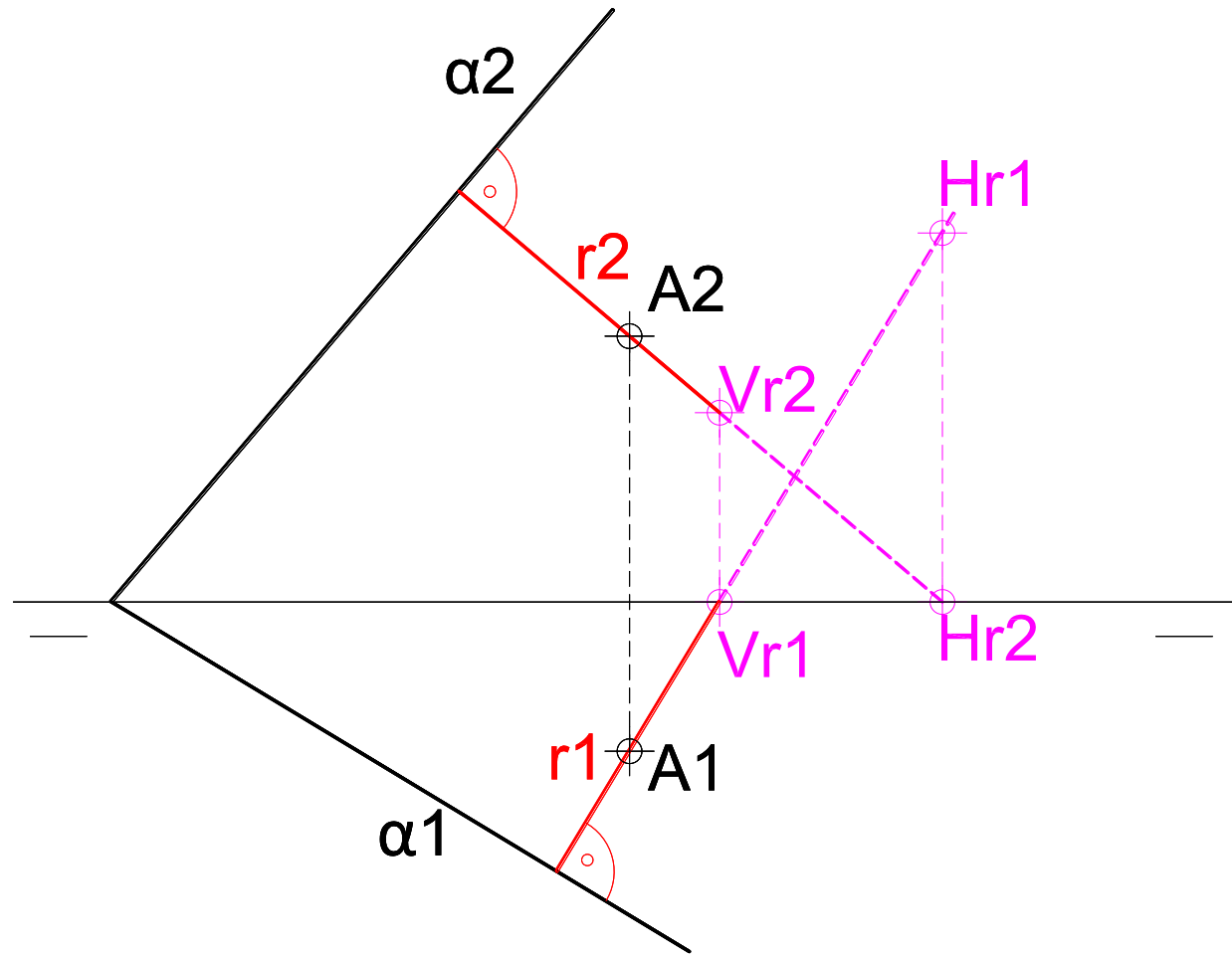
3. LINES PERPENDICULARITY

1. Line perpendicular to another line by a given point



LINE AND PLANE PERPENDICULARITY

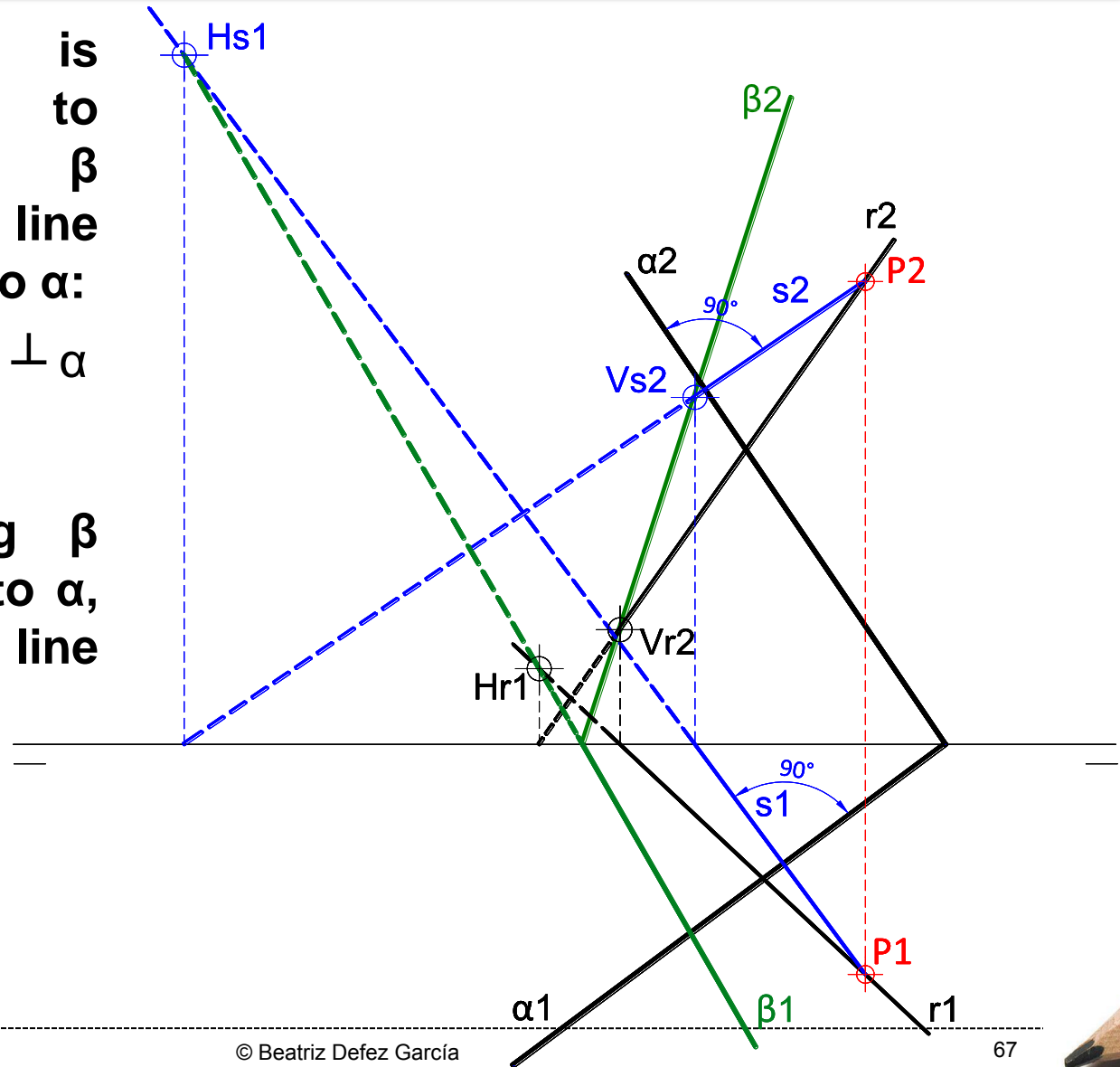
- The projections of the line are perpendicular to the traces of the plane on the same projection plane.
 - $r1 \perp \alpha1$
 - $r2 \perp \alpha2$
- Case: drawing r perpendicular to α by point A



PLANES PERPENDICULARITY

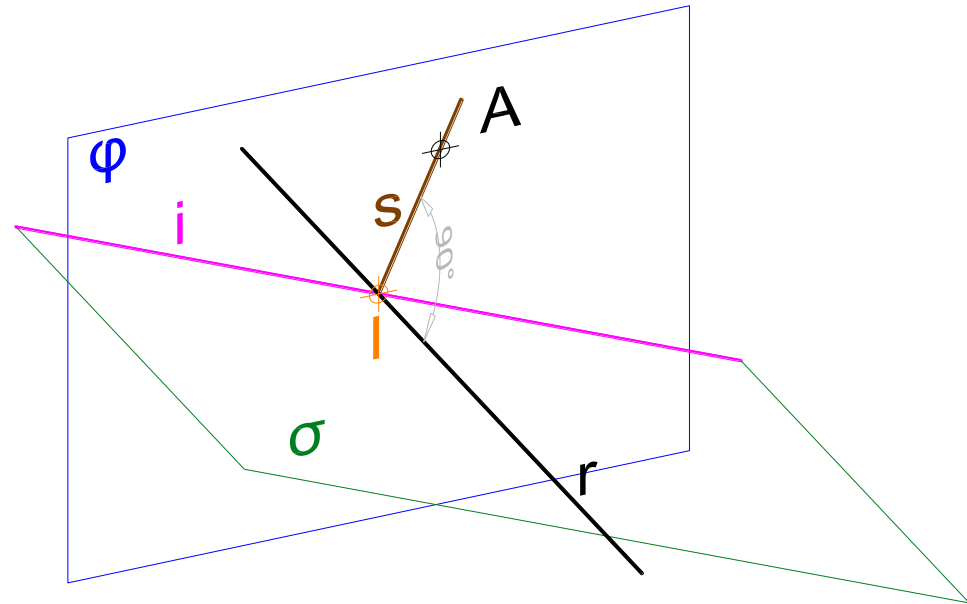
- Plane β is perpendicular to plane α , if β contains any line perpendicular to α :
 $\beta \perp \alpha \leftrightarrow s \in \beta ; s \perp \alpha$

- Case: drawing β perpendicular to α , and containing line r



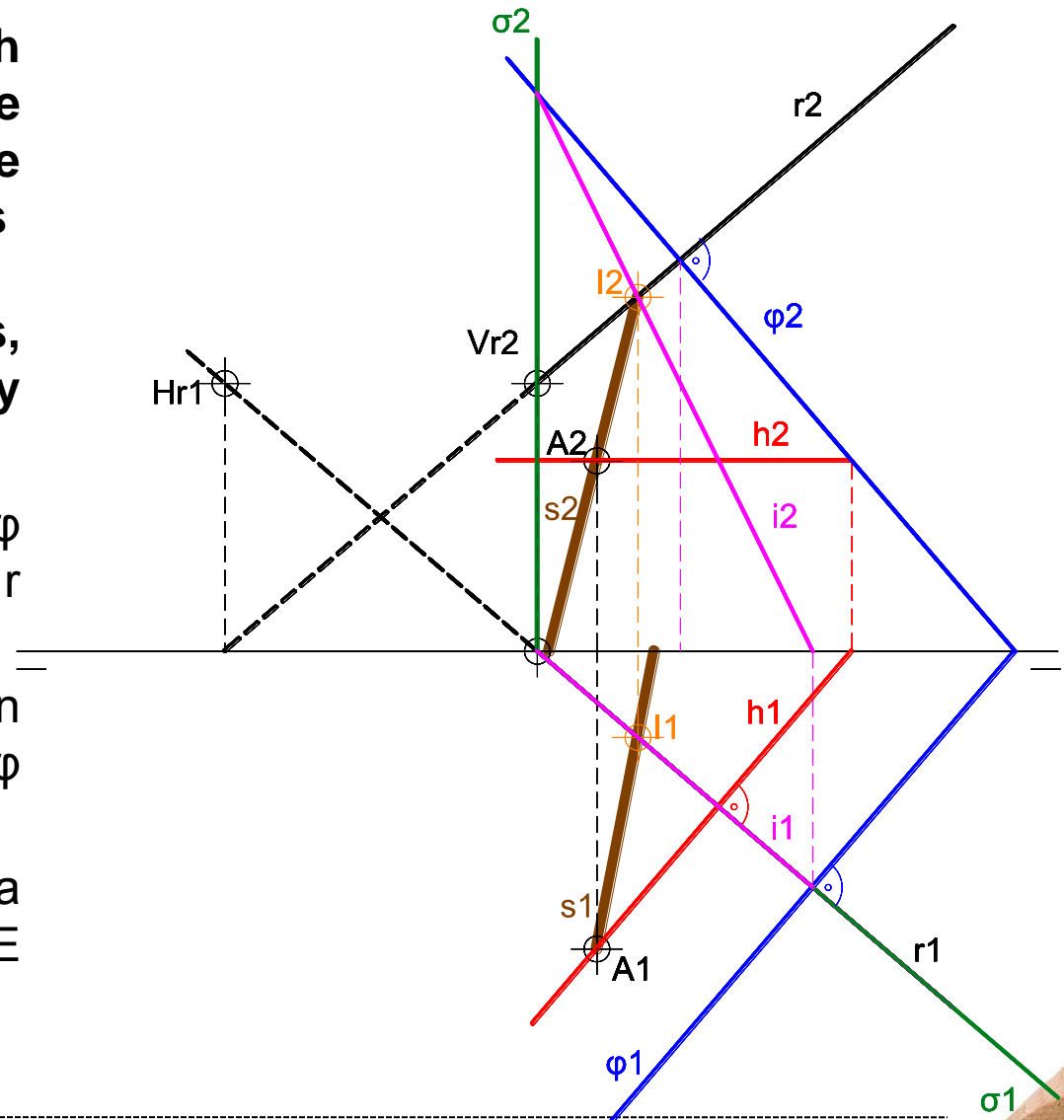
LINES PERPENDICULARITY

- In general two lines which are perpendicular in the space do not have perpendicular projections
- Case: drawing line s , perpendicular to line r , by point A :
 - Build an auxiliar plane φ perpendicular to line r by point A
 - Find the intersection point I between plane φ and line r .
 - Join points A and I by a straight line. THIS LINE IS S , THE SOLUTION



LINES PERPENDICULARITY

- In general two lines which are perpendicular in the space do not have perpendicular projections
- Case: drawing line s , perpendicular to line r , by point A :
 - Build an auxiliar plane ϕ perpendicular to line r by point A
 - Find the intersection point I between plane ϕ and line r
 - Join points A and I by a straight line. THIS LINE IS S , THE SOLUTION



ESPECIAL LINES AND PLANES

- **For special lines and planes, it is necessary to work with their 3rd projection or 3rd trace to draw perpendicular elements**
 - Profile lines
 - Planes parallel to the E.L.
 - Planes containing the E.L.

- **The perpendicular angle could be drawn on a profile plane**



Graphic Expression

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7 - ABASEMENTS

TABLE OF CONTENTS

1. **PREVIOUS CONCEPTS**
2. **POINT ABASEMENT**
 1. GENERIC METHOD
 2. HORIZONTAL ABASEMENT. TRIANGLE METHOD.
3. **PLANE ABASEMENT**
 1. COMMON PLANES
 2. REDUCED ABASEMENT METHOD FOR POINTS AND LINES
 3. PROJECTING PLANES
 4. SPECIAL PLANES
 1. PLANES PARALLEL TO THE E.L.
 2. PLANES CONTAINING THE E.L.
4. **AFINITY**



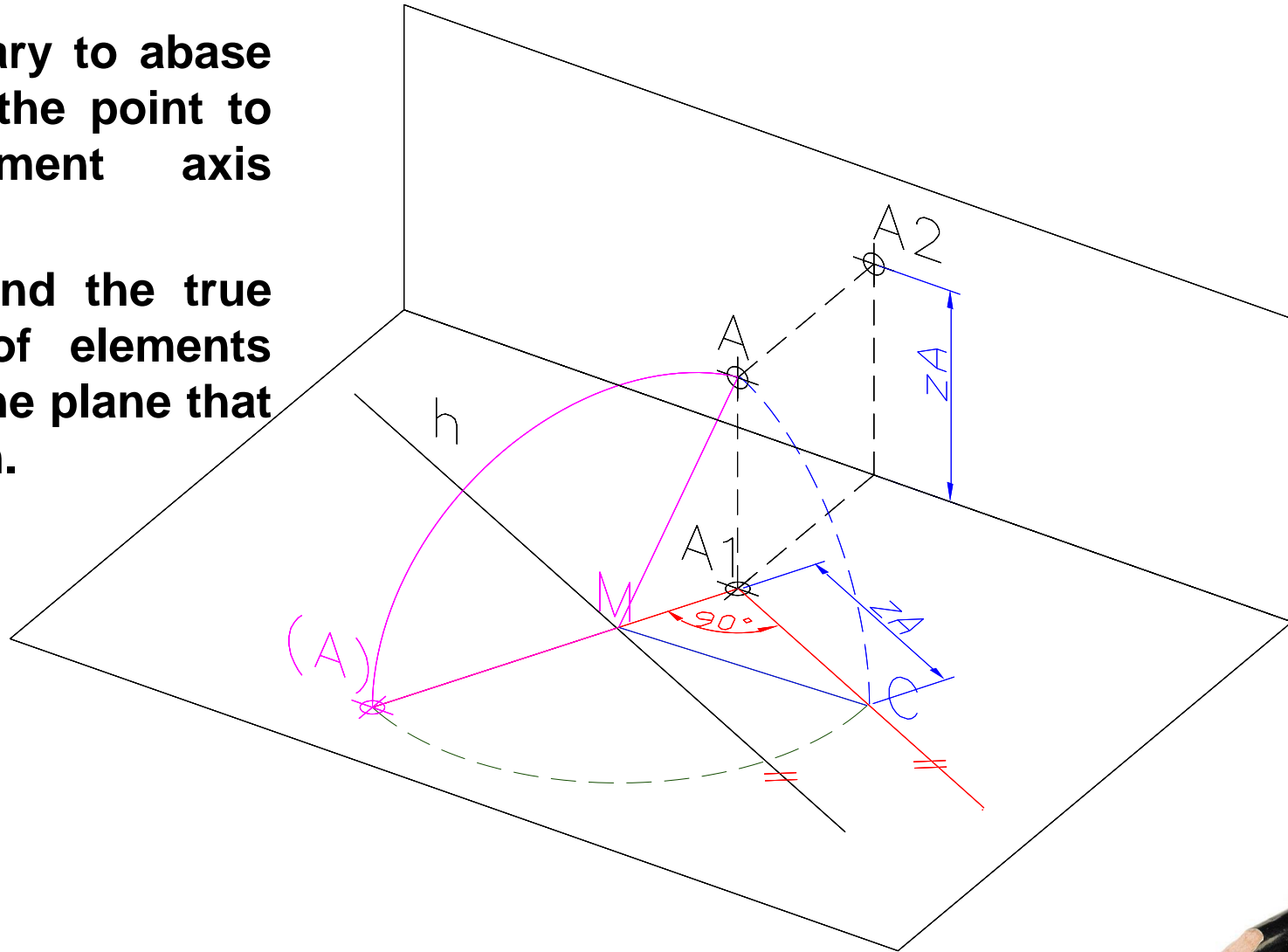
PREVIOUS CONCEPTS

- **ABASEMENT:** turn of one element around one abasement axis (“charnela”) to place it on one of the projection planes or a plane parallel to them (either a horizontal or a vertical plane)
- **OBJECTIVE:** to obtain the true magnitude (distances and angles) of the elements contained on any kind of plane
- **LETTERING**
 - (A)
 - (r)
 - ($\alpha 1$), ($\alpha 2$)



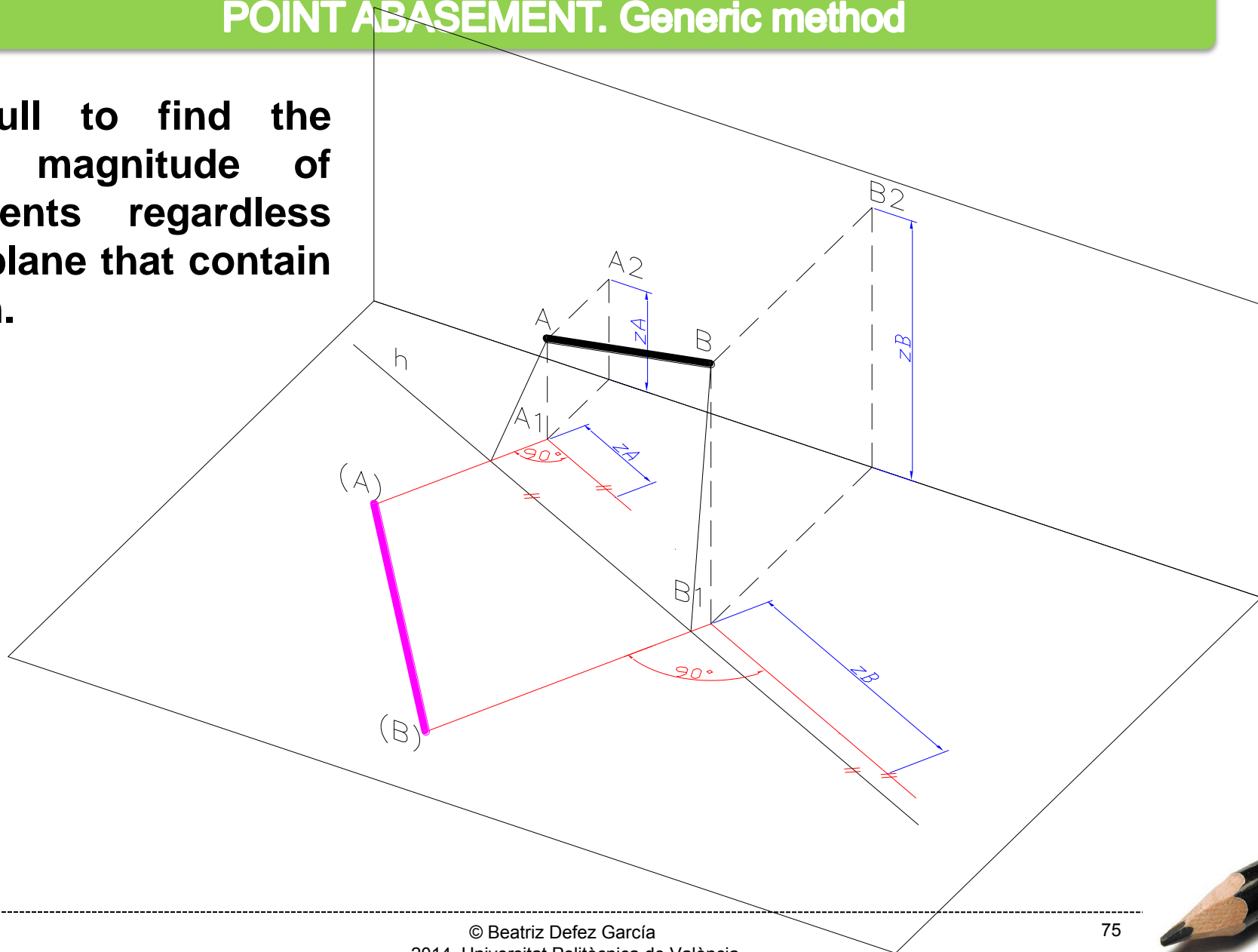
POINT ABASEMENT. Generic method

- It is necessary to abase distance of the point to the abasement axis around it
- Usefull to find the true magnitude of elements regardless the plane that contain them.

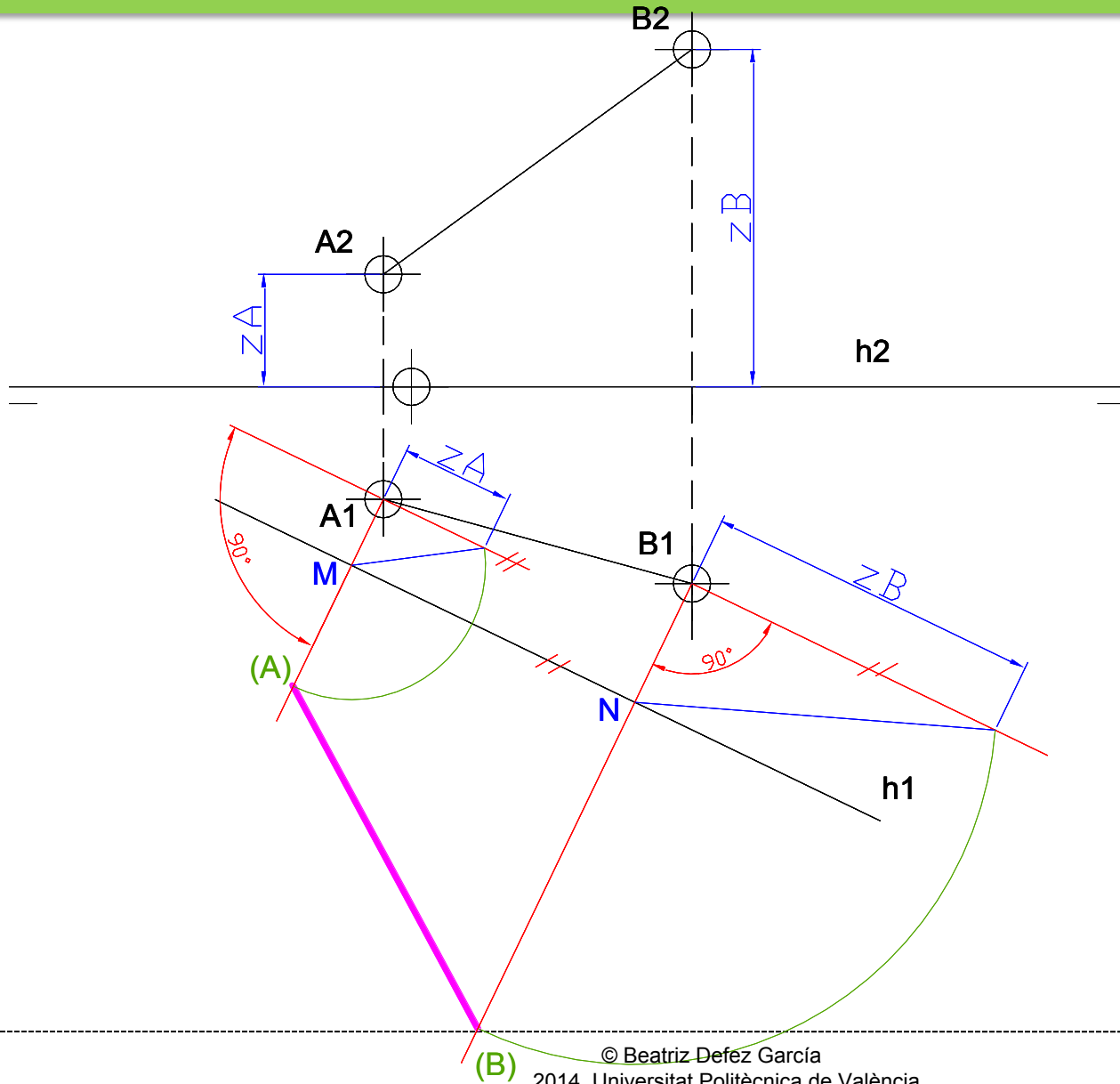


POINT ABASEMENT. Generic method

- Usefull to find the true magnitude of elements regardless the plane that contain them.

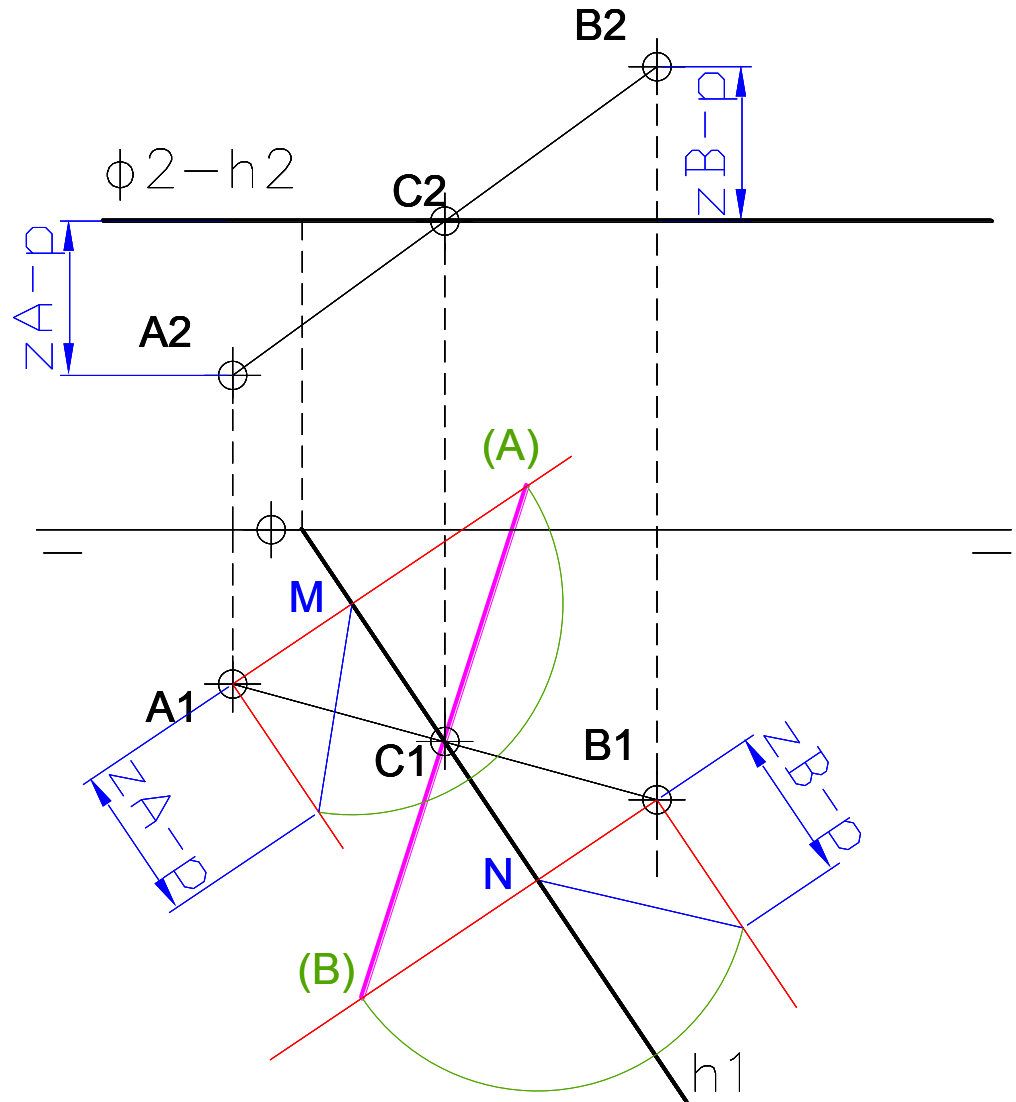


POINT ABASEMENT. Generic method



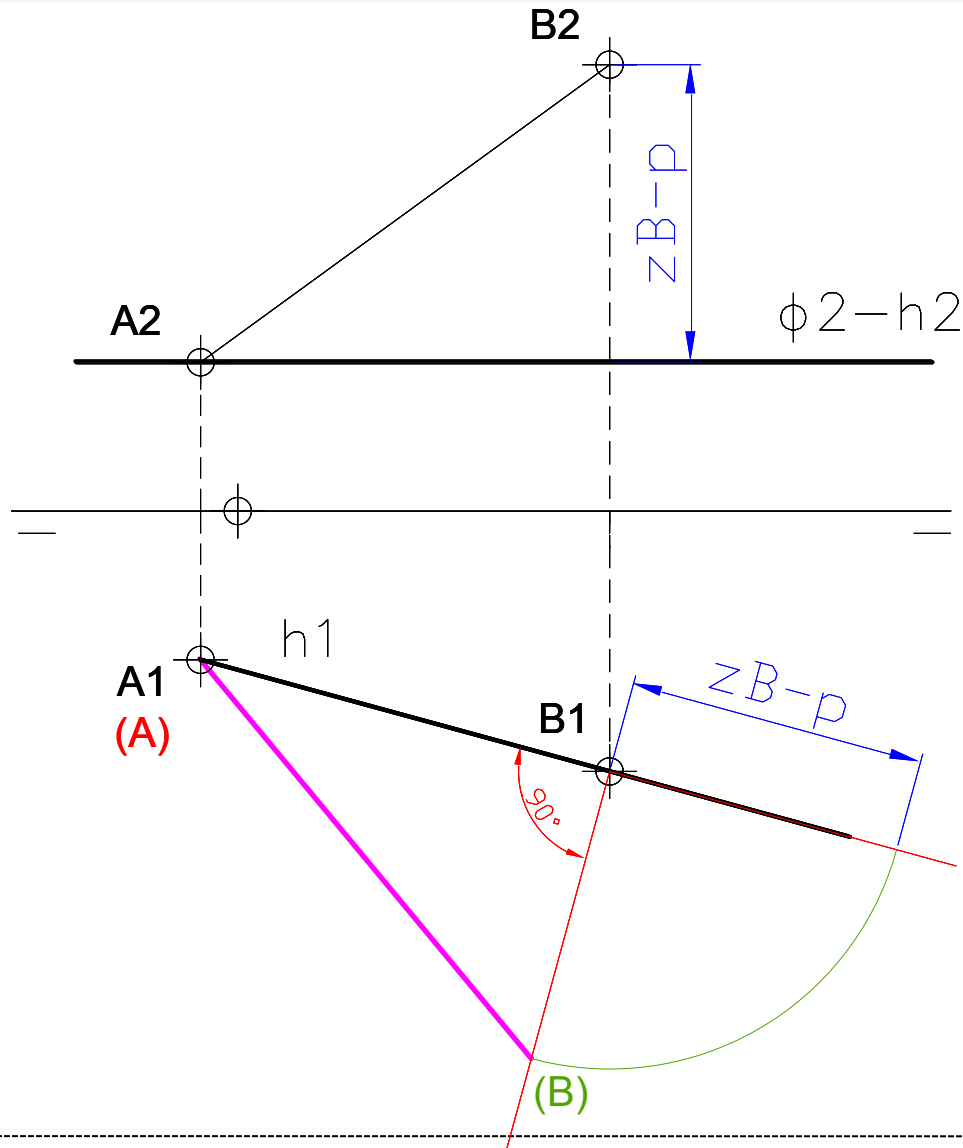
POINT ABASEMENT. Horizontal (or vertical) abasement

- Elements are turned on a plane parallel to one projection plane.
- Useful to find the true size of figures.
- The generic method for the points abasement is applied.



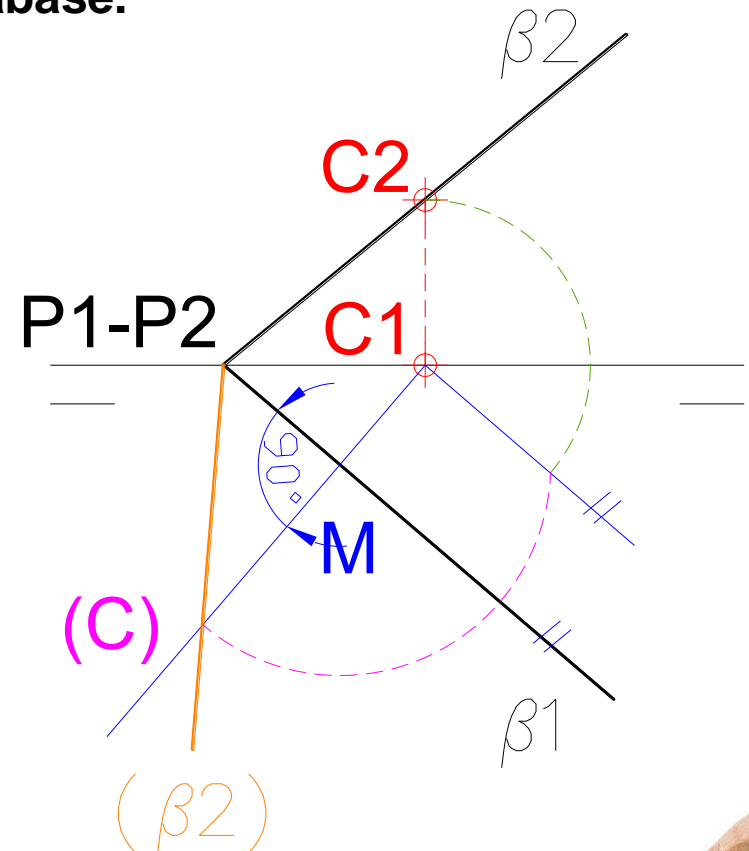
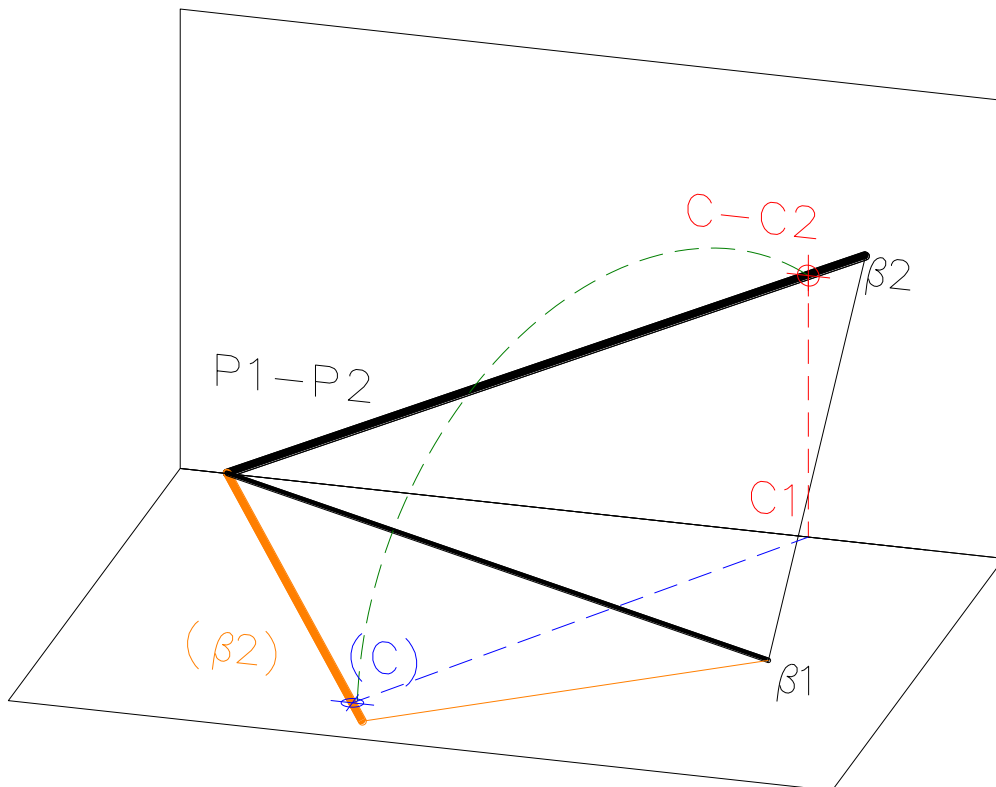
POINT ABASEMENT. Horizontal (or vert.) abasement. Triangle method

- Elements are turned on a plane parallel to one projection plane.
- Useful to find the true size of figures.
- The generic method for the points abasement is applied.



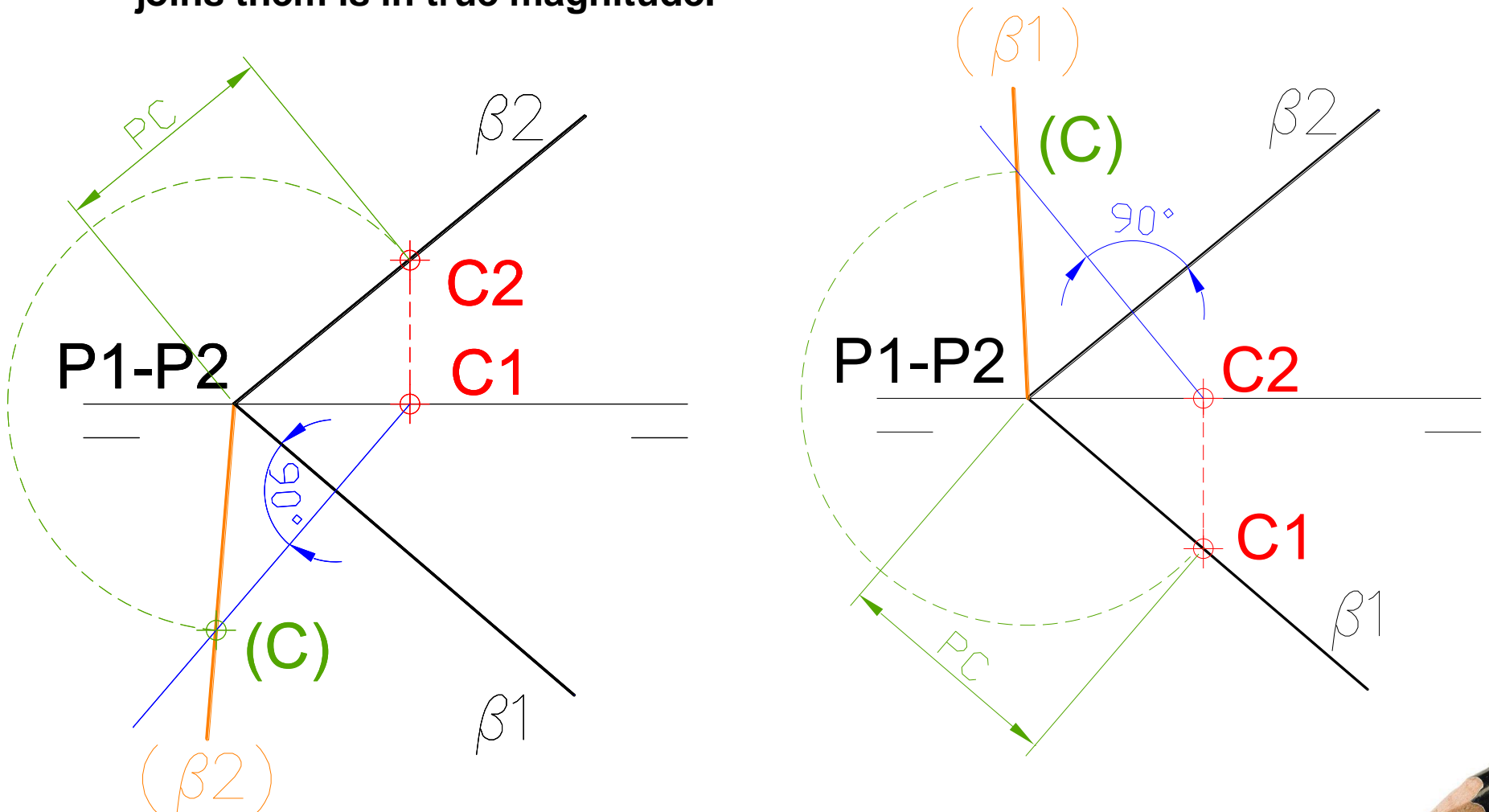
PLANE ABASEMENT. Common planes

- Abasement of one trace around the other one to place it on the corresponding projection plane.
- It is made by the abasement of two points: the plane end (remains invariant) and one point belonging to the trace to abase.



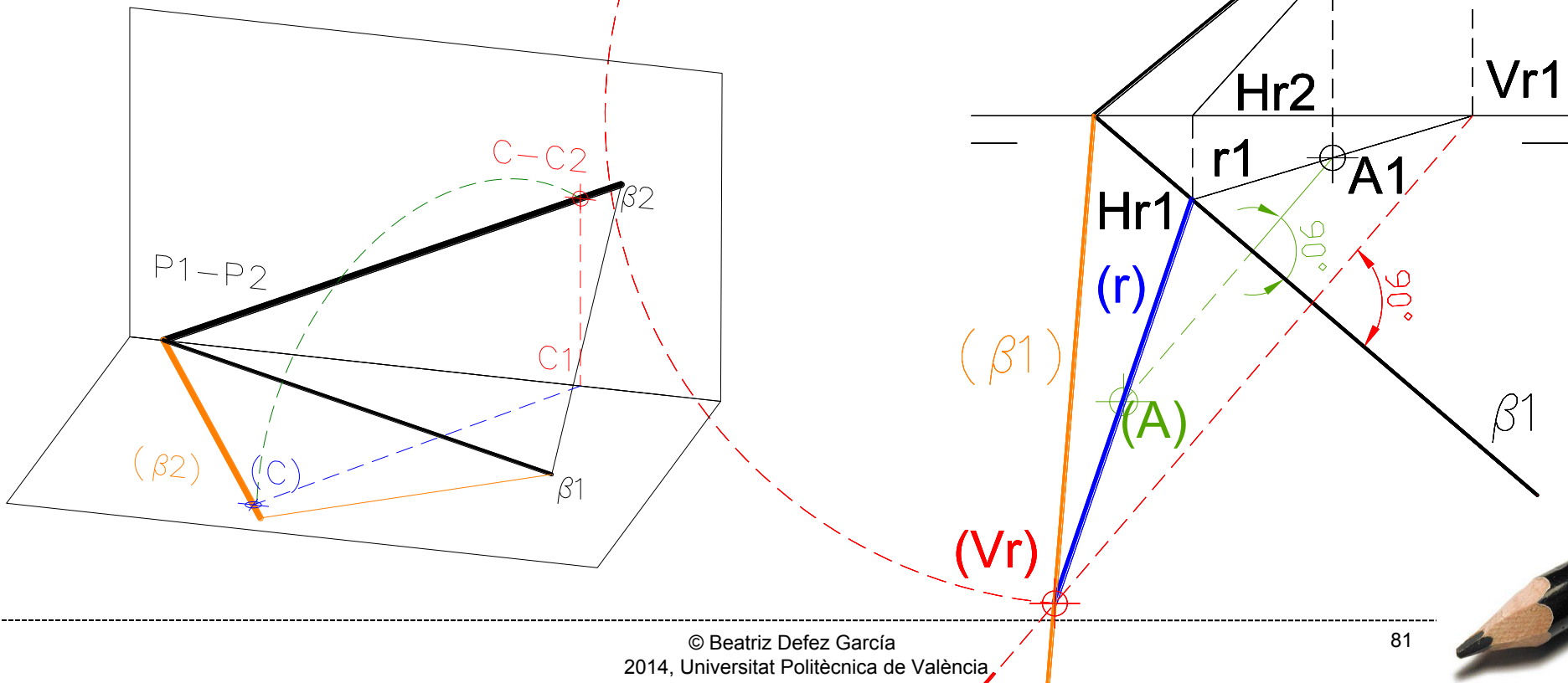
PLANE ABASEMENT. Common planes

- Since both points belong to one projection plane, the segment that joins them is in true magnitude.



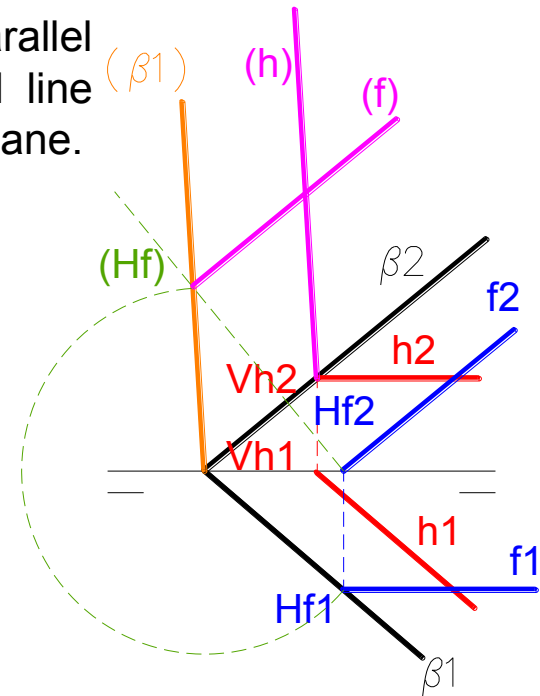
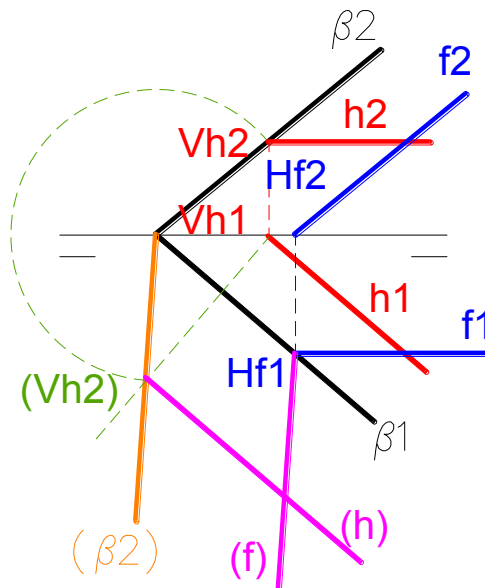
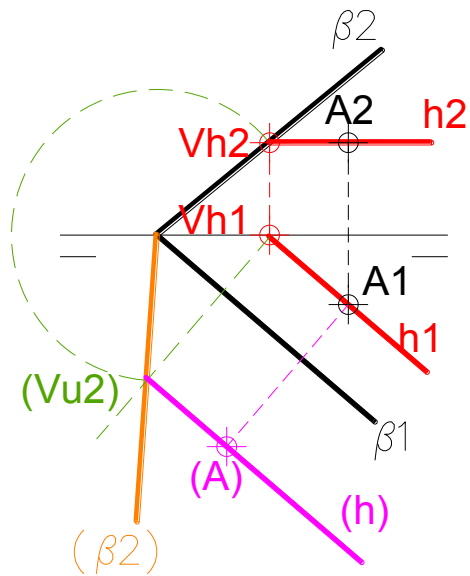
REDUCED ABASEMENT METHOD FOR POINTS AND LINES

- Based on the abasement of the plane that contains the elements



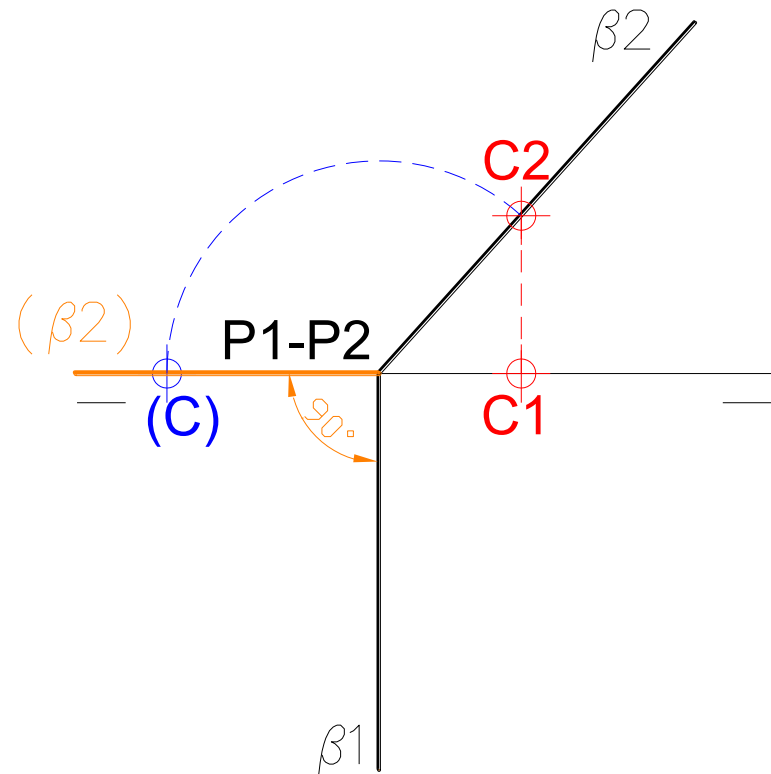
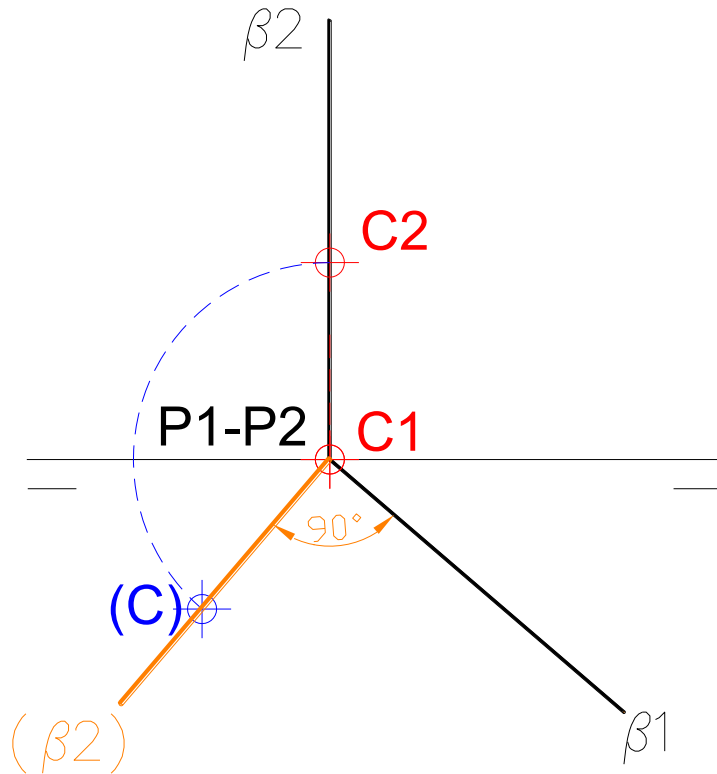
REDUCED ABASEMENT METHOD FOR POINTS AND LINES

- Horizontal and frontal lines are used to abase points.
- On an abasement on the HPP, a horizontal line remains parallel to the horizontal trace of the plane, and a frontal line remains parallel to the abased vertical trace of the plane.
- On an abasement on the VPP, a frontal line remains parallel to the vertical trace of the plane, and a horizontal line remains parallel to the abased horizontal trace of the plane.
- Profile lines are abased using their 3rd projection.

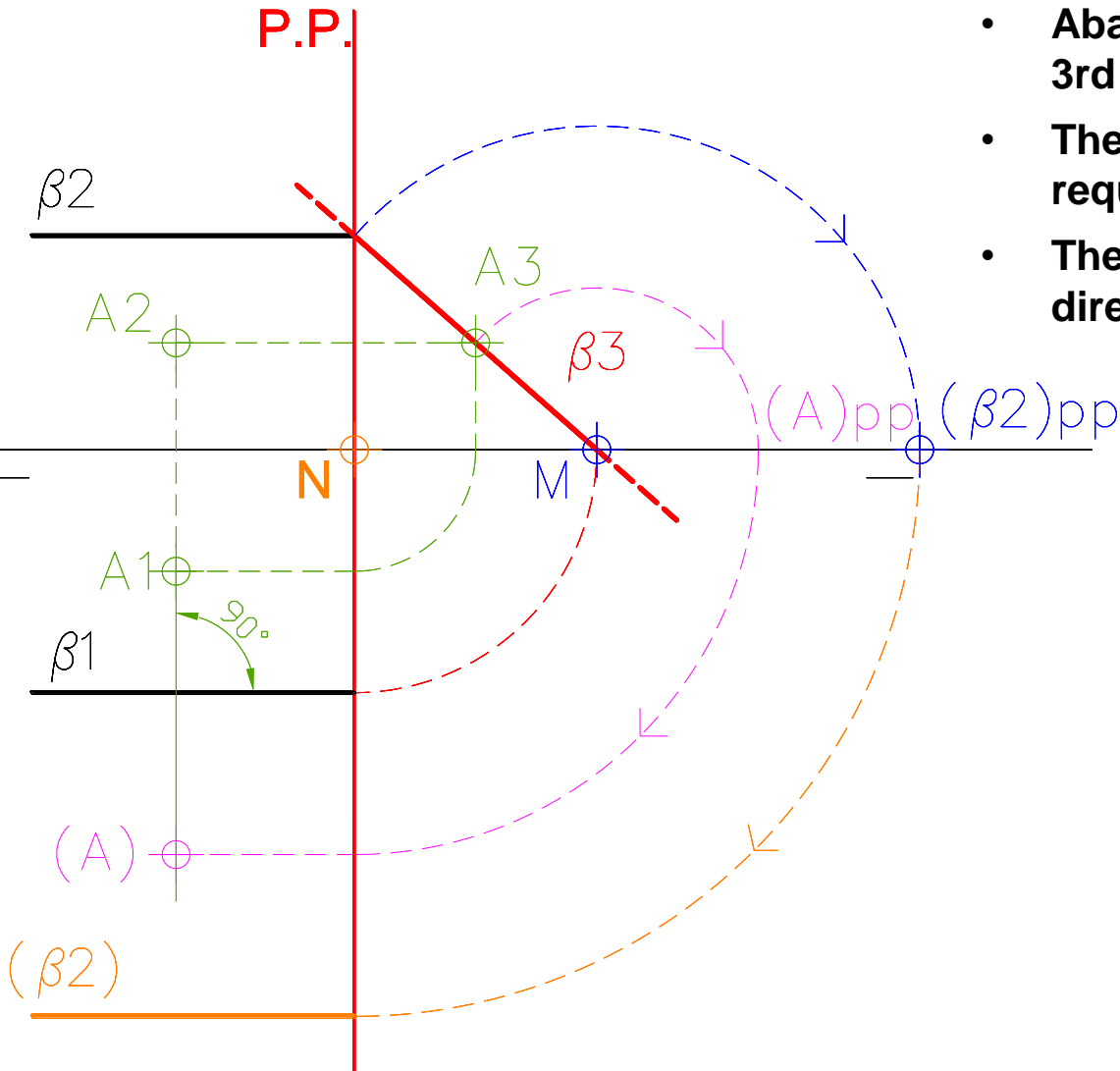


PLANE ABASEMENT. Projecting planes

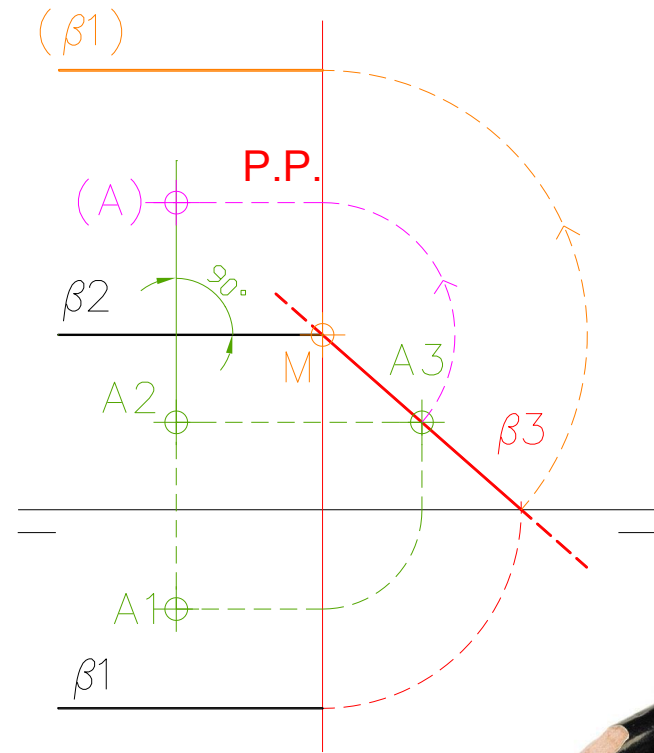
- The abased trace holds 90° with the abasement axis



PLANE ABASEMENT. Planes parallel to the E.L.

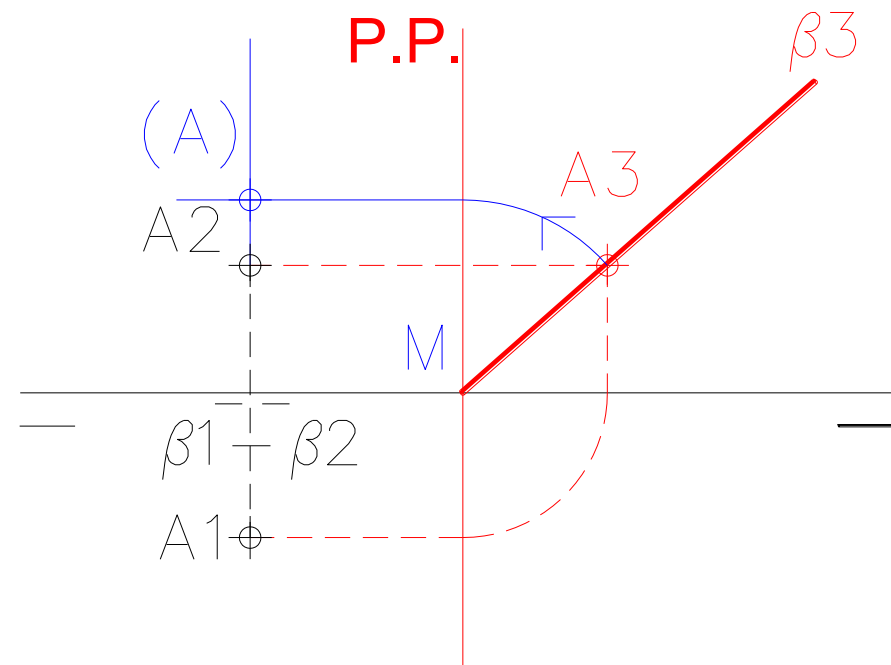
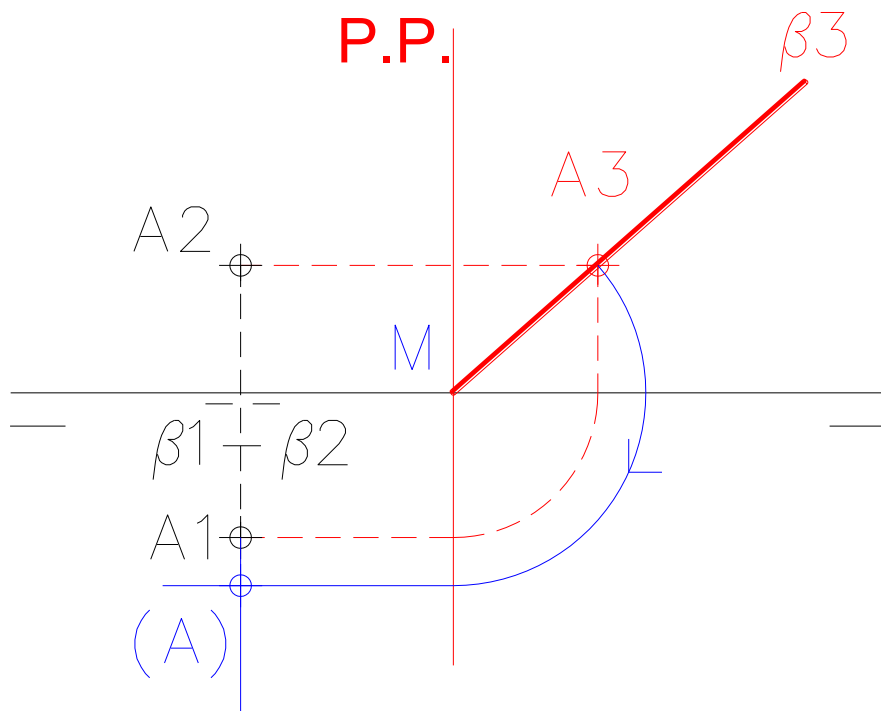


- Abasement done with help of their 3rd trace.
- The abasement on the HPP requires and intermediate turn.
- The abasement on the VPP is direct.



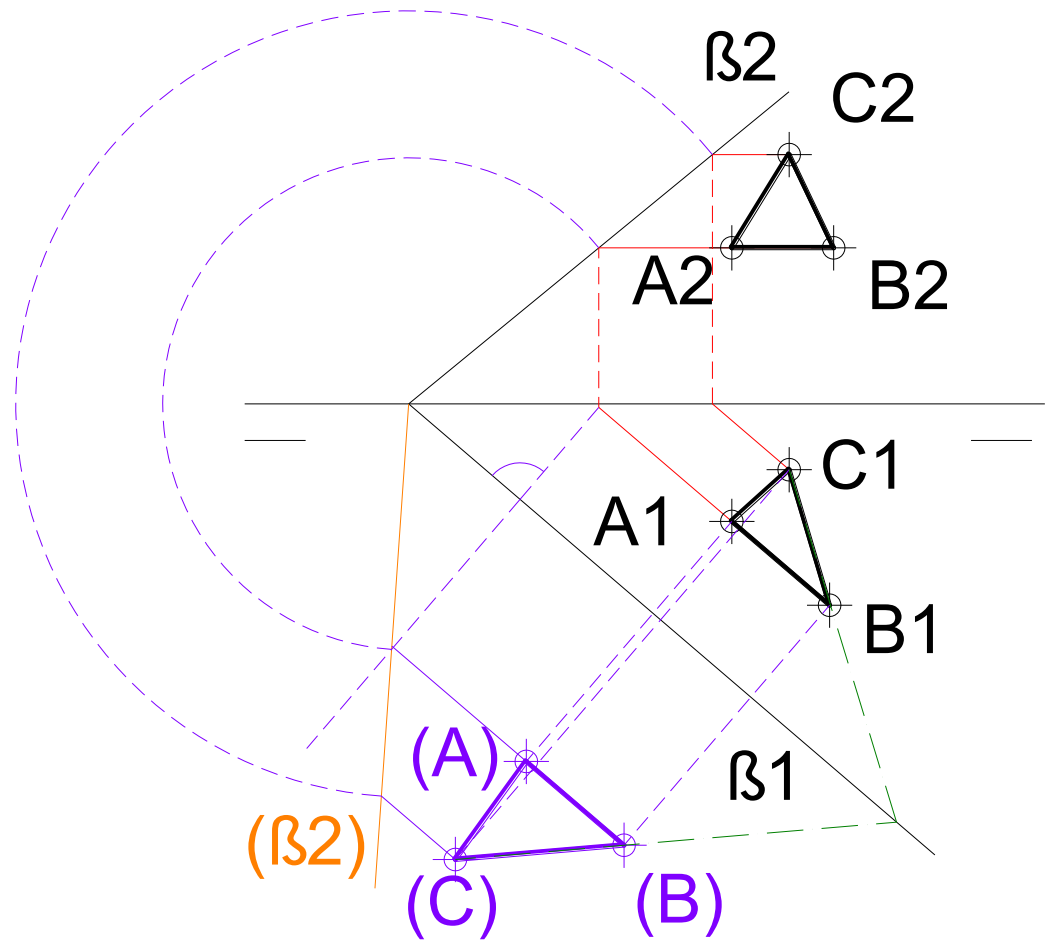
PLANE ABASEMENT. Planes containing the E.L.

- **Abasement done with help of their 3rd trace.**



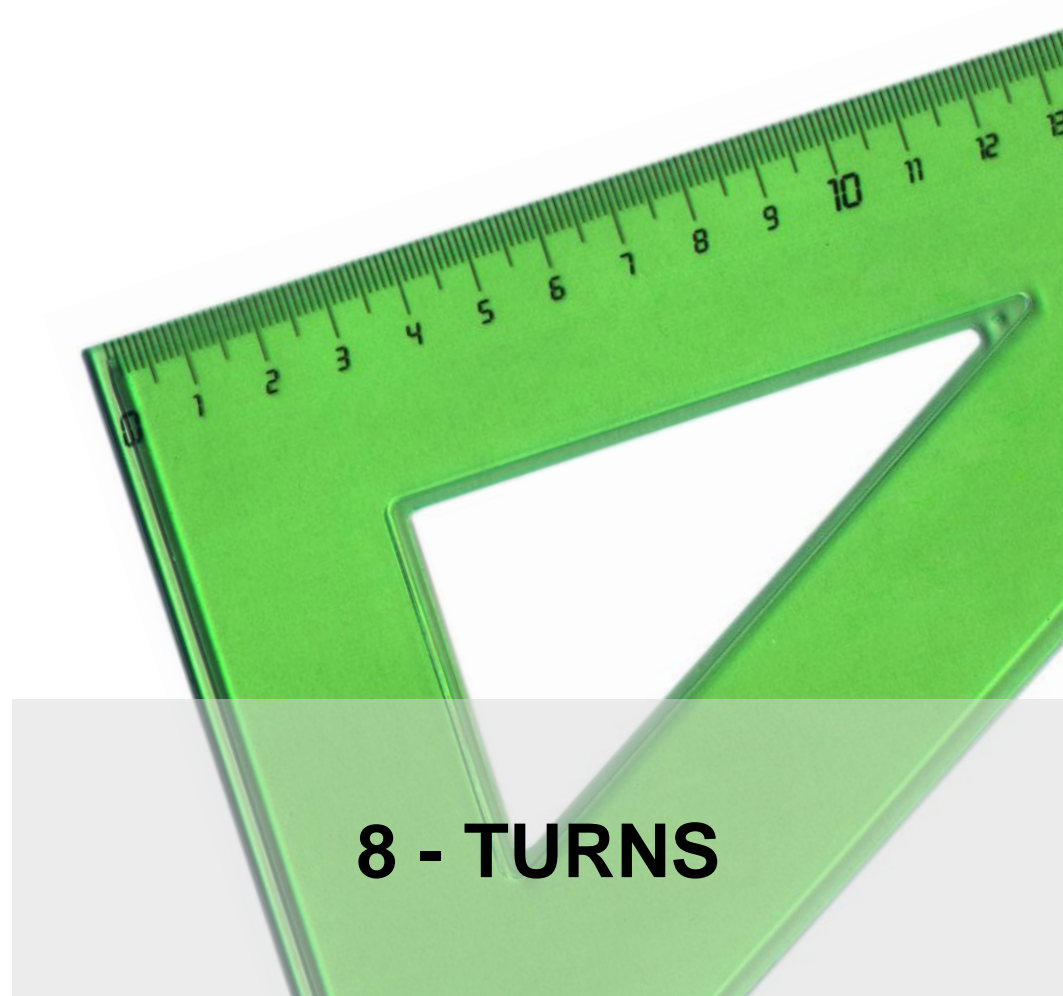
AFINITY

- **Afinity could be applied to simplify the building of figures**
 - The points of the turning axis are abased and projected simoustanteously
 - The geometric correlations of the figure elements are kept in both the abasement and the projections



Graphic Expression

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8 - TURNS

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1. **PREVIOUS CONCEPTS**
 1. ELEMENTS SHOWING TRUE MAGNITUDES
 2. TRUE DISTANCES

2. **POINT TURN**
 1. AROUND A VERTICAL AXIS
 2. AROUND AN EXTREME AXIS (“EJE DE PUNTA”)

3. **LINE TURN**
 1. GETTING FRONTAL AND HORIZONTAL LINES
 2. GETTING SPECIAL LINES

4. **PLANE TURN**
 1. GENERAL TURN
 2. GETTING PROJECTING PLANES
 3. GETTING SPECIAL PLANES

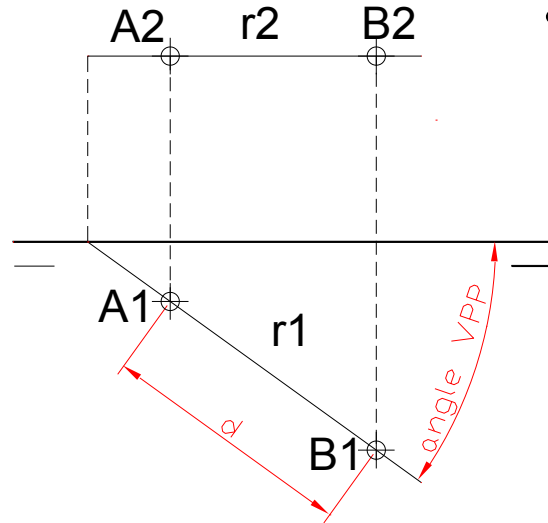
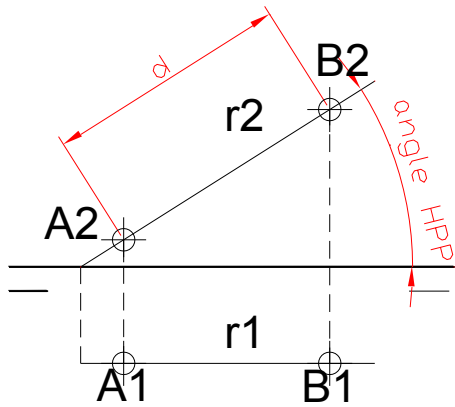


PREVIOUS CONCEPTS

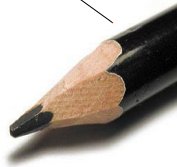
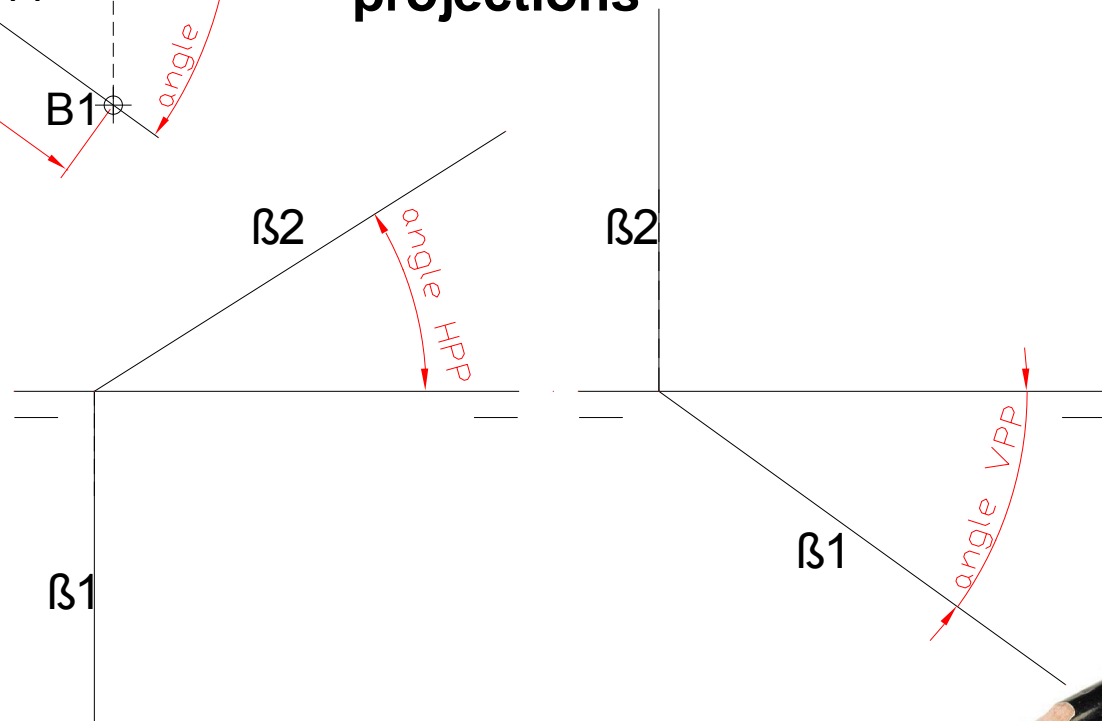
- **TURN:** angular displacement of one element around one turning axis to place it on a more convenient position. The turn usually involves a change in the nature of the element.
- **TURNING AXIS:**
 - Vertical lines: change on the horizontal projection of the element
 - Extreme lines (“rectas de punta”): change on the vertical projection of the element.
- **OBJECTIVE:** to obtain the true magnitude (distances and angles) of the elements regardless their initial nature.
- **LETTERING**
 - $A1', A2'$
 - $r1', r2'$
 - $\alpha1', \alpha2'$



PREVIOUS CONCEPTS. Elements showing true magnitudes

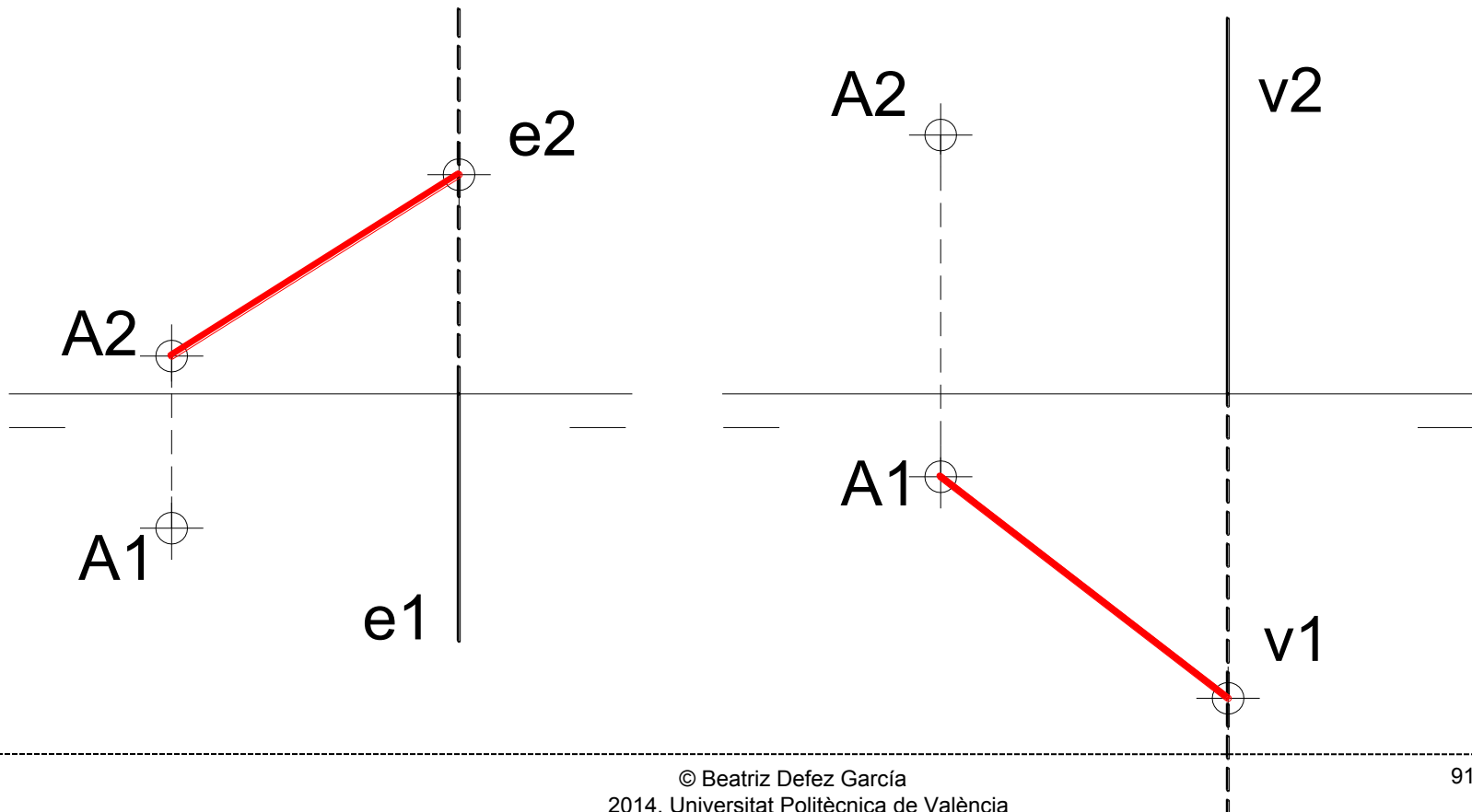


- Horizontal and frontal lines, horizontal and vertical projecting planes, show true magnitudes on their respective projections



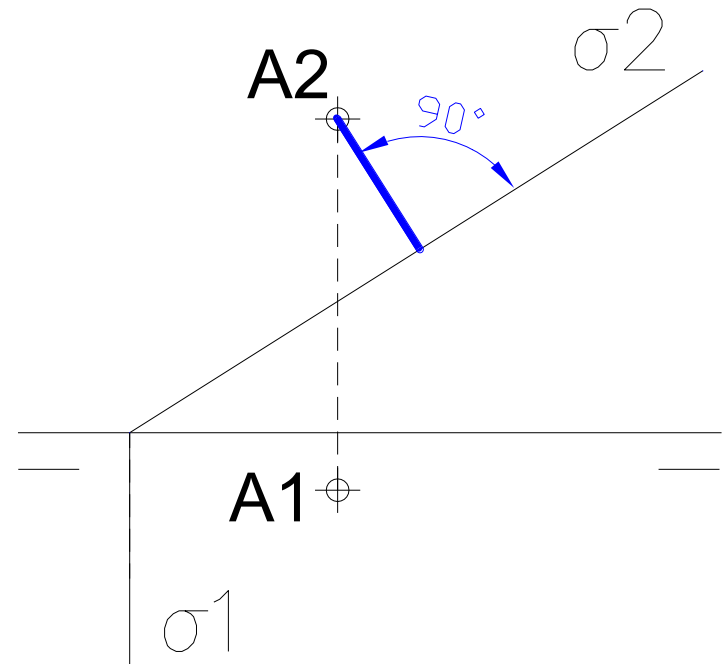
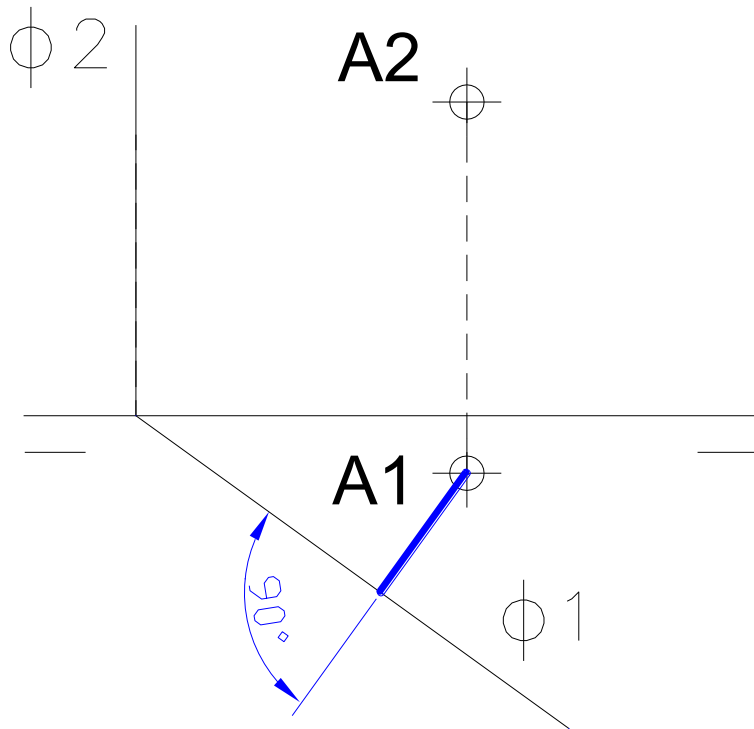
PREVIOUS CONCEPTS. True distances

- The distance between one point and one line could be directly measured, if the line is:
 - EXTREME LINE: Distance A-e = Distance A2-e2
 - VERTICAL LINE: Distance A-v = Distance A1-v1



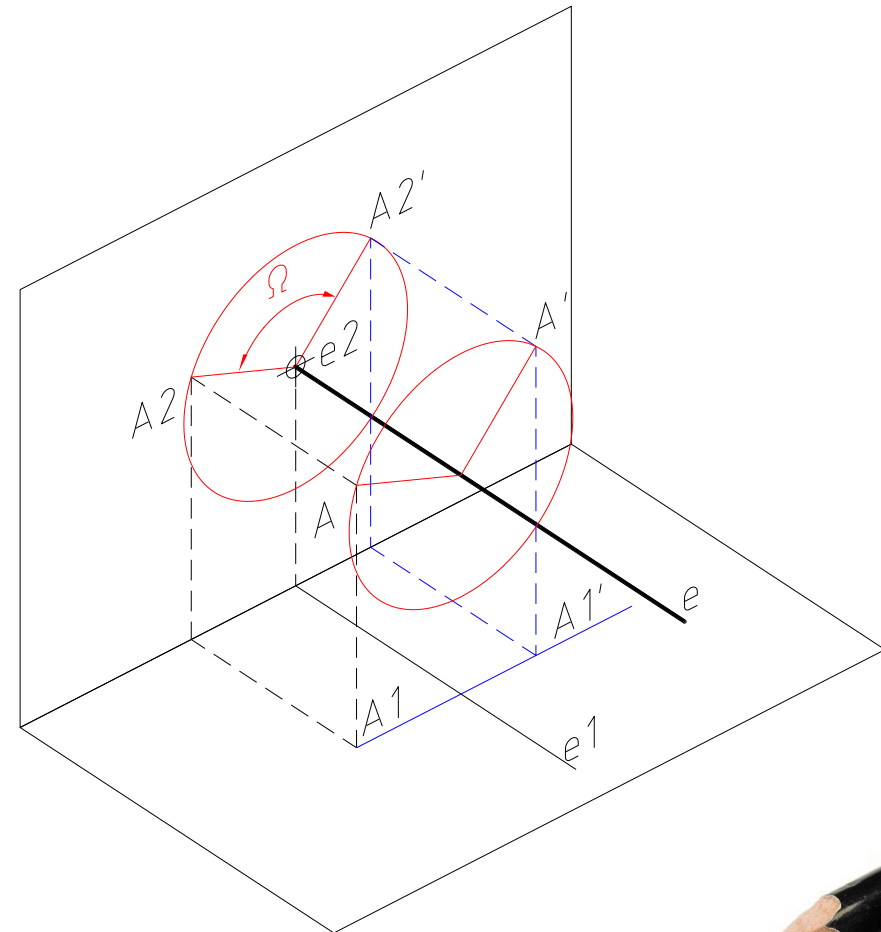
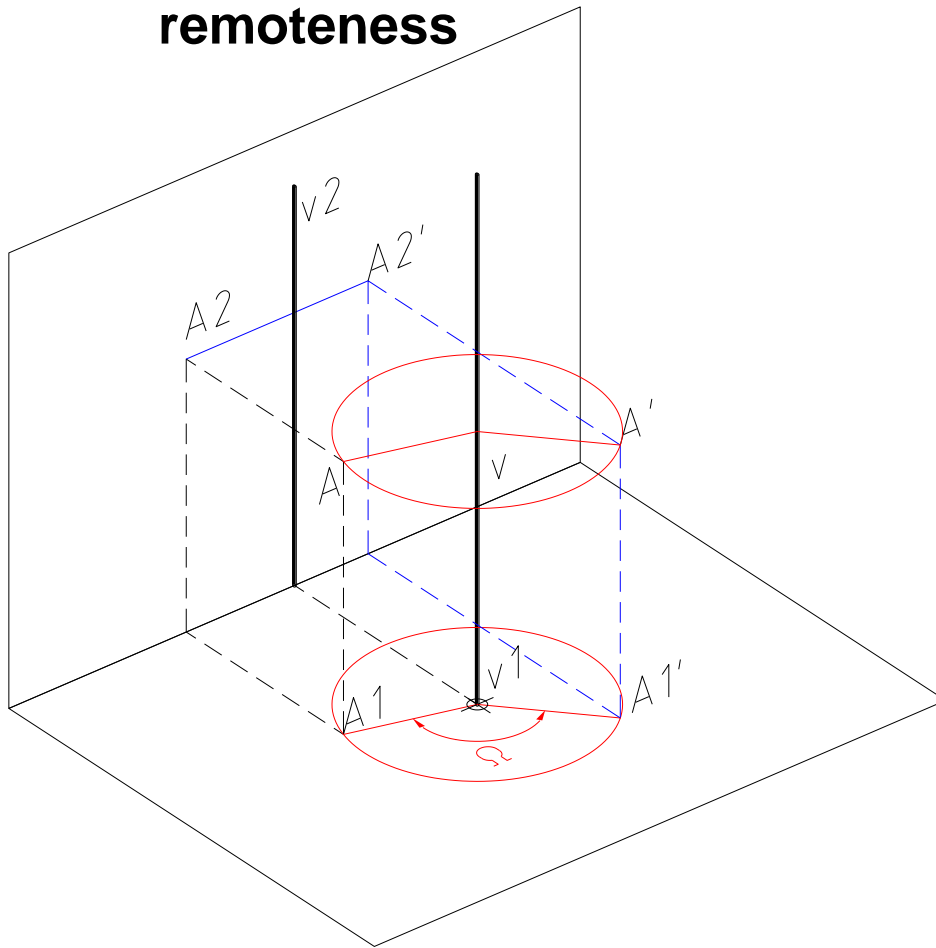
PREVIOUS CONCEPTS. True distances

- The distance between one point and one line could be directly measure if the plane is:
 - HORIZONTAL PROJECTING PLANE: Distance $A-\phi =$ Distance $A1-\phi 1$
 - VERTICAL PROJECTING PLANE: Distance $A-\sigma =$ Distance $A2-\sigma 2$



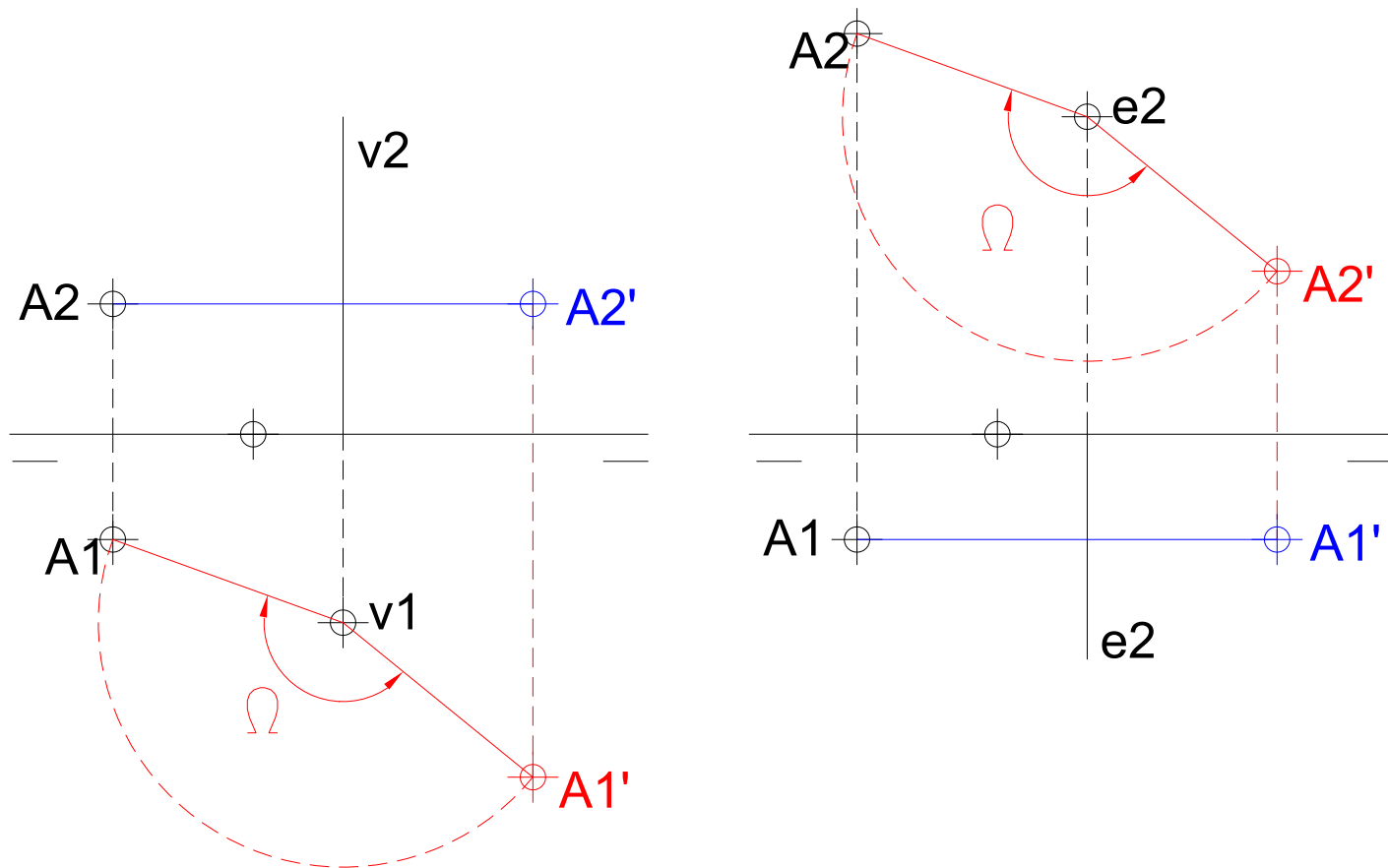
POINT TURN

- Around a vertical axis: A1 rotates, A2 keeps the same height.
- Around an extreme axis: A2 rotates, A1 keeps the same remoteness



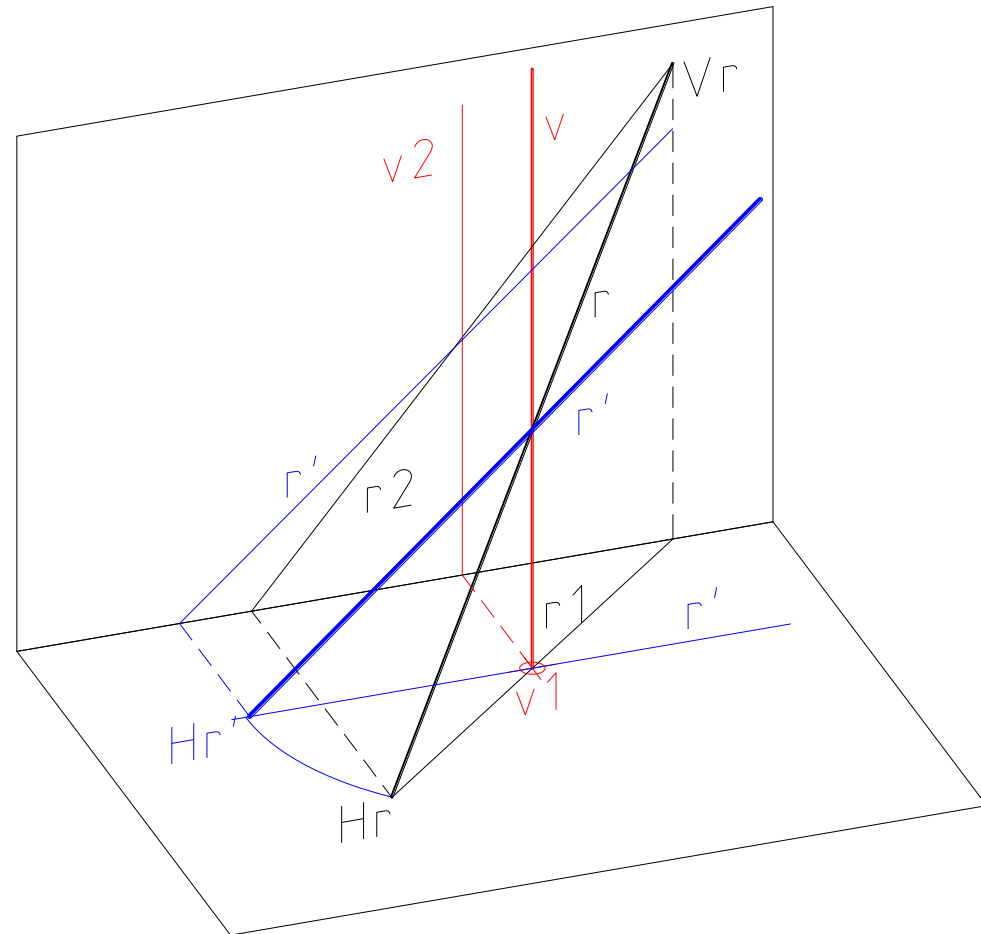
POINT TURN

- Around a vertical axis: A1 rotates, A2 keeps the same height.
- Around an extreme axis: A2 rotates, A1 keeps the same remoteness



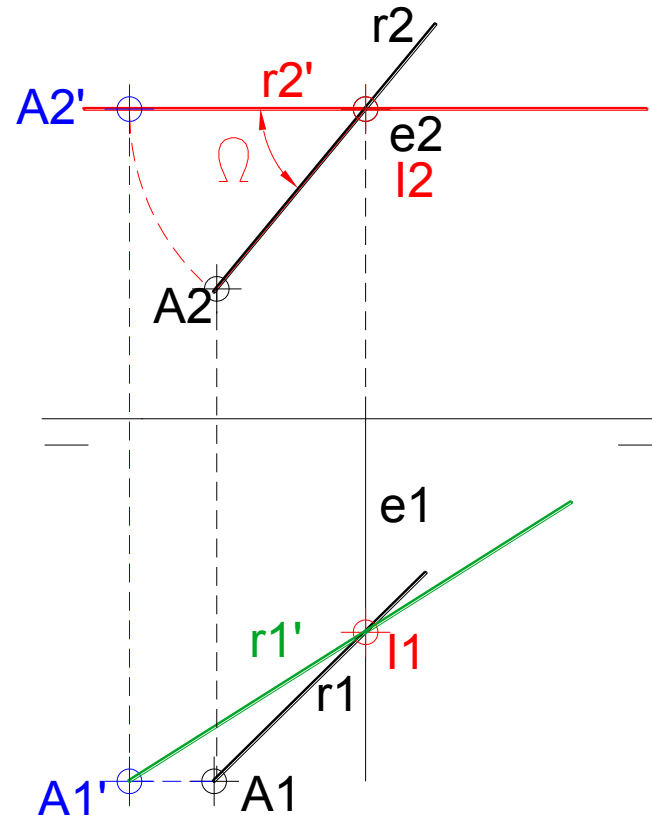
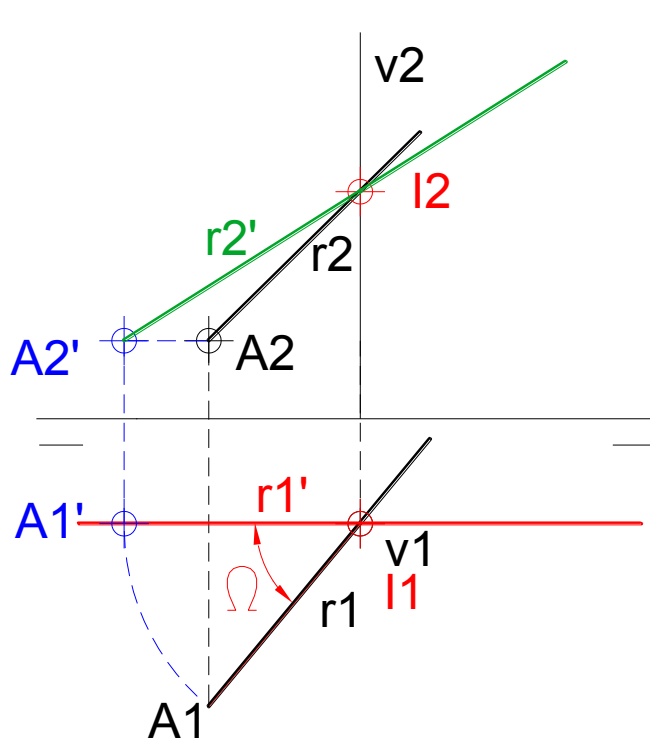
LINE TURN. Getting frontal and horizontal lines

- **Made by the turn of two of its points**
 - Around a vertical axis: getting a frontal line
 - Around an extreme axis: getting a horizontal line
- **Two directions (clockwise and counter-clockwise are possible)**
- **Turning axis cuts the line: the intersección point remains invariable**
- **If the turning axis does not cut the line: the “tangency” point T has to be found and turned first**



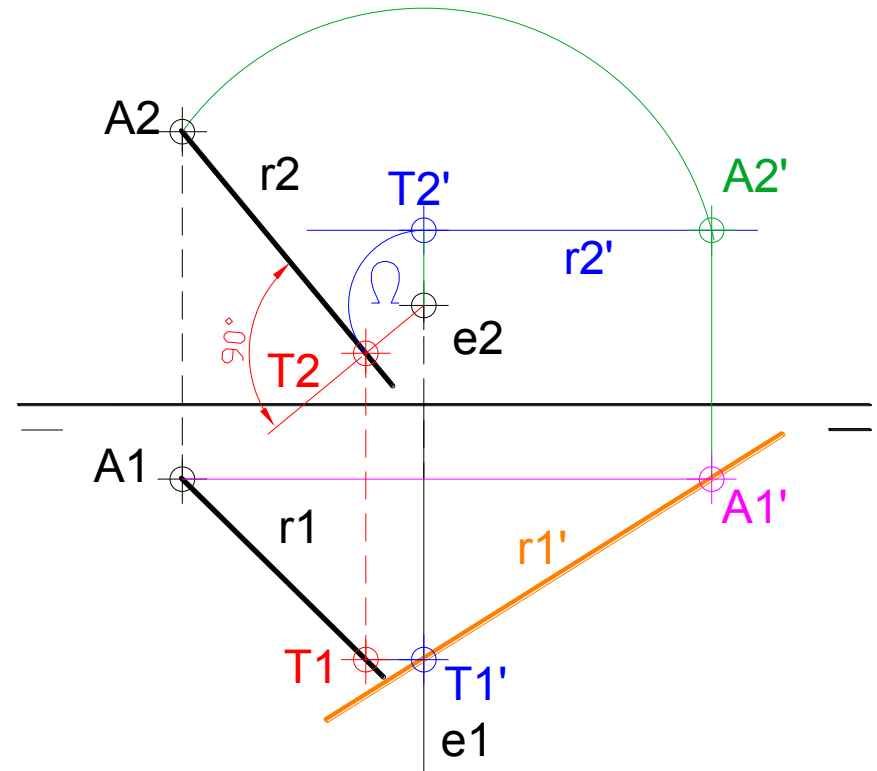
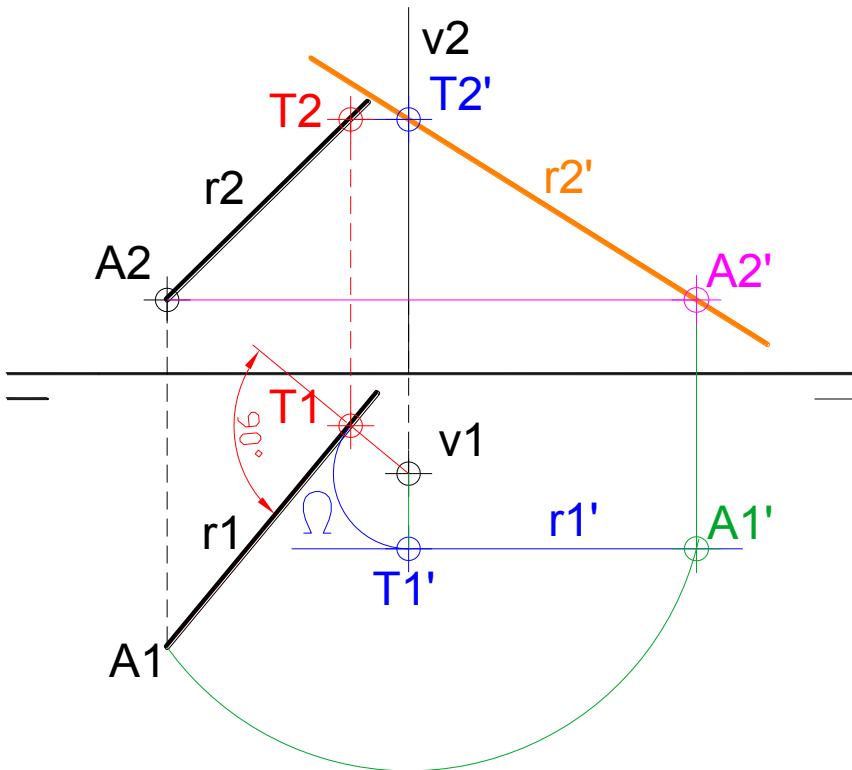
LINE TURN. Getting frontal and horizontal lines

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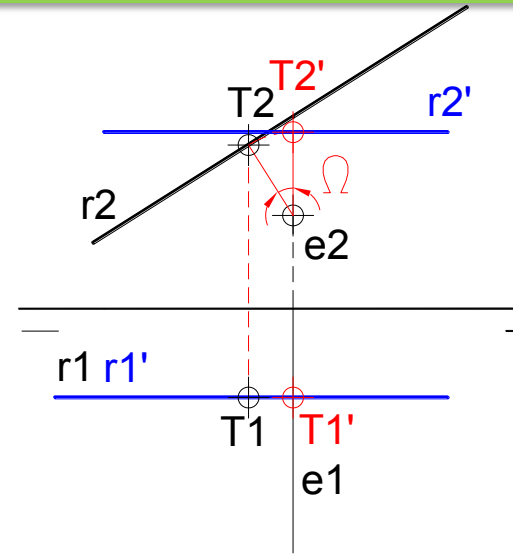
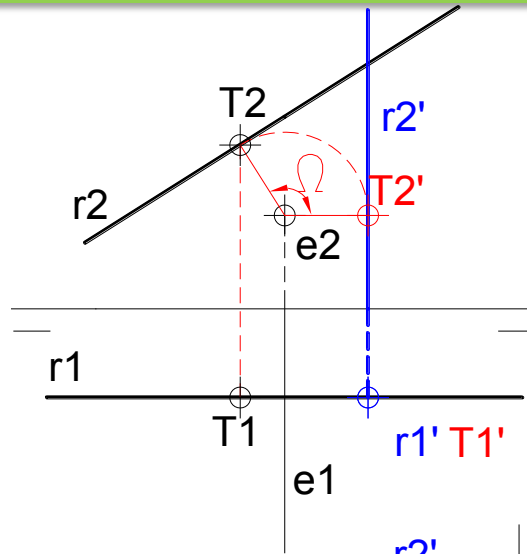
LINE TURN. Getting frontal and horizontal lines

- If the turning axis does not cut the line: the “tangency” point T has to be found and turned first

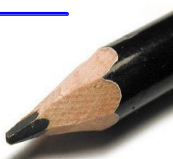
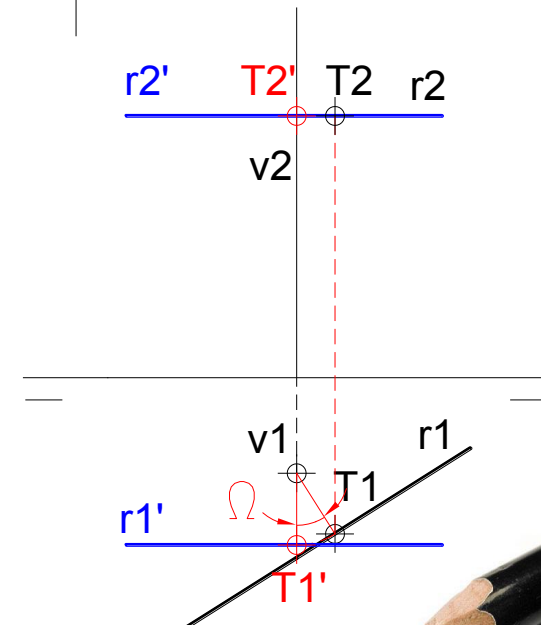
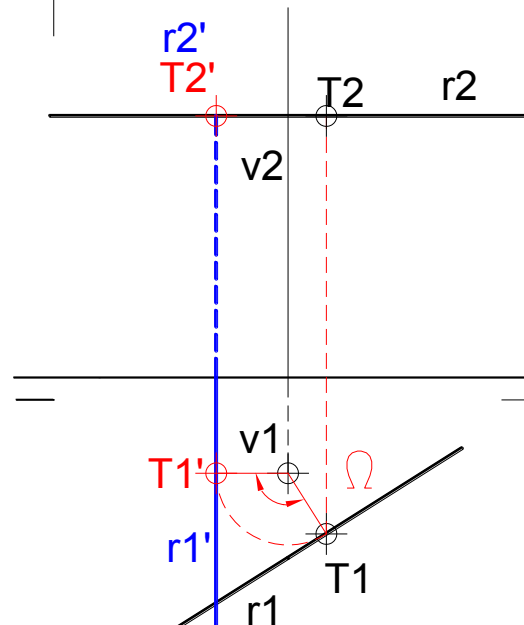


LINE TURN. Getting special lines

- Frontal line around a vertical axis: or parallel to the E.L.

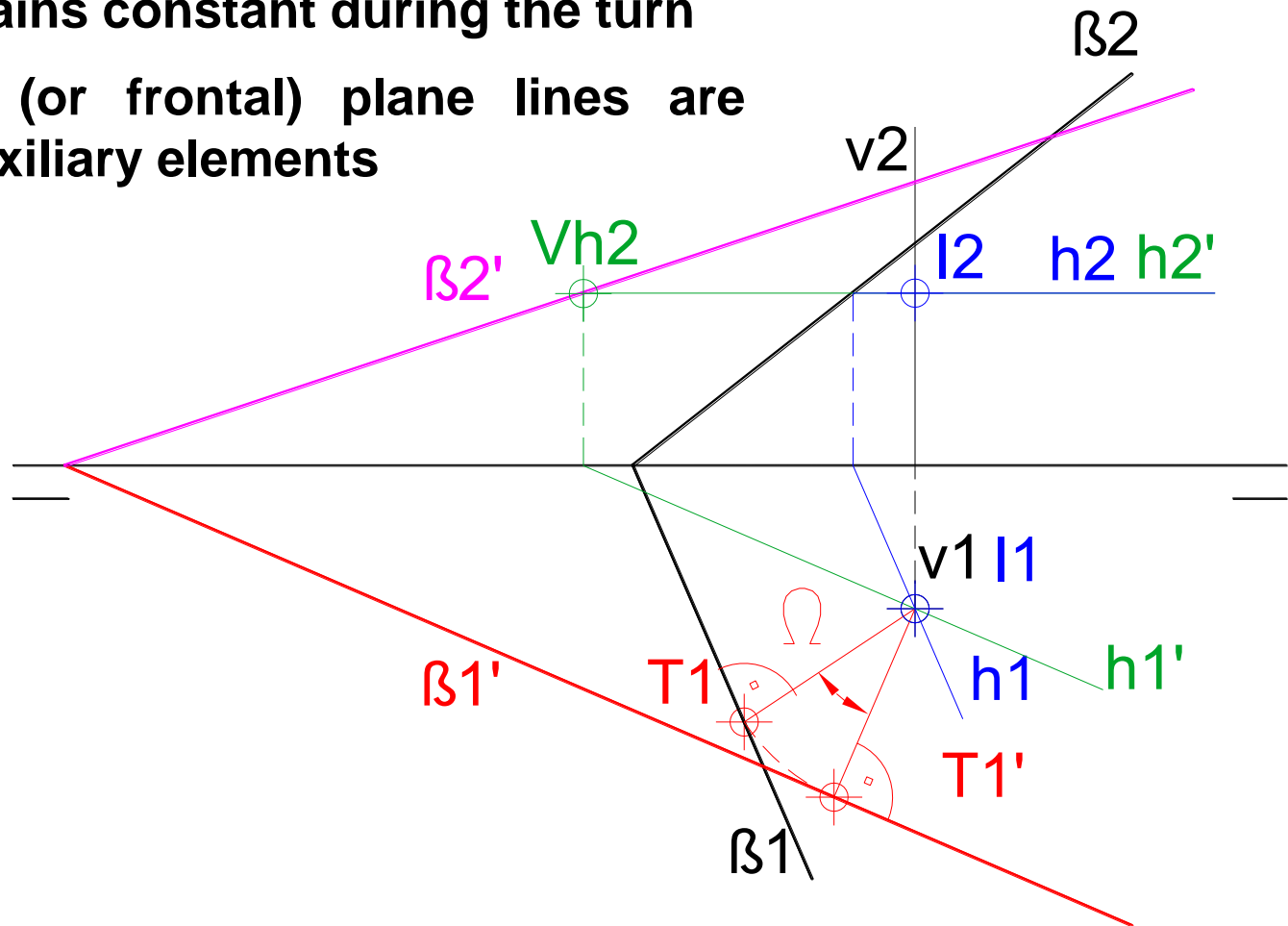


- Horizontal line around a vertical axis: or parallel to the E.L.



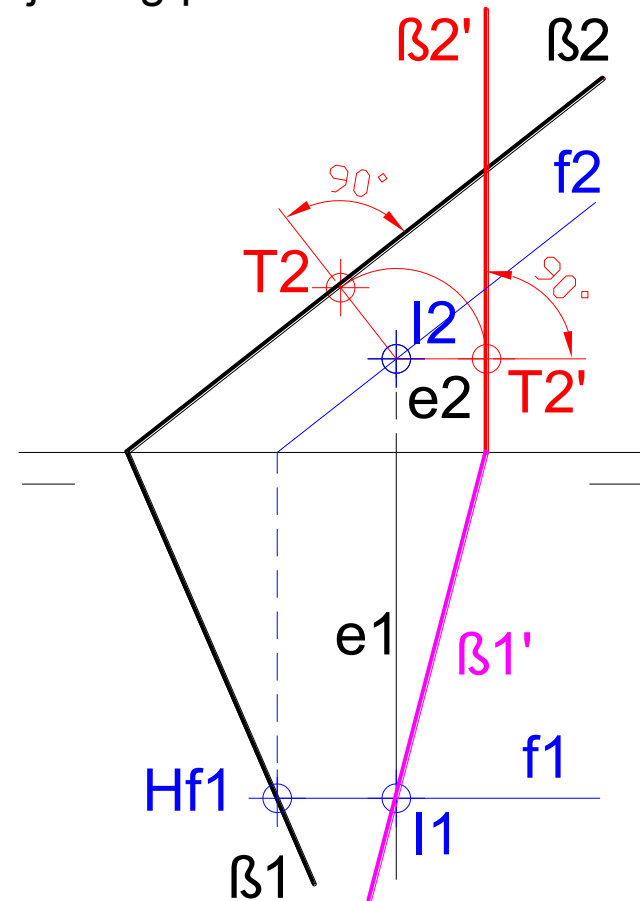
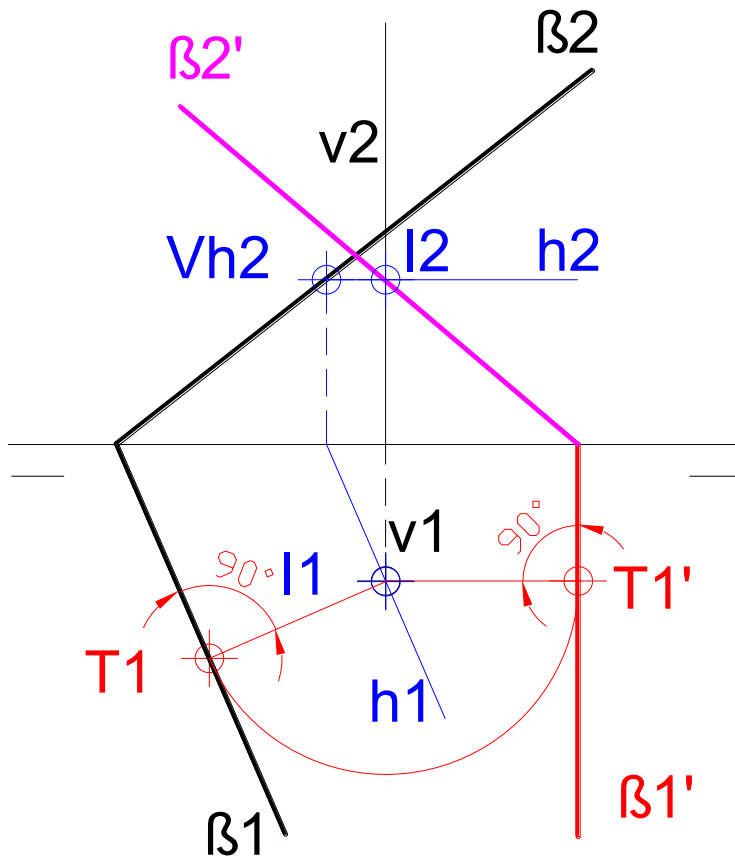
PLANE TURN

- I, interseccion point between axis and plane, remains constant during the turn
- Horizontal (or frontal) plane lines are used as auxiliary elements



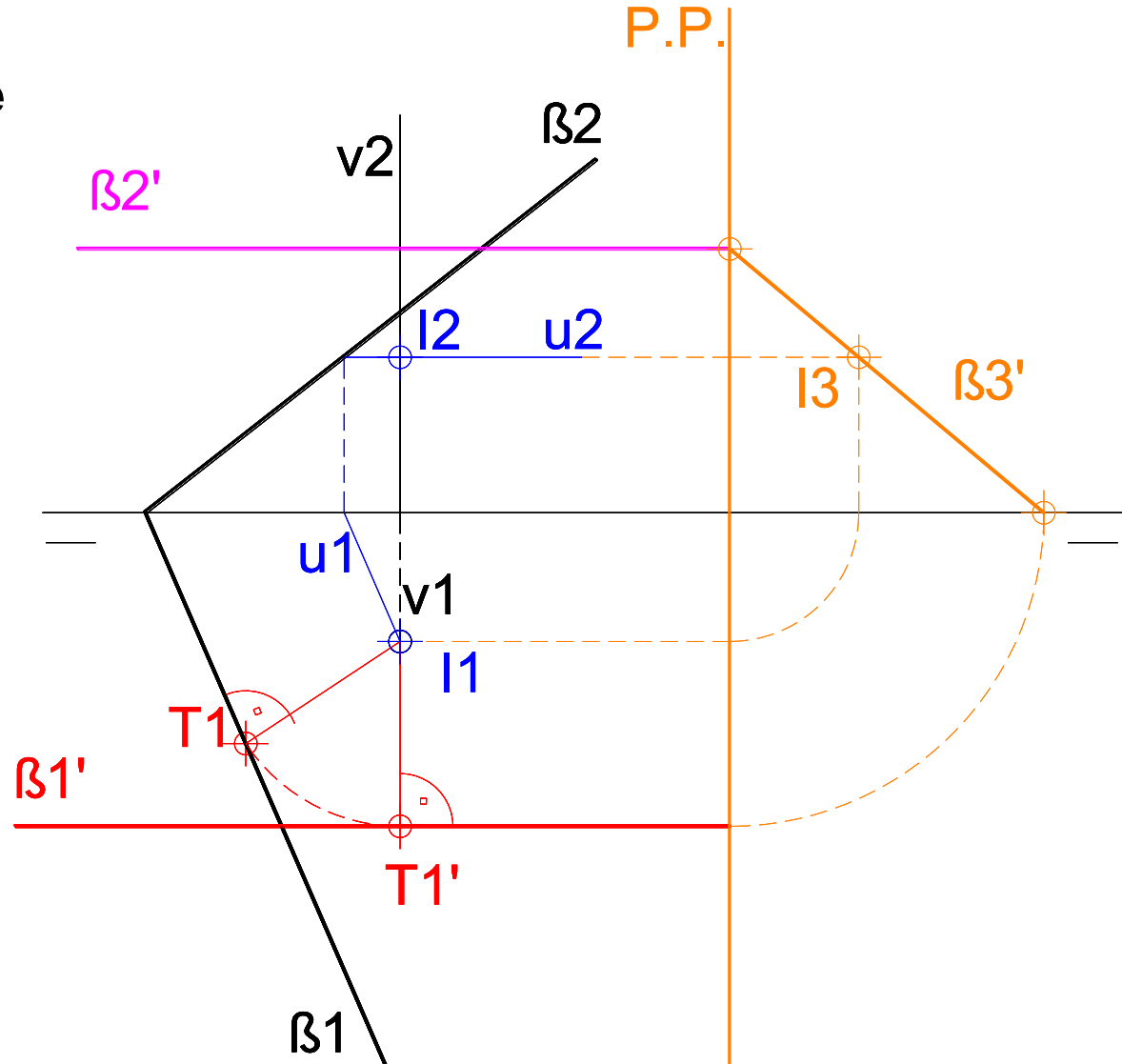
PLANE TURN. Getting projecting planes

- Specific turns could change generic planes into projecting planes:
 - Around a vertical axis: vertical projecting plane
 - Around an extrem axis: horizontal projecting planes



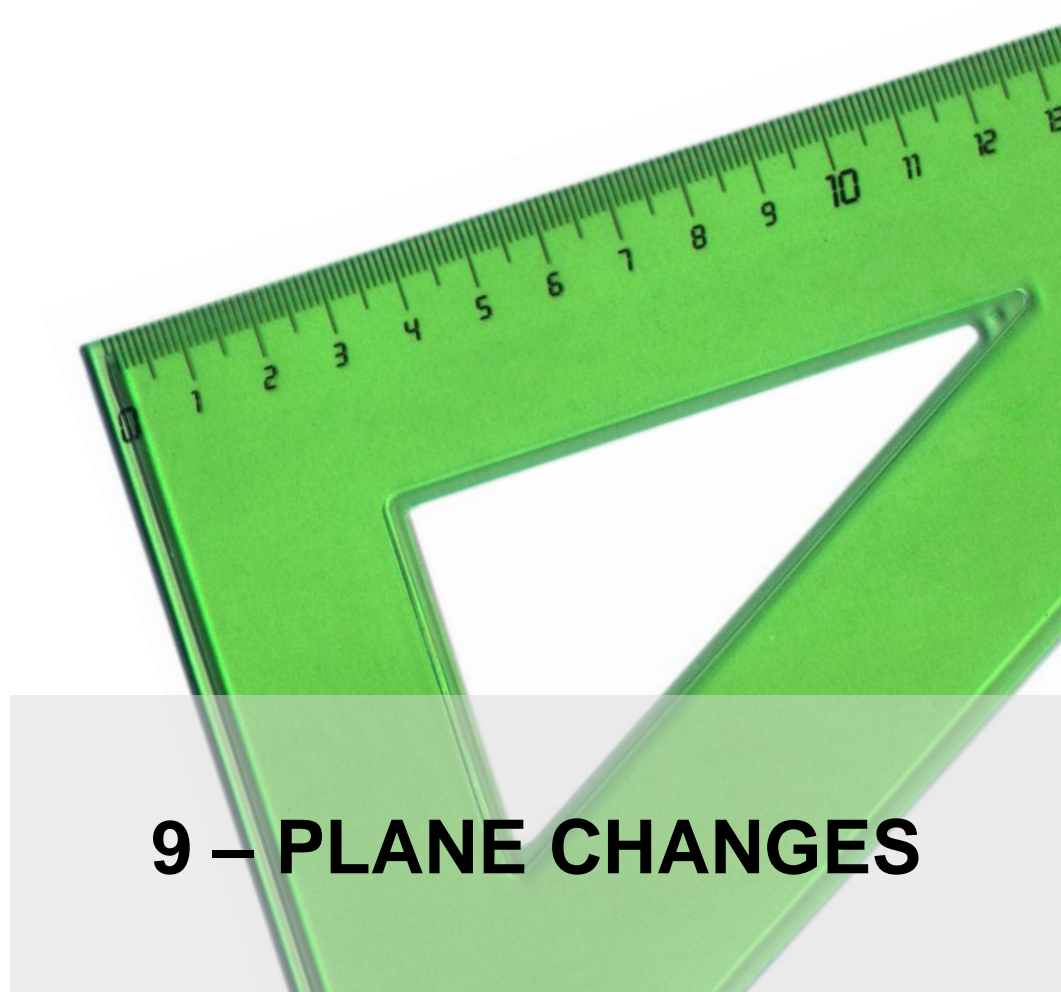
PLANE TURN. Getting special planes

- For instance, getting a plane parallel to the E.L.



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9 – PLANE CHANGES

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 3. GETTING LINES PARALLEL TO THE E.L.
4. **PLANE PLANE CHANGE**
 1. GETTING PROJECTING PLANES
 2. GETTING FRONTAL AND HORIZONTAL PLANES
 3. GETTING PLANES PARALLEL TO THE E.L.



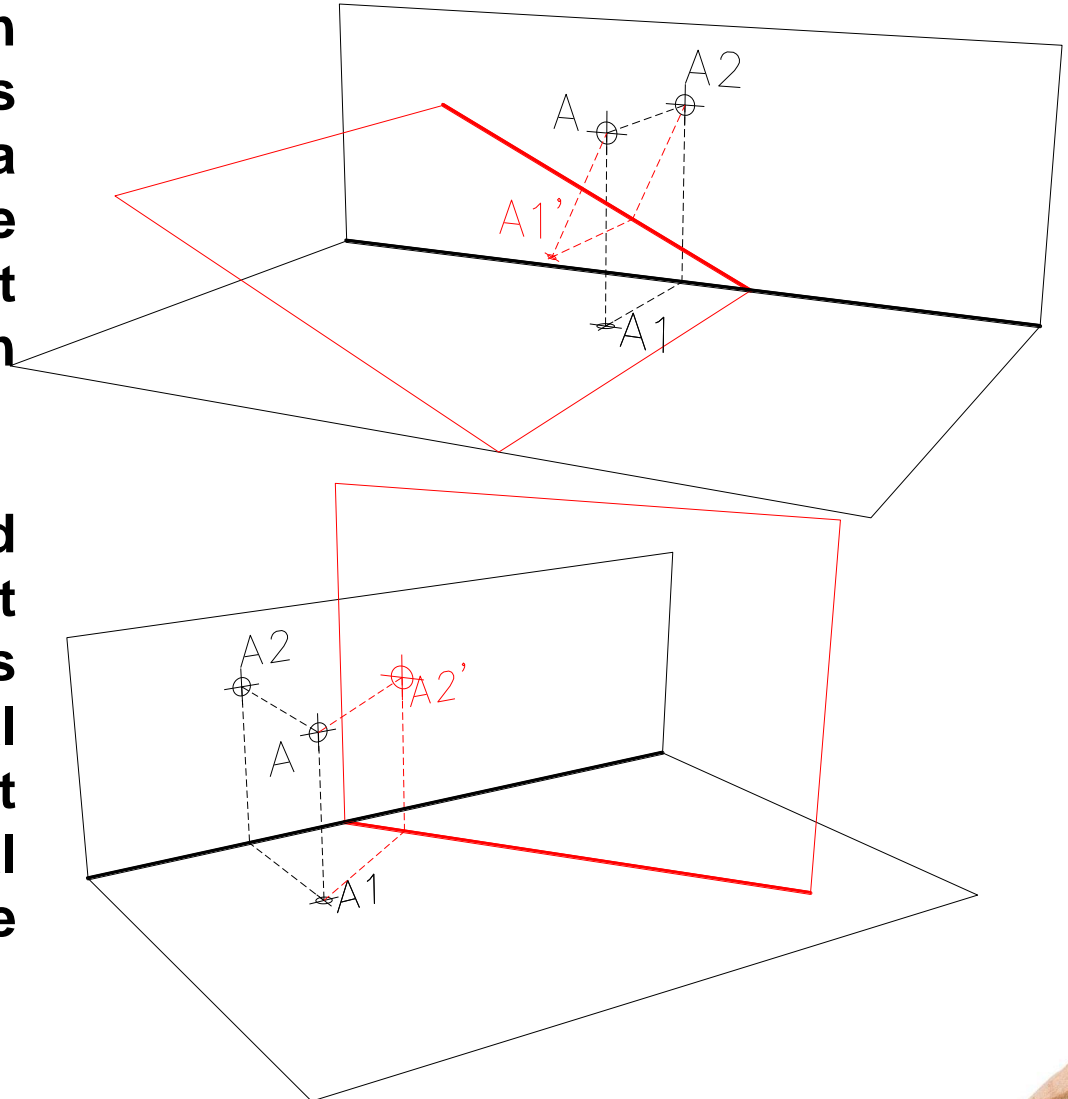
PREVIOUS CONCEPTS

- **PLANE CHANGE:** change of one of the PROJECTION PLANES at a time to change the projection of the graphic elements. The plane change usually involves a change in the nature of the element with respect to the new projection planes.
- **OBJECTIVE:** to obtain the true magnitude (distances and angles) of the elements regardless their initial nature.
- **LETTERING**
 - $A1', A2'$
 - $r1', r2'$
 - $\alpha1', \alpha2'$
- **PLANE CHANGE NOTATION**
 - Each new E.L. is accompanied by an additional pair of lateral strokes. The location of the strokes determine the positive sense of the remoteness and height axes.
 - Each new E.L. is accompanied by a leged consisting of a key, a capital letter (H or V) indicating the projection plane that changes, the number of that plane change, and a second capital letter indicating the projection plane that remains invariant (H or V).



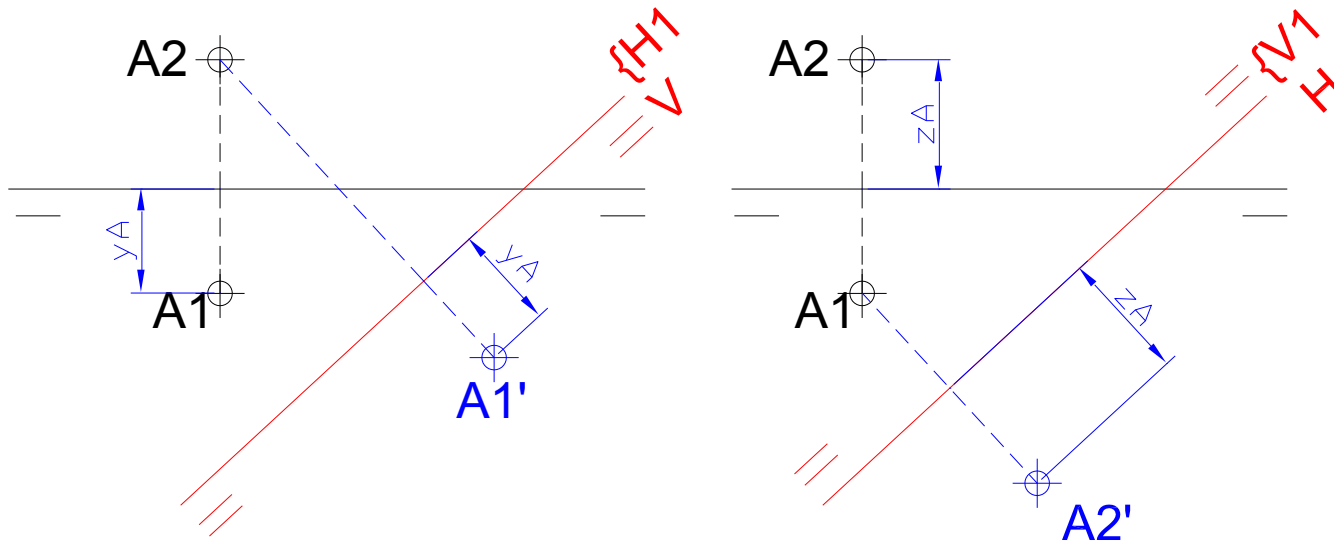
POINT PLANE CHANGE

- One of the projection planes changes its location. As a consequence, the projection of the point on that projection plane changes.
- However, the magnitude of the projection that changes (remoteness for the horizontal projection; and height for the vertical projection) remains the same.



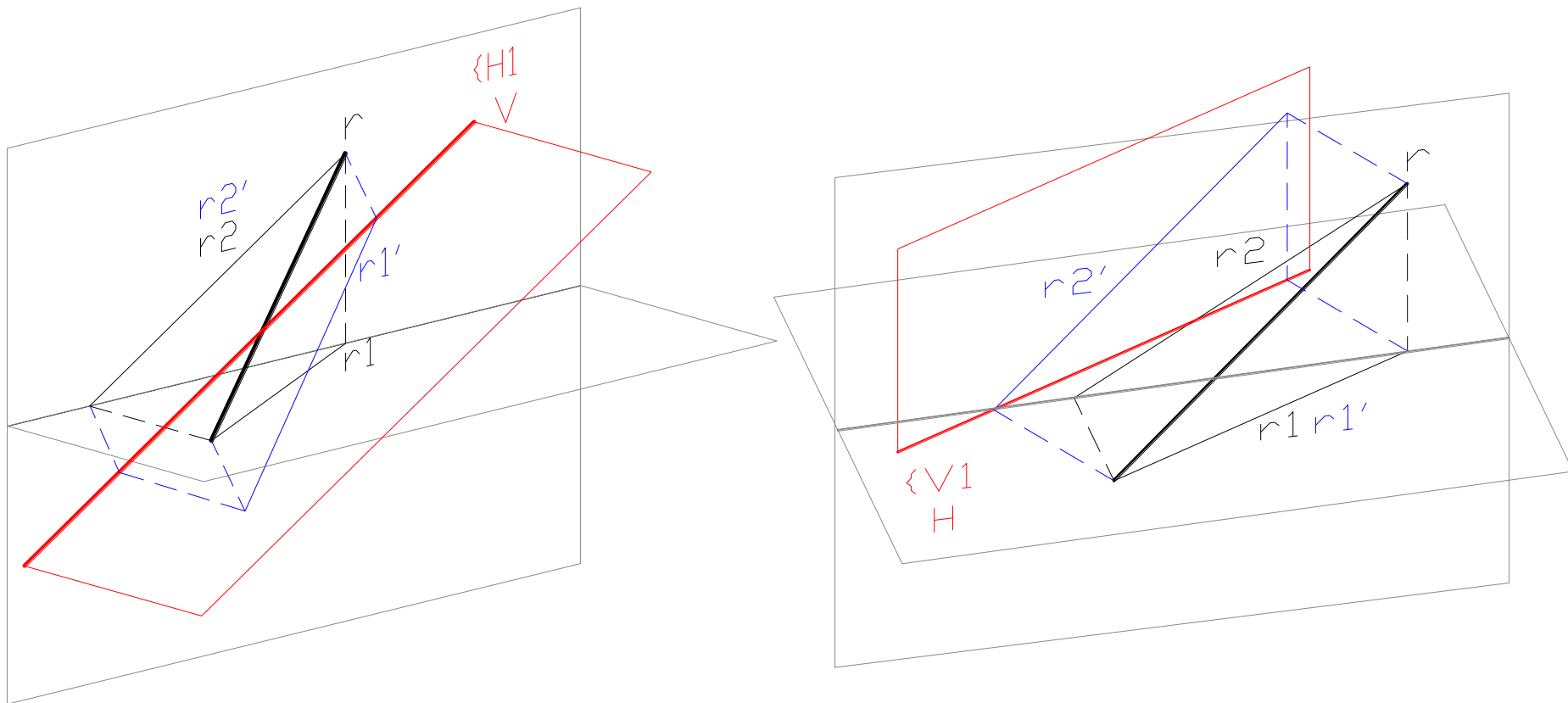
POINT PLANE CHANGE

- **HORIZONTAL PLANE CHANGE:**
 - **A2** remains the same, but **zA** changes
 - **A1** changes, but **yA** remains the same: **A1'**
- **VERTICAL PLANE CHANGE:**
 - **A2** changes, but **zA** remains the same: **A2'**
 - **A1** remains the same, but **yA** changes



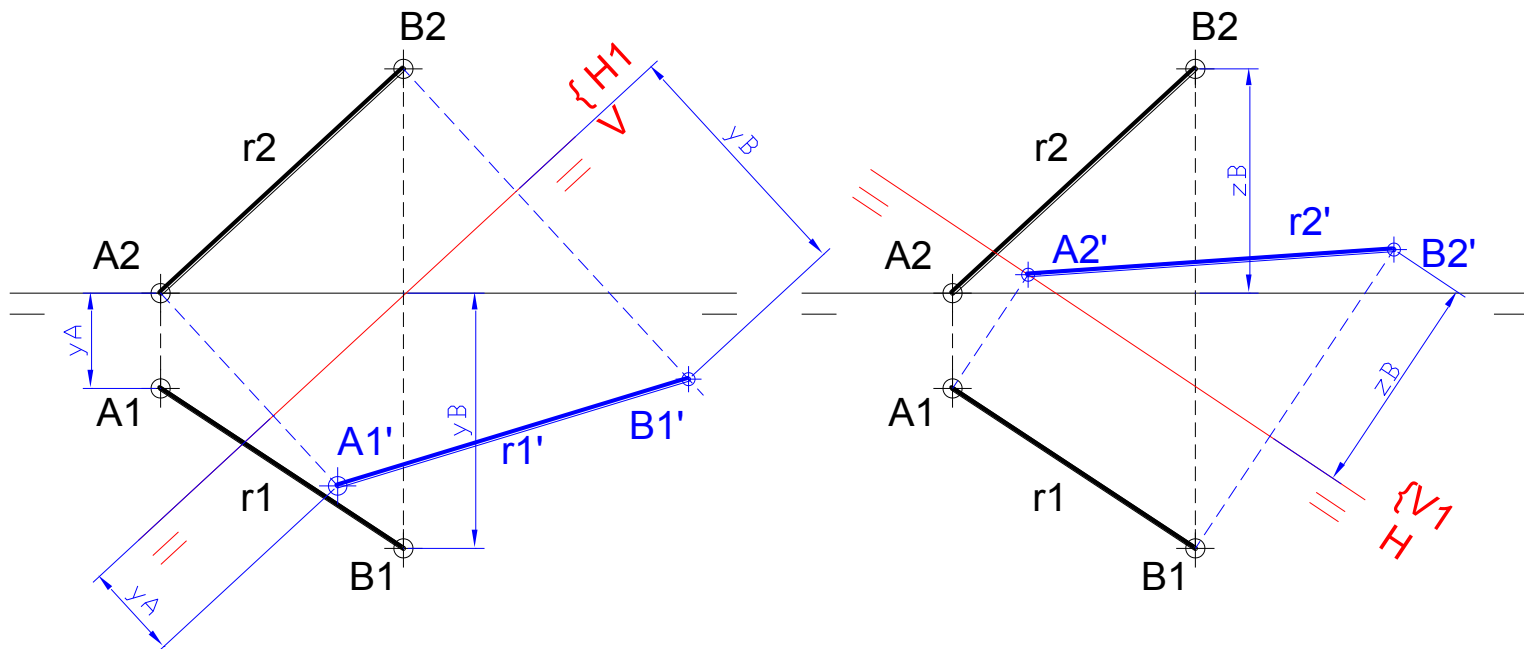
LINE PLANE CHANGE. Getting horizontal and frontal lines

- One of the projection planes changes to become parallel to the line.
- The new E.L. becomes parallel to one of the projections of the line



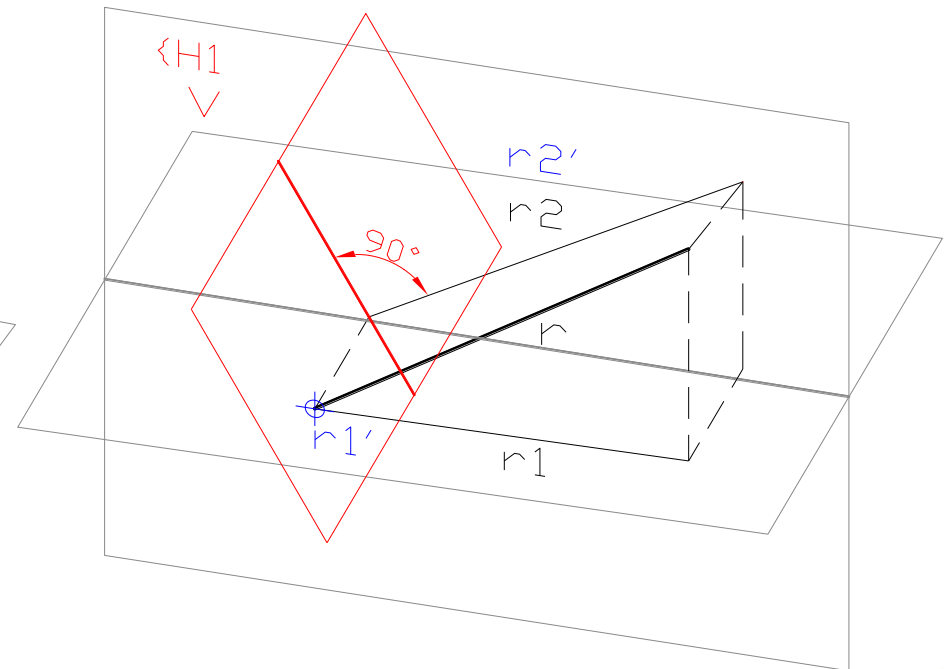
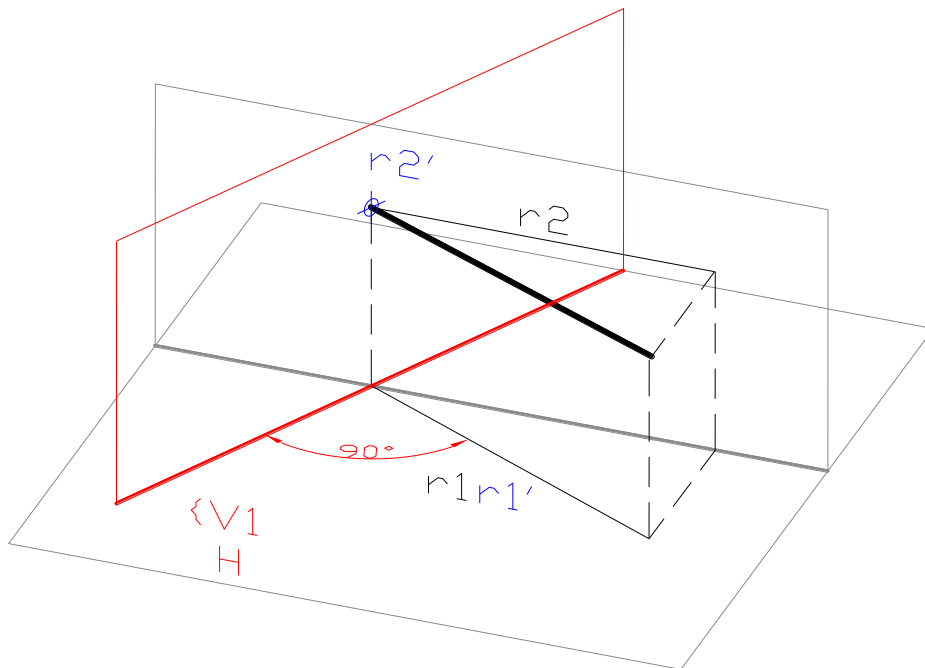
LINE PLANE CHANGE. Getting horizontal and frontal lines

- **HORIZONTAL PLANE CHANGE: getting a horizontal line**
 - **r2** remains the same, but **with a constant height: r2' parallel to the E.L**
 - **r1** changes, but its points keep the same remoteness
- **VERTICAL PLANE CHANGE: getting a frontal line**
 - **r2** changes, but its points keep the same height
 - **r1** remains the same, but **with a constant remoteness: r1' parallel to the E.L**



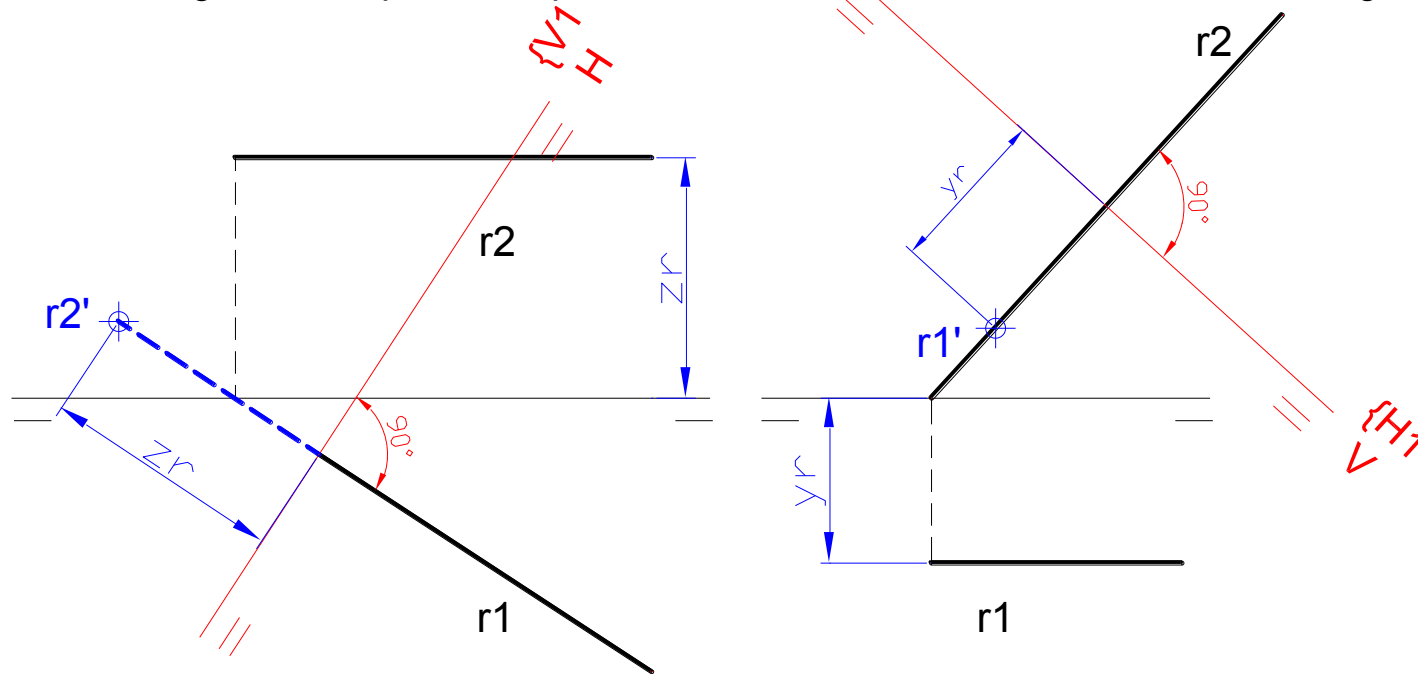
LINE PLANE CHANGE. Getting extreme and vertical lines

- The initial line should be a horizontal or a frontal line
- One of the projection planes changes to become perpendicular to the line.
- The new E.L. becomes perpendicular to one of the projections of the line



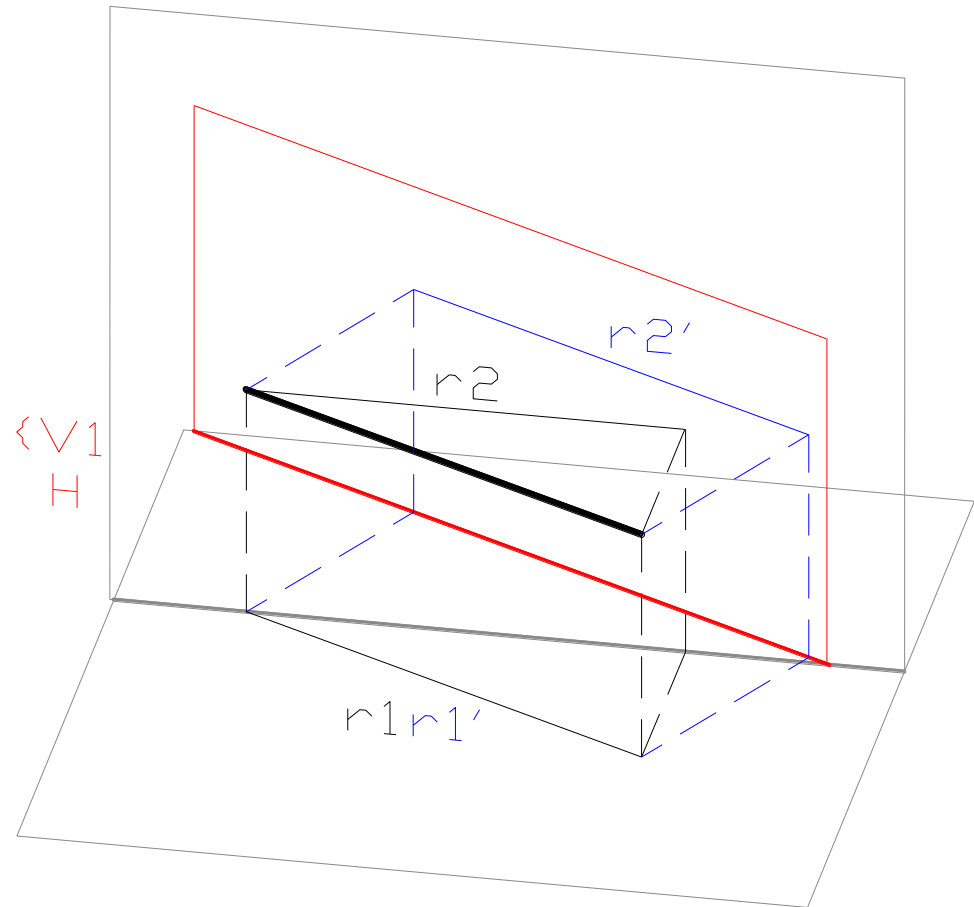
LINE PLANE CHANGE. Getting extreme and vertical lines

- FROM A HORIZONTAL LINE, A VERTICAL PLANE CHANGE COULD GET AN EXTREME LINE
 - r2 changes, but its points keep the same height and concentrate on a single point
 - r1 remains the same, but perpendicular to the E.L
- FROM A FRONTAL LINE, A HORIZONTAL PLANE CHANGE COULD GET A VERTICAL LINE
 - r2 remains the same, but perpendicular to the E.L
 - r1 changes, but its points keep the same remoteness and concentrate on a single point



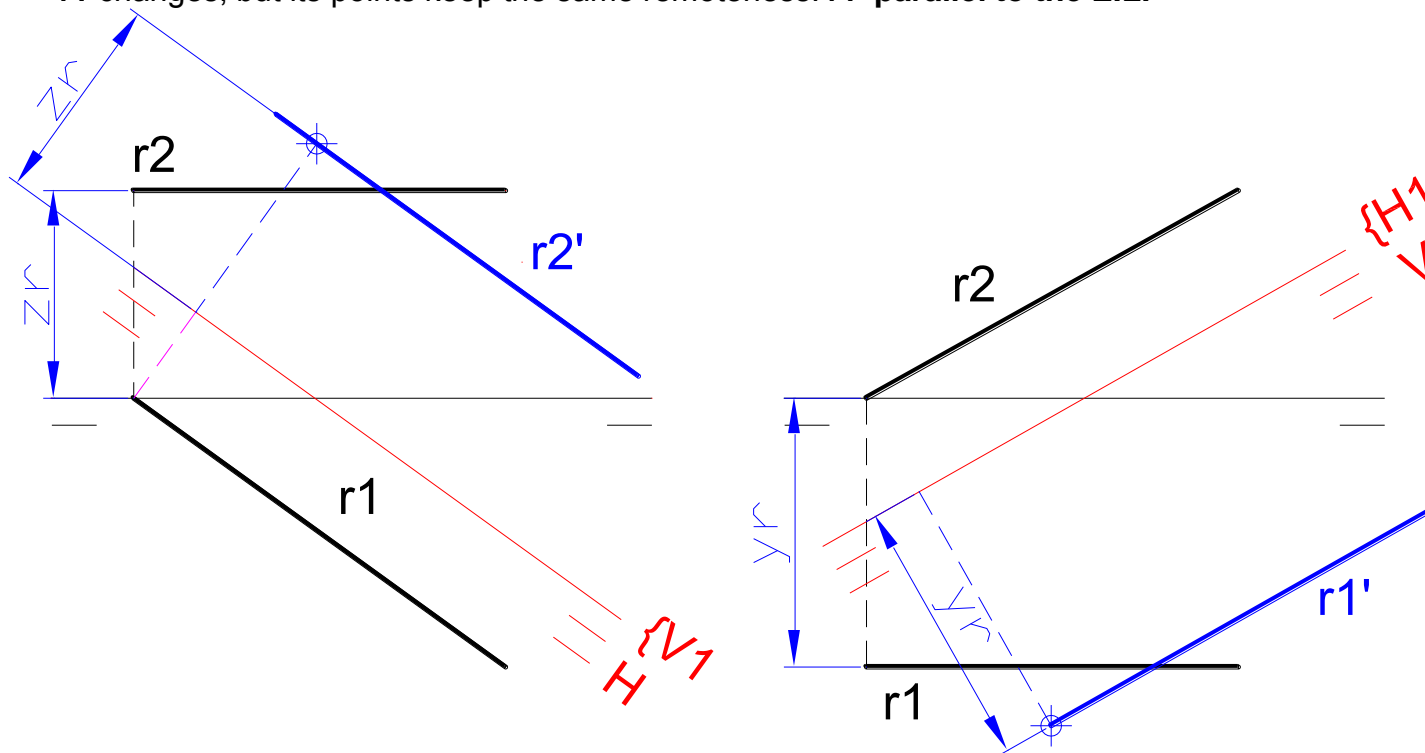
LINE PLANE CHANGE. Getting lines parallel to the E.L.

- The initial line should be a horizontal or a frontal line
- One of the projection planes changes to become parallel to the line.
- The new E.L. becomes parallel to both projections of the line



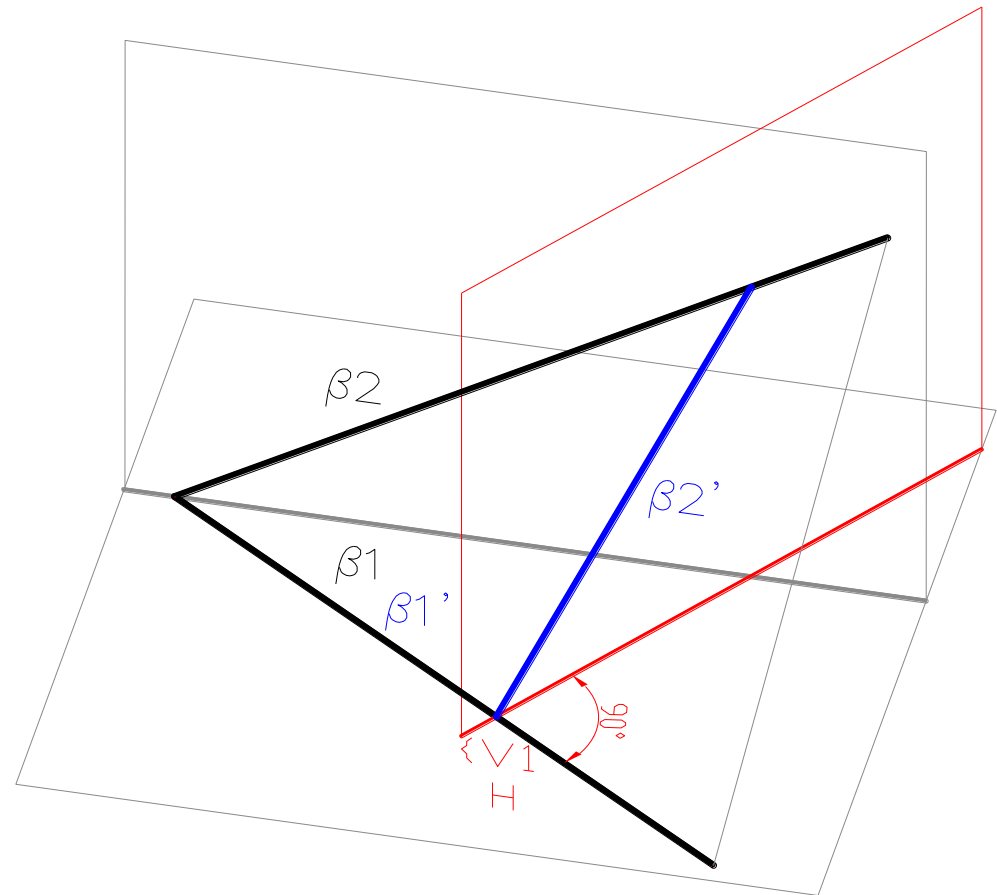
LINE PLANE CHANGE. Getting lines parallel to the E.L.

- FROM A HORIZONTAL LINE, A VERTICAL PLANE CHANGE COULD GET LINE PARALLEL TO THE E.L.
 - r2 changes, but its points keep the same height: r2' parallel to the E.L.
 - r1 remains the same, but parallel to the E.L
- FROM A FRONTAL LINE, A HORIZONTAL PLANE CHANGE COULD GET A LINE PARALLEL TO THE E.L.
 - r2 remains the same, but is parallel to the E.L
 - r1 changes, but its points keep the same remoteness: r1' parallel to the E.L.



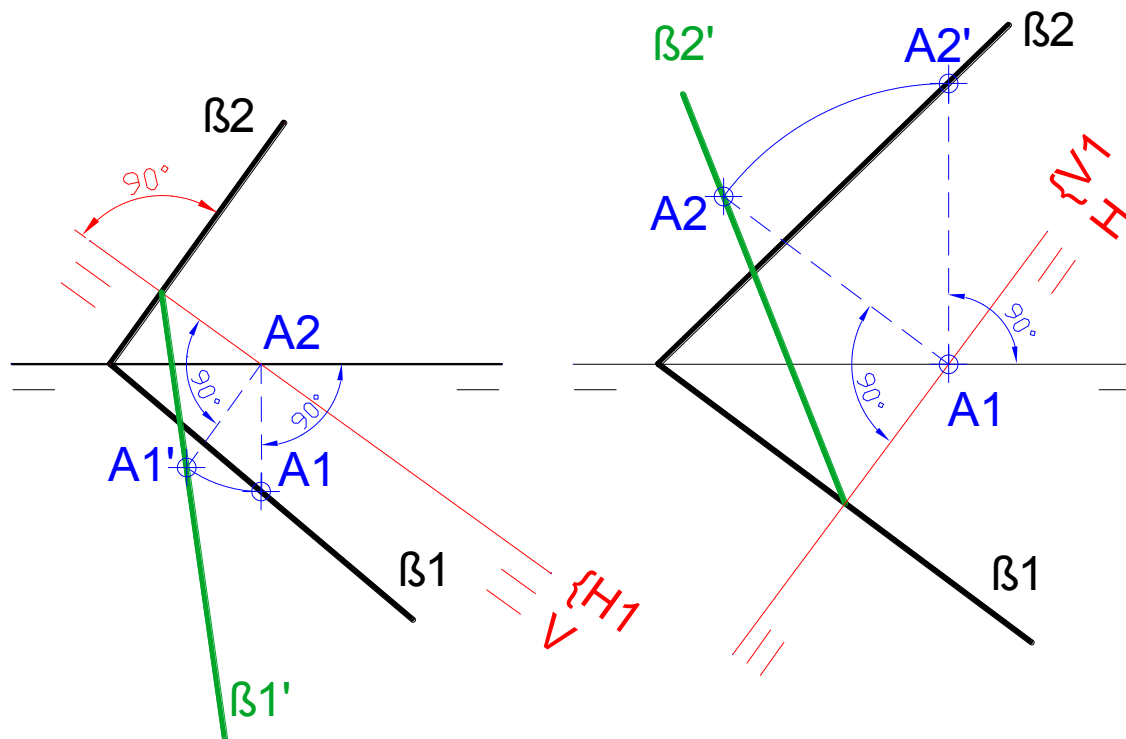
PLANE PLANE CHANGE. Getting frontal and horizontal planes

- One of the projection planes changes to become perpendicular to the plane
- The new E.L. becomes perpendicular to one of the traces of the plane



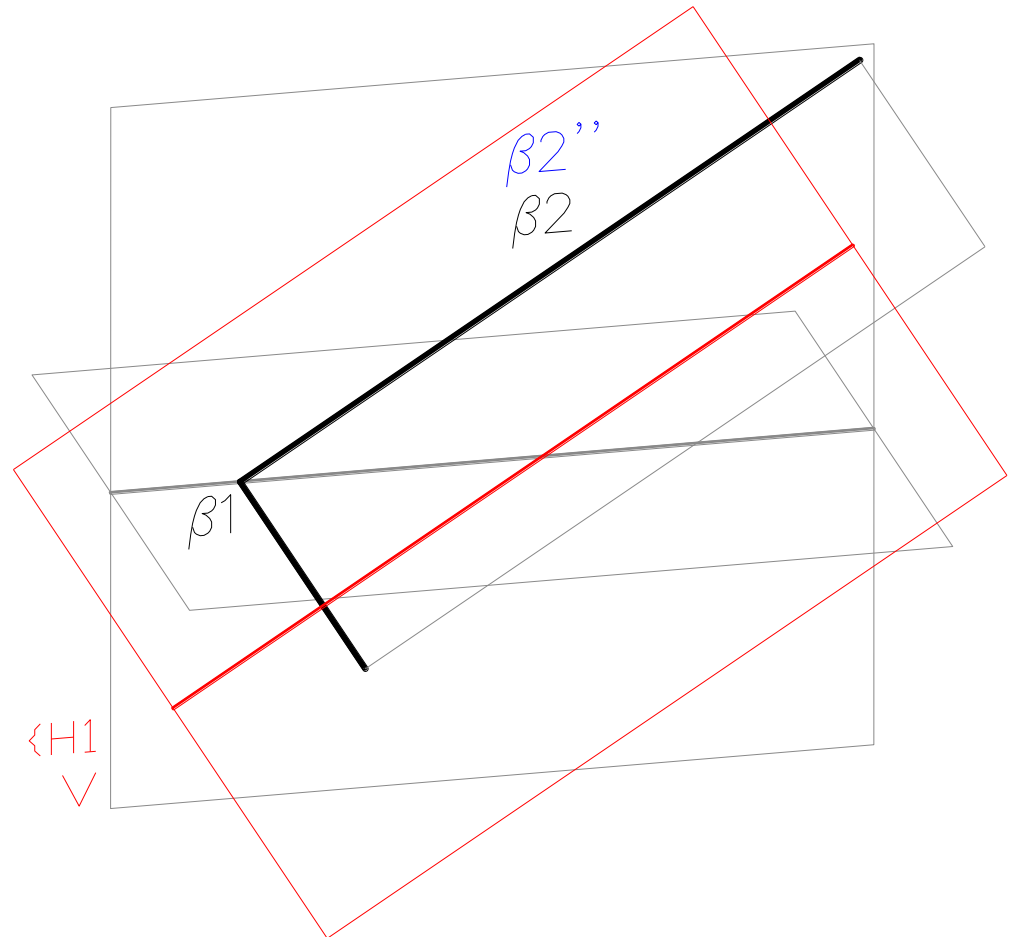
PLANE PLANE CHANGE. Getting projecting planes

- **HORIZONTAL PLANE CHANGE: getting a horizontal projecting plane**
 - $\beta 2$ remains the same, but perpendicular to the E.L.
 - $\beta 1$ changes
- **VERTICAL PLANE CHANGE: getting a vertical projecting plane**
 - $\beta 2$ changes
 - $\beta 1$ remains the same, but perpendicular to the E.L.



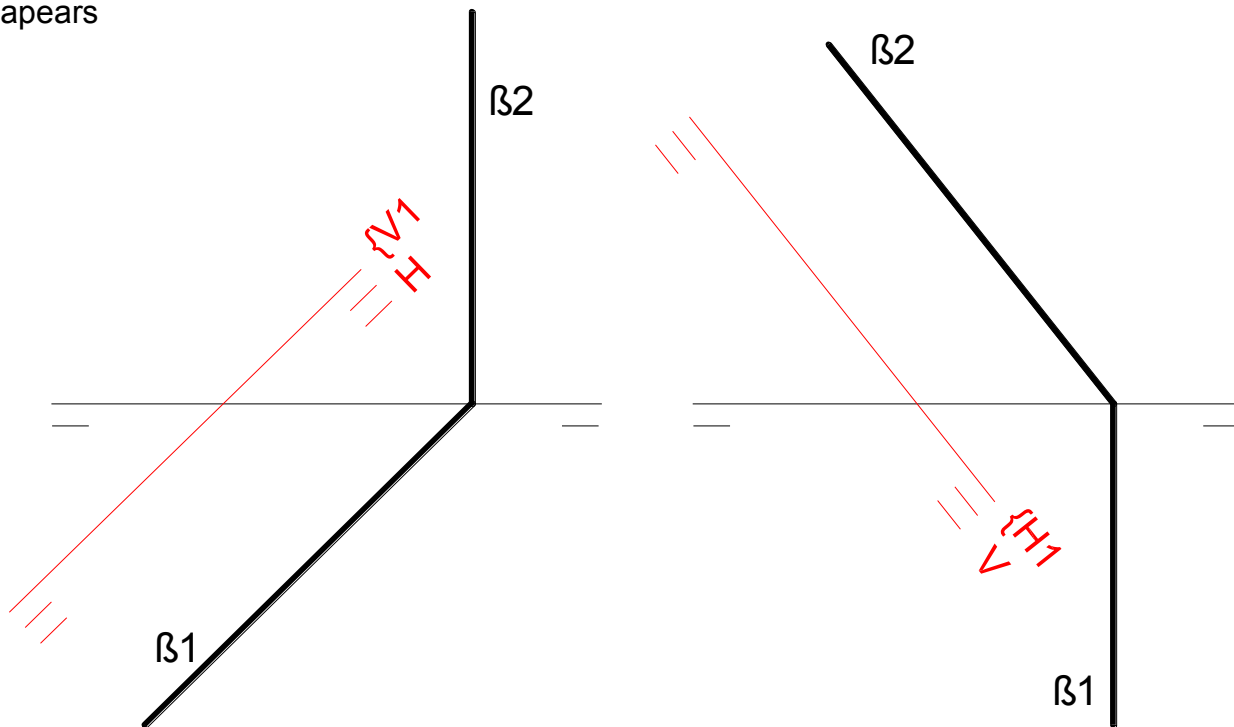
PLANE PLANE CHANGE. Getting frontal and horizontal planes

- The initial plane should be a horizontal or a vertical projecting plane
- One of the projection planes changes to become parallel to the plane
- The new E.L. becomes parallel to both planes



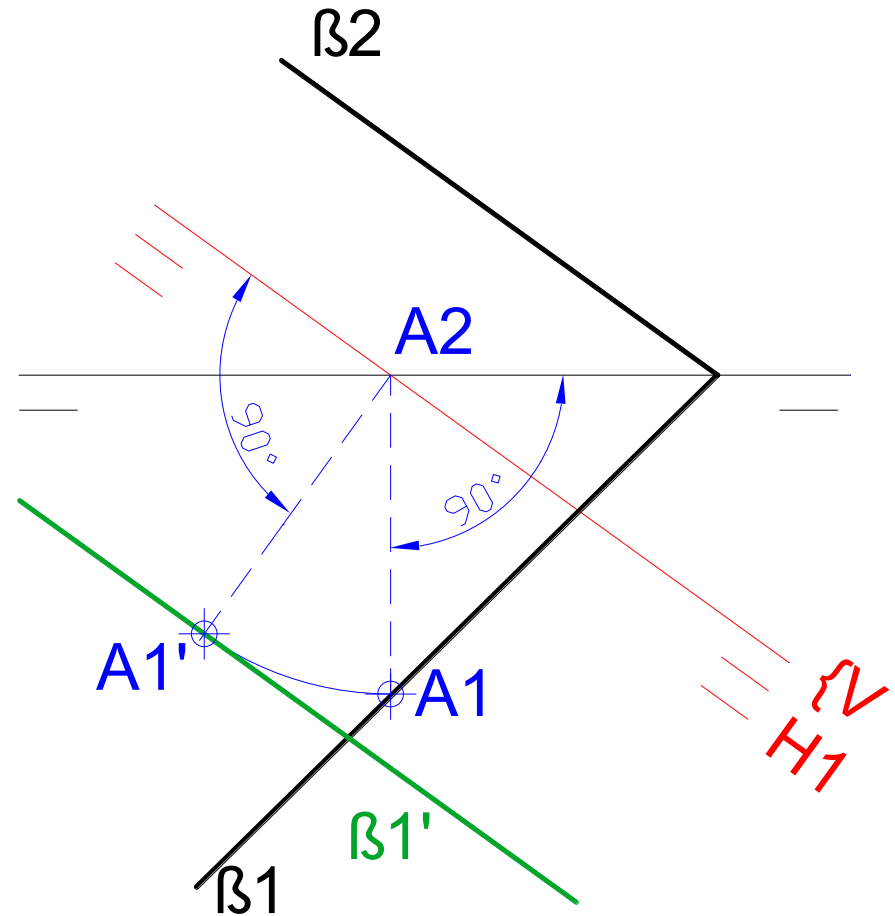
PLANE PLANE CHANGE. Getting frontal and horizontal planes

- FROM A HORIZONTAL PROJECTING PLANE, A VERTICAL PLANE CHANGE COULD GET A FRONTAL PLANE
 - $\beta 2$ disappears
 - $\beta 1$ remains the same, but parallel to the E.L
- FROM A VERTICAL PROJECTING PLANE, A HORIZONTAL PLANE CHANGE COULD GET A HORIZONTAL PLANE
 - $\beta 2$ remains the same, but parallel to the E.L
 - $\beta 1$ disappears



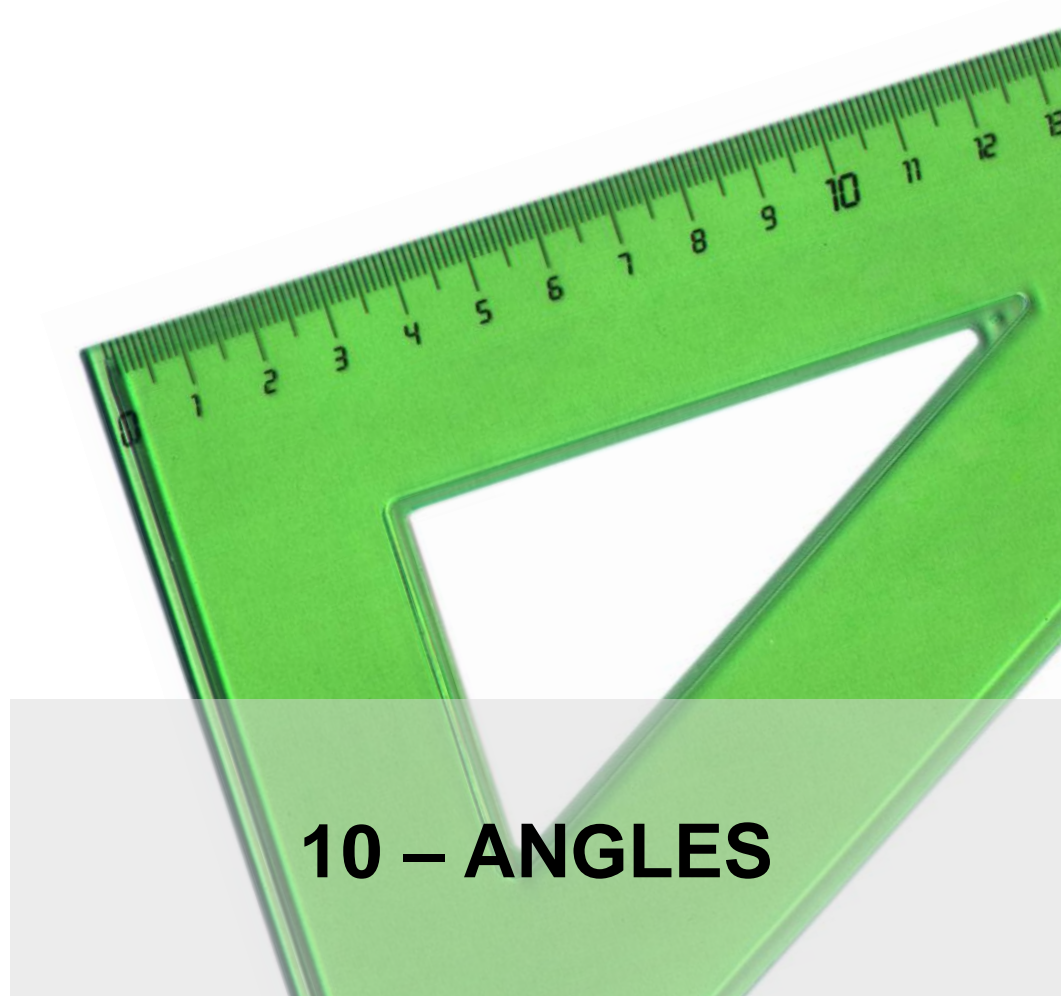
PLANE PLANE CHANGE. Getting planes parallel to the E.L.

- **HORIZONTAL PLANE CHANGE:** getting a plane parallel to the E.L.
 - $\beta 2$ remains the same, but parallel to the E.L.
 - $\beta 1$ changes, $\beta 1'$ parallel to the E.L.
- **VERTICAL PLANE CHANGE:** getting a plane parallel to the E.L.
 - $\beta 2$ changes, $\beta 2'$ parallel to the E.L.
 - $\beta 1$ remains the same, but parallel to the E.L.



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10 – ANGLES

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1. ABASEMENT (GENERIC OR REDUCED)

3. ANGLE BETWEEN A PLANE AND THE PROJECTION PLANES

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2. PLANE CHANGE
3. ABASEMENT OF PLANE'S MAX. SLOPE AND MAX. TILT ANGLE LINES

4. ANGLE BETWEEN LINE AND PLANE

5. ANGLE BETWEEN TWO PLANES

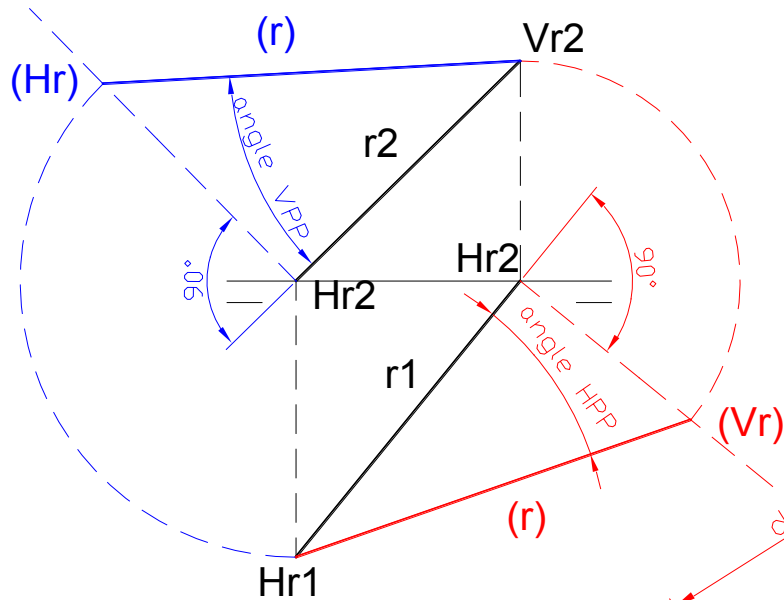
6. CONDITIONING ANGLES

1. LINES
2. PLANES

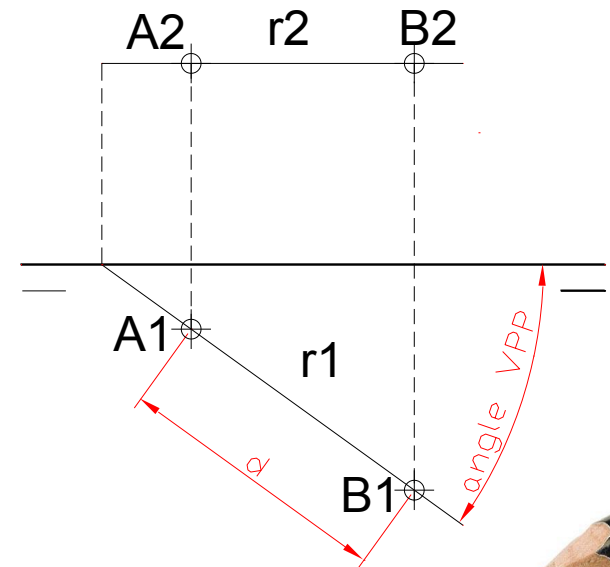
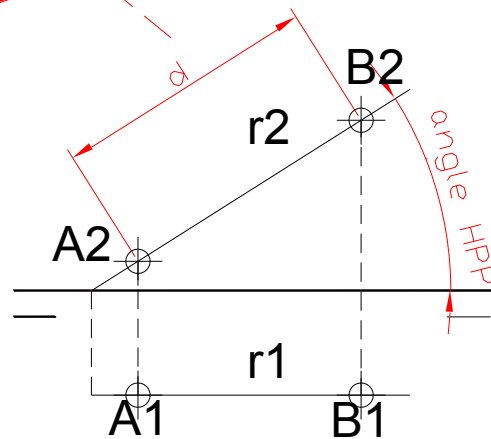


ANGLE BETWEEN A LINE AND THE PROJECTION PLANES

• ABASEMENT (TRIANGLE METHOD)

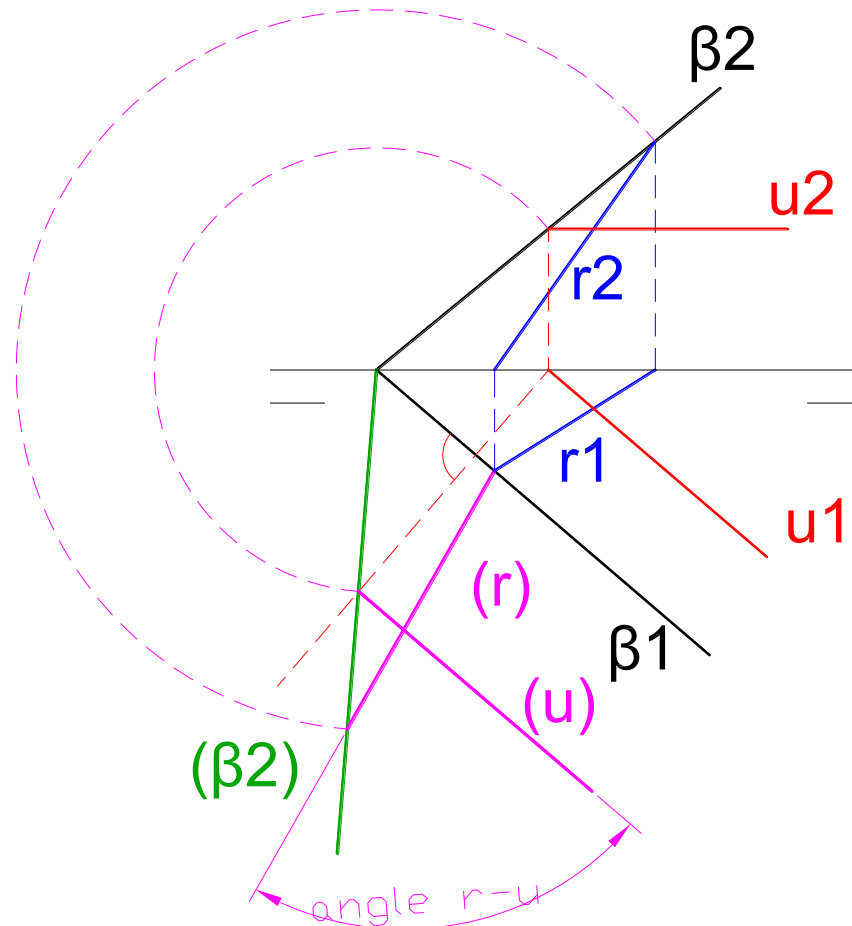


• TURNS AND PLANE CHANGES



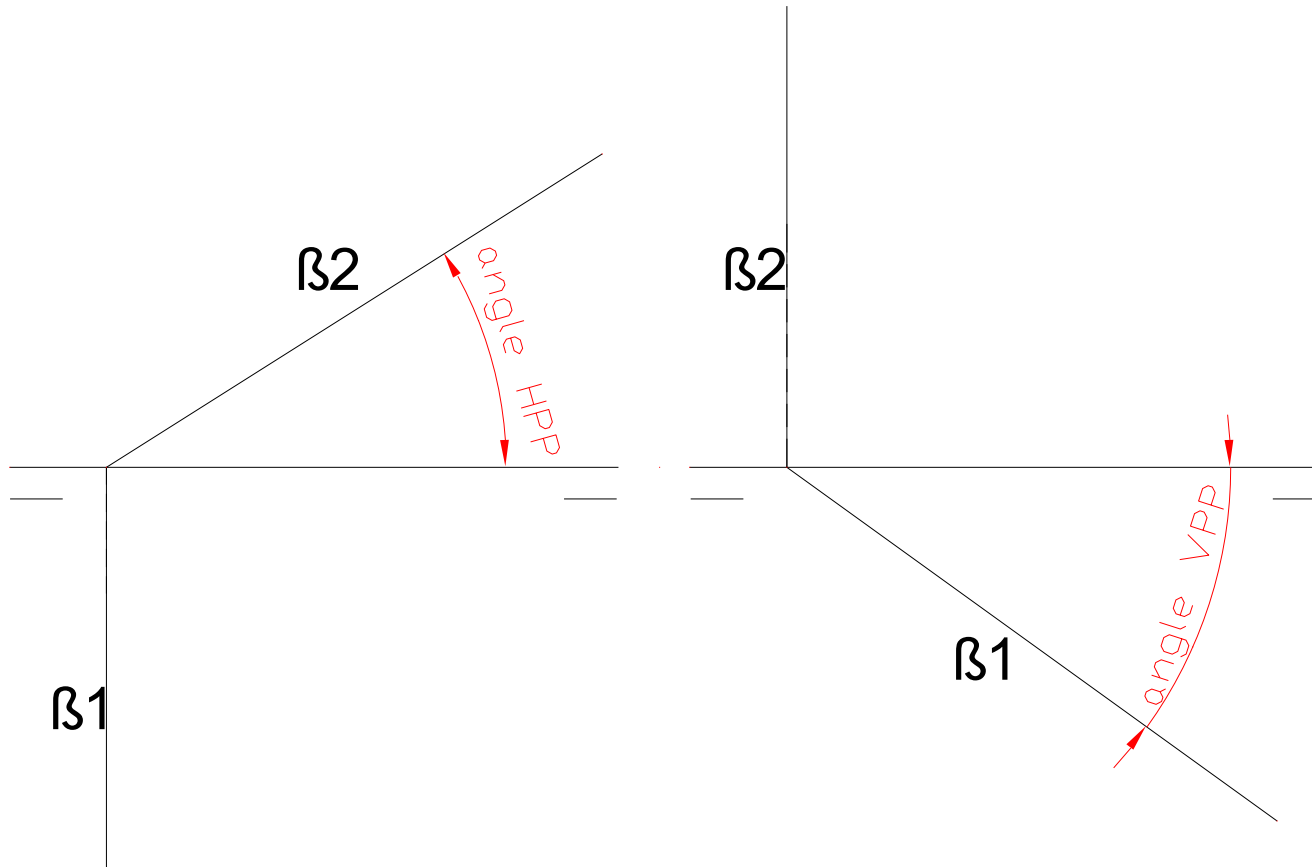
ANGLE WITHIN LINES

- **ABASEMENT OF BOTH LINES, USING THE SAME METHOD (GENERIC OR REDUCED)**



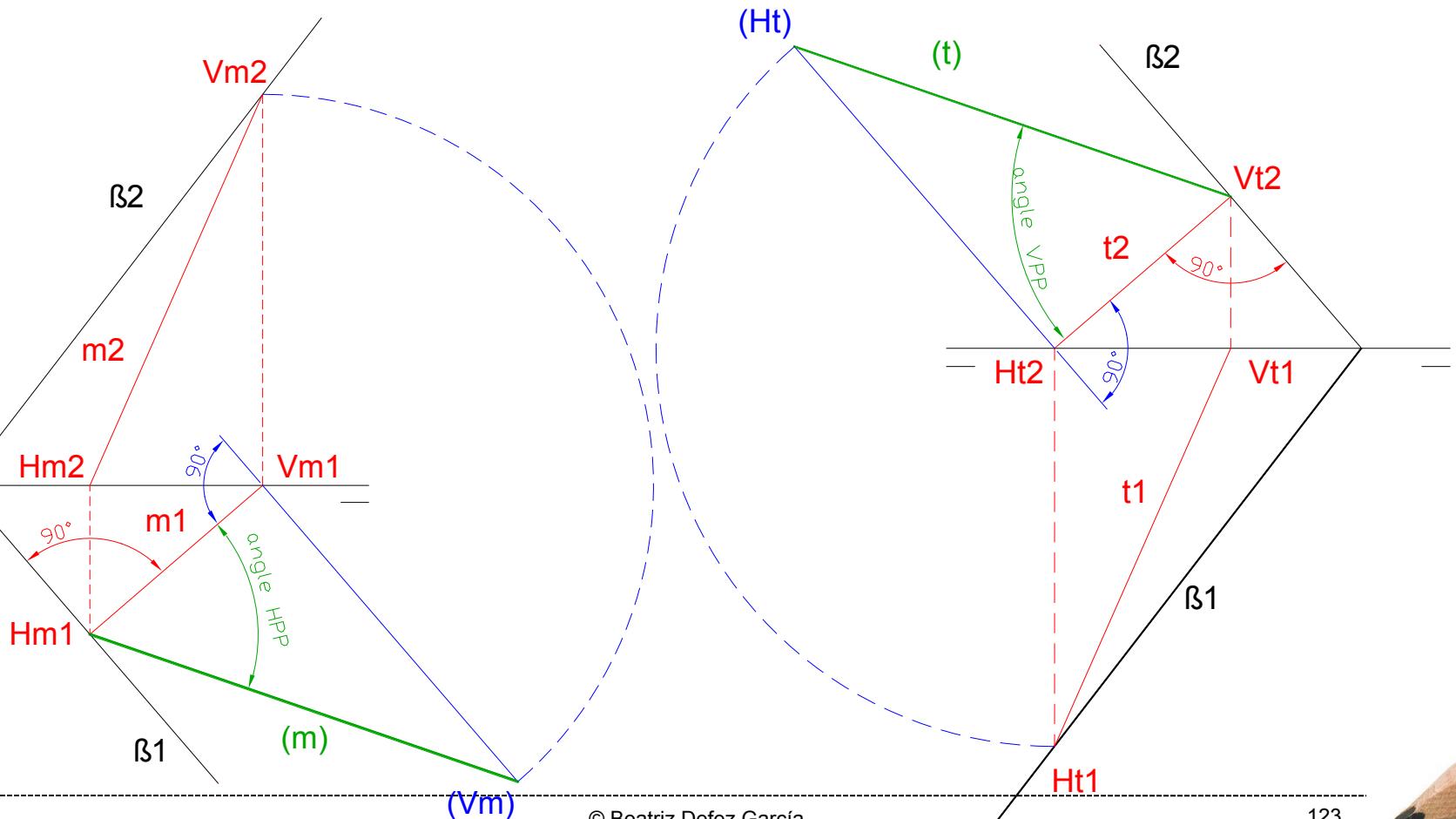
ANGLE BETWEEN A PLANE AND THE PROJECTION PLANES

- **URNS AND PLANE CHANGES**



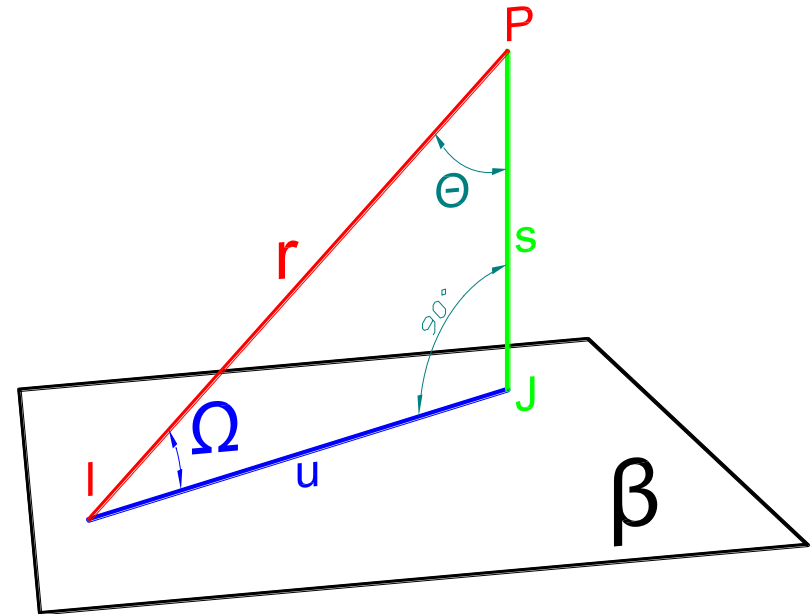
ANGLE BETWEEN A PLANE AND THE PROJECTION PLANES

- **ABASEMENT OF**
 - **MAX. SLOPE LINE ON THE HPP: angle with HPP**
 - **MAX. TILT LINE ON THE VPP: angle with VPP**



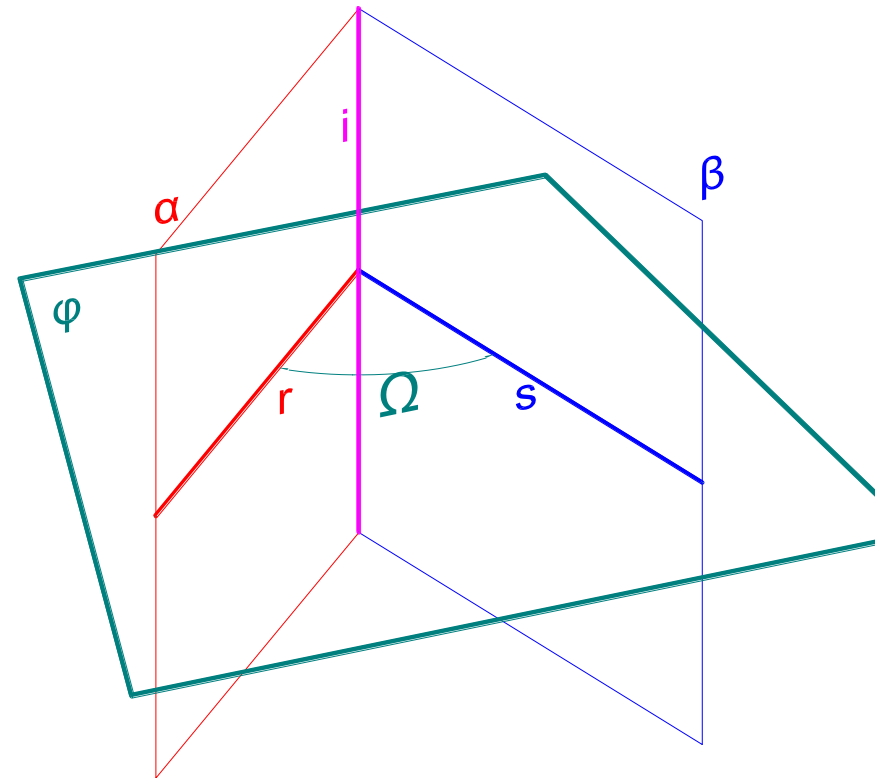
ANGLE BETWEEN LINE AND PLANE

- 1) Find point I, the intersection between r and β
- 2) Trace line s, perpendicular to β by a point of r, point P
- 3) Find point J, the intersection between s and β
- 4) Trace line u by I and J
- 5) Find plane φ , which contains r and u
- 6) Abase φ . Abase r and u accordingly. Measure the angle between r and u on the abasement. This is angle between r and β



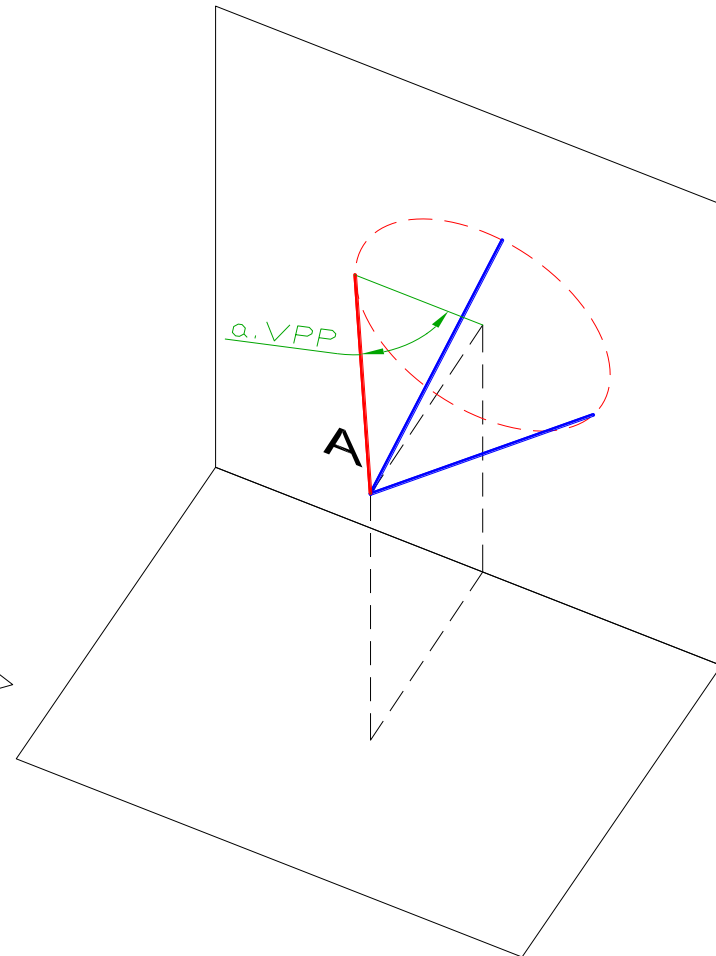
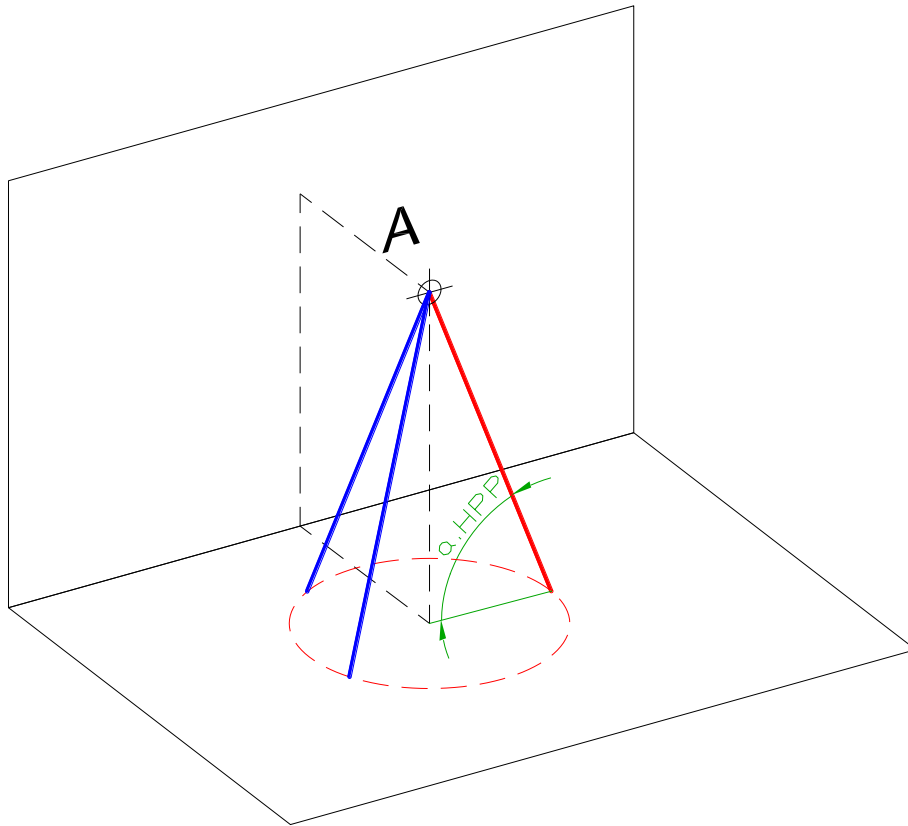
ANGLE BETWEEN TWO PLANES

- 1) Find line i , the intersection line between α and β
- 2) Draw plane φ , perpendicular to α and β (and therefore to i) by any given point
- 3) Find line r , the intersection line between α and φ
- 4) Find line s , the intersection line between β and φ
- 5) Abase φ . Abase r and s accordingly. Measure the angle between r and s on the abasement. This is angle between α and β



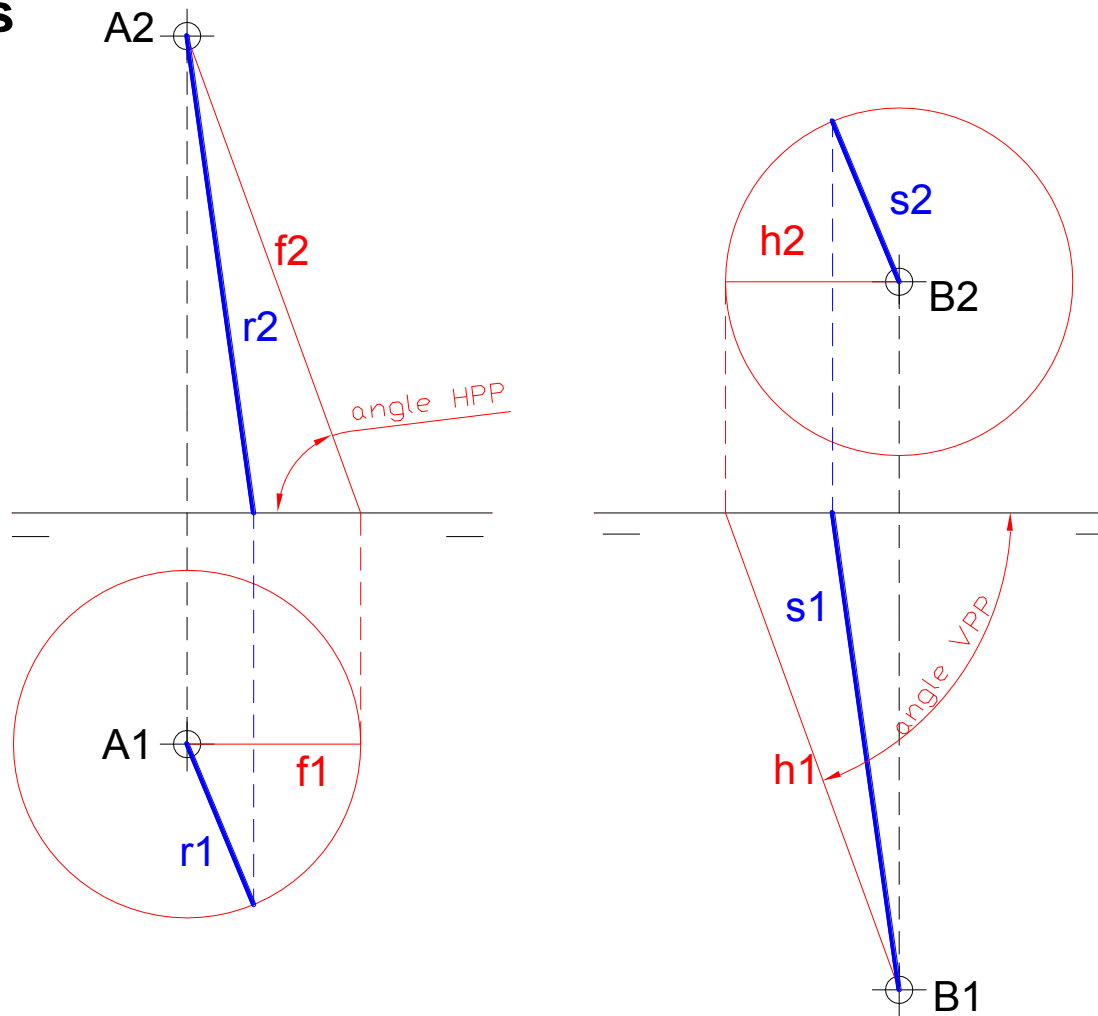
CONDITIONING ANGLES. Lines

- Drawing lines which hold specific angles with the projection planes



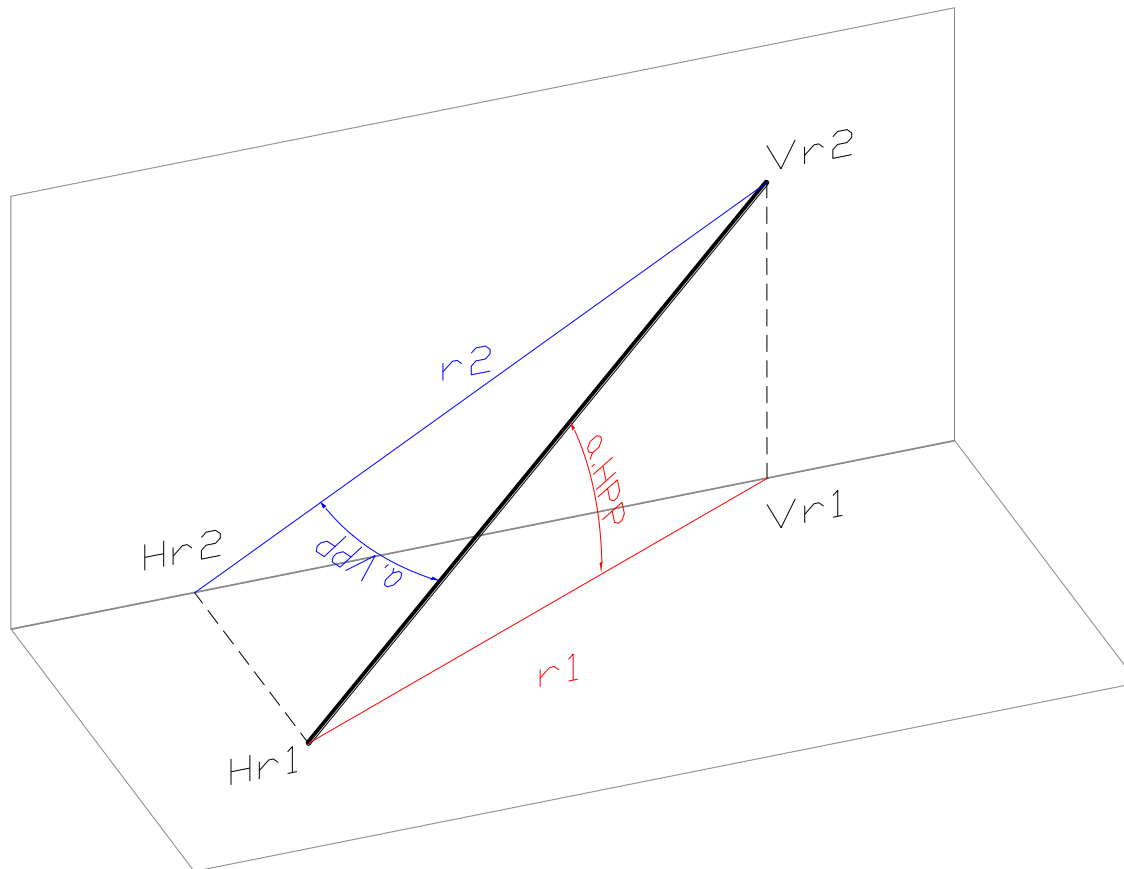
CONDITIONING ANGLES. Lines

- Drawing lines which hold specific angles with the projection planes



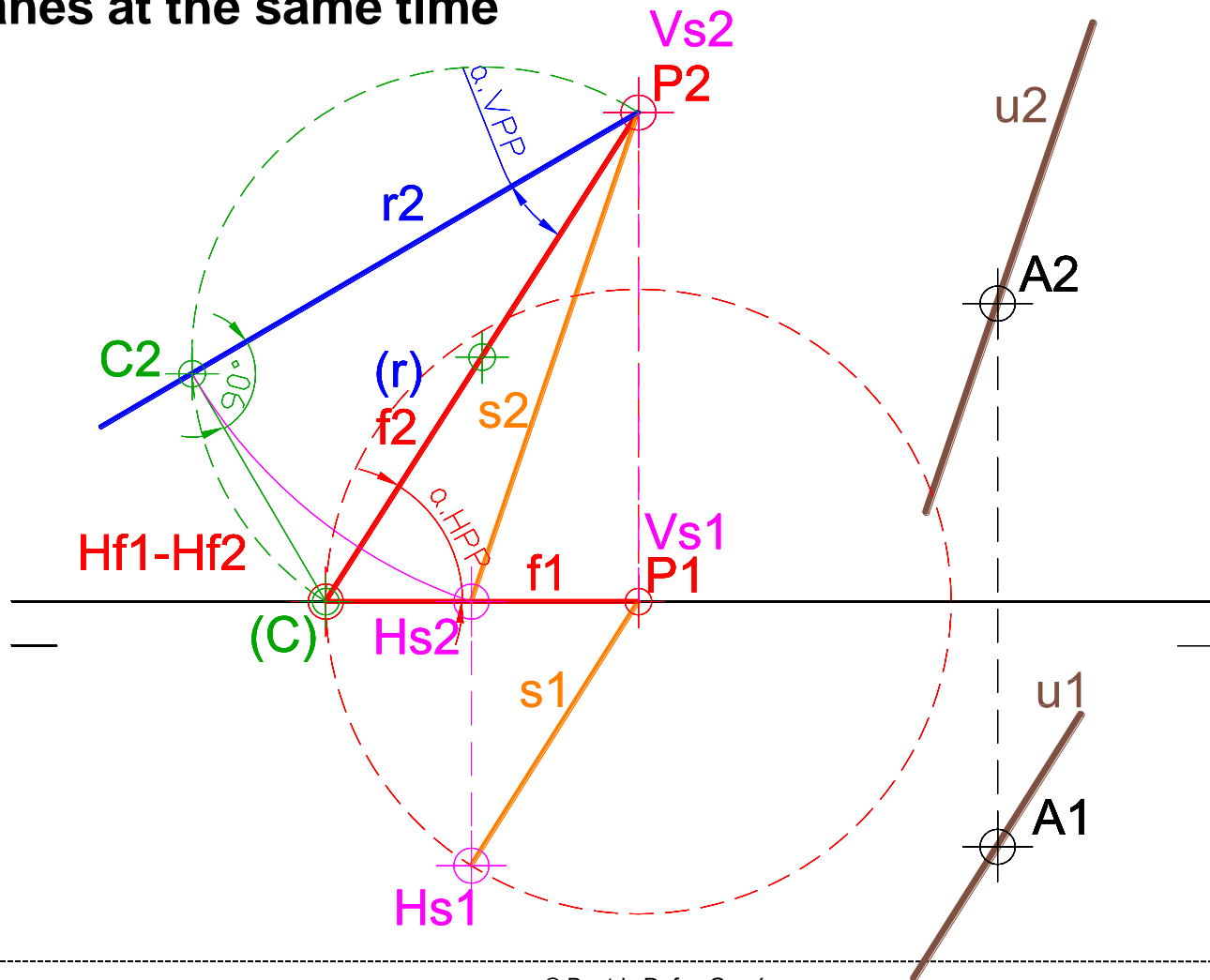
CONDITIONING ANGLES. Lines

- Drawing lines which hold specific angles with both projection planes at the same time



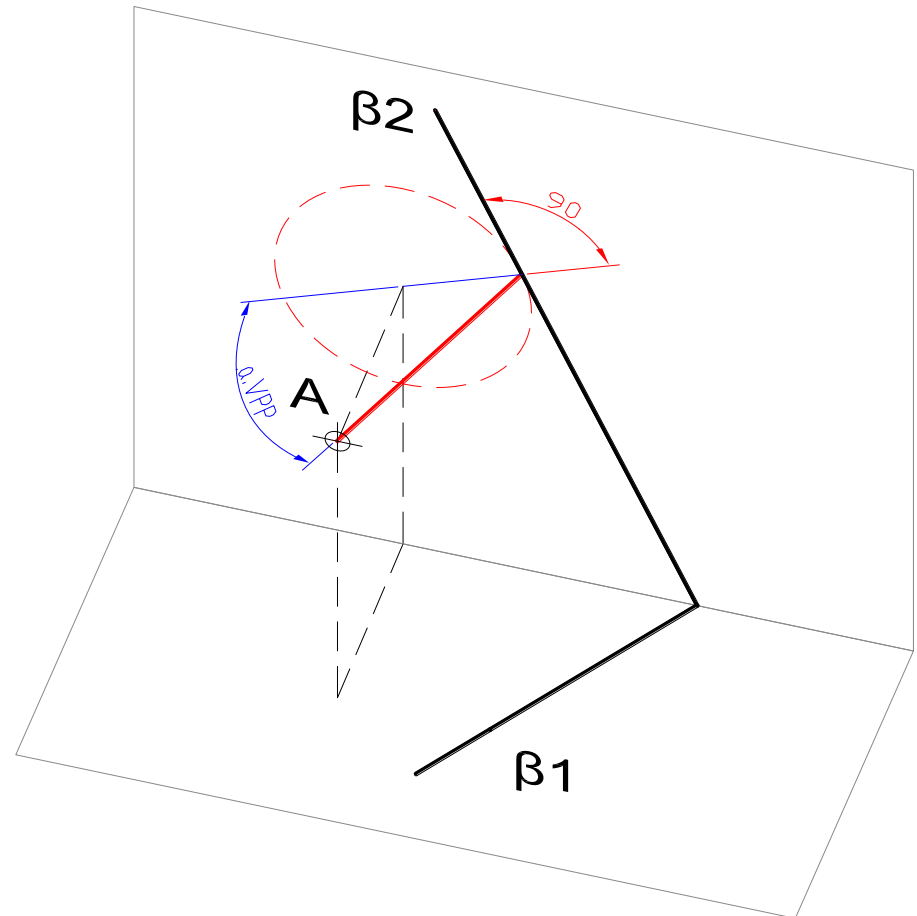
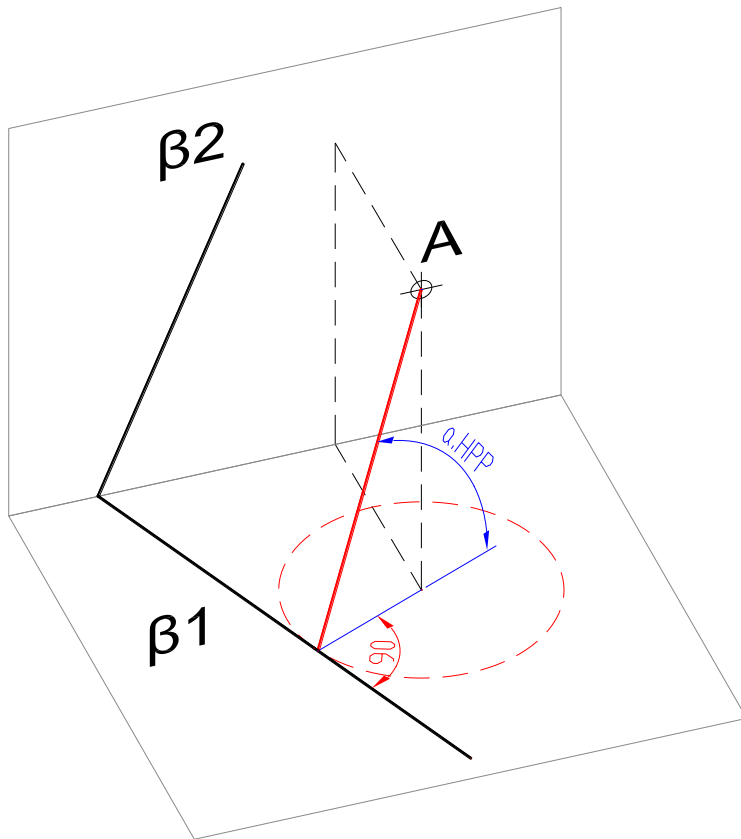
CONDITIONING ANGLES. Lines

- Drawing lines which hold specific angles with both projection planes at the same time



CONDITIONING ANGLES. Planes

- Drawing planes which hold specific angles with the PP: conditioning their maximal slope or maximal tilt lines



CONDITIONING ANGLES. Planes

- Drawing planes which hold angles with the PP: conditioning their maximal slope or maximal tilt lines

