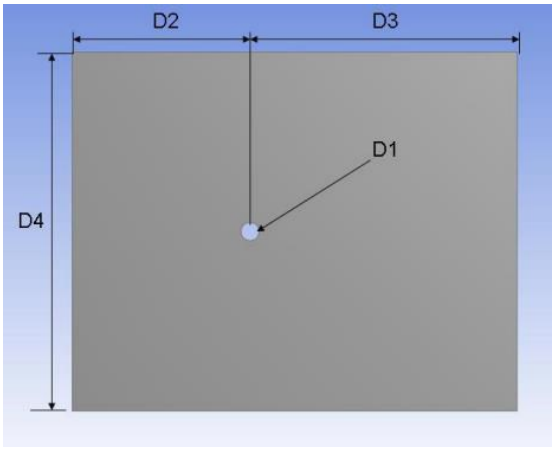
Student No: **Surname, Name:** **Signature:**

30.10.2026 Friday 9.00 – COMLAB

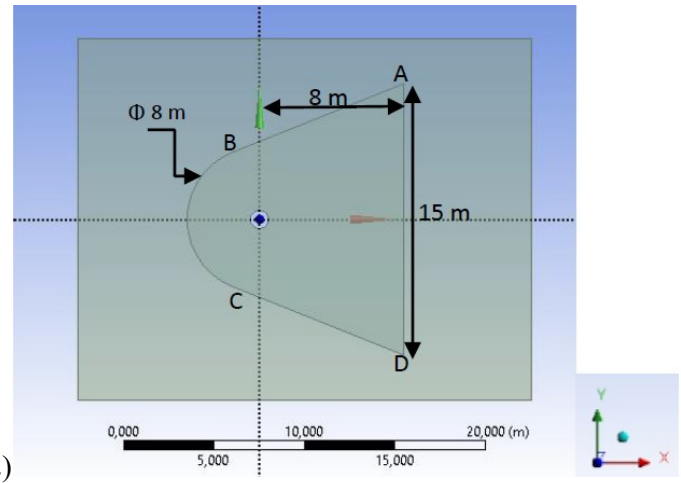
Assoc. Prof. Dr. Emre Kara Duration: 60 min

AE427 INTRODUCTION TO COMPUTATIONAL FLUID DYNAMICS
MIDTERM 1

Simulation Design



(Fig.1)



(Fig.2)

Name	Location	Dimension
Cylinder	D1	1 m (dia.)
Inlet Length	D2	10 m = 10 D
Outlet Length	D3	15 m = 15 D
Width	D4	20 m = 20 D

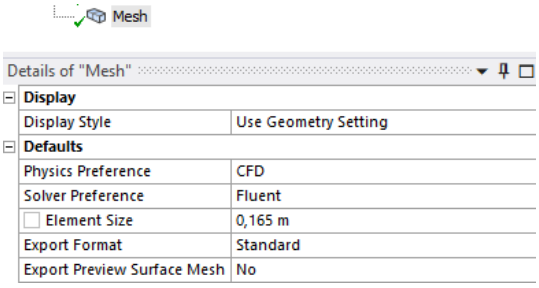
Draw the computational domain and circular cylinder using the specified dimensions. The cylinder is centered at (0, 0), with the domain boundaries positioned according to *D2*, *D3*, and *D4*/2. The shaded region in Figure 2 represents the Body of Influence (BOI), which is symmetric. Lines AB and CD are tangent to the circular arc BC. **Note:** The BOI must be created as a separate geometry from the computational domain. It is used for mesh sizing and is not a physical boundary of the flow domain.

Write down your answers **inside the boxes** below the question.

Q1 — Geometry construction (15 pts): Calculate the perimeter of the BOI.

Length (m)	46.113

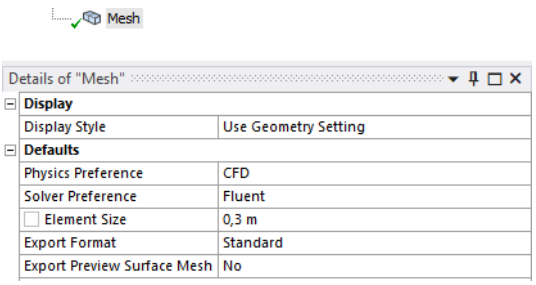
(A) Generate Mesh A using global element size control only. Develop an unstructured mesh without body of influence and without inflation. Use the following size control.



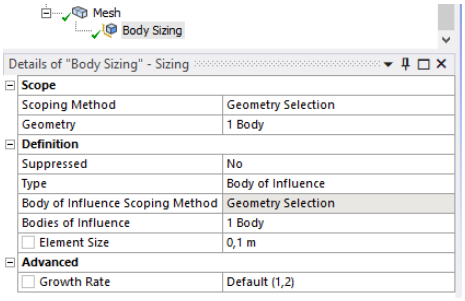
(1: General Mesh)

(B) Generate Mesh B using a Body of Influence (BOI) for local refinement and inflation layers along the cylinder wall. Use the following procedures.

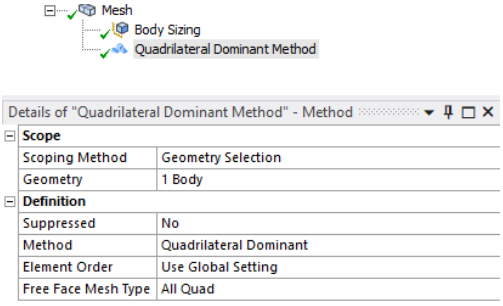
(1: General Mesh)



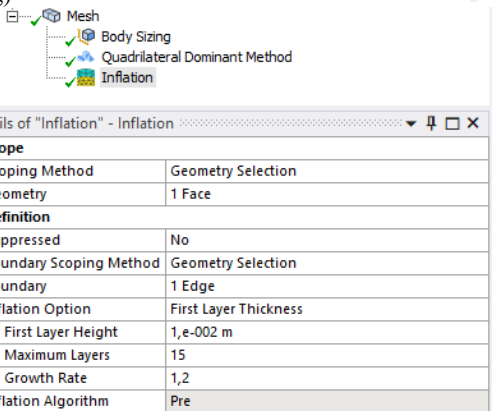
(2: Body Sizing)



(3: Quad dominant)



(4: Inflation)



Q2 — Mesh statistics (30 pts): Record the total number of nodes and elements for each mesh. Mesh A uses global element-size control only; Mesh B uses BOI refinement and inflation.

	Number of Nodes	Number of Elements
(A)	18686	18406
(B)	18224	18074

Q3 — Mesh quality (30 pts): Record the minimum orthogonal quality and maximum skewness for each mesh.

	Min. Orth. Quality		Max. skewness
(A)	0.83396	(A)	0.44054
(B)	0.47258	(B)	0.72464

Q4 — Comments (35 pts) Answer briefly in the spaces provided.

Mesh A — Global element-size control: Describe the element distribution and the main advantages and limitations of this approach. The mesh is generated using global element-size control, without BOI or inflation. Its element distribution is primarily controlled by the global sizing parameters. It has better reported mesh-quality metrics, but it does not specifically control the near-wall or wake resolution.
Mesh B — Body of Influence and inflation: Describe the local refinement and inflation layers, and explain their intended purpose. The BOI provides local mesh refinement in a selected region, while inflation generates layered cells near the cylinder wall. These features are intended to improve spatial resolution in regions with strong flow gradients. However, the resulting mesh has worse reported quality metrics than Mesh A.
Conclusion: Which mesh has better reported quality metrics? Does this automatically mean it is more suitable for every CFD application? Mesh A has better minimum orthogonal quality and maximum skewness. However, this does not automatically make it more suitable for every CFD application. Mesh B may provide more appropriate local resolution near the cylinder and in the wake, depending on how it is constructed.
Element distribution: How does the element distribution differ between A and B? Mesh A uses global size control, whereas Mesh B concentrates cells in selected regions and near the cylinder wall.
Mesh quality: What do the orthogonal quality and skewness values indicate? Mesh A has a minimum orthogonal quality of 0.83396 and maximum skewness of 0.44054. Mesh B has a minimum orthogonal quality of 0.47258 and maximum skewness of 0.72464. Thus, Mesh A has better values for both reported metrics.
Purpose of BOI: Explain why a separate BOI geometry is used during mesh generation. BOI defines a region for local mesh-size control, allowing finer elements in areas of interest without refining the entire domain.
Purpose of inflation: Explain why layers of cells are generated near the cylinder wall. Inflation creates layers of cells adjacent to the cylinder wall to resolve steep near-wall velocity gradients and support the calculation of wall shear stress and boundary-layer behaviour.
Critical interpretation: Explain why mesh quality metrics alone are insufficient to determine which mesh is better for a CFD simulation. Mesh-quality metrics describe cell shape, not whether the mesh has sufficient spatial resolution in important regions. Therefore, neither mesh can be declared universally better based on these metrics alone.

Comment section	Points
Mesh A	4
Mesh B	5
Conclusion	5
Element distribution	4
Mesh quality	5
Purpose of BOI	4
Purpose of inflation	4
Critical interpretation	4
Total	35