

AE510 HOMEWORK-1

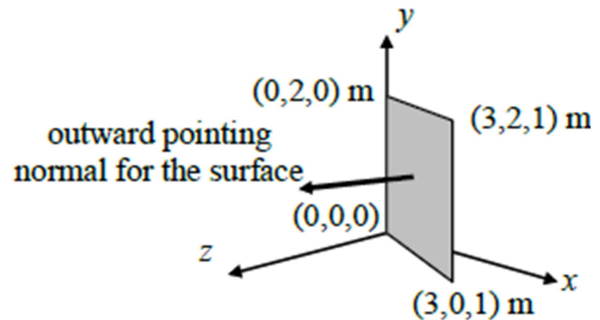
(Submit it at the start of the next lecture, 8 Oct 2026)

Q1) A fluid moves through a control surface S with a nonuniform velocity field. The velocity distribution is described by the given expression in the accompanying figure, where the constants have the values:

$$\mathbf{u}_{\text{fluid}} = A x \hat{\mathbf{i}} + B y \hat{\mathbf{j}} + C z \hat{\mathbf{k}}$$

$$A=1 \text{ s}^{-1}, B=2 \text{ s}^{-1}, C=3 \text{ (m s)}^{-1}.$$

The surface S is stationary and has the geometry and orientation indicated in the figure, coordinates of the corners are in meters.

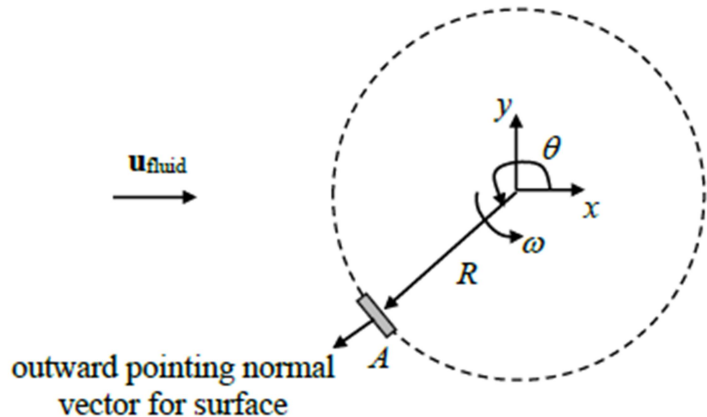


- Using the velocity distribution, evaluate the net volume of fluid crossing S per unit time. Report the magnitude of this quantity.
- Based on your result from Part 1, calculate the surface-averaged speed normal to S . Give the magnitude of the average velocity through the surface.

Q2) A moving control surface is attached to the end of a rigid arm of length R . The arm rotates about the origin in the x - y plane with a constant angular velocity ω , as illustrated in the accompanying figure. The surrounding fluid has a velocity field of the form

$$\mathbf{u}_{\text{fluid}} = C \hat{\mathbf{i}}$$

where C is a constant. The control surface has a fixed area A and remains attached to the rotating arm.



- Determine the instantaneous volumetric flow rate across the surface as the arm rotates.
- Express your final answer using only the relevant quantities from C , R , ω , A , q , and simplify your expression as far as possible. Clearly indicate any dependence of the flow rate on the angular position of the arm.

Submit only a HANDWRITTEN report.

IMPORTANT NOTE: Students are expected to adhere to the principles of academic integrity throughout the course. All reports must represent the student's own work, and all sources must be properly acknowledged. Artificial intelligence (AI) tools (e.g., ChatGPT, Copilot, Gemini) are not permitted other than plots/graphics/tables generation. However, any use of AI tools should be appropriately disclosed in acknowledgements section, and students remain fully responsible for the accuracy, originality, and integrity of all submitted work. AI-generated content must not replace the student's own understanding, analysis, or original work. Violations of academic integrity will be handled in accordance with the University's academic regulations.