21MES102L
Engineering Graphics and Design
School of Mechanical Engineering

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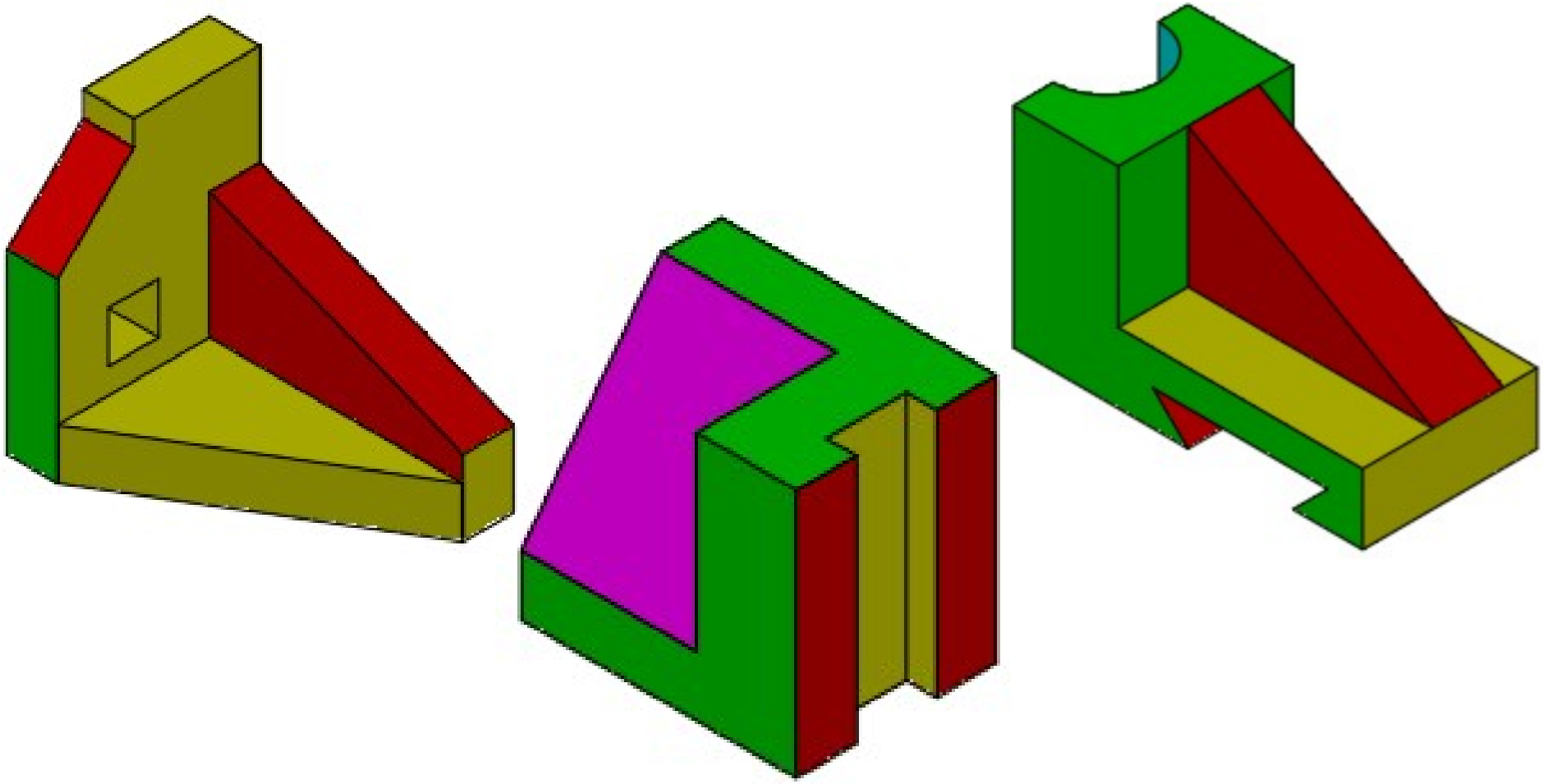
21MES102L
Engineering Graphics and Design

E11Solid Modeling using Primitives & Boolean Operations



Topics Covered

- Principles in Constructive Solid Geometry (CSG) concepts
- Significance of Boolean operations
- Solid models using CSG and Boolean operations

Constructive Solid Geometry

- **Solid Modeling** is one of the most effective **geometric modeling** method to make the object more **Realistic Solid** for the **Viewer**.
- Geometric (**3D**) models are easier to interpret.
- Less expensive than building a Physical model.
- Can be used for Presentations and Marketing.

Solid Primitives

The **Solid Primitives** used for Constructing the models are

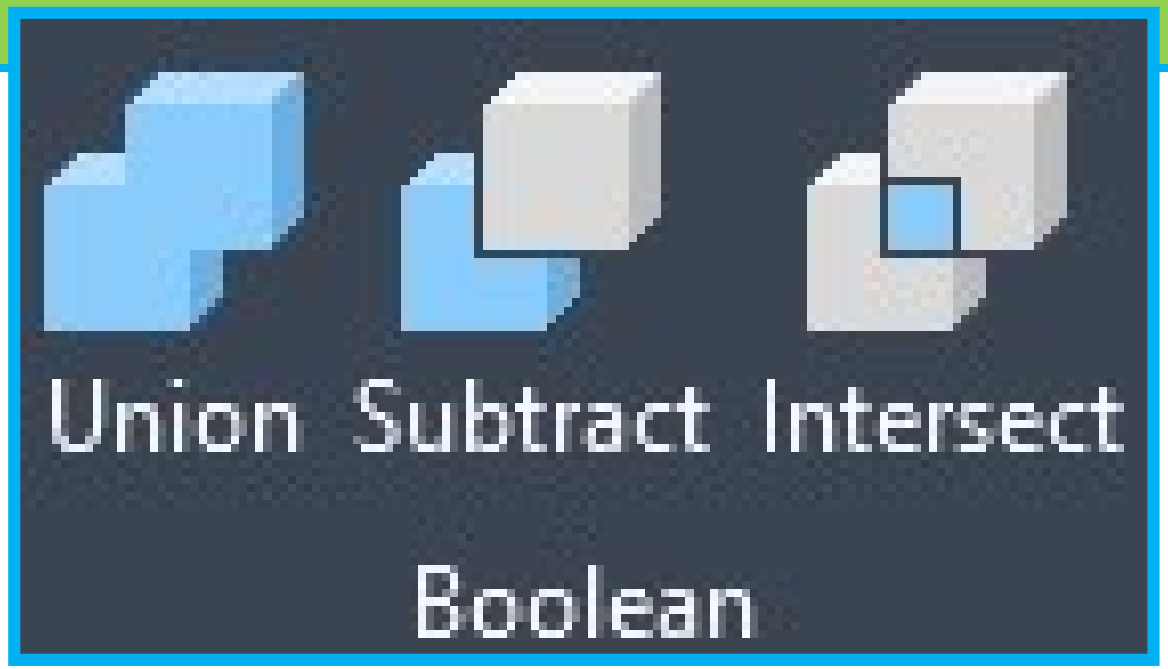
- Box
- Cylinder
- Cone
- Sphere
- Pyramid
- Wedge
- Torus

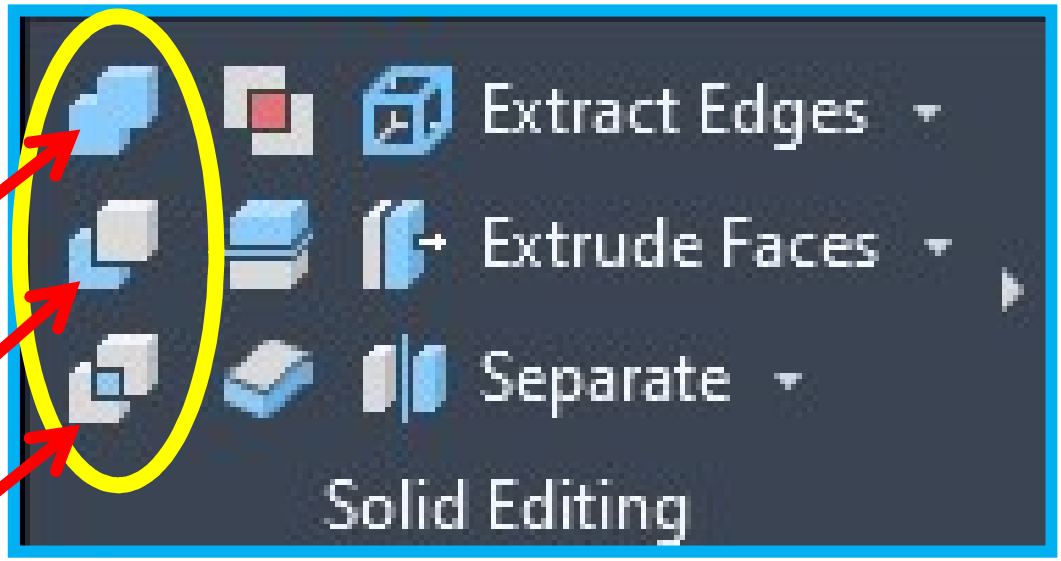
Boolean operations

The **Boolean** commands work only on **Solids** or **Regions**.

The first stage in a Solid Model creation consists in obtaining one or more Primitives.

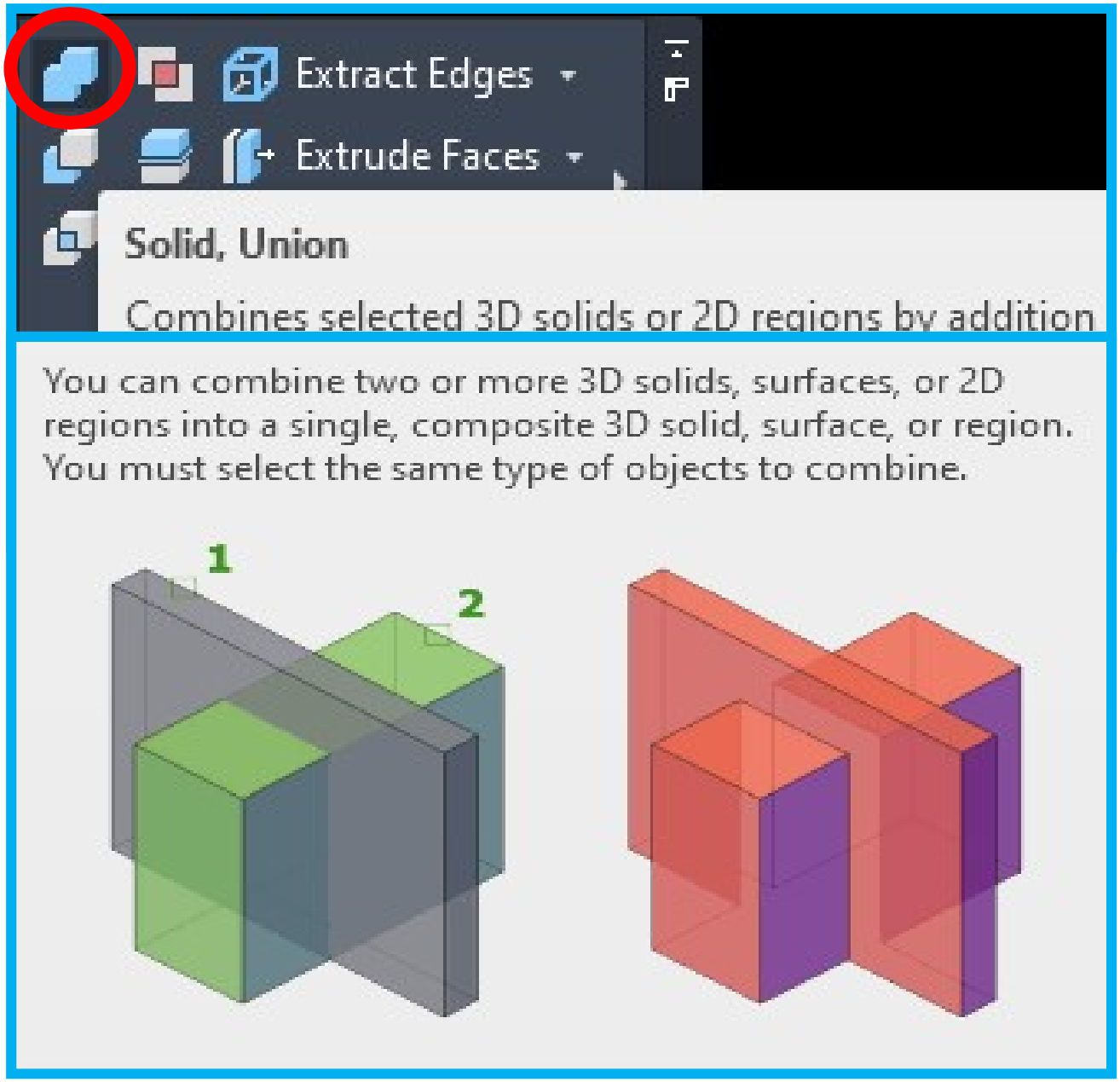
The next stage consists in using **Boolean operations** of

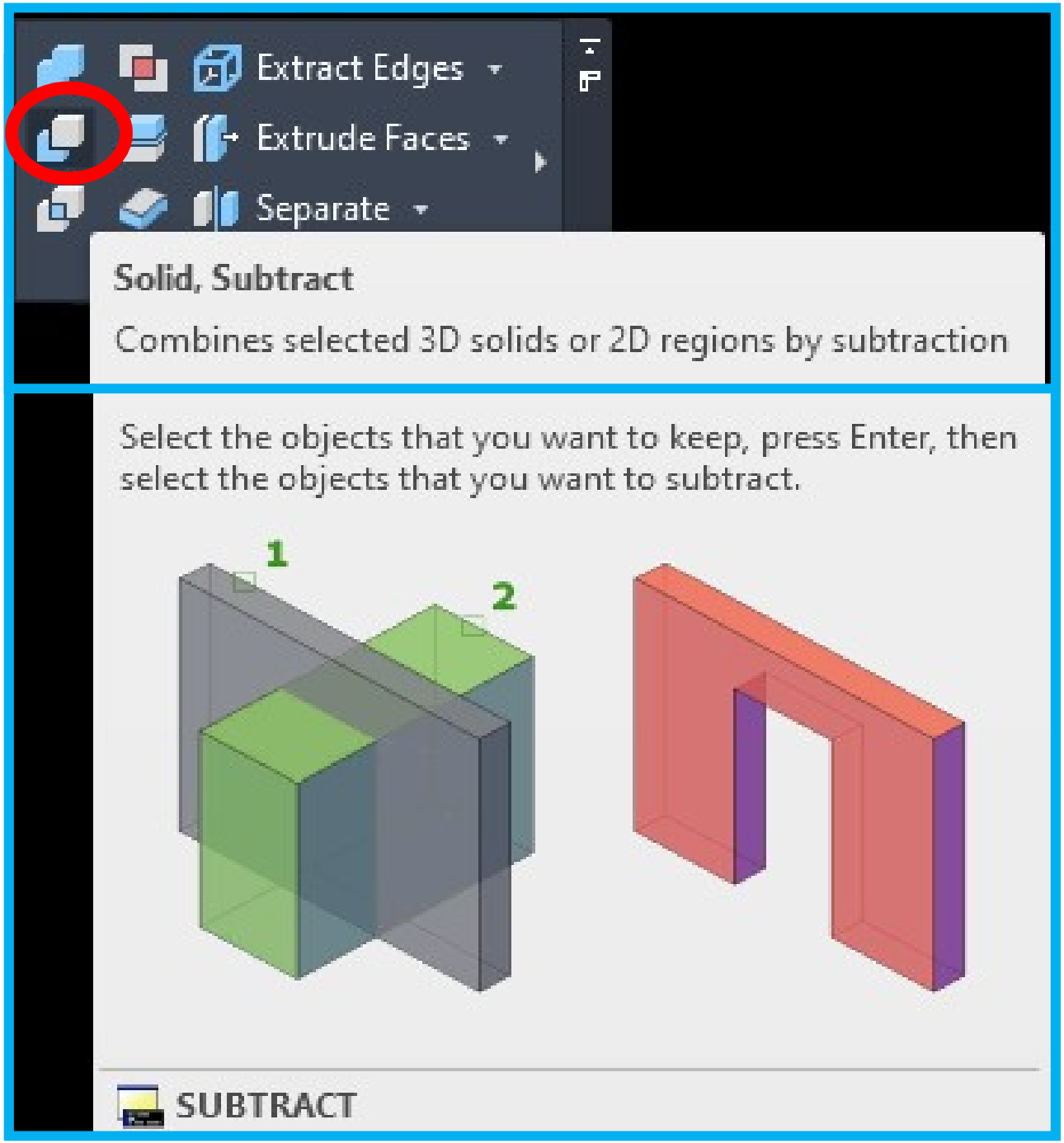


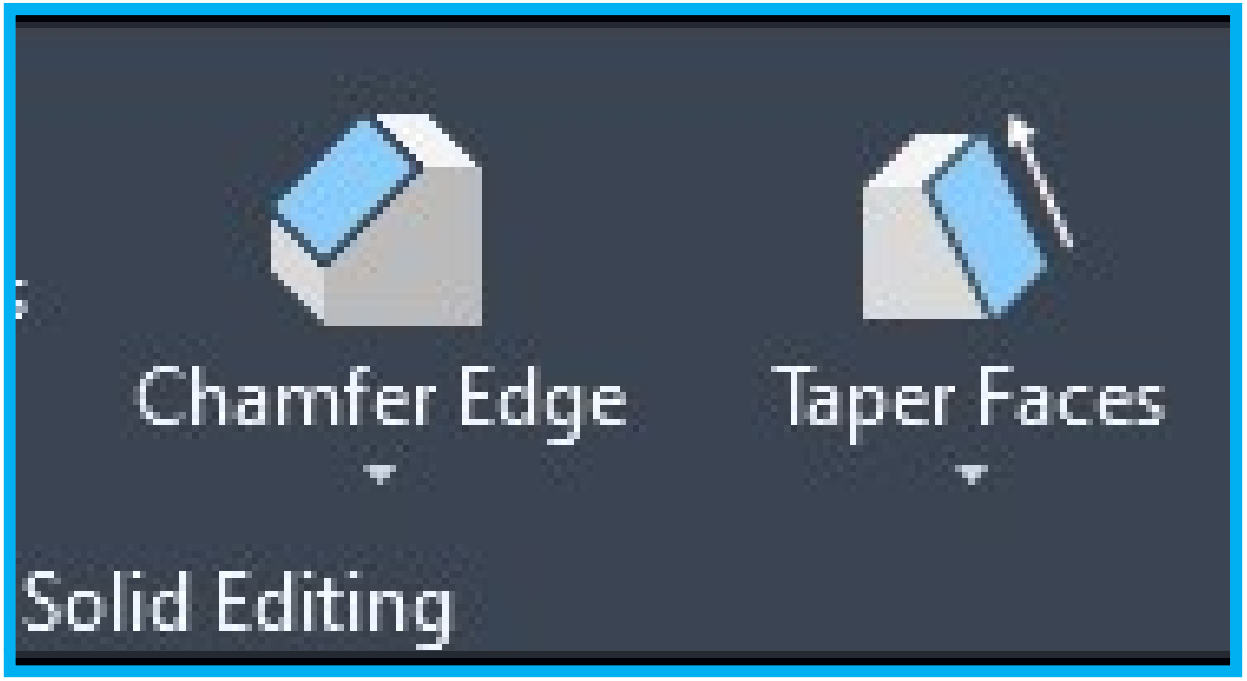


- **Solid Union**
- **Solid Subtract**
- **Solid Intersect**

Boolean operations are used to combine **Solid Primitives** to form the desired solid.

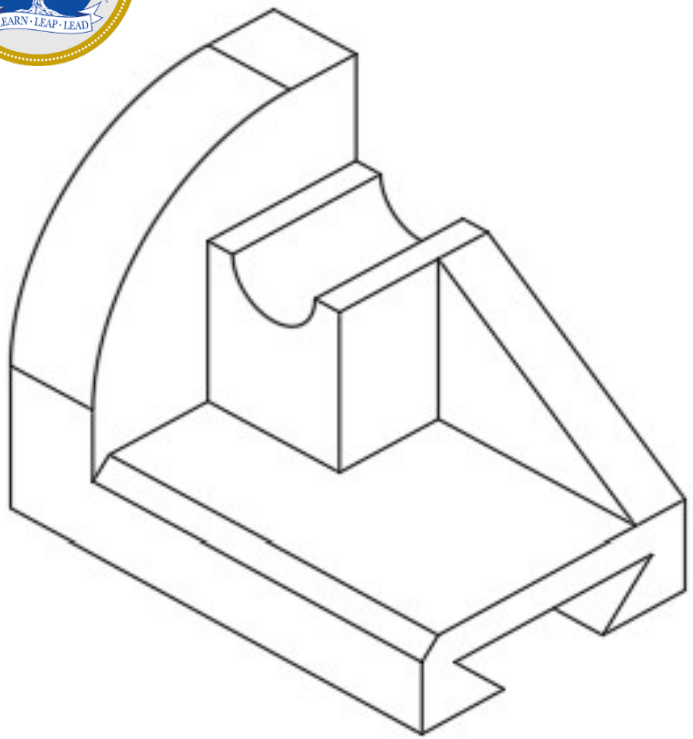

Extract Edges
Extrude Faces
Solid, Union
Combines selected 3D solids or 2D regions by addition
You can combine two or more 3D solids, surfaces, or 2D regions into a single, composite 3D solid, surface, or region. You must select the same type of objects to combine.
1
2

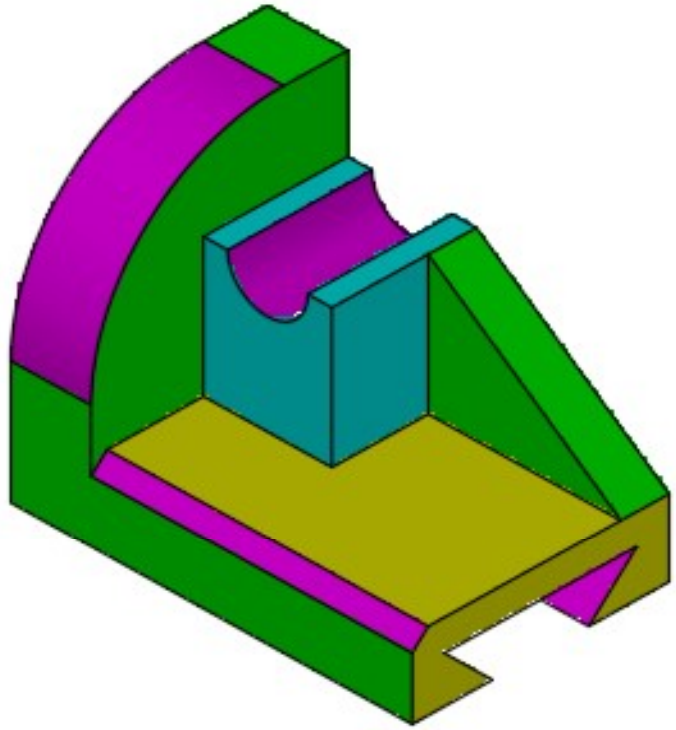

Extract Edges
Extrude Faces
Separate
Solid, Subtract
Combines selected 3D solids or 2D regions by subtraction
Select the objects that you want to keep, press Enter, then select the objects that you want to subtract.
1
2
SUBTRACT



- As similar to Boolean Operations **Solid Editing** tool bar facilitates to modify/form the required shape in the existing solid

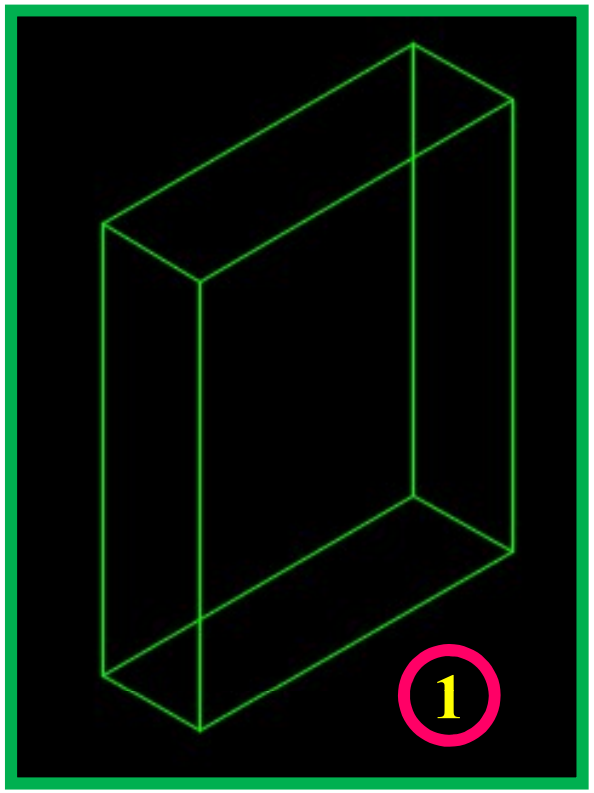
Solid Model Creation using Primitives

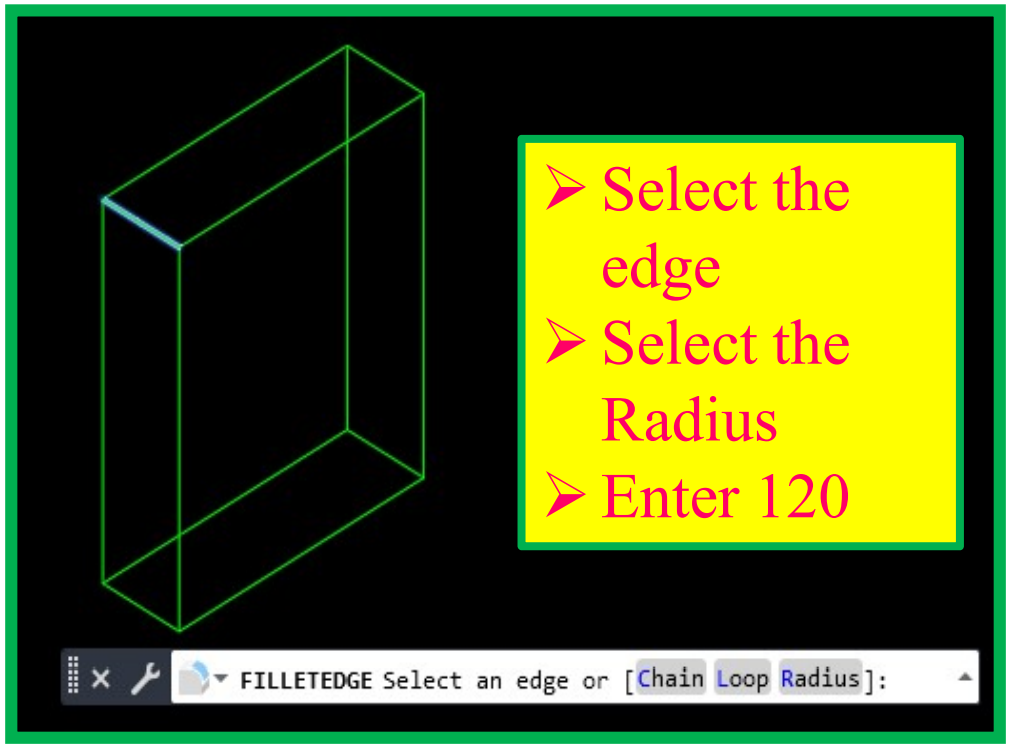


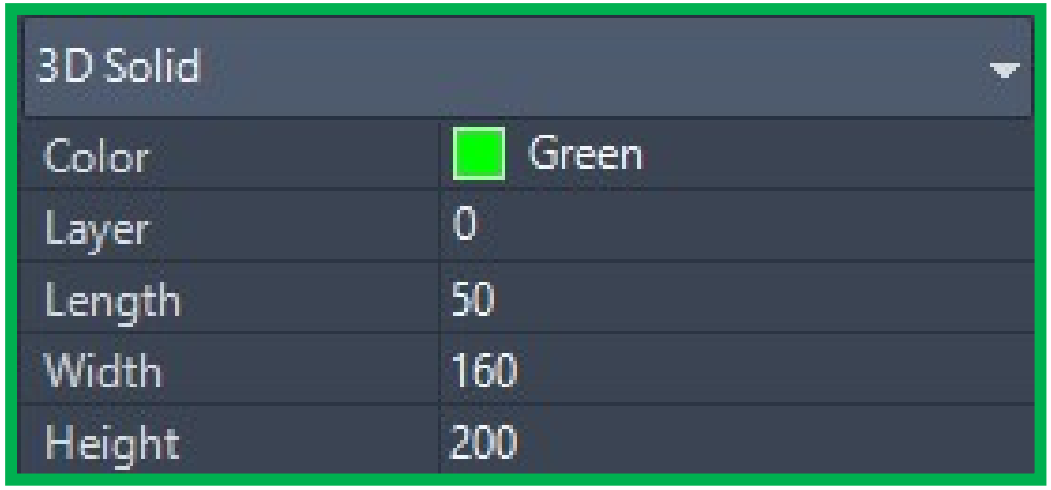


- Set the workspace for 3D modeling
- Select SE Isometric Plane

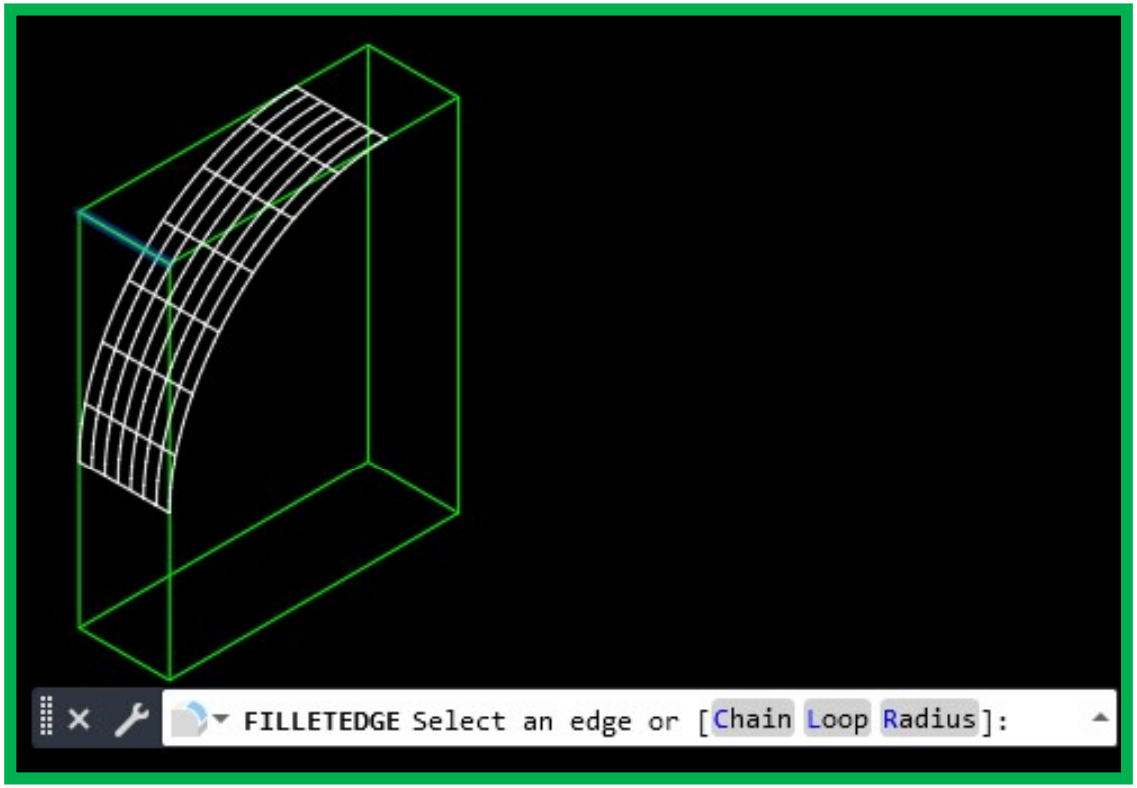
- List of primitives used
- Box 4 Numbers
- Cylinder 1 Number
- Wedge 1 Number

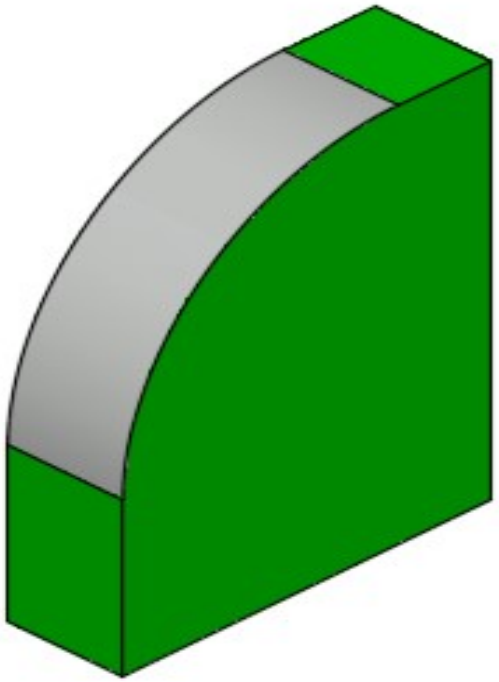

1


➢ Select the edge
➢ Select the Radius
➢ Enter 120
FILLETEDGE Select an edge or [Chain Loop Radius]:

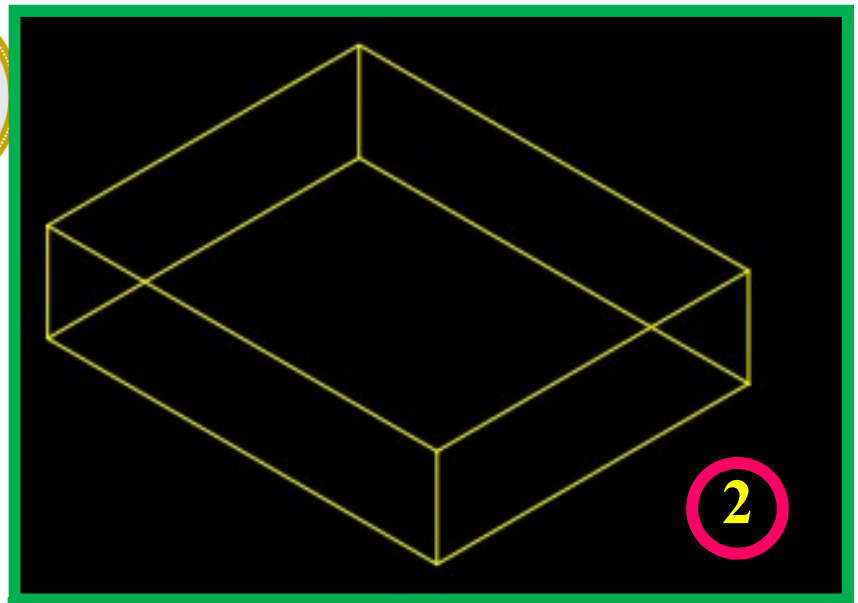

3D Solid
Color
Green
Layer
0
Length
50
Width
160
Height
200


Fillet Edge
Solid Editing

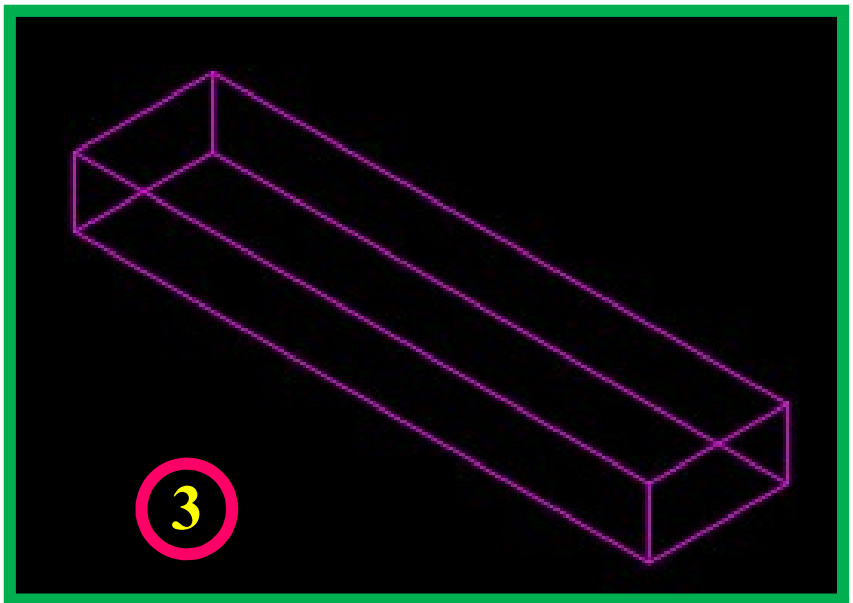




- The first Base plate is created using **Box Primitive** Command & **Fillet Edge** from **Solid Editing** Tool bar

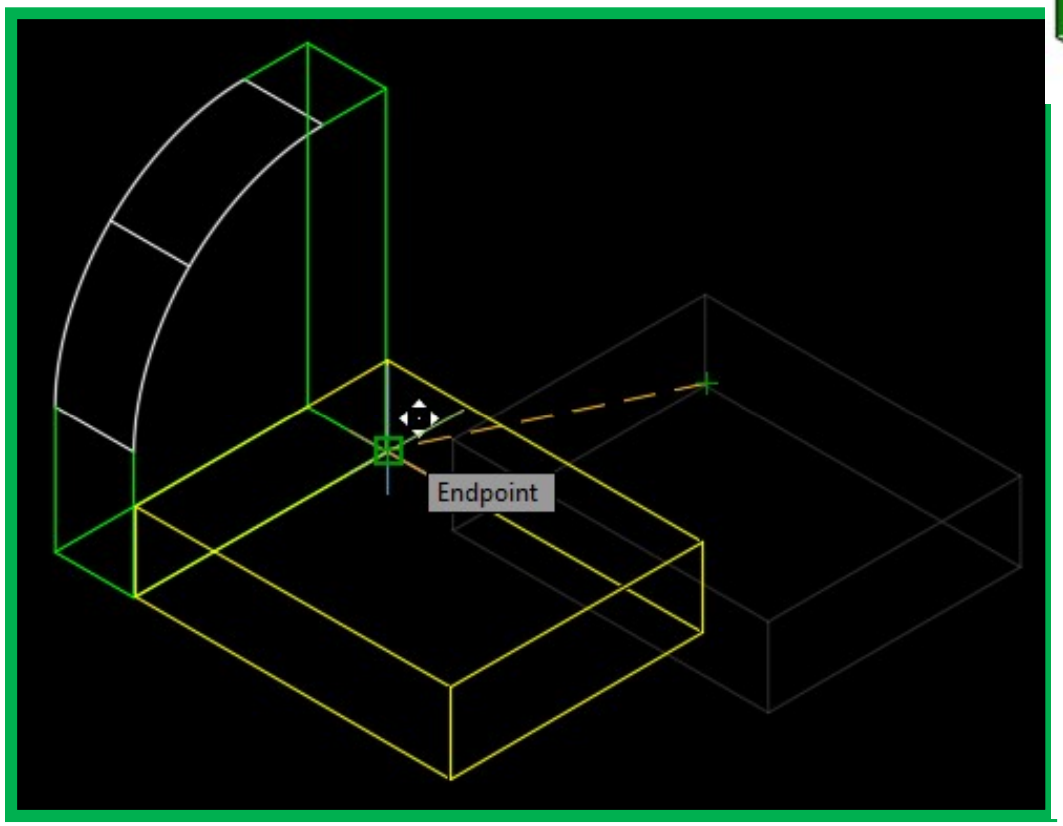


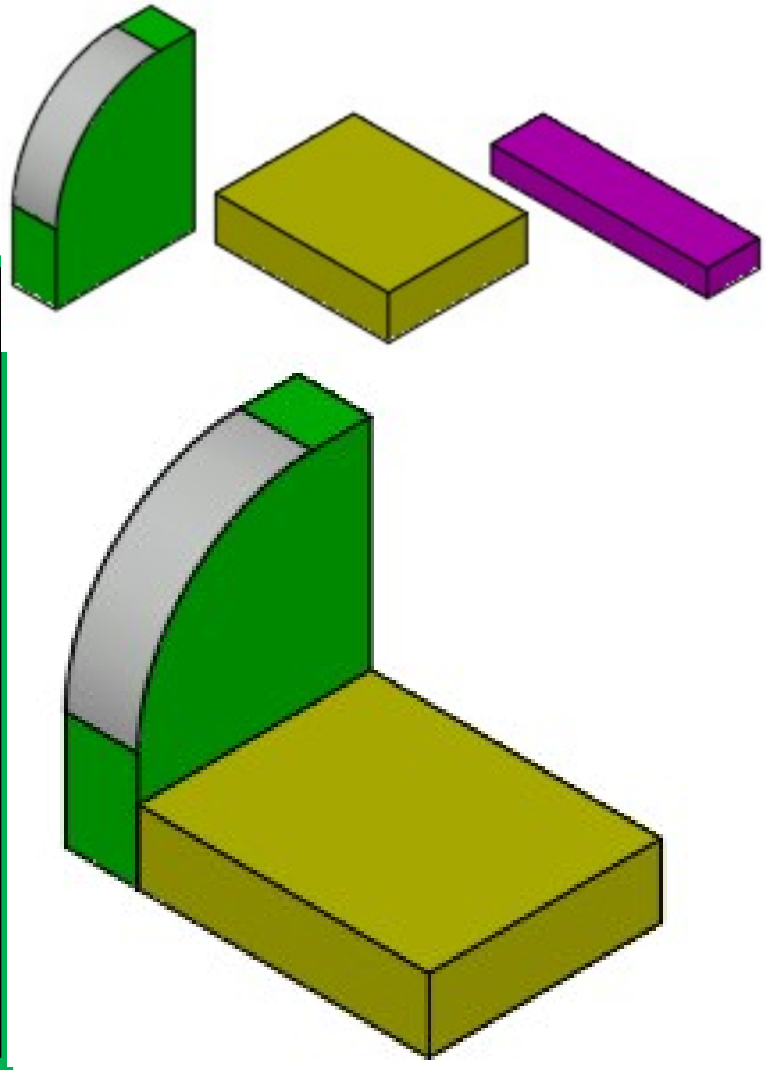
3D Solid	
Color	Yellow
Layer	0
Length	200
Width	160
Height	50



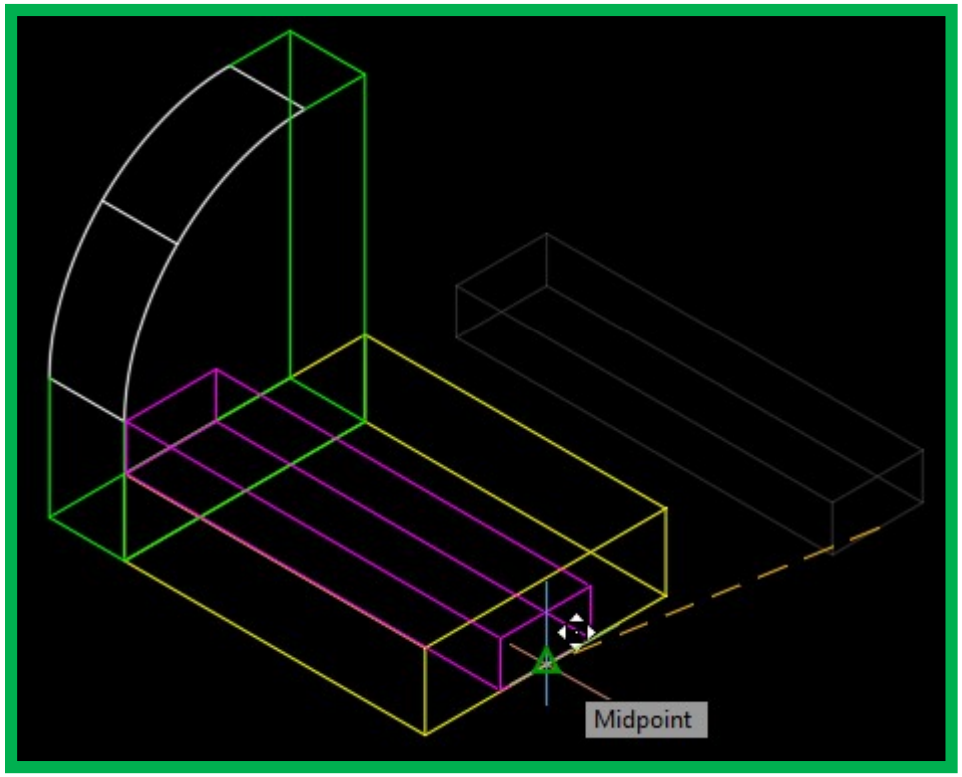
3D Solid	
Color	Magenta
Layer	0
Length	250
Width	60
Height	30

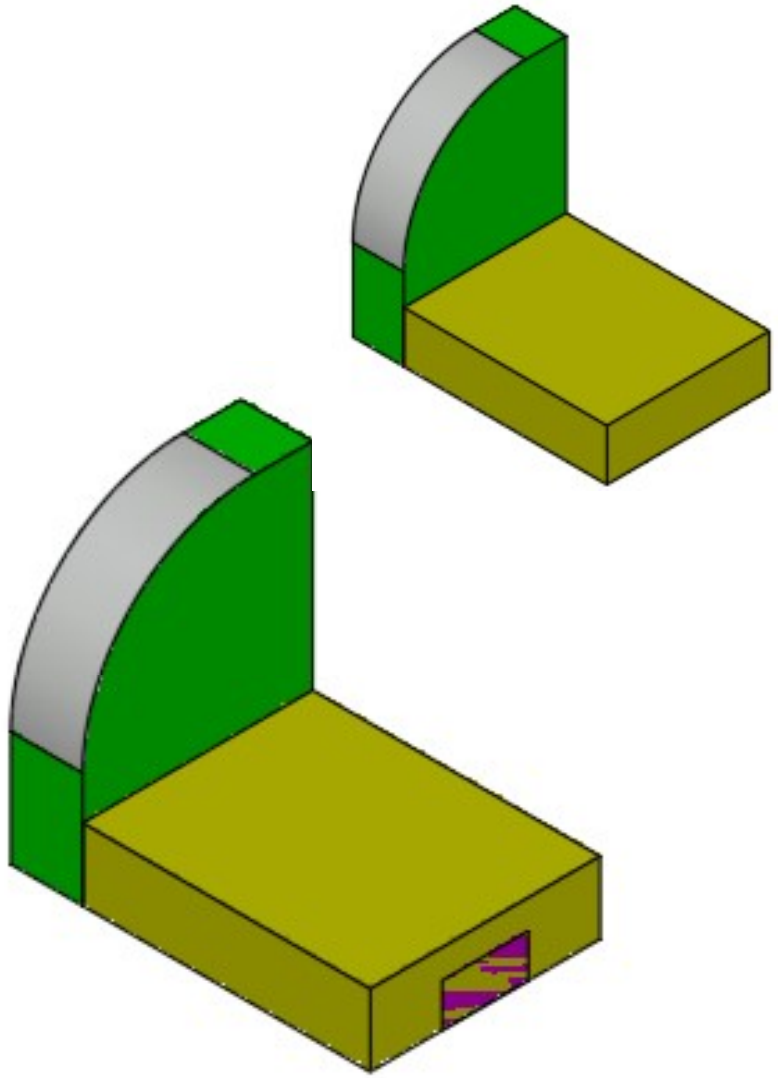
➢ Two boxes created using **Box Primitive** Command





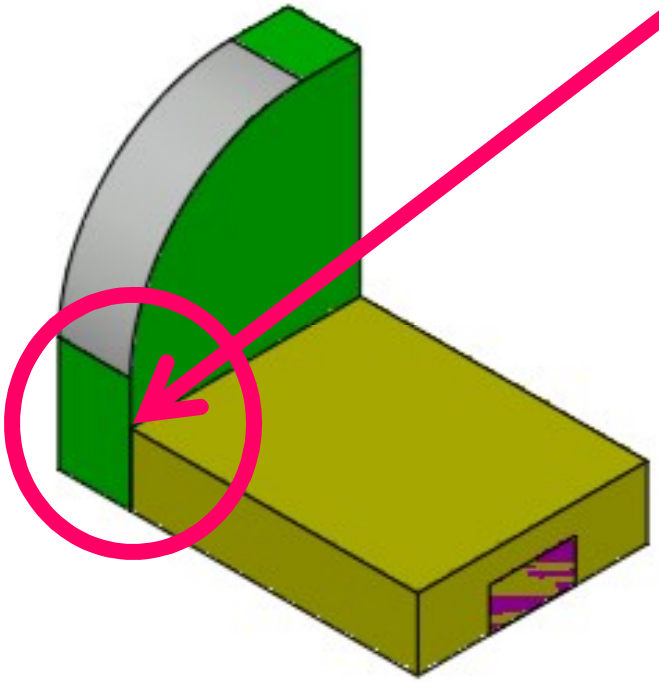
➢ Use the **Move** Command to move the **Box 2** to **Box 1**



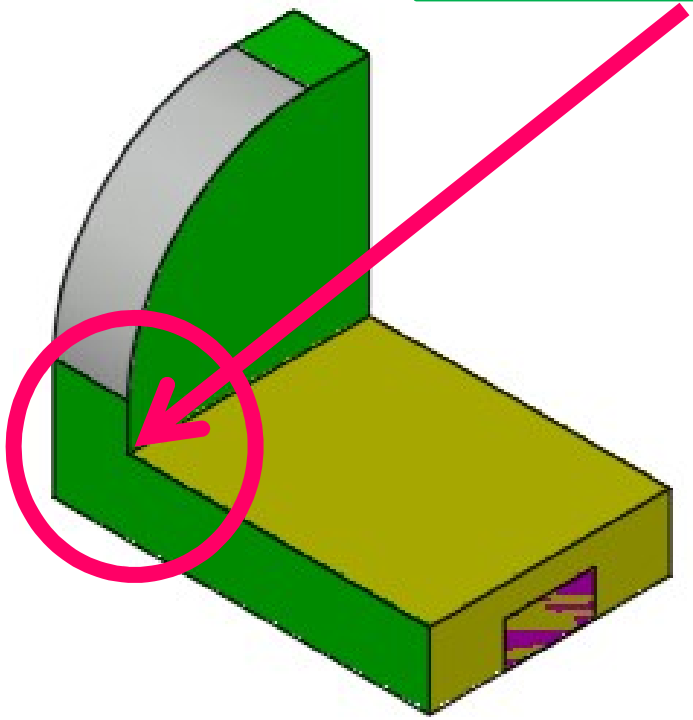


➢ Use the **Move** Command to move the **Box 3** to **Box 2** & place it in the **midpoint of the base** as shown

➢ **Before Union**



➢ **After Union**

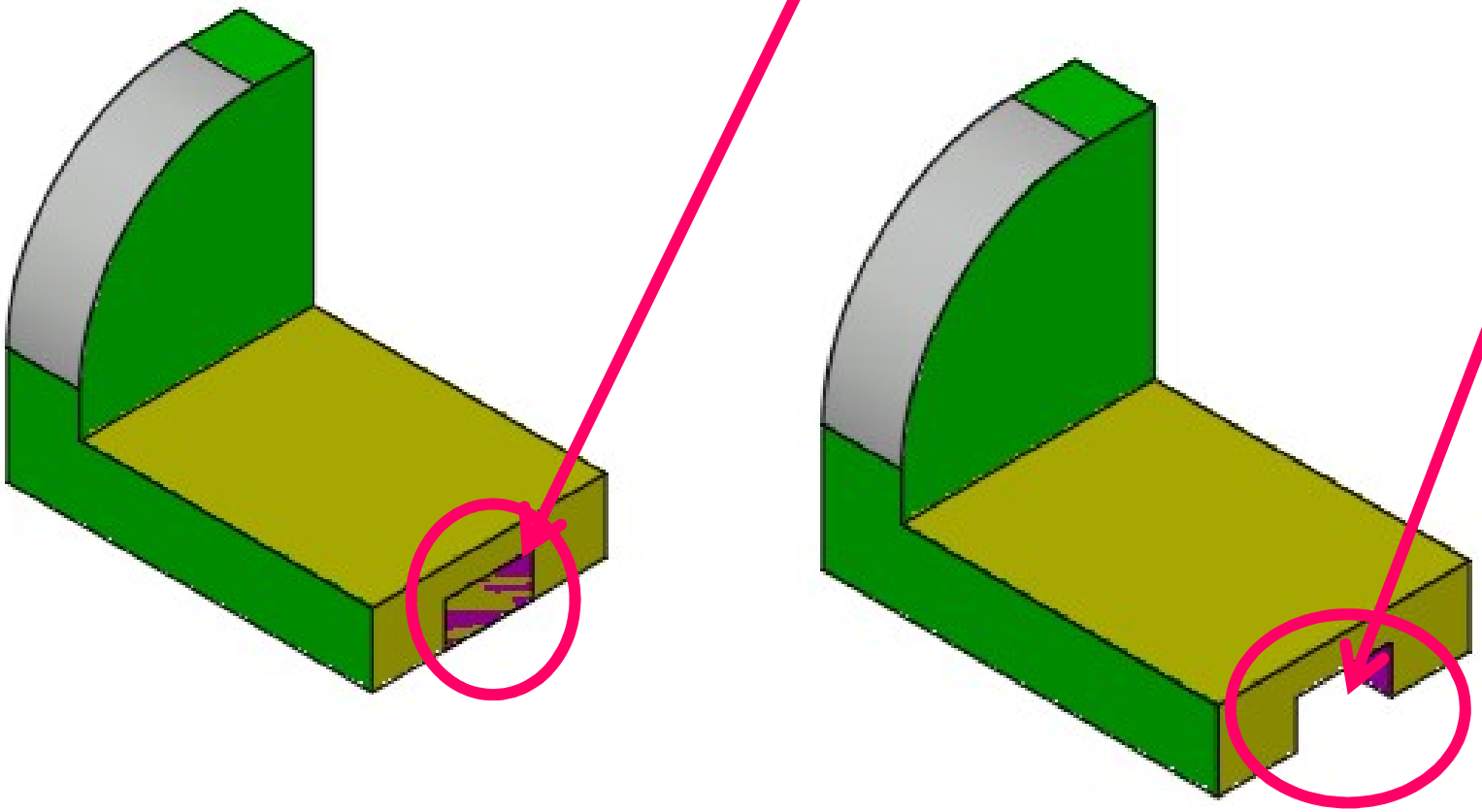


➢ Use the **Solid Union** to Join the **Box 1** & **Box 2**

➢ **After Union** the solids **1** & **2** are **Merged** with each other

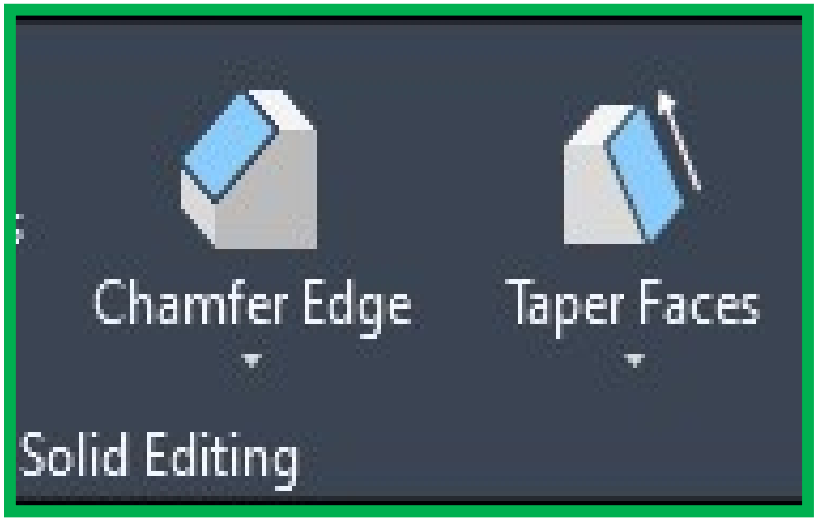
➢ Before Subtract

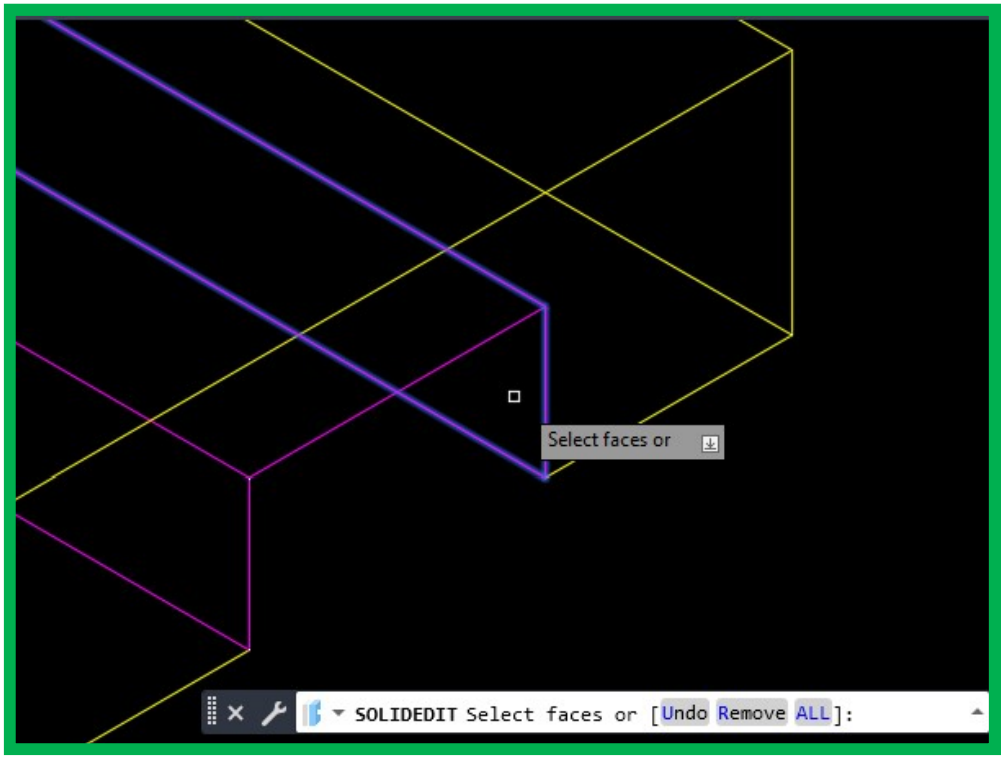
➢ After Subtract



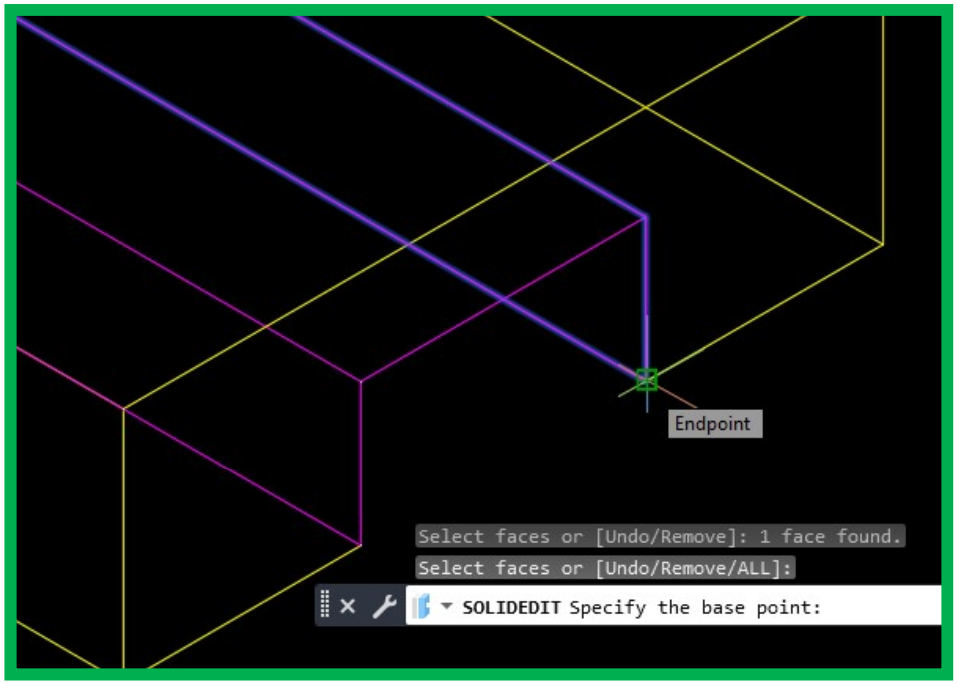
➢ Use the **Solid Subtract** to **Subtract** the **Box 3** from **Box 2**

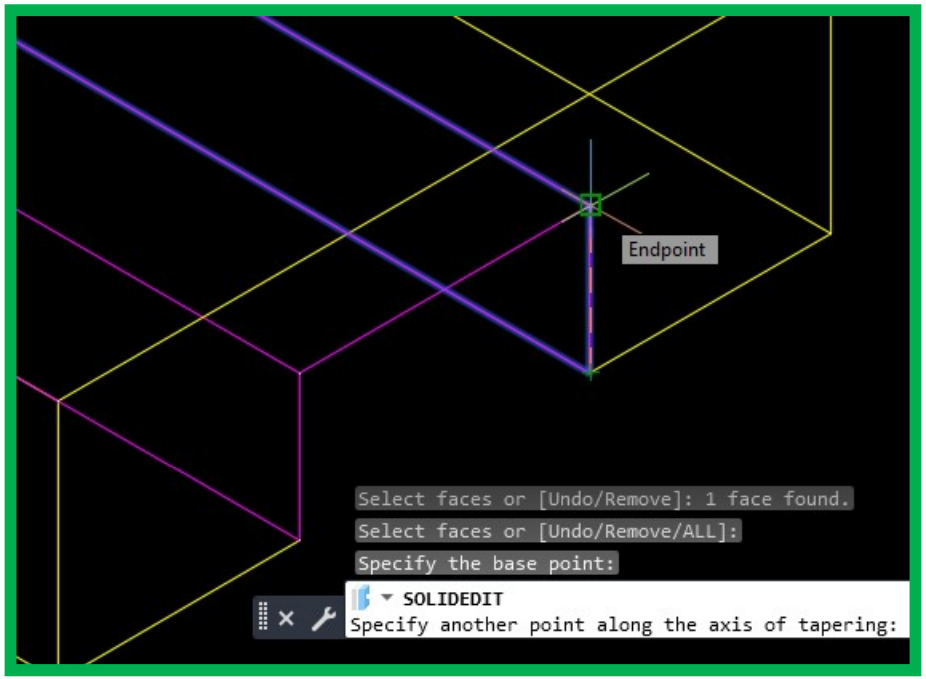
➢ Select the **Major component First** & the **Minor component Next**



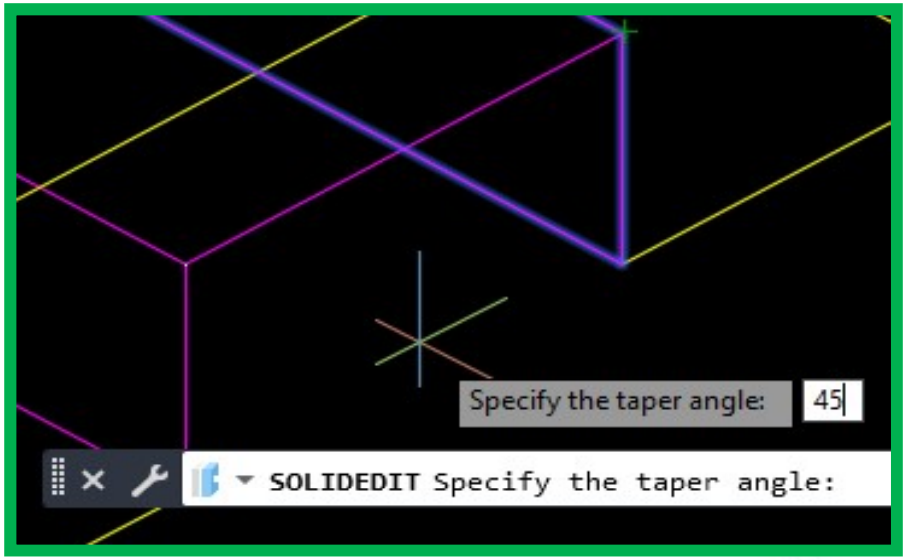


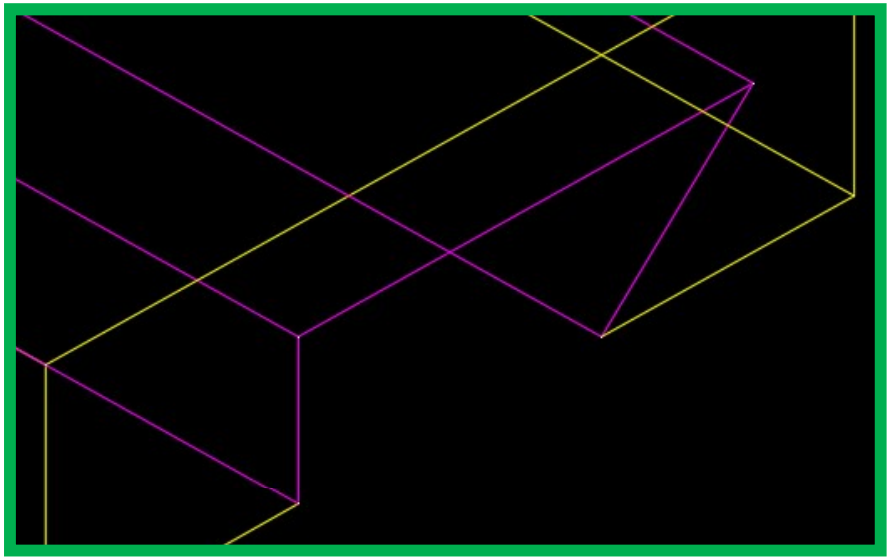
- Select the **Taper Faces** from **Solid Editing** tool bar to create dovetail shape Select the Required face as shown in the figure

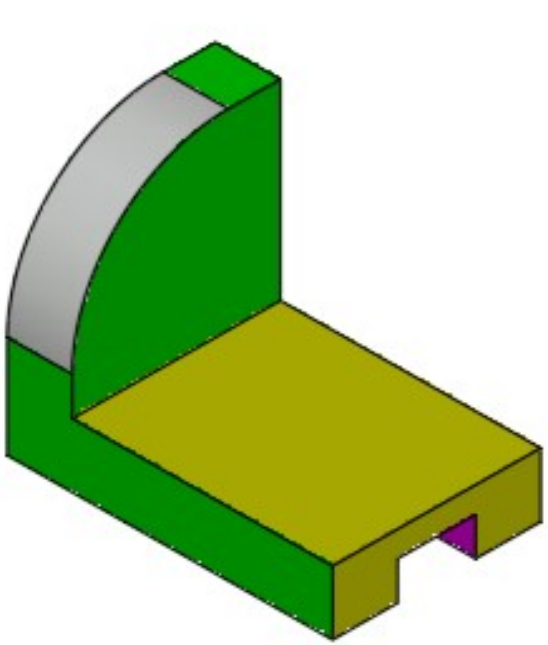


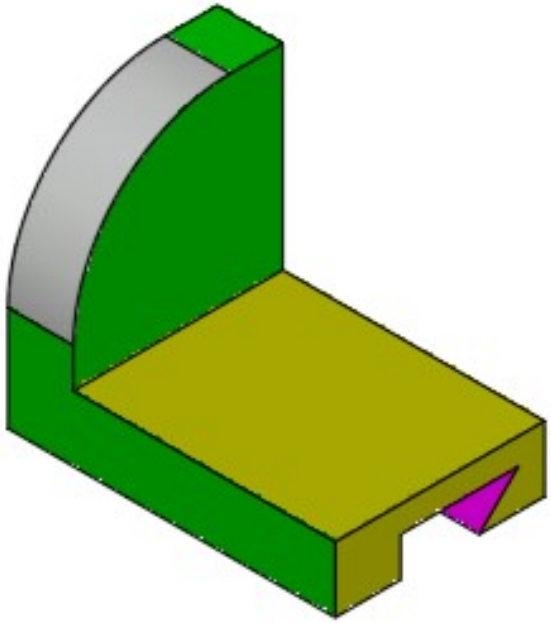


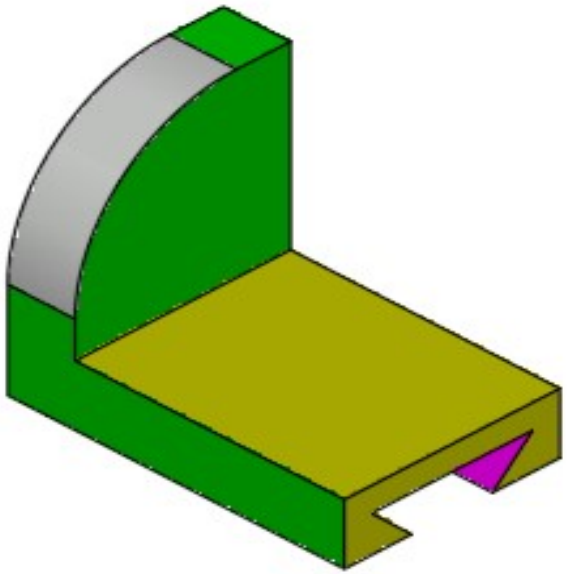
- Specify the base point **bottom corner first** & **upper corner next** as shown in the figure & **Repeat** the same procedure on the other side


Specify the taper angle:
45
SOLIDEDIT Specify the taper angle:

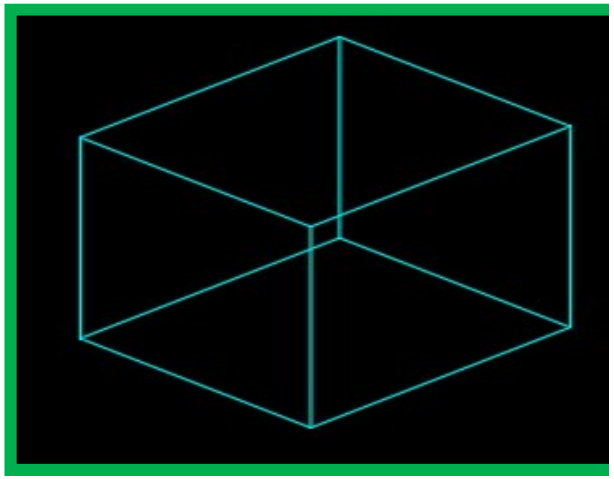


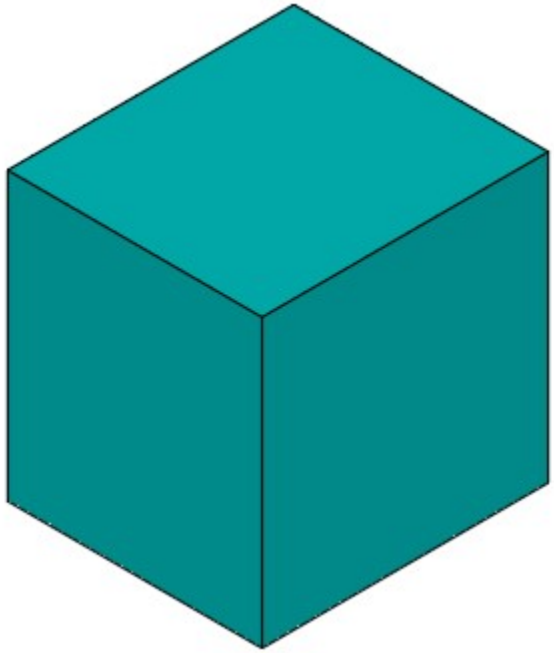




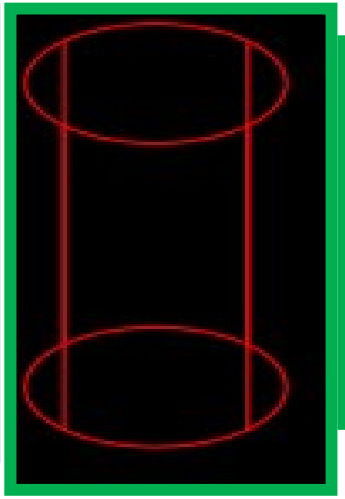


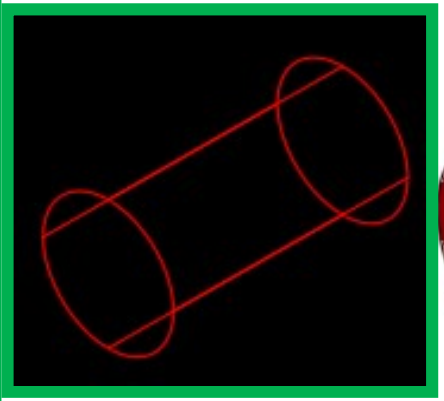
3D Solid	
Color	Cyan
Layer	0
Length	80
Width	90
Height	90

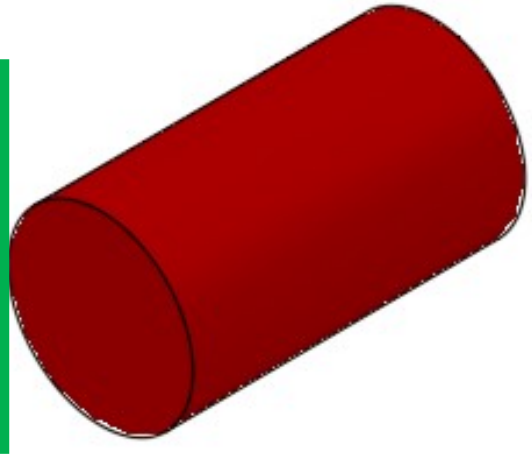




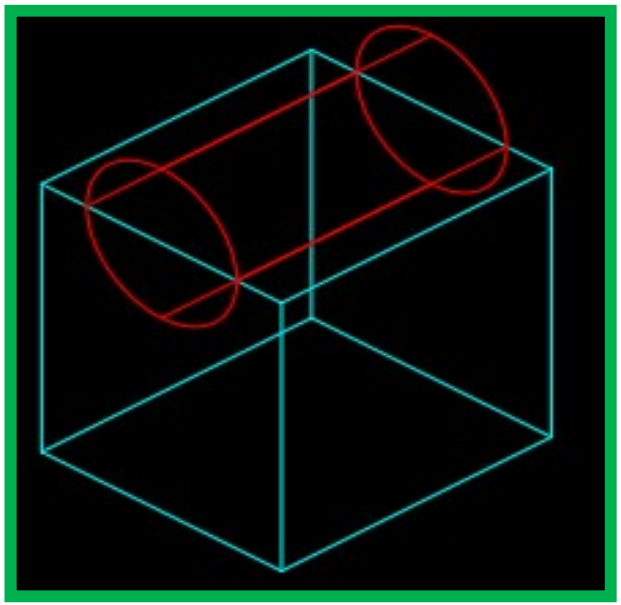
3D Solid	
Color	Red
Layer	0
Elliptical	No
Radius	25
Height	90

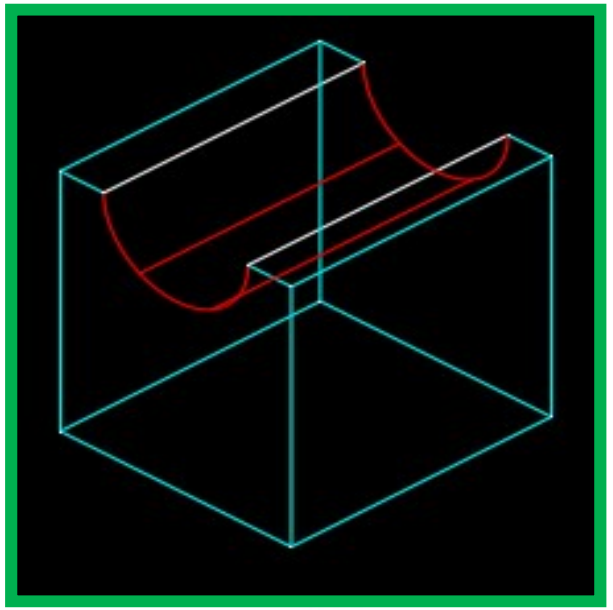


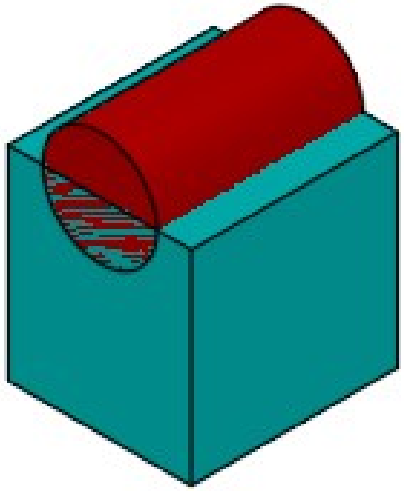


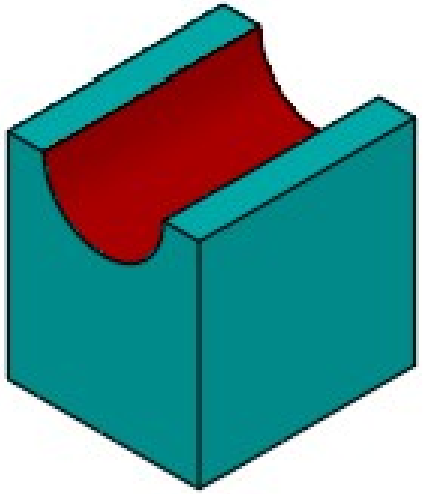


➢ Create a **Box** & a **Cylinder**, & **Rotate the Cylinder** for **90º**



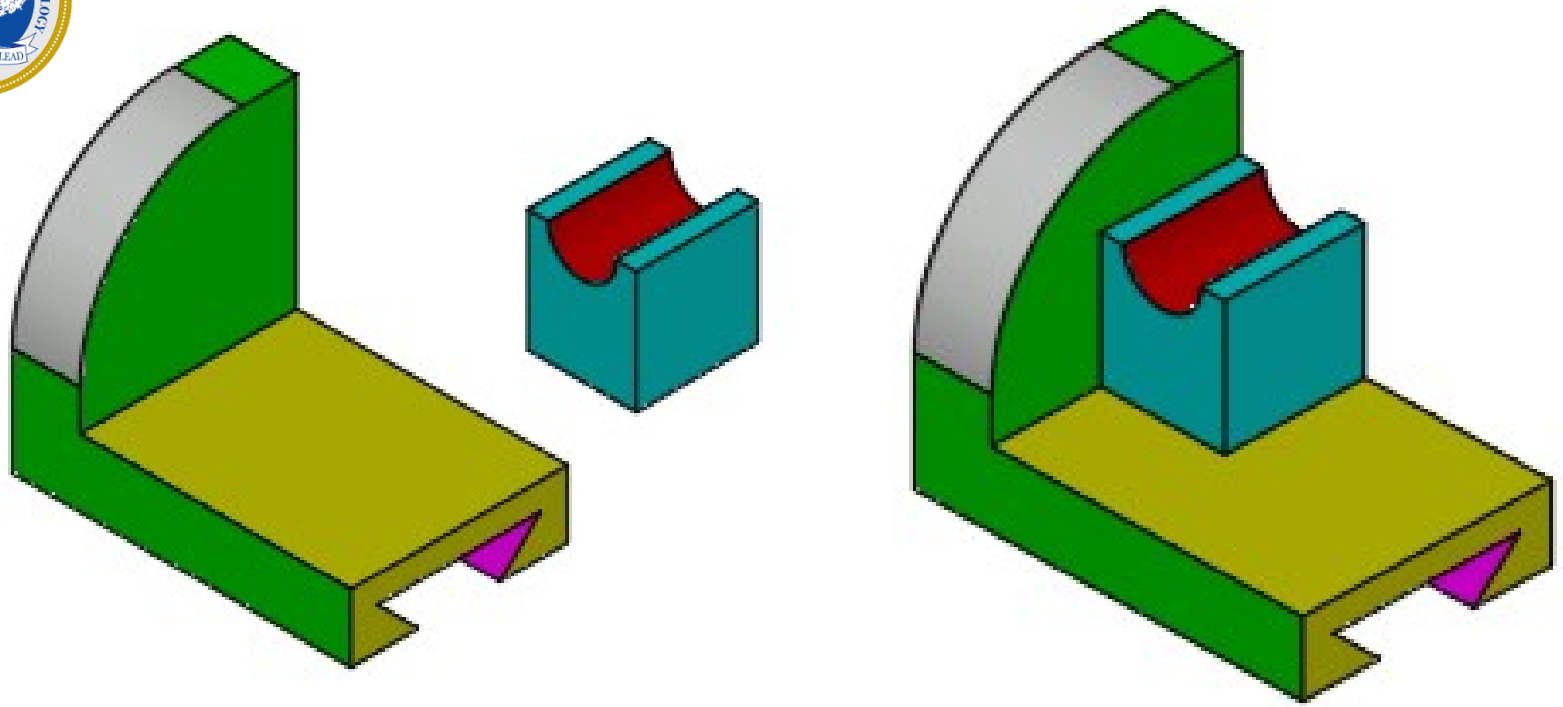






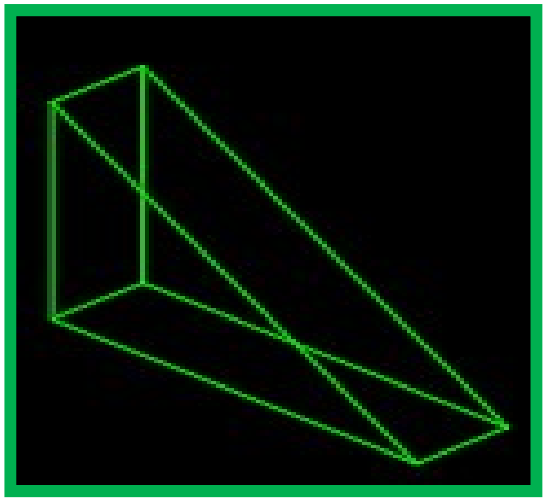
- Move the **Cylinder** to the **Top Edge midpoint** of the **Box** &

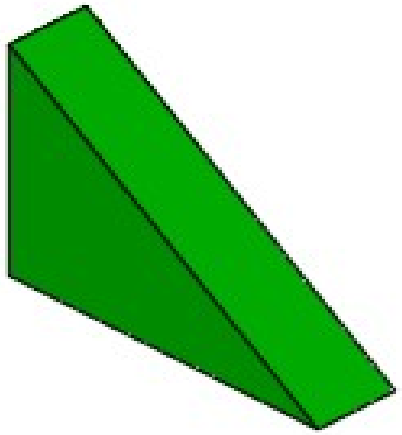
  Subtract the **Cylinder** from the **Box**



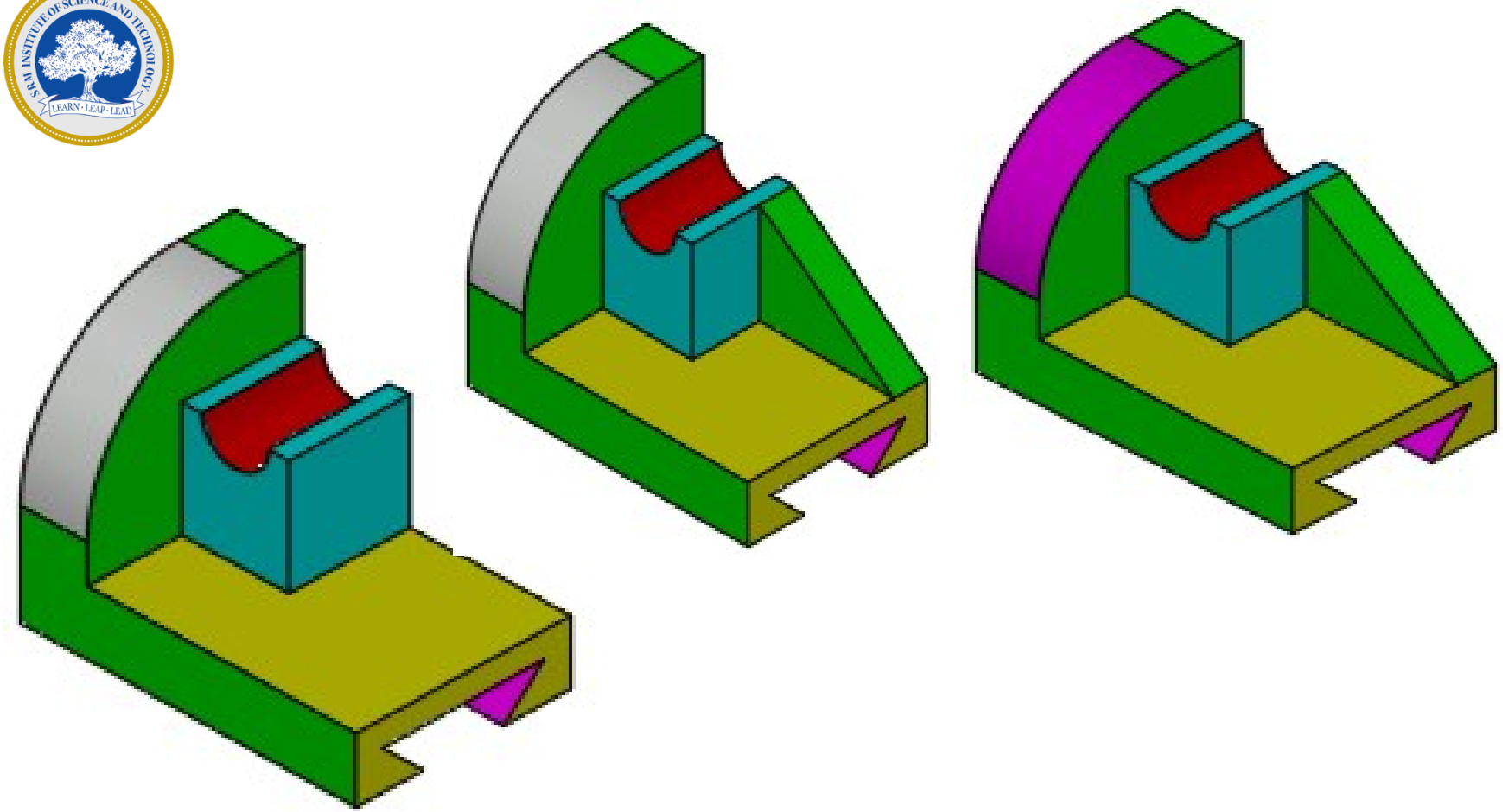
- Move the **Cyan color Solid** & place on the **Top Right corner**
- Perform the Boolean operation **Solid Union**

3D Solid	
Color	Green
Layer	0
Length	120
Width	30
Height	90



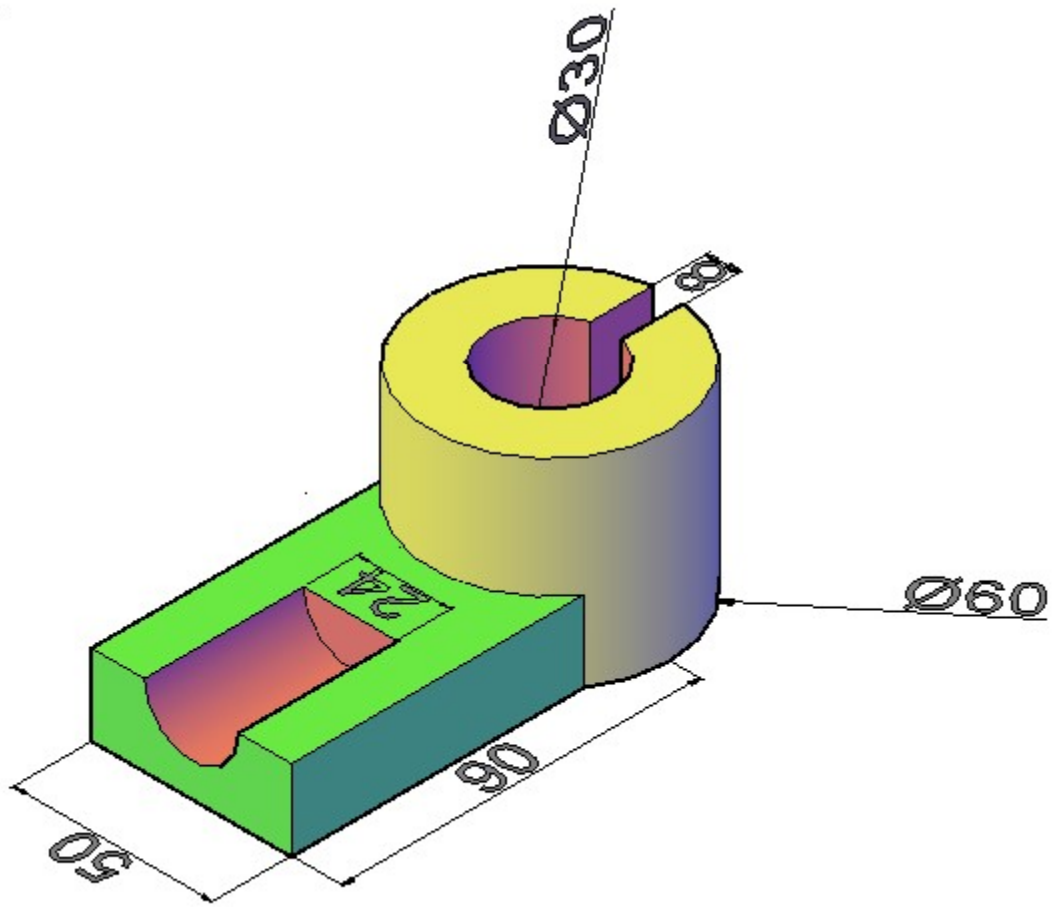


- Use the **Wedge primitive** to create the as per dimensions in the same **SE isometric plane**

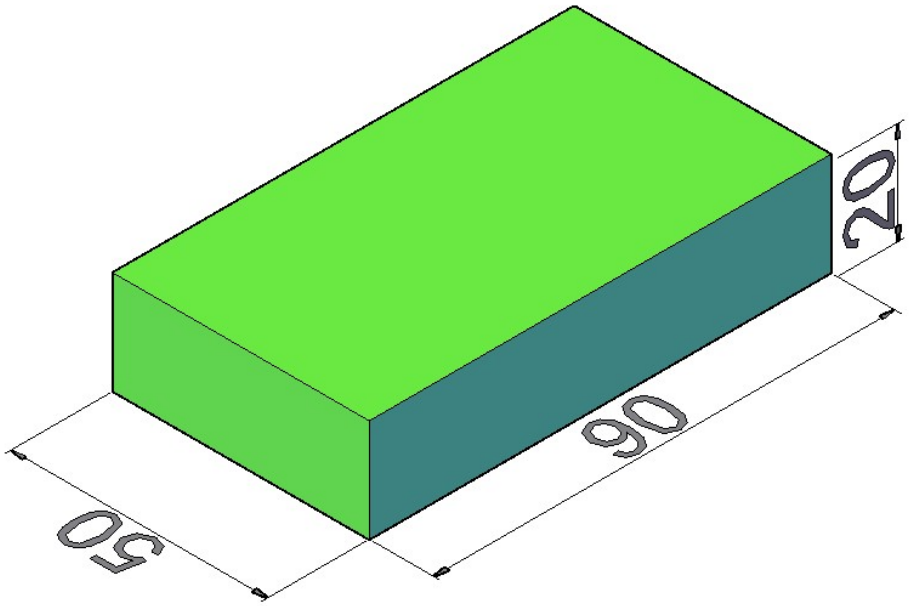


➢ Move the **Wedge Solid** & place on the **Top Right Corner** as shown in the figure & perform the **Solid Union** to make as a **Single Solid**

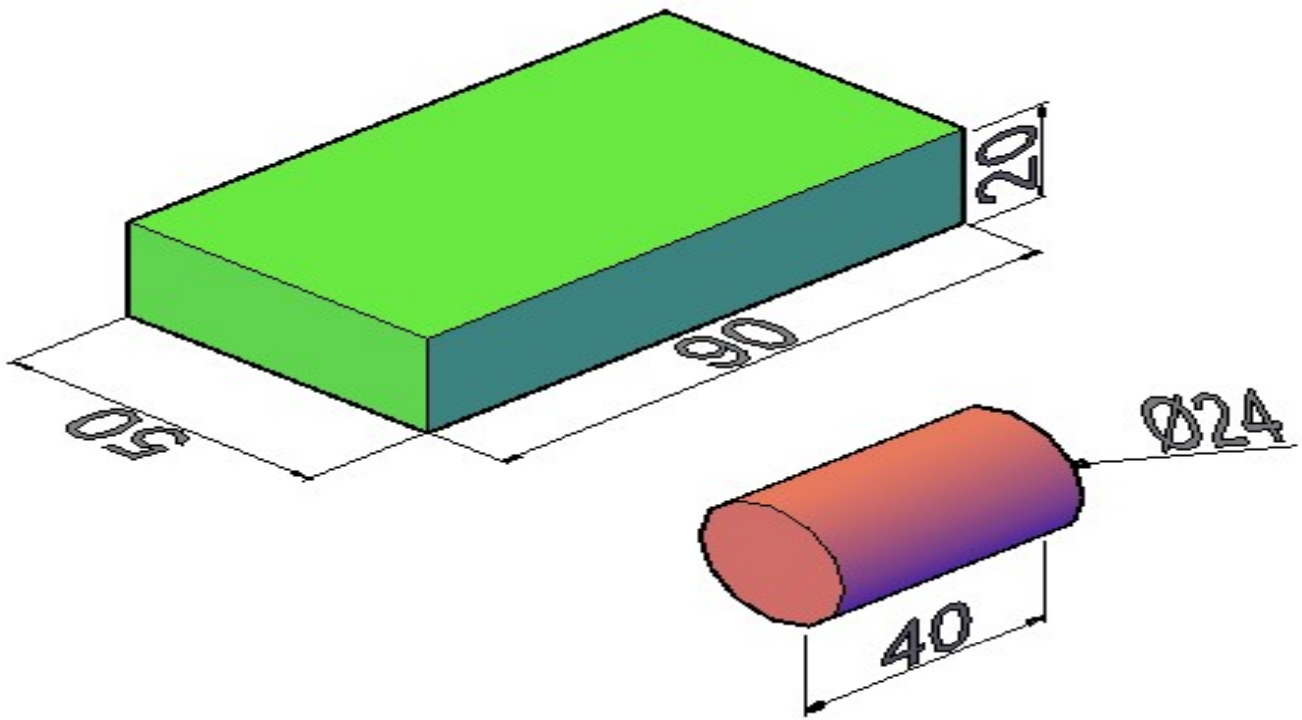
Solid Model Creation using Primitives



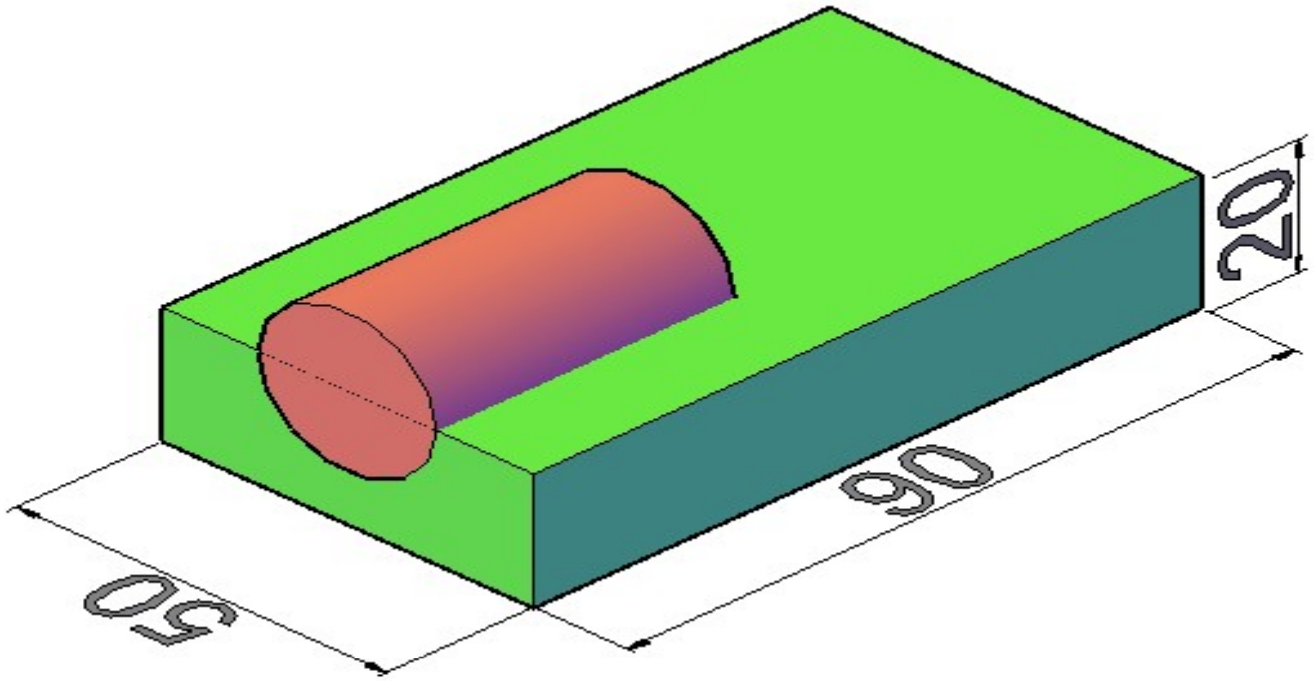
- Change the work space environment to **3D Modeling** (**WORKSPACE SWITCHING**)
- Complete the preliminary steps (setting **UNITS** & **LIMITS**)
- Set the **TOP** plane in **VIEW CONTROLS**
- Start with **TOP** view (since **True** shape of the **Solid** is visible in **TOP** view)



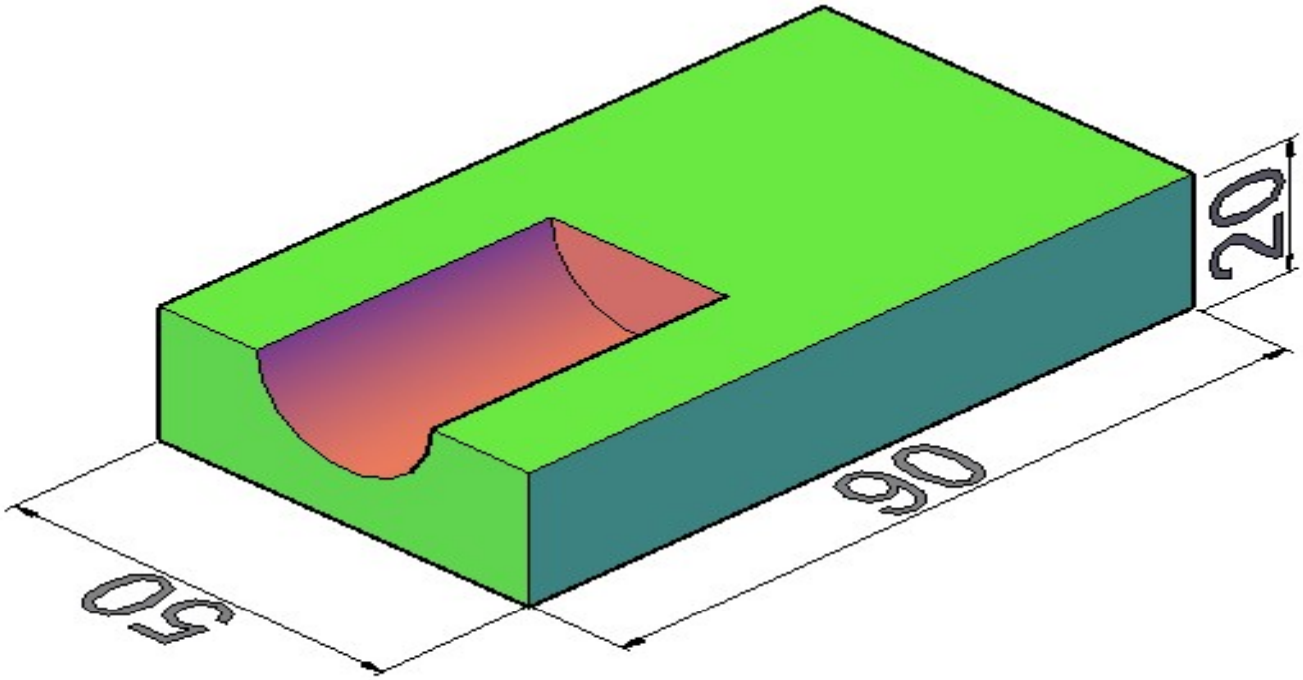
- Use **BOX** command(**ORTHO ON**) from **MODELLING** tool bar to create the Rectangle prism for the given dimension
- Set the **SE Isometric** in **VIEW CONTROLS** to view the Rectangle prism in Isometric



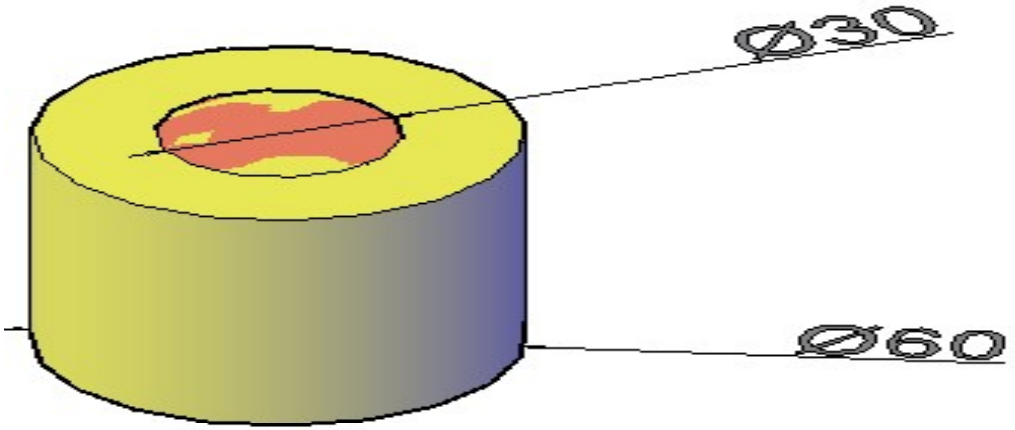
- Set the **LEFT** plane in **VIEW CONTROLS** to change the position of the prism.
- Use **Cylinder** command (**ORTHO ON**) from **MODELLING** tool bar to create the **Cylinder** for the given dimension.



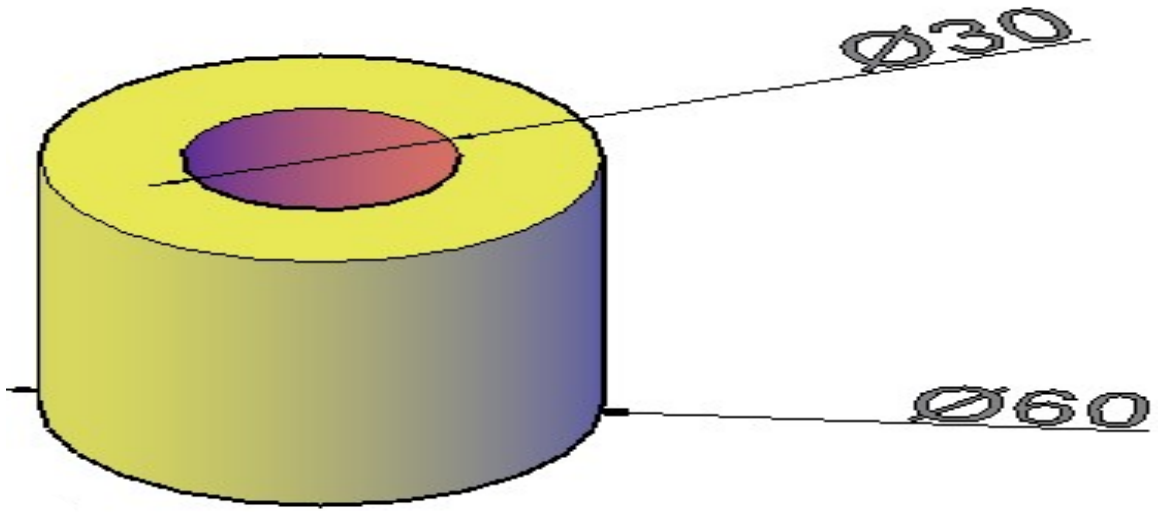
- Use **Move** command (**ORTHO ON**) from **Modify** tool bar and select the **Cylinder** & press Enter.
- Select the **Centre point** of cylinder as base point & place the center point of cylinder on **Top** side width face center of the Rectangular prism



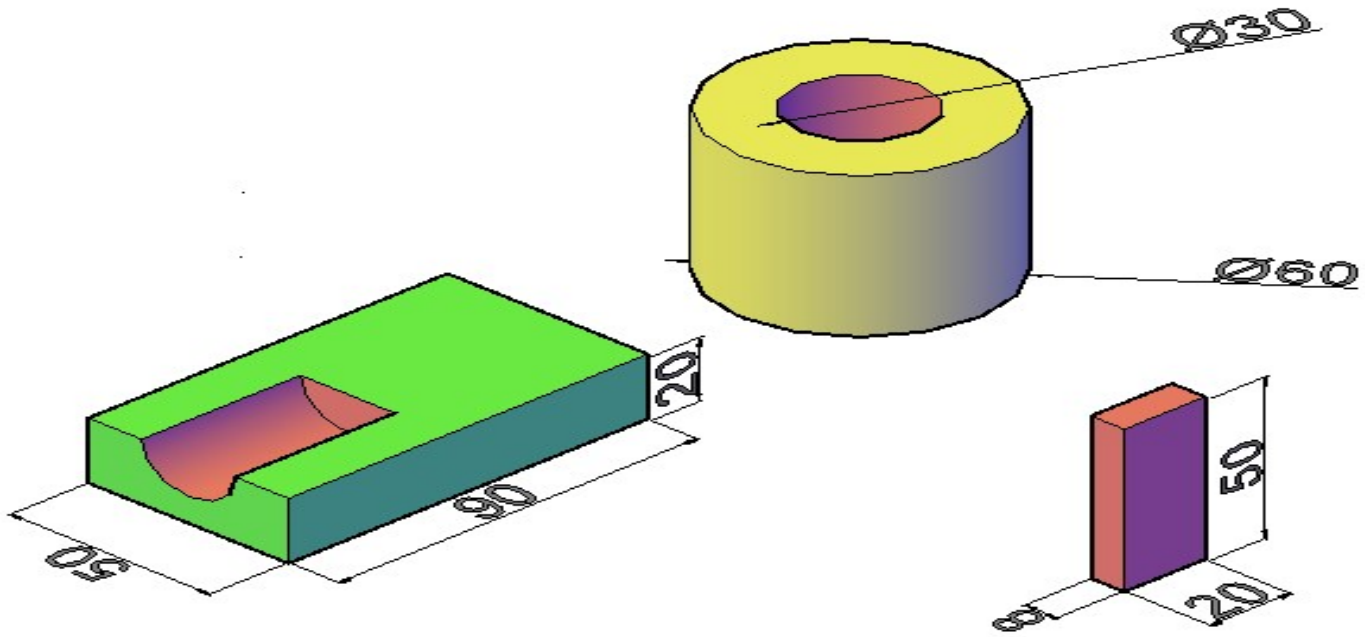
- Select the **Solid, Subtract** from **Solid Editing** Tool bar, select Prism & Cylinder then press Enter to get the Semi Cylindrical Slots in the Rectangular prism.



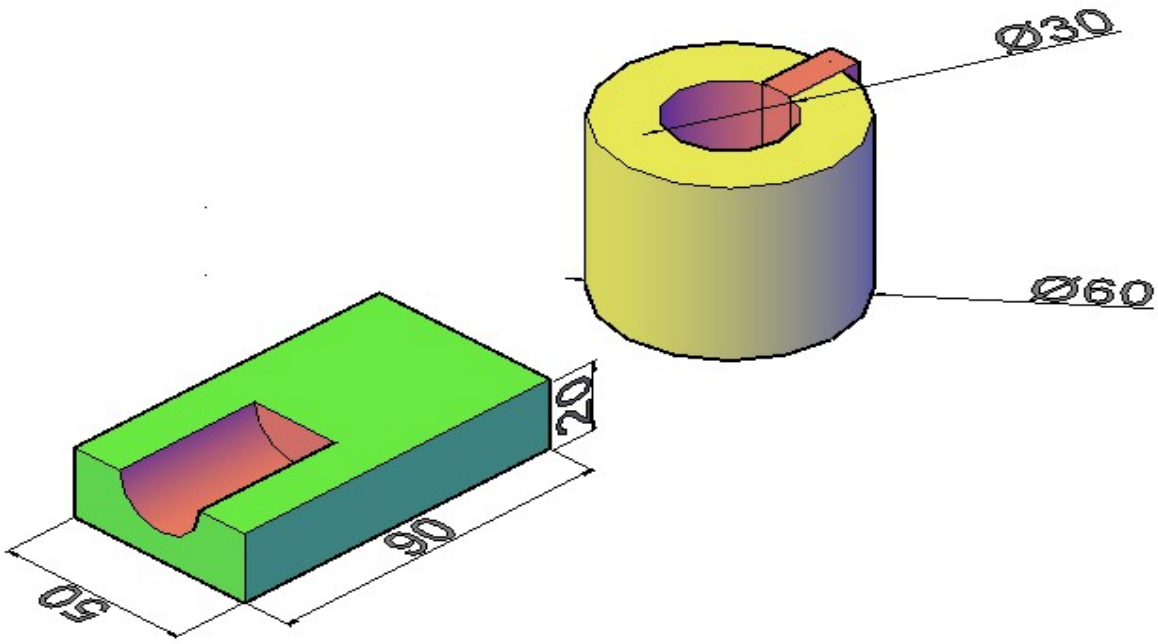
- Set the **TOP** plane in **VIEW CONTROLS**
- Use **Cylinder** command(**ORTHO ON**) from **MODELLING** tool bar to create the Two Cylinders with same center having diameters of **60** mm & **30** mm and height of **50** mm.



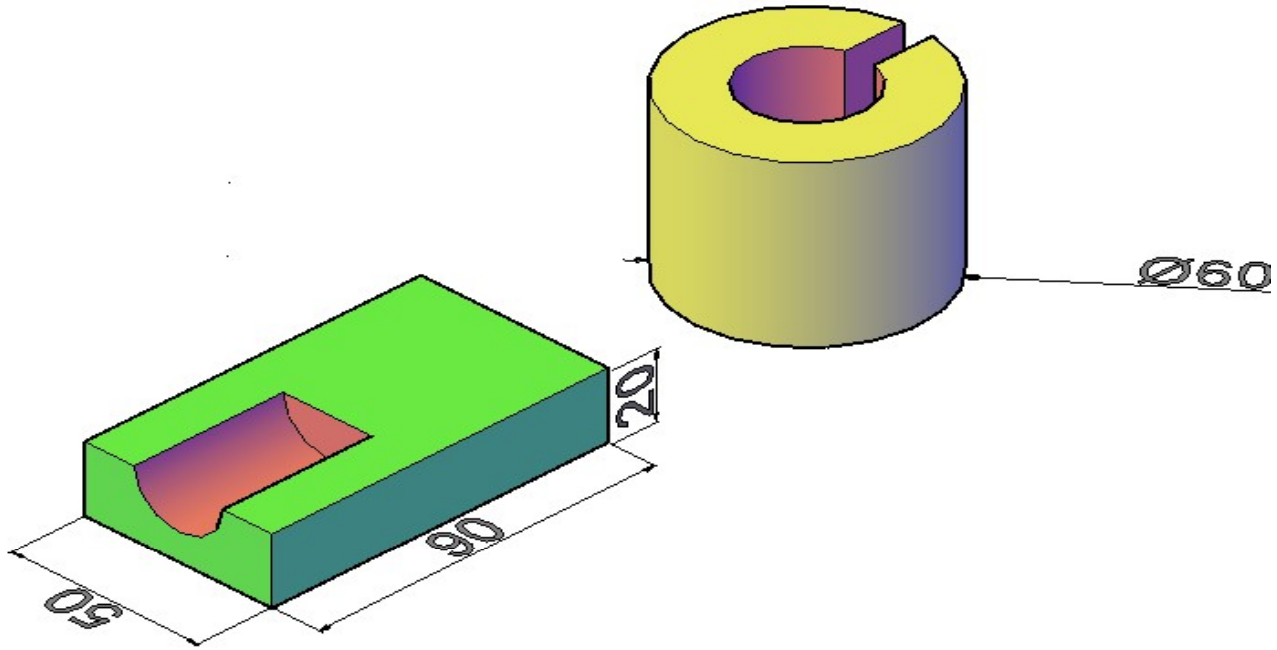
- Set the **SE Isometric** plane in **VIEW CONTROLS** & **2D Wireframe** in **Visual Style Controls**.
- Select the **Solid, Subtract** from **Solid Editing** Tool bar, select Both Cylinders & press Enter.



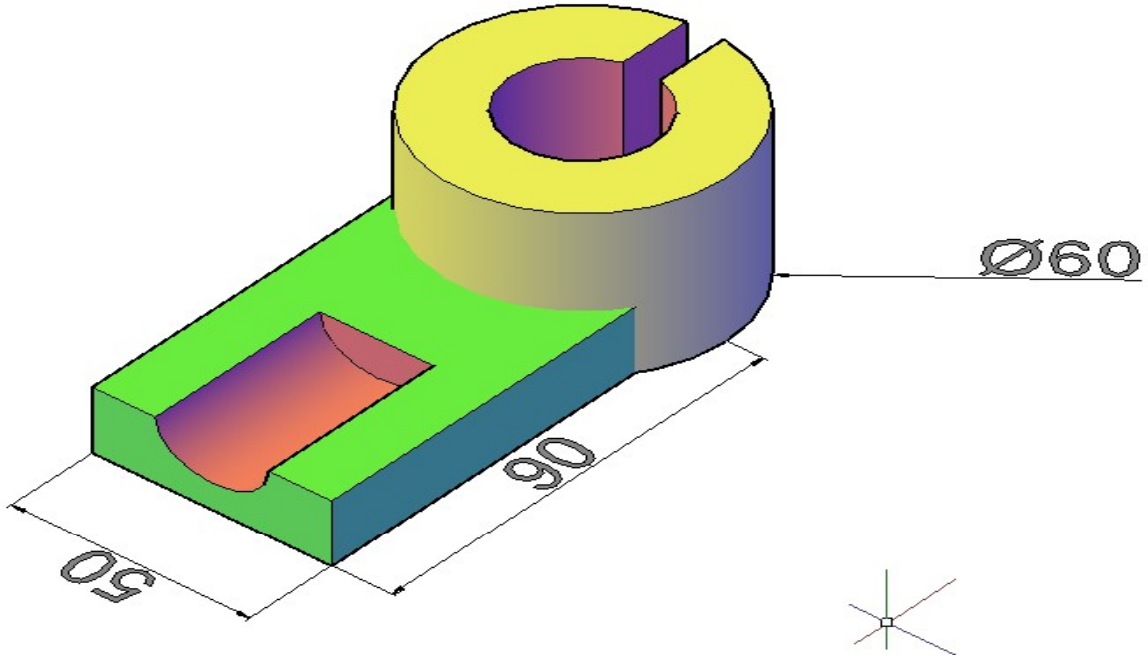
- Use **BOX** command(**ORTHO ON**) from **MODELLING** tool bar to create the Rectangle prism for the given dimension
- Set the **SE Isometric** in **VIEW CONTROLS** to view the Rectangle prism in Isometric



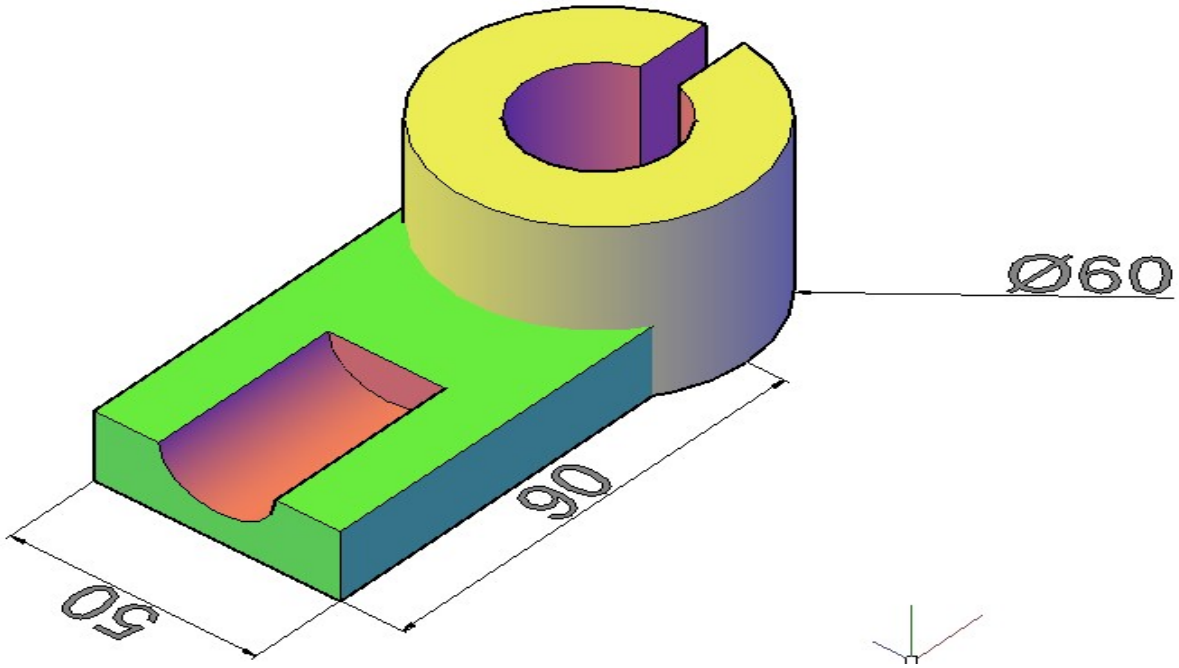
- Use **Move** command (**ORTHO ON**) from **Modify** tool bar and select the prism of smaller in size & press Enter.
- Select the Center point on Top side width face center of the Rectangular prism and place on the point of top surface of the inner edge of the hollow cylinder.



- Select the **Solid, Subtract** from **Solid Editing** Tool bar, select Cylinder & Prism then press Enter to get the Rectangular slots in the hollow Cylinder.

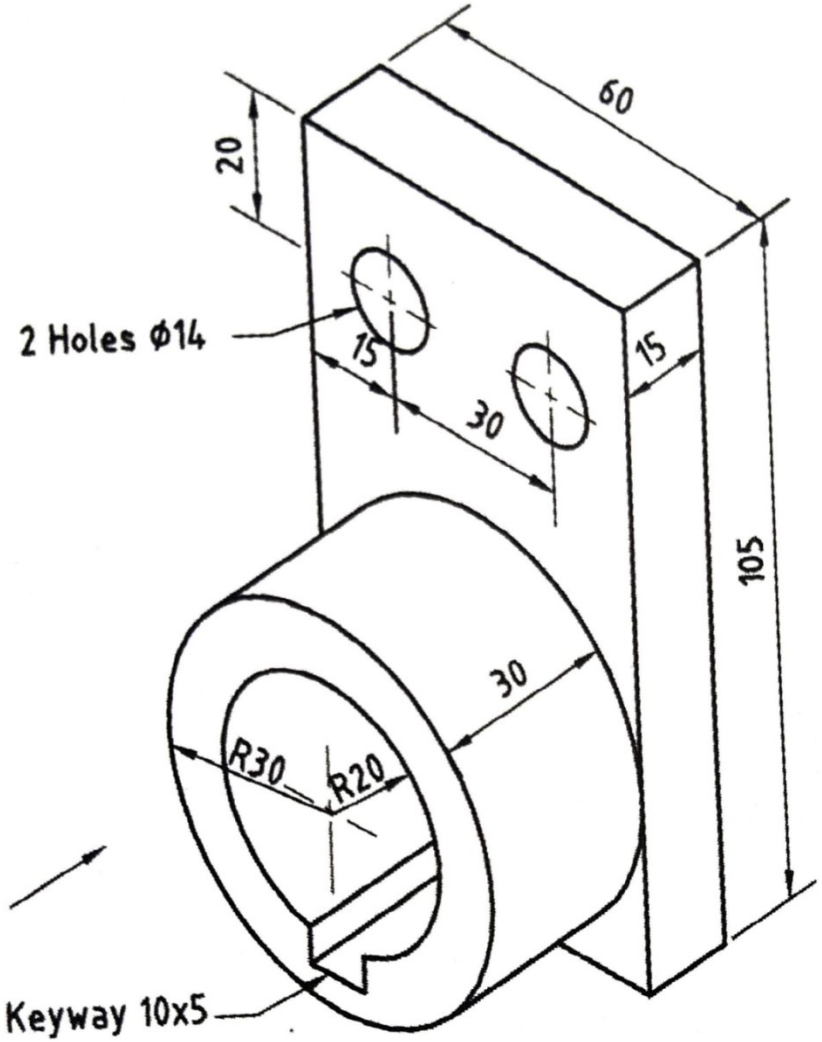


- Set the **SE Isometric** plane in **VIEW CONTROLS** & **2D Wireframe** in **Visual Style Controls.**
- Use **Move** command (**ORTHO ON**) from **Modify** tool bar and select the Slotted hollow Cylinder & press Enter.

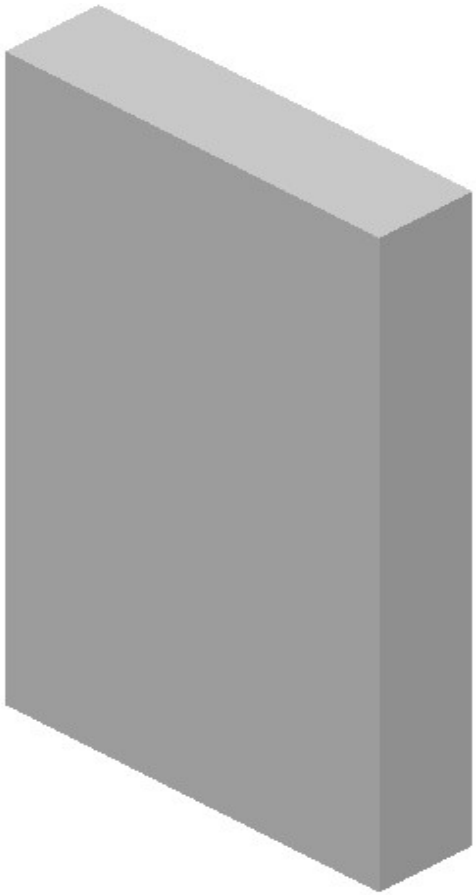


- Select the Bottom Base Center point of the Cylinder and drag the cursor and place on the Bottom side width face center of the Rectangular prism.
- Select the **Solid, union** from **Solid Editing** Tool bar, select Cylinder & Prism then press Enter to get the required **solid model**.

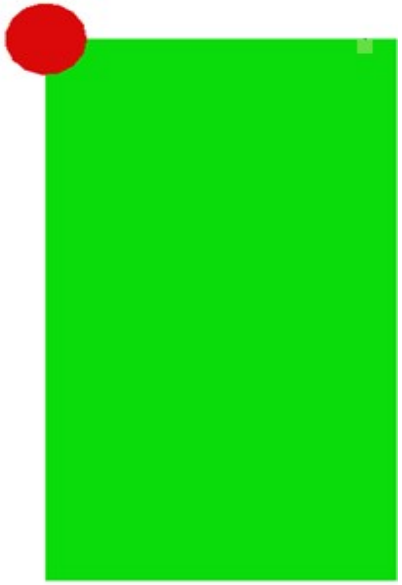
Solid Model Creation using Primitives



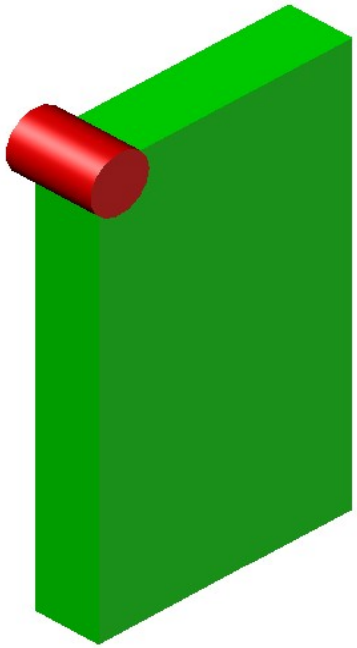
- Change the work space environment to **3D Modeling** (**WORKSPACE SWITCHING**)
- Complete the preliminary steps (setting **UNITS** & **LIMITS**)
- Set the **FRONT** plane in **VIEW CONTROLS**
- Start with **FRONT** view (since **True** shape of the solid is visible in **FRONT** view)
- Use **BOX** command(**ORTHO ON**) from **MODELLING** tool bar to create the Rectangle prism for the given dimension



- Set the **SE Isometric** in **VIEW CONTROLS** to view the Rectangle prism in Isometric



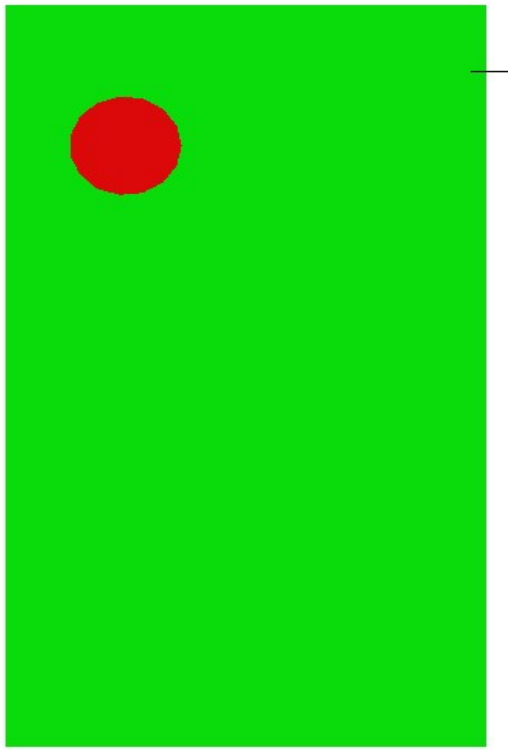
Set the **FRONT** plane in **VIEW CONTROLS** to change the position of the prism.

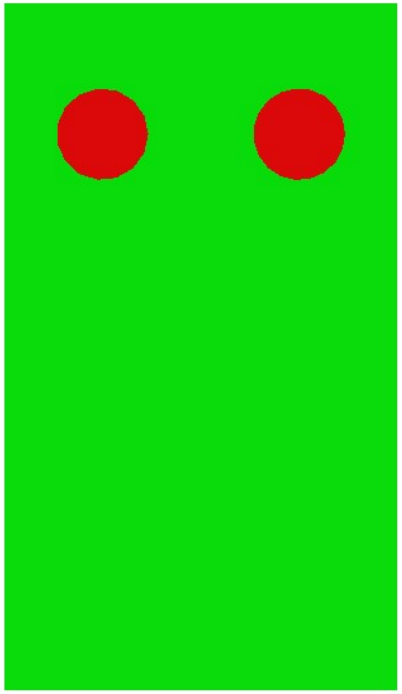


- Use **Cylinder** command(**ORTHO ON**) from **MODELLING** tool bar to create the **Cylinder** & place the Center point of Cylinder on top left corner of the prism and enter the dimensions.

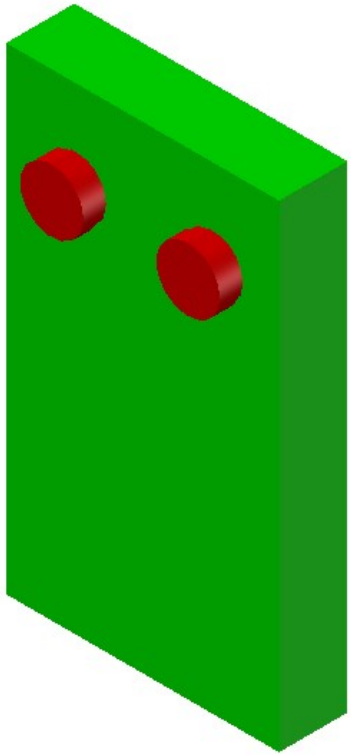
- Use **Move** command (**ORTHO ON**) from **Modify** tool bar and select the cylinder & press Enter.
- Select the centre point of cylinder as base point to move the cylinder **20** mm downwards & press Enter.
- Use **Move** command (**ORTHO ON**) from **Modify** tool bar and select the cylinder & press Enter.
- Select the Centre point of Cylinder as Base point to move the Cylinder **15** mm towards right & press Enter.

- Use **Copy** command (**ORTHO ON**) from **Modify** tool bar & select the Cylinder & press Enter.
- Select the Base point as Cylinder & Drag towards right and enter the distance **30** mm & press Enter.

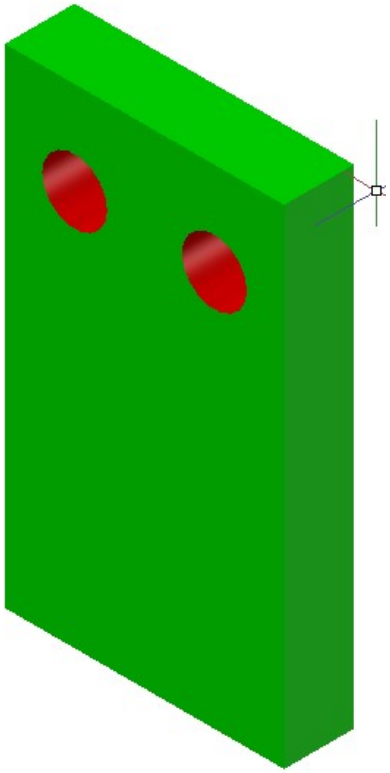


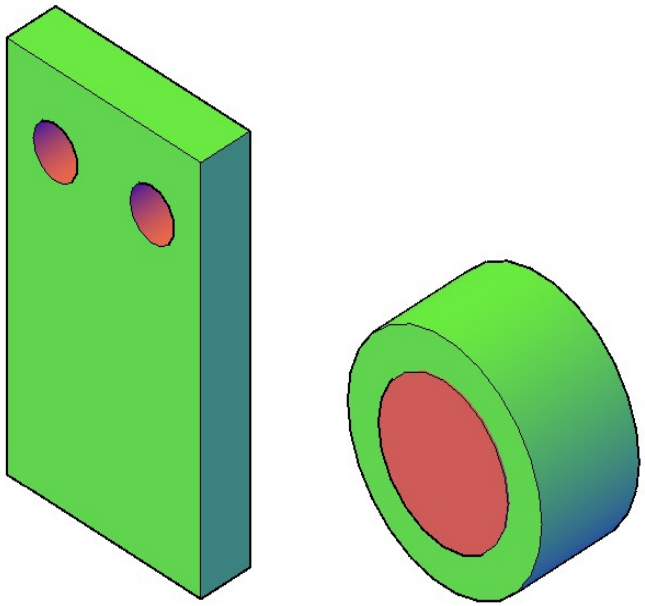


- Use **Copy** command (**ORTHO ON**) from **Modify** tool bar & select the cylinder & press Enter.
- Select the Base point as Cylinder & Drag towards Right and enter the distance **30** mm & press Enter.



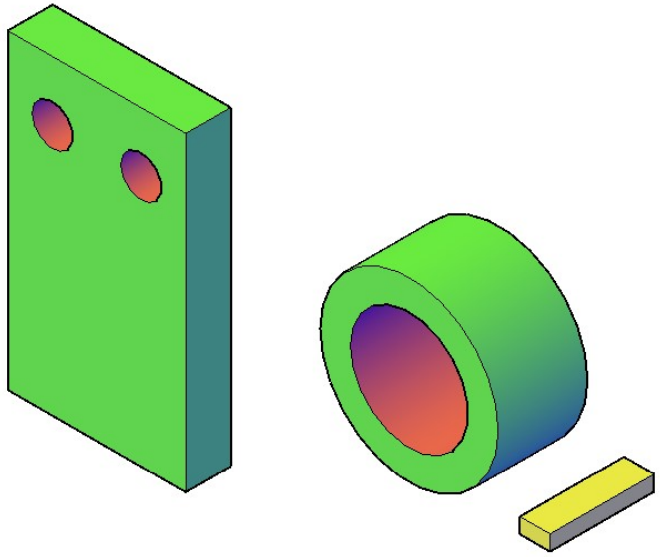
- Select the Solid from main menu and select **SUBTRACT** from **Boolean** toolbar
- Select the Rectangular prism and press Enter. Then select the cylinders and press Enter to get the Cylindrical holes in the Rectangular prism.



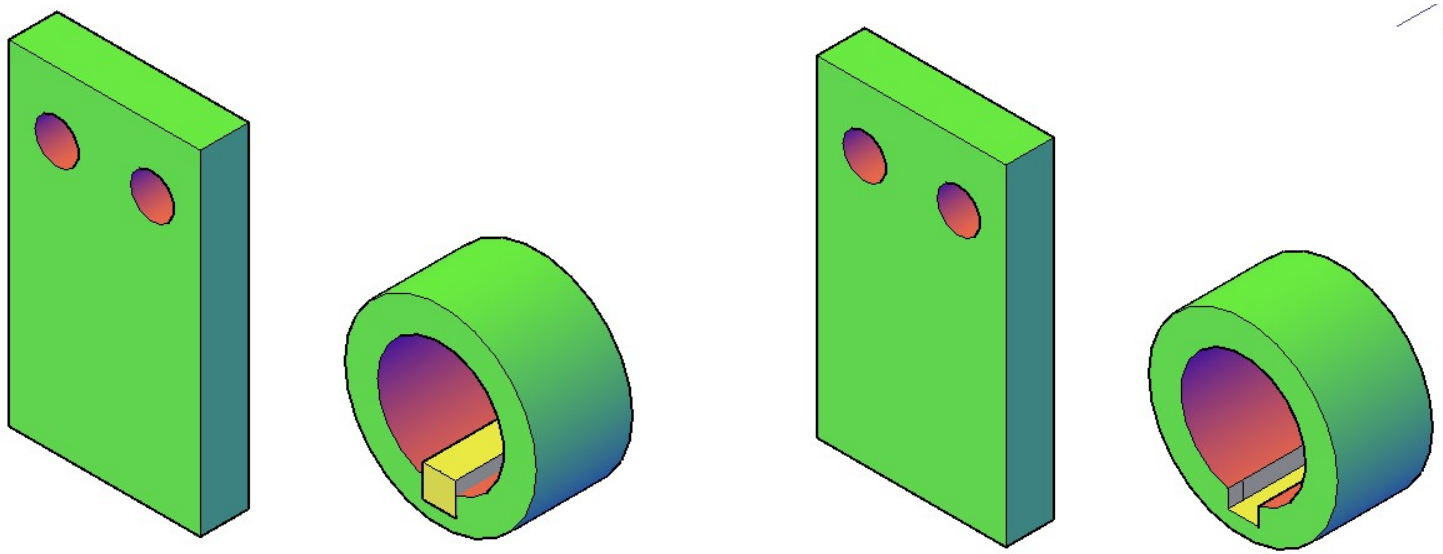


- Set the **FRONT** plane in **View controls** to change the position of the prism.

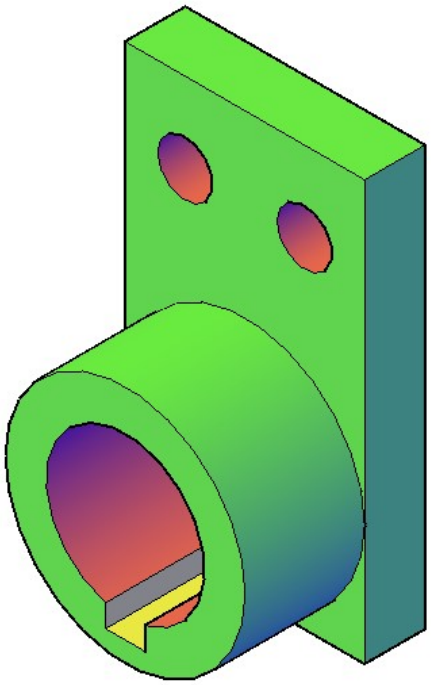
- Use **Cylinder** command(**ORTHO ON**) from **MODELLING** tool bar to create the Cylinder of **30** mm radius and **30** mm height at beside the prism and press Enter.
- Use **Cylinder** command(**ORTHO ON**) from **MODELLING** tool bar for create a another Cylinder of **20** mm radius and **30** mm height at the center point of the previous drawn cylinder the prism and press Enter.



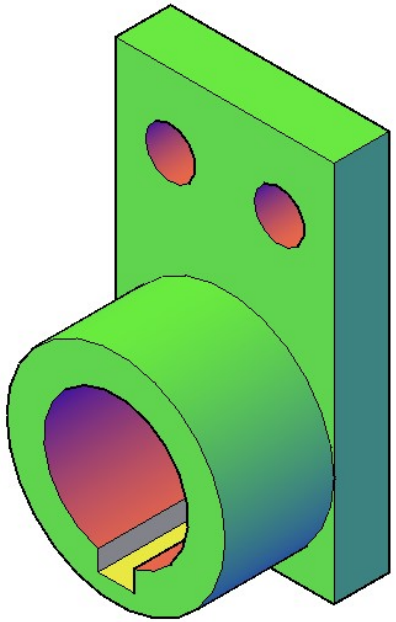
- Select the Solid from main menu and select **Subtract** from Boolean toolbar
- Select the outer cylinder and press Enter. Then select the inner cylinder and press Enter to get the hollow cylinder.
- Select the **BOX** command from **Modelling** tool bar to create a Rectangular prism with a given dimensions.
- Use **Move** command (**ORTHO ON**) from **Modify** tool bar and select the Rectangular prism & press Enter.



- Select the Centre point of Rectangular prism as base Center point, and place the prism into the inner Cylindrical surface.
- Select the Solid from main menu and select **Subtract** from **Boolean** toolbar
- Select the hollow Cylinder and press Enter. Then select the prism and press Enter to get the keyway in the Cylinder.



- Use **Move** command (**ORTHO OFF**) from **Modify** tool bar and select the Cylinder & press Enter.
- Select the Centre point of Cylinder as base point, and place the Cylinder at bottom right corner of the Rectangular prism.
- Use **Move** command (**ORTHO ON**) from **Modify** tool bar and select the Cylinder & press Enter.



- Select the Centre point of Cylinder as base point to move the Cylinder **30** mm towards left & press Enter.
- Use **Move** command (**ORTHO ON**) from **Modify** tool bar and select the Cylinder & press Enter.
- Select the Centre point of Cylinder as base point to move the Cylinder **30** mm upwards & press Enter.
- Thus the given model was drawn using **Primitives** and **Boolean** operations

REFERENCE BOOKS

- JEYAPOOVAN T, “ENGINEERING GRAPHICS AND DESIGN”, 2023, Vikas Publishing House Pvt Ltd,
- K.V.NATARAJAN, “Engineering Graphics”, 2015, Dhanalakshmi Publishers.