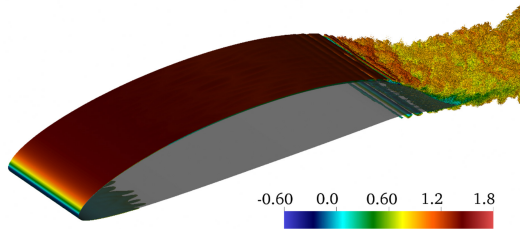


APL361 - Advanced fluid dynamics

Prateek Gupta

Department of Applied Mechanics, IIT Delhi



Overview lecture
July 25, 2025
prgupta@am.iitd.ac.in





Brief recap of APL106

APL361

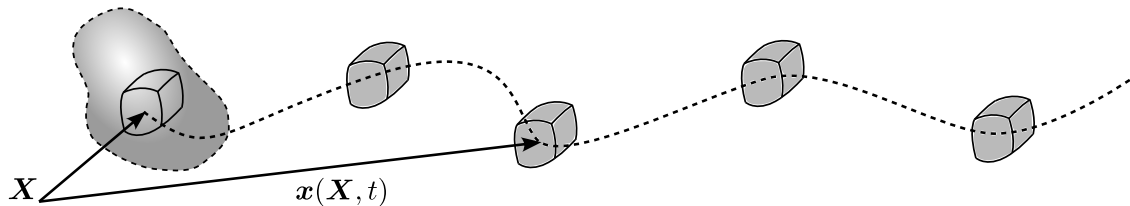
Course policy and takehome

2023-2024 Semester 1

2024-2025 Semester 1

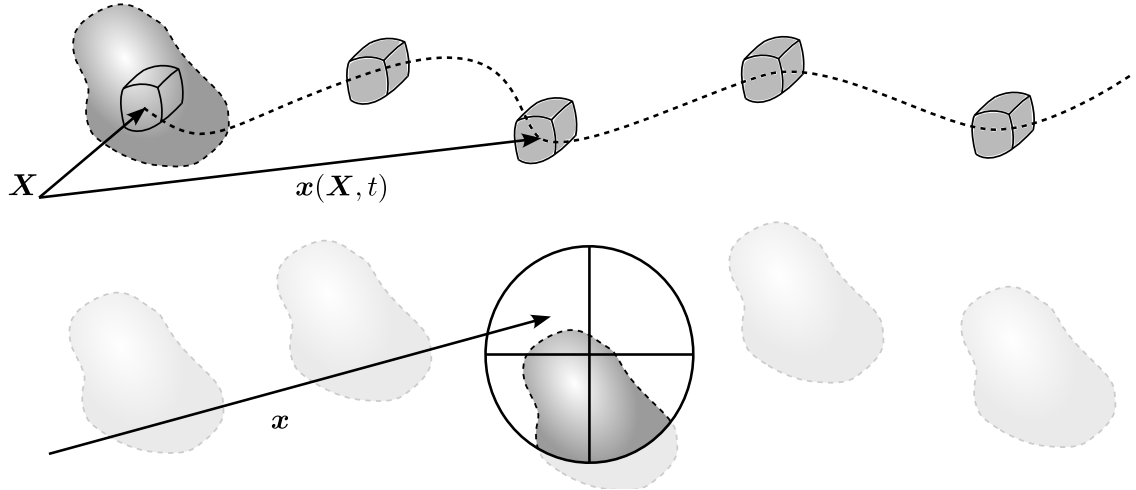


APL106 : Lagrangian vs Eulerian



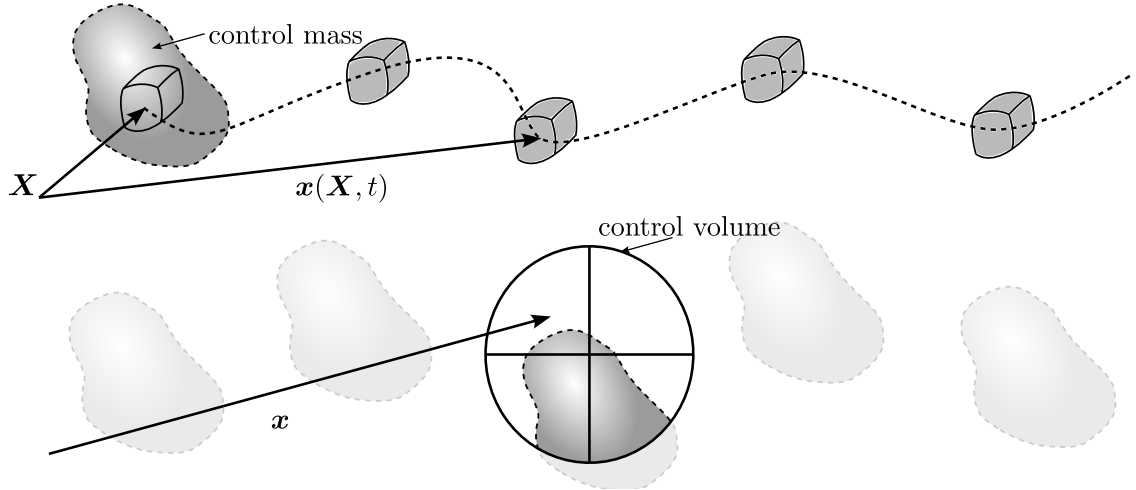


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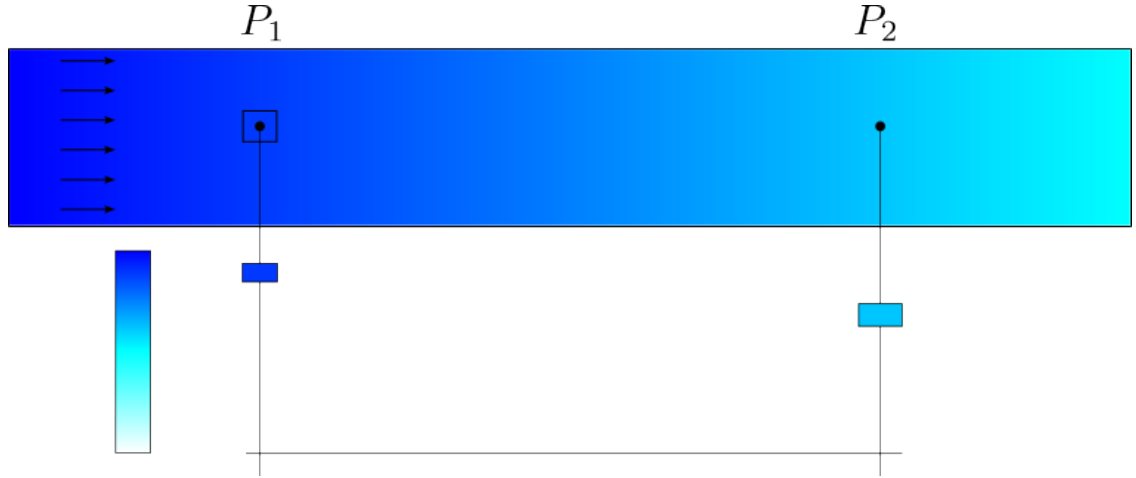


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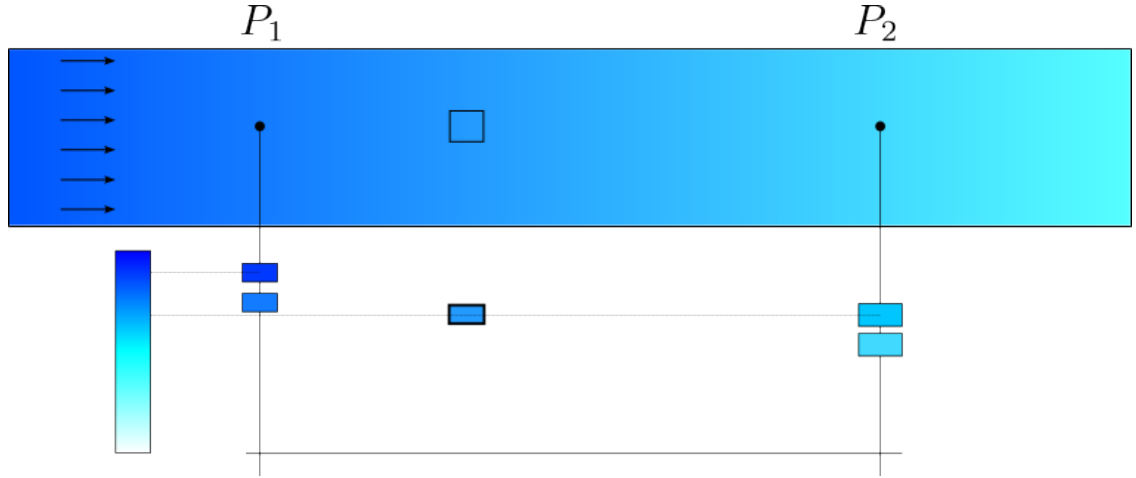


APL106 : Material derivative



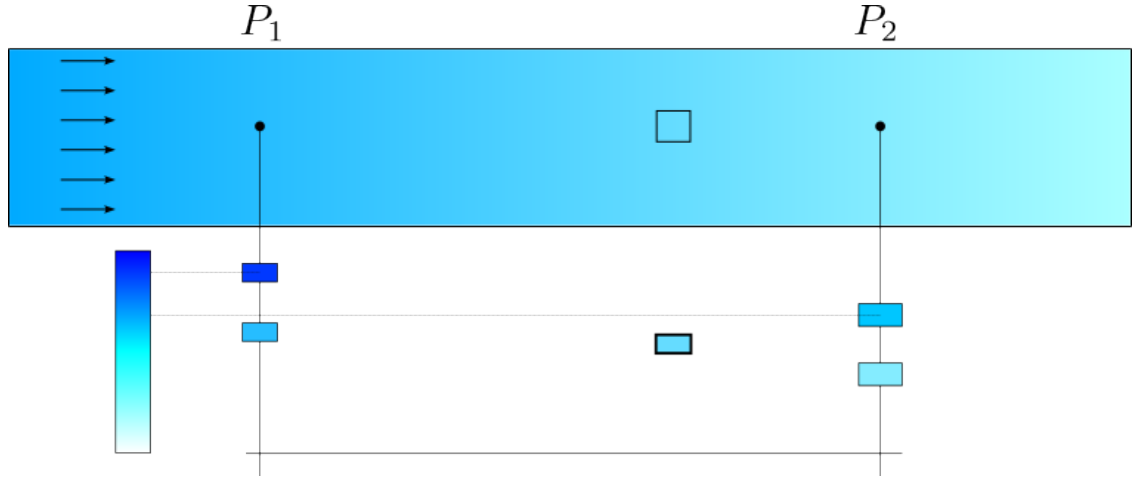


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APL106 : Material derivative



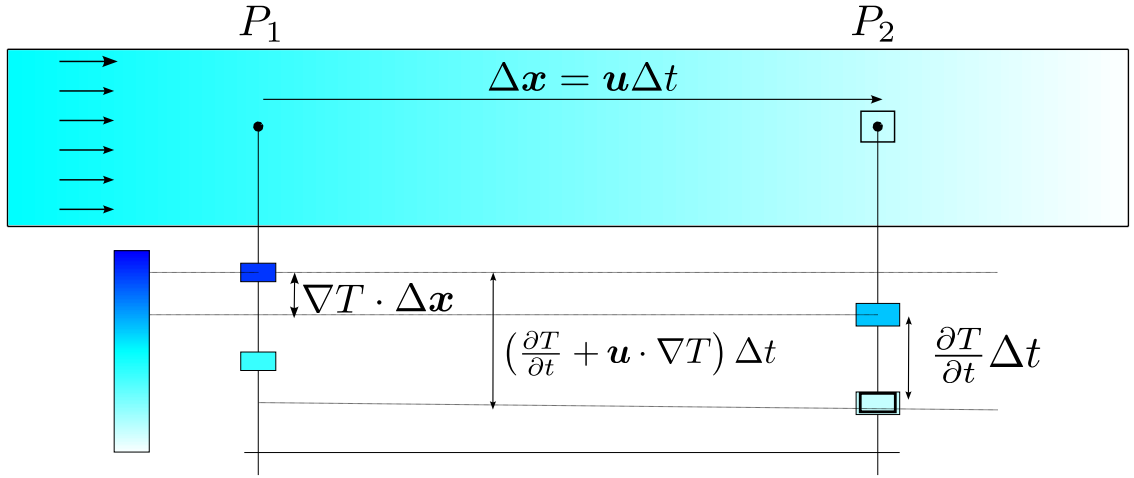


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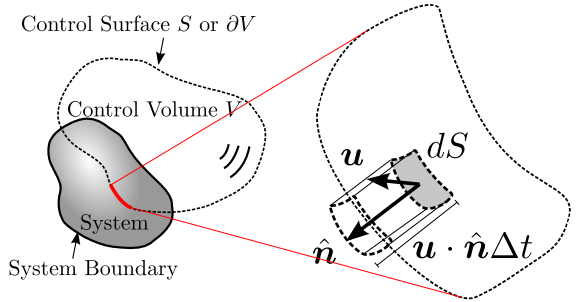


APL106 : Material derivative



APL106 : Reynolds Transport Theorem

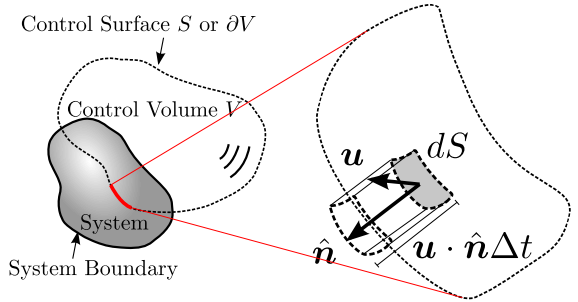
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APL106 : Reynolds Transport Theorem

- flux of an intensive quantity ϕ : $\mathbf{f} = \rho\phi\mathbf{u}$
- Total rate of change of extensive quantity Φ :

$$\frac{d\Phi}{dt} = \frac{d}{dt} \int_{\text{System}} \phi dm$$



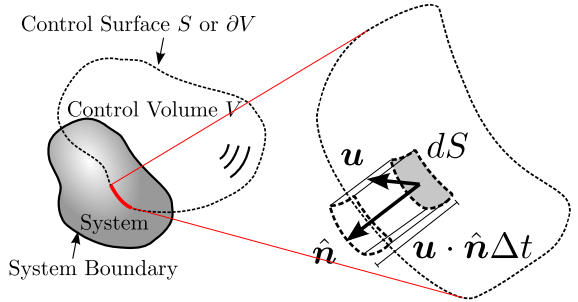
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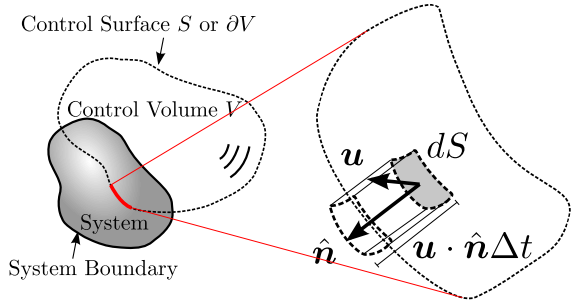
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- and whatever is leaving the CV per unit time

$$= \oint_S \mathbf{f} \cdot \hat{\mathbf{n}} dS$$



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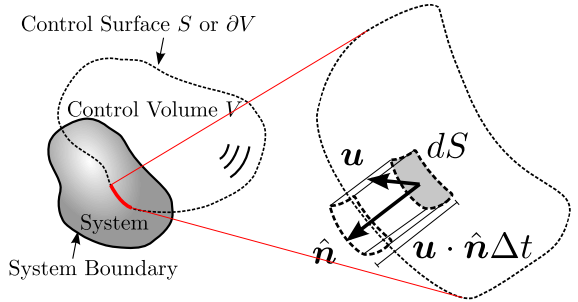
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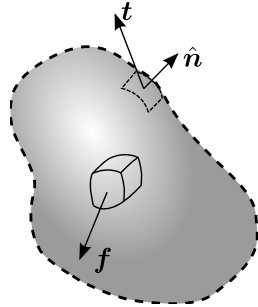
- Reynolds Transport Theorem

$$\frac{d\Phi}{dt} = \frac{\partial}{\partial t} \int_V \rho\phi dV + \oint_S \mathbf{f} \cdot \hat{\mathbf{n}} dS$$

APL106 : Governing equations

- for $\Phi = m$, $\phi = \frac{d\Phi}{dm} = 1$, we get continuity equation

$$\frac{\partial}{\partial t} \int_V \rho dV + \oint_S \rho \mathbf{u} \cdot \hat{\mathbf{n}} dS = 0.$$



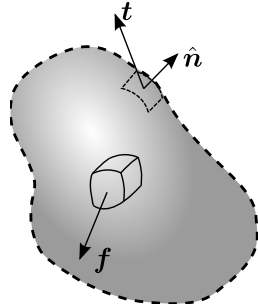
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- for $\Phi = m\mathbf{u}$, $\phi = \mathbf{u}$, we get momentum equation

$$\frac{d\Phi}{dt} = \frac{\partial}{\partial t} \int_V \rho \mathbf{u} dV + \oint_S \rho \mathbf{u} \mathbf{u} \cdot \hat{\mathbf{n}} dS = \int_V \mathbf{f} dV + \oint_S \mathbf{t} dS$$



APL106 : Governing equations

- for $\Phi = m$, $\phi = \frac{d\Phi}{dm} = 1$, we get continuity equation

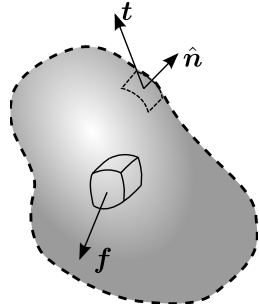
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- for $\Phi = m\mathbf{u}$, $\phi = \mathbf{u}$, we get momentum equation

$$\frac{d\Phi}{dt} = \frac{\partial}{\partial t} \int_V \rho \mathbf{u} dV + \oint_S \rho \mathbf{u} (\mathbf{u} \cdot \hat{\mathbf{n}}) dS = \int_V \mathbf{f} dV + \oint_S \mathbf{t} dS$$

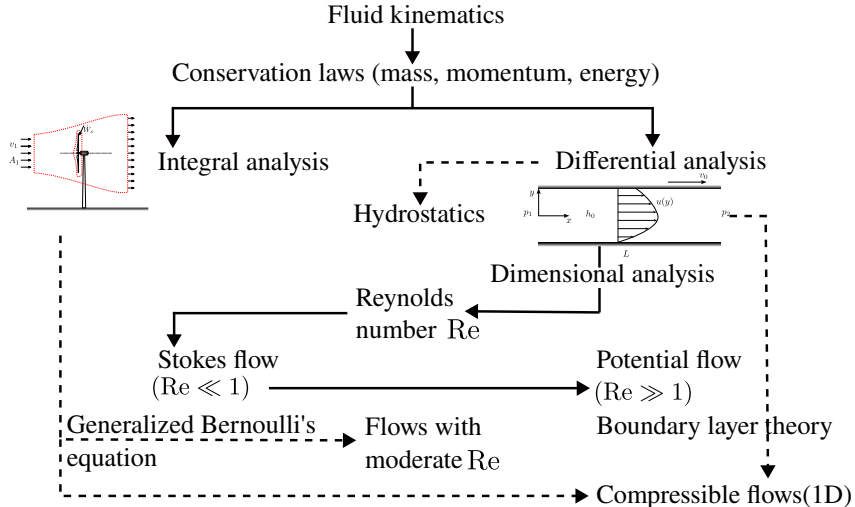
- for $\Phi = me$, $\phi = e$ (total energy), we get the total energy equation

$$\frac{d\Phi}{dt} = \frac{\partial}{\partial t} \int_V \rho e dV + \oint_S \rho e \mathbf{u} \cdot \hat{\mathbf{n}} dS = \int_V \mathbf{f} \cdot \mathbf{u} dV + \oint_S \mathbf{t} \cdot \mathbf{u} dS + \oint_S \mathbf{q} \cdot \hat{\mathbf{n}} dS$$

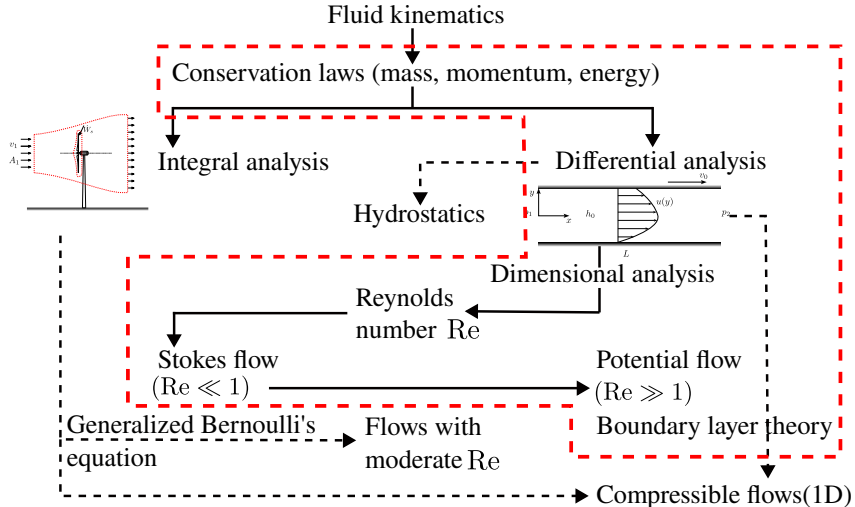




APL106 : Fluid Mechanics

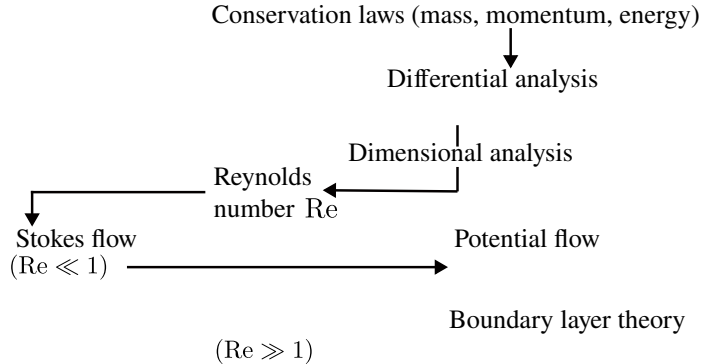


APL106 : Fluid Mechanics



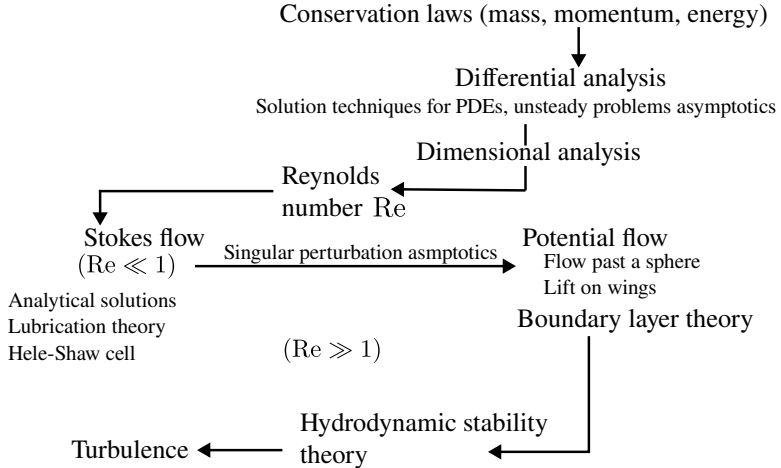


APL361 : Advanced fluid dynamics





APL361 : Advanced fluid dynamics





APL361 : Course policy and takehome

- Assessment: Mid-term (30%), Major exam (30%), Best 5 (out of 7) quizzes (40%)
- Tentative audit criterion - 30%

A Course Coordinator may choose any one or more of the following as attendance policy.

- (a) The Course Coordinator can assign 10% of the total marks to surprise quiz(zes). If attendance of the student is greater than 90%, result of the best three quizzes will be considered, else average of all quizzes will be considered.
- (b) The Course Coordinator can allocate specific marks for participation in discussions in the class on a regular basis.

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Courses of Study 2023-2024

- (c) If a student's attendance is less than 75%, the student will be awarded one grade less than the actual grade that he/she has earned. For example, a student who has got an A grade but has attendance less than 75% will be awarded an A (-) grade.
- (d) A student cannot get NP for an audit course if his/her attendance is less than 75%.



APL361 : Course policy and takehome

- Assessment: Mid-term (30%), Major exam (30%), Best 5 (out of 7) quizzes (40%)
- Tentative audit criterion - 30%

By the end of the this course, hopefully,

- you would know how to solve a few linear PDEs and how to reduce a few nonlinear PDEs into nonlinear ODEs.
- you would have some idea of how asymptotics work. Regular and singular perturbation techniques will be used extensively in the course.
- fluid dynamics will seem less daunting...
- turbulence won't give you nightmares...



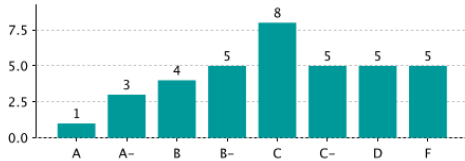
APL361 : 2023-2024 Semester 1

Course Title ADVANCED FLUID DYNAMICS

Course Id : APL361

Faculty : PRATEEK GUPTA

Year and Semester Registration 2023-24 Sem (1)



- Eventually 2 students failed (after re-major).
- Around 15% of the class was actually interested in the course material (that too only to a limited extent).
- Intermediate difficulty of exams (from my side). Quiz-1 was same as your APL106 quiz-1.
- Avg scores: Quiz -1 (20.5/50), Quiz - 2(14/50), Midterm (20.4/140), Major (28/160)
- Max scores: Quiz -1 (45/50), Quiz - 2 (29/50), Midterm (58/140), Major (90/160)



APL361 : 2023-2024 Semester 1 - feedback

- 4 Bb
- 5 drop the course
- 6 i liked the course
- 7 I think the mid semester exam was too lengthy (too many subparts). The length of quizzes was just right, and I wish the midsem exam would have been like that.
- 8 N/A
- 9 nil
- 10 no
- 11 No Opinion
- 12 remove this professor - bring someone who teaches with passion (like him) but also respects other careers too.

- As usual, most of the feedback was “No opinion”. Participants - 18/36
- A few disliked long exams.
- A few hated that I didn't approve of their career choices.





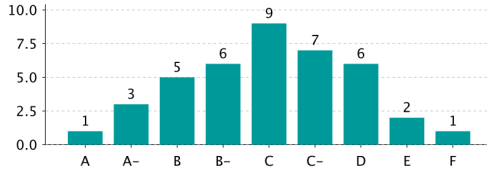
APL361: 2024-2025 Semester 1

Course Title ADVANCED FLUID DYNAMICS

Course Id : APL361

Faculty : PRATEEK GUPTA

Year and Semester Registration 2024-25 Sem (1)



- Eventually 1 student failed (after re-major).
- Around 10% of the class was actually interested in the course material (that too only to a limited extent). Thanks to our esteemed faculty reinforcing that SDE at “Microsoft” (and the likes) is a core job for ECM batch, and then keeping advanced fluid mechanics as a core course!
- Avg scores: Quiz -1 (15/40), Quiz - 2(9.8/40), Quiz - 3 (11.6/40), Quiz-4 (11.3/40), Quiz-5 (2.14/40), Quiz-6 (9.7/40), Quiz-7 (11.7/40) Midterm (29.9/120), Major (22/120)
- Max scores: 29, 32.5, 36, 28.5, 20, 32, 30, 89, 70



APL361: 2024-2025 Semester 1-feedback

Question : Any suggestions or comments about the course

- 1 -
- 2 .
- 3 I DONT UNDERSTAND WHY EVERYONE DISLIKE THE PROF, BUT THE PROFESSOR TEACHES THE BEST I FEEL AND CALM TOO
- 4 make it easier or remove the course
- 5 n/a
- 6 NA
- 7 No need to keep such an advanced course as core for everyone. Keeping it as an elective would make much more sense. Showing practical applications of the topics being taught would help appreciate them better.
- 8 No Opinion
- 9 None

Question : What did you dislike most about this course?

- 1 -



APL361: 2024-2025 Semester 1-feedback

- 2 7 quizzes did not help at all. Quiz questions were not of appropriate length. Some of the content just doesn't seem to have any practical applications.
- 3 n/a
- 4 NA
- 5 No Opinion
- 6 Prof. Prateek gupta is very insensitive and inhuman.
- 7 SCALING DOWN OF EXAM WEIGHTAGE WERE TOO HIGH
- 8 The course content , too heavy
- 9 The timing of the course, if the course were in 6th semester (exchanging with some other core course) or if the amount of core courses in 7th semester were lower, then this course would have been done better.

Question : What did you like the most about this course?

- 1 -
- 2 As someone who likes maths, I liked a nice mathematical deep dive into fluid dynamics. It has been long since I studied something new in fluids.
- 3 Even though the math was tough at times, really liked the way it was taught. Quizzes also helped a lot.
- 4 n/a



APL361: 2024-2025 Semester 1-feedback

Question : What did you like the most about this course?

- 1 -
- 2 As someone who likes maths, I liked a nice mathematical deep dive into fluid dynamics. It has been long since I studied something new in fluids.
- 3 Even though the math was tough at times, really liked the way it was taught. Quizzes also helped a lot.
- 4 n/a
- 5 NA
- 6 No Opinion
- 7 nothing
- 8 The passion of the professor
- 9 The way the professor try and makes us understands the topic
- 10 We delved deep into fluid mechanics which helped build a better understanding. The passion of the coordinator for the course was appreciable.

- Participants - 24/40
- Majority said quizzes helped in continuous learning.
- A few did not like that I was not human being enough!
- Link to my blood report.....



APL361 : learnings

"You can only take a horse to the water but you can't make it drink"

- My commitment is towards the subject and doing justice to the content, considering your background knowledge.
 - I am not here to put my judgement of your personalities in writing. I would appreciate if you do the same.
 - My personal opinions towards your career choices should matter as much as anyone else's. Afterall, it is your choice, and if it is an informed choice, it shouldn't matter what others think.
 - Even if you are not particularly interested in the subject, it is your core course.
 - Feedback is the key to continuous improvement.
-
- Index notation....