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UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

OPEN-BOOK, OPEN-NOTES COMPUTER-BASED ENDSEM EXAMINATION, May 2021

Program: B-Tech Mechanical Engineering	**Semester: IV**
Subject (Course): Fluid Mechanics & Fluid Machines	**Max. Marks: 100**
Course Code : MECH2026	**Duration: 3 Hrs**
No. of page/s: 06	

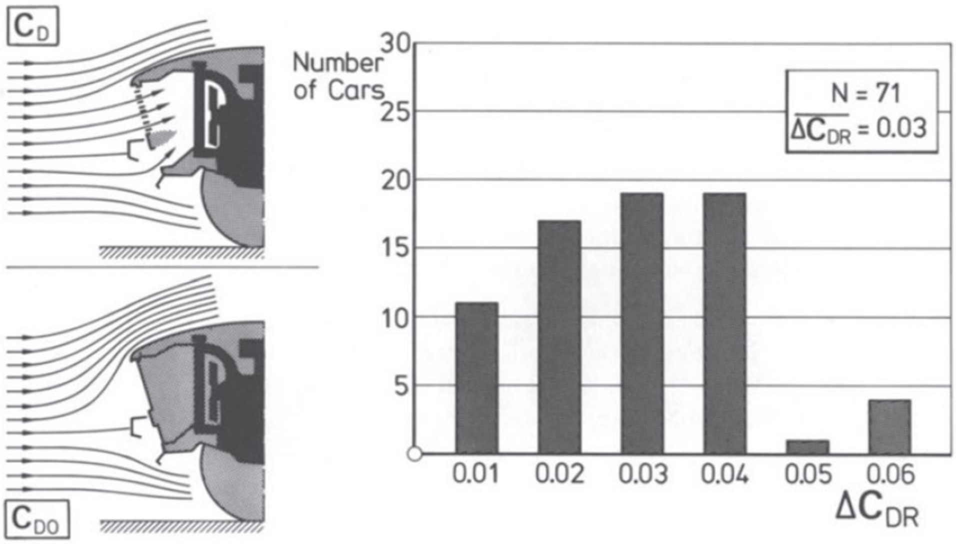
Instructions:

- Type your Name, Enrollment Number, and SAPID at the top of Word File. Use the MS-Word template already provided.
- Use of the Internet or WhatsApp is STRICTLY PROHIBITED during the exam. Any violation of this stipulation, detected later will naturally lead you to fail in the exam.
- You must stick to MS-Excel or any other software. However, only PDF submissions will be accepted. You may copy portions from your Excel sheet or your codes etc. as a proof of your work. **No Excel files will be accepted as a part of your submission.** These must be embedded in the word file itself.
- Your answers should be in the form of a well-documented report, akin to what is expected of an engineer. You must write the thought process that goes in every single step, and the equations must be typed using MS Word Equation Editor.
- Once you are done, convert your solutions into a PDF and **save by your SAPID and name** (e.g. 40001645_Akash Trivedi.PDF).
- The question paper consists of Section-A containing six 5-marks questions (6 x 5 = 30 Marks); Section-B consisting of five 10-marks questions (5 x 10 = 50 Marks) and section-C consisting of a single 20-Marks question. All questions are compulsory. Answer only one part where options are given (there are two such questions: one each in Section B and Section C)

<table>
<tr><td colspan="4">Section A (Attempt all)</td></tr>
<tr><td>1</td><td>


The figure above shows three different Volkswagen car designs, which fall into the category of 1-‘Fastback’,2-‘Notchback’, and 3-‘Square back’ cars. What would be your understanding of the total drag experienced by these cars? Write a brief comparison, explaining the reason behind it and assumptions taken (Be brief!)</td><td>[5]</td><td>CO1</td></tr>
<tr><td>2</td><td>Automobiles need to breathe air for purposes such as cooling engines. This lead to an additional ‘cooling drag’ on the automobiles The pictures and the plots below represent this phenomenon:

The figure above shows setups for an experiment conducted in which the drag coefficient was estimated. The difference between the drag coefficient is shown below:</td><td>[5]</td><td>CO1</td></tr>
</table>

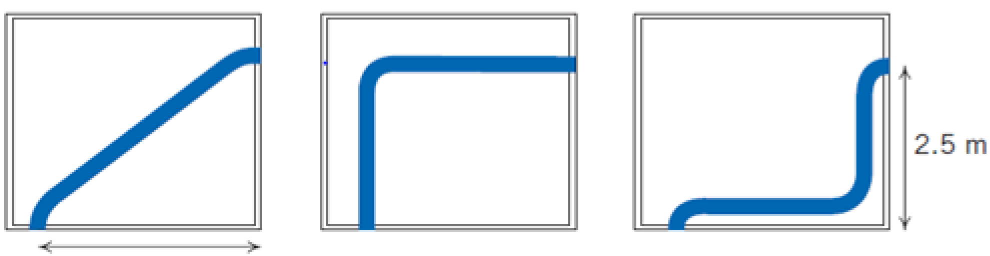
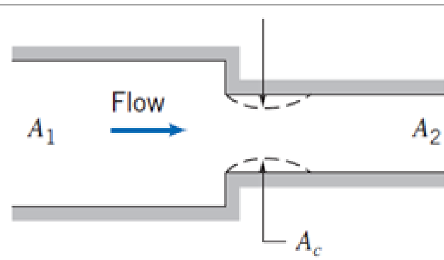
<table>
<tr><td></td><td>

Explain, in which case the drag coefficient will be larger & Why? (Be brief!)</td><td></td><td></td></tr>
<tr><td>3</td><td>Consider the flow field equation.

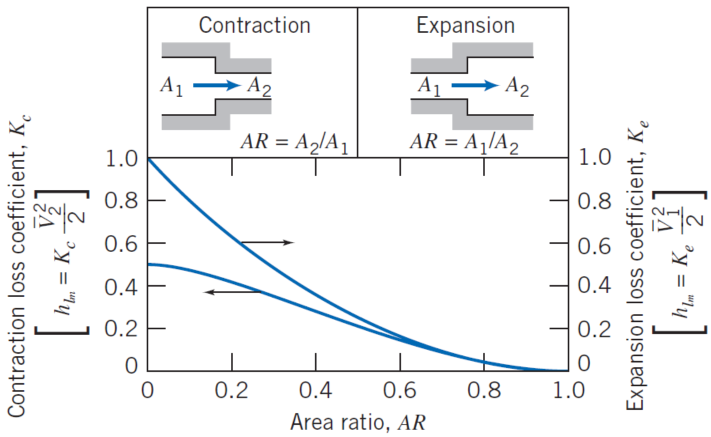
$$V = xi + ytj$$

This flow is unsteady (it depends on time) and two-dimensional (it depends on two space coordinates, x, and y).
Plot-
(a) The streamline and;
(b) The pathline passing through the point [1,1] at time t = 0.</td><td>[5]</td><td>C
O
1</td></tr>
<tr><td>4</td><td>The Martian atmospheric gas has a mean molecular mass of 32.0 and a constant temperature of 200 K(take ideal condition). The atmospheric density at the surface is ρ = 50.015 kg/m^3 and Martian gravity is taken as 3.92 m/s^2. Calculate the atmospheric density at the height of 520 km above the surface. Plot the ratio of density to surface density as a function of height. Compare with that for data on the Earth's atmosphere.</td><td>[5]</td><td>C
O
2</td></tr>
<tr><td>5</td><td>A centrifugal water pump running at speed ω = 800 rpm has the following data for flow rate, Q, and pressure head, Δp.
<table>
<tr><td>Q (m^3/min)</td><td>0</td><td>1.416</td><td>2.124</td><td>2.832</td><td>3.398</td><td>3.964</td><td>4.247</td><td>4.672</td></tr>
<tr><td>Δp (N/m^2)</td><td>361.017</td><td>349.047</td><td>327.979</td><td>293.027</td><td>229.825</td><td>145.077</td><td>113.955</td><td>58.892</td></tr>
</table>
The pressure head is a function of the flow rate, speed, impeller diameter D, and water density $\boldsymbol{\rho}$. Plot graph between pressure head versus flow rate. Find the two Π parameters for this problem, and, from the above data, plot one against the other. By using Excel to perform a trendline analysis on this latter curve, generate and plot data for pressure head versus flow rate for impeller speed of 600 rpm and 1200 rpm.</td><td>[5]</td><td>C
O
2</td></tr>
<tr><td>6</td><td>The flow in circular tubes, a transition to turbulence usually occurs around Re ≈ 2300.</td><td>[5]</td><td>C</td></tr>
</table>

	Investigate the circumstances under which the flow of (a) Standard air and (b) Water at 15 degrees celsius become turbulent. On log-log graphs, plot: the average velocity, the volume flow rate, and the mass flow rate, at which turbulence first occurs, as functions of tube diameter Also, add these fluids: 1) Ethylene Glycol 2) Gasoline Or Two immiscible fluids having equal density are flowing down on an inclined surface at a 60-degree. The thickness of two-fluid layers is h= 10 mm; the kinematic viscosity of the upper fluid is 1/5th that of the lower fluid, which is V lower = 0.01 m^2/s. Find the velocity at the interface and the velocity at the free surface. Plot the velocity distribution.		O 2
	Section B (Attempt all)		
1	Gasoline flowing in an underground pipeline at 15-degrees Celsius (Constant Temperature). Two pumping stations at the same elevation are located 13 km apart. The pressure drop between the stations is 1.4 MPa. The pipeline is made from a 0.6-m-diameter pipe. The material used is commercial steel but age and corrosion increased the pipe roughness to approximately that for galvanized iron. Compute the volume flow rate. How long will it take for the Gasoline flowing through such a pipeline to fill a 10,000 L tank?	[10]	CO 2
2	Maintenance work on high-pressure hydraulic systems requires special precautions. A small leak can create a high-speed jet of hydraulic fluid that can penetrate the skin and cause serious injury (therefore troubleshooters are cautioned to use a piece of paper or cardboard, *not a finger*, to search for leaks). Calculate the jet speed of a leak versus system pressure, for the highest pressure of 40 MPa (gage). Explain how a high-speed jet of hydraulic fluid can cause injury.	[10]	CO 3
3	Velocity profiles in laminar boundary layers often are approximated by the equations Linear : $\frac{u}{U} = \frac{y}{\delta}$ Sinusoidal : $\frac{u}{U} = \sin\left(\frac{\pi}{2}\frac{y}{\delta}\right)$ Parabolic : $\frac{u}{U} = 2\left(\frac{y}{\delta}\right) - \left(\frac{y}{\delta}\right)^2$ Compare the shapes of these velocity profiles by plotting y/δ (on the ordinate) versus u/U (on the abscissa).	[10]	CO 3
4	The Colebrook equation for computing the turbulent friction factor is implicit in f. An explicit expression that provides desirable accuracy is-	[10]	CO

	$$f_0 = 0.25\left[\log\left(\frac{e/D}{3.7} + \frac{5.74}{Re^{0.9}}\right)\right]^{-2}$$ Compare the accuracy of this expression for f with Eq. 8.37 by computing the percentage discrepancy as a function of Re and e/D, for Re = 10^4 to 10^8 , and e/D = 0, 0.0001, 0.001, 0.01, and 0.05. What are the maximum discrepancy for these Re and e/D values? Plot f against Re with e/D as a parameter. Or A school project for fabricating ultralight airplane models. The material provided to students for making an airfoil from the plastic sheet of 1.524 m long 1.128 m wide & angle of attack need to be considered is ϴ = 10 degrees. At this airfoil's aspect ratio and angle of attack, the lift and drag coefficients are C_L = 0.75 and C_D = 0.19. If the airplane flies at U = 12.19 m/s, what is the maximum total payload it can carry? What will be the thrust required to maintain flight? Does this condition given seem feasible? Plot the maximum payload and thrust required as a function of airplane velocity.		3
5	A water pipeline of 5cm dia has to pass through a room in a government building. Three possible layouts for the pipeline are given, as shown. Find the best option, based on optimizing losses? The pipe material used is galvanized iron and a flow rate of 350 L/min.  (*a*) Two miter bends (*b*) A standard elbow (*c*) Three standard elbows	[10]	CO4
SECTION C (Attempt any One)			
1	 The figure shows flow-through a sudden contraction. The minimum flow area at vena contracta is given in terms of the area ratio by the contraction coefficient, $$C_c = \frac{A_c}{A_2} = 0.62 + 0.38\left(\frac{A_2}{A_1}\right)^3$$	[20]	CO4

The loss in a sudden contraction is mostly a result of the vena contracta: The fluid accelerates into the contraction, there is flow separation is shown by the dashed lines, and the vena contracta acts as a miniature sudden expansion with significant secondary flow losses. Use these assumptions to obtain and plot estimates of the minor loss coefficient for a sudden contraction, and compare with the data presented in the figure below.



Or

The entrance region of a parallel, rectangular duct flow is shown in the figure. The duct has a width W and height H, where W >> H. The fluid density $\boldsymbol{\rho}$ is constant, and the flow is steady. The velocity variation in the boundary layer of thickness δ at the station is assumed to be linear, and the pressure at any cross-section is uniform.

(a) Plot U_1/U_2 as a function of δ/H.

(b) Defining pressure coefficient at any x as the ratio of $(P_1 - P_x)$ and the dynamic pressure at 1, plot pressure coefficient as a function of x.

(c) $\boldsymbol{F_v}$ is the total viscous force acting on the walls of the duct, define a parameter C_V as the ratio of F_v and the product of area (WH) and dynamic pressure at location 1. Then, plot C_V as a function of δ/H. Also, write the expression derived before your plot.