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CINEC CAMPUS
Beyond A Graduate

Faculty of Engineering & Technology
Department of Civil Engineering
BSc. Hons. (Eng.) in Automotive/ Civil/ Electronic/ Mechanical/ Mechatronic Engineering
Semester 2 Final Examination 2026

Batch: 08

Module Code: CE1322	**Module Title: Fluid Mechanics**
Date: 24th April 2026	**Duration: 3 hrs**
Examiner:	**Mr. Umal Fernando**

Instructions to Candidates:

- *This is a closed book examination. No reference materials are allowed.*
- *This paper consists of four 05 questions and 7 pages. Answer all questions.*
- *The marks allocated to each question are listed in the column on the far right. Final mark of the question paper will be calculated out of 100.*
- *Use only the provided answer booklet, additional sheets, and graph papers for your answers.*
- *Write clearly and legibly. Use a blue or black pen only.*
- *Write your student number on all sheets.*
- ***Start each question on a new page** in the answer booklet, answer sheets. **Clearly indicate the question number at the top of the page.***
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b) Determine the inside pressure of a water droplet of diameter 0.04 mm if surface tension is given as 0.073 N/m of water. Assume atmospheric pressure = 10.325 N/cm². $(P = \frac{4\sigma}{d})$ [03]

Total [20]

Q2. i) A 3 m high and 6 m wide rectangular gate is hinged at the top edge at A and is restrained by a fixed ridge at B. The gate retains water to a depth of 5 m. (see **Figure 3**)

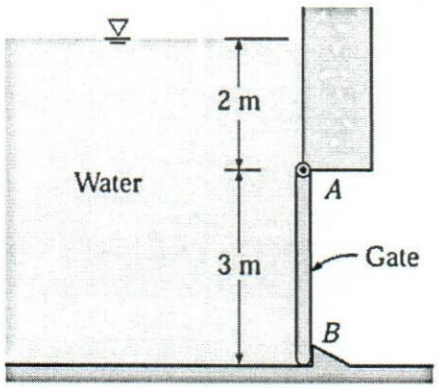


Figure 3

a) Draw the hydrostatic pressure distribution diagram acting on the gate. [02]

b) Determine the hydrostatic force acting on the gate and the location of the centre of pressure. [03]

c) Determine the reaction force at ridge B. [03]

$$(F = \rho g A \bar{h}\,, \quad h^* = \frac{I_G}{\bar{h}} + \bar{h}\,)$$

ii) a) Define the terms, Buoyancy and metacentric height. [02]

b) A solid cylinder of 3.6 m diameter and 2.8 m height is floating in water with its axis vertical. If the specific gravity of the material of the cylinder is 0.7, determine the metacentric height of the cylinder. $(I = \frac{\pi}{64} d^4, GM = \frac{I}{V} - BG)$ [07]

c) Name the three types of equilibrium (stability) of a floating body with respect to metacentric height. State the condition of metacentric height GM for each case. [03]

Total [20]

Q3. **i)** Differentiate between, [04]

a) Steady and unsteady flows
b) Compressible and incompressible flows

ii) A 25 cm diameter pipe carries oil of sp.gr. 0.9 at a velocity of 3 m/s. At another section the diameter is 20 cm. Find the velocity at this section and also the mass flow rate of oil. [04]

iii) A pipe of 300 mm diameter in horizontal plane carries water at a flow rate of 0.25 m^3/s. The pipe changes direction through an angle of 135^0 as shown in **Figure 4**. Determine the magnitude and direction of the resultant force exerted on the pipe bend. The pressure of the flowing water is given as 3.92×10^5 Pa.

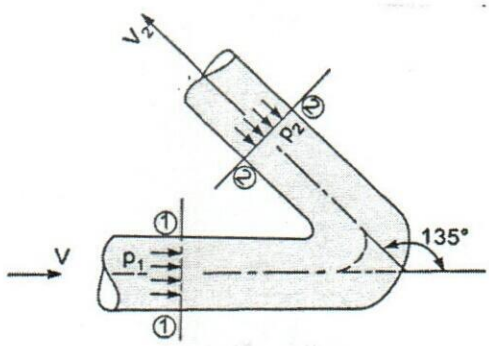


Figure 4 [08]

iv) A differential manometer is connected at the 2 points A and B as shown in **Figure 5.** At B air pressure is 9.81 N/cm^2. Find the pressure at A.

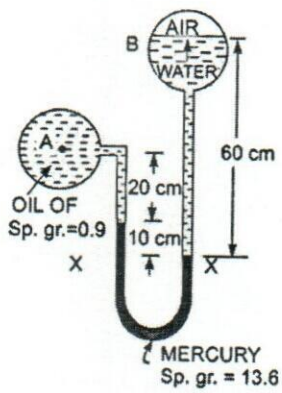


Figure 5 [04]

Total [20]

Q4. **i)** A horizontal venturi meter is installed in a pipeline to measure water flow. The diameters at the inlet and the throat are 300 mm and 150 mm, respectively (See **Figure 6**). A differential manometer connected between these two sections shows a reading of 200 mm of mercury. Determine the discharge through the pipe. (Cd = 0.96)

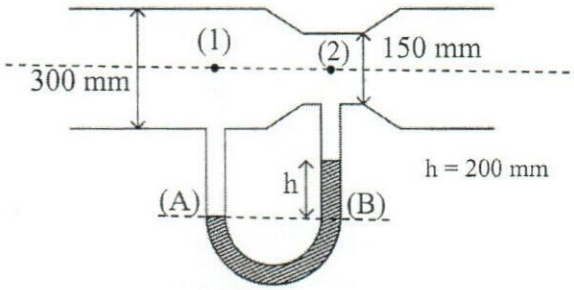


Figure 6 [05]

ii) Notches and weirs are commonly used to measure the flow rate in open channels. However, the theoretical discharge differs from the actual discharge due to several factors. A group of students conducted a laboratory experiment using a rectangular weir to determine the coefficient of discharge (C_d). The observations obtained during the experiment are given in the **Table 1** below.

a) Show that discharge over a rectangular weir is given by

$$Q = \frac{2}{3} L\sqrt{2gH^3}$$

Where H is the head of water over the crest and L is the length of the weir. [03]

b) For each set of observations, calculate the theoretical discharge using equation you derived in part (a) and actual discharge based on the experimental measurements. (L = 0.195) [05]

c) Plot a suitable graph to evaluate C_d and determine the average value of C_d. [05]

e) Briefly comment on why theoretical discharge differs from actual discharge. [02]

Total [20]

Q5. **i)** A water distribution pipe of length 720 m and diameter 400 mm has an absolute roughness of 0.3 mm. The average flow rate through the pipe is 1250 m^3/h, and the water temperature is 30°C. Determine the frictional head loss in the pipe. (Moody diagram is provided if needed at the end of the paper)

[06]

$$\mathrm{Re} = \frac{\mathrm{vD}}{\nu}, \nu = \frac{497 \times 10^{-6}}{(T + 42.5)^{1.5}} \quad T \text{ is in } C$$

$$\frac{1}{\sqrt{f}} = -2\log\left[\frac{5.1286}{Re^{0.89}} + \frac{k}{3.7D}\right], h_f = \frac{flv^2}{2Dg}$$

ii) Determine the discharge in each pipe of the network shown in **Figure 7** using the Hardy Cross method. The head loss in each pipe is given by $h_f = rQ^2$ where $r$is the resistance coefficient for each pipe. The values of $r$for all pipes, along with the inflows and outflows at the nodes, are provided in the **Figure 7**. For the initial trial, assume the following flow rates:

- Q_{AD} =30 m^3/s , flowing from node A to node D
- Q_{BD} = 10 m^3/s, flowing from node B to node D

Carry out the necessary iterations to determine the balanced flow distribution in the network. $(\Delta Q = \frac{-\sum rQ_0^2}{\sum 2rQ_0})$

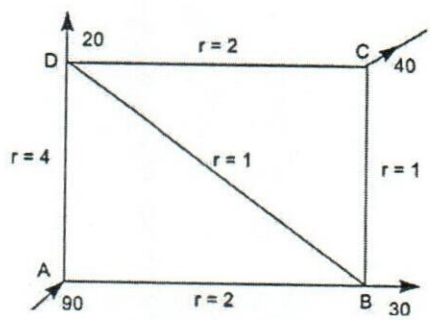


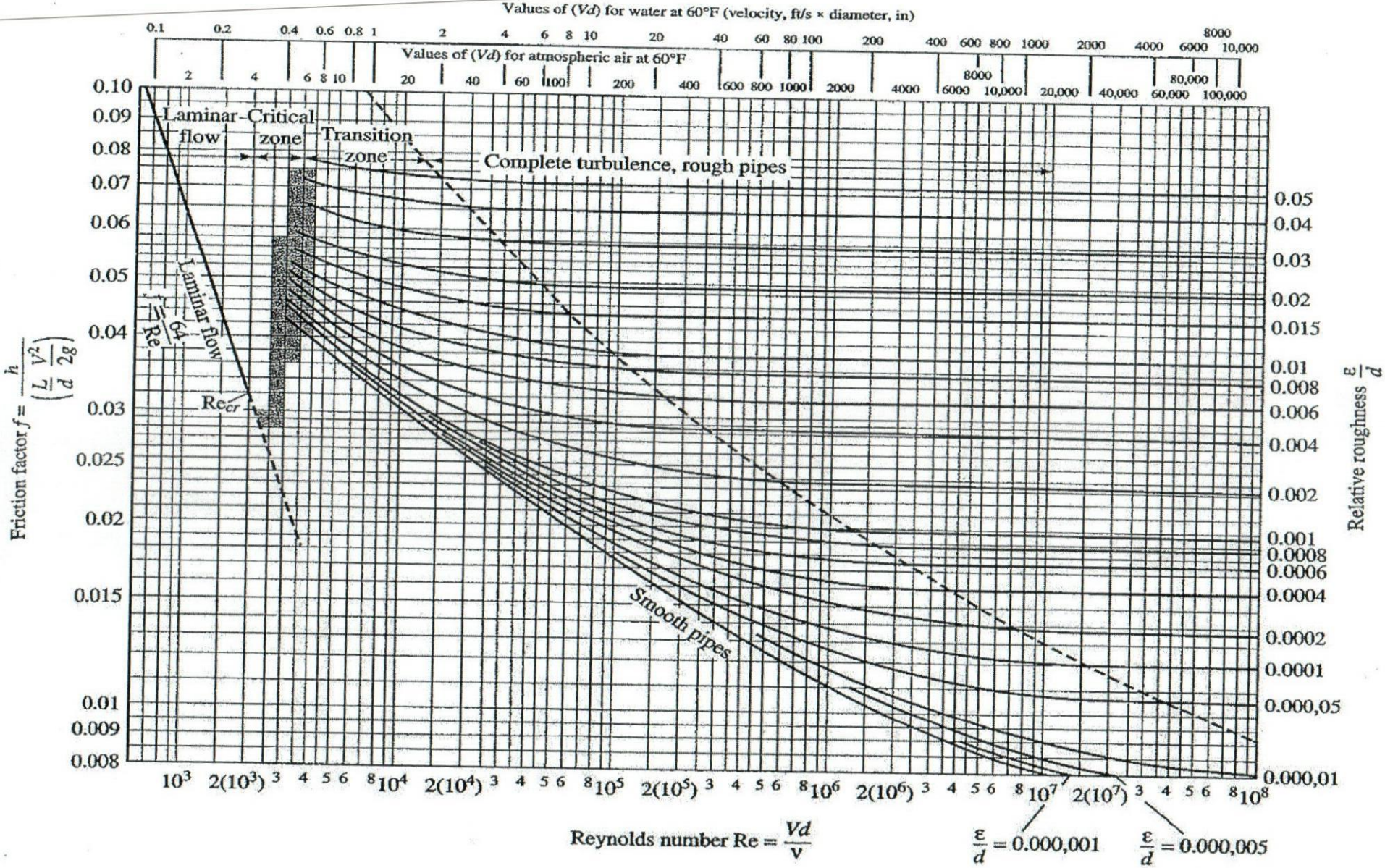
Figure 7

[14]

Total [20]

Table 1 – Observation sheet

No	Datum Height (m)	Water surface Elevation (m)	Volume collected (L)	Time for collection (s)
1	0.025	0.030	5	65
2		0.031		40
3		0.033		25
4		0.035		16
5		0.036		13


Values of (Vd) for water at 60°F (velocity, ft/s × diameter, in)
Values of (Vd) for atmospheric air at 60°F
Laminar flow
Critical zone
Transition zone
Complete turbulence, rough pipes
Laminar flow
f = 64/Re
Re_cr
Smooth pipes
Friction factor f = h / (L/d V²/2g)
Relative roughness ε/d
Reynolds number Re = Vd/ν
ε/d = 0.000,001
ε/d = 0.000,005

CINEC CAMPUS
Beyond A Graduate

Faculty of Engineering & Technology
Department of Civil Engineering
BSc. Hons. (Eng.) in Civil Engineering
Semester 5 Re-Sit - Final Examination 2025
Batch: 05

Module Code: CE3324	**Module Title: Highway & Transportation Engineering**
Date: 07 02 2026	**Duration: 3 hours**
Examiner 1: **Examiner 2:**	**Eng. (Mr.) Chathura Vidanapathirana**

Instructions to Candidates:

This is an open book examination. you are allowed to bring in your study notes and a calculator only.

- *This paper consists of four (4) questions and 6 pages. Answer all questions.*
- *The marks allocated to each question are listed in the column on the far right. Final mark of the question paper will be calculated out of 100.*
- *Use only the provided answer booklet, additional sheets, and graph papers for your answers.*
- *Write clearly and legibly. Use a blue or black pen only.*
- *Write your student number on all sheets.*
- *Start each question on a new page in the answer booklet, answer sheets. Clearly indicate the question number at the top of the page.*
- *If parts of the same question are written discontinuously in non-consecutive sheets, ensure that each part is relevantly labelled with its corresponding question number.*
- *A graph sheet will be provided*

Q1	i)	Elaborate on the procedure for determining the space mean speed of a road section using a traffic survey, including the necessary calculation steps in you explanation		[04]
	ii)	A speed survey was conducted on a highway section. Initially, one direction of the highway was considered, with two enumerators stationed at locations P and Q, which are 1.7 km apart. The survey data collected for movements from P to Q are presented in Table 1 below. In addition, the spot speeds of vehicles were measured at location P.		
		a)	Based on the survey data, determine the 'time mean speed at location P' and the 'space mean speed' of the above highway section in km/h	[06]
		b)	Explain why 'space mean speed' is more suitable for traffic analysis compared to time mean speed	[02]
	iii)	The traffic on a freeway follows the Greenshields' model. Estimations show a free-flow speed of 75km/h for this traffic stream. The maximum traffic density observed on this freeway is 150veh/km/lane		
		a)	Calculate the space mean speed of the traffic when the density is 50veh/km/lane	[03]
		b)	Calculate the flow rate of the scenario mentioned in Q1-iii-a	[02]
		c)	If the condition of the same traffic changes and the new space-mean speed is 25km/h, what would the new traffic density be?	[02]
		d)	Determine the traffic flow rate of the scenario mentioned in Q1-iii-c	[02]
		e)	Compare and discuss the flow rates obtained in Q1-iii-b and Q1-iii-d. You are expected to use a graphical illustration to support your answer	[04]
			Total	**[25]**
Q2	i)	Discuss why the deterministic queuing models are more suitable for analysis when the vehicles are arriving steadily at a queue counter		[03]
	ii)	A cinema hall has two ticketing counters to issue tickets. The time taken by the operator to issue a ticket is 1 minute. The cinema opens at 10 a.m. and people start queuing up on a single channel. Till 11:00 a.m., only one counter is operated and after 11.00 a.m. both counters are put into operation for the rest of the day. The arrival of people at the cinema is at a constant rate of 90 people/hour.		

	a)	State whether the given scenario can be analysed with a deterministic approach. Clearly mention your arguments	[02]
	b)	Illustrate the queuing situation at the ticketing counters on a graph	[06]
	c)	Identify the point of dissipation of the queue on the graph and mention the time	[02]
	d)	What is the maximum individual delay observed during the queuing phase?	[02]
	e)	What is the maximum queue length observed during the queuing phase?	[02]
	f)	Calculate the total system delay during the queuing phase	[03]
	g)	Determine the average queue length and average delay per person	[04]
	h)	Estimate the delay experienced by the 180th person to arrive at the cinema	[01]
		Total	**[25]**

Q3 A two-way two-lane class I highway is being designed to offer transport facilities for the next 20 years. The design has a carriageway width of 3.6m and a shoulder of 1.1m. A base free-flow speed of 80km/h has been recommended, and the design has considered a peak hour factor of 0.9 with a present-day demand volume of 800vph.

The highway is 10km long and is on a level terrain in a non-built-up area. 25 access points are available along the stretch of the highway having restrictions on vehicle passing limited to 50% of the entire length. This route is used for transportation of goods, hence, 20% of the traffic is trucks. Trips are happening on both directions with a split of 50/50.

You have been assigned as the consultant to the project and are required to assess the above design for the year 2046. The traffic growth of the road network is 2.048% per year. You may consider the capacity of a two-lane highway as 1,700 pc/h for each direction of travel and the total capacity as 3,200 pc/h.

The preferred design standard in this analysis is Highway Capacity Manual 2000. The following questions are regarding the situation in 2046.

i)	Estimate the demand volume for the year 2046	[02]
ii)	Considering the characteristics of the highway, calculate the free-flow speed of this highway.	[03]

	iii)	Calculate the demand flow rate (v_p) required to determine average travel speed	[05]
	iv)	Calculate the demand flow rate (v_p) required to determine percent time spent following	[04]
	v)	Perform a check to see if the obtained demand flowrates comply with the capacity of the highway	[02]
	vi)	Determine the level of service of the highway with respect to the travel speed.	[04]
	vii)	Determine the level of service of the highway with respect to the percent time spent following	[04]
	viii)	What do you recommend as the final level of service of this highway?	[01]
		Total	**[25]**
Q4	i)	A crash test was done on a vehicle. The test specifications require the vehicle to travel at a speed of 80km/h and apply breaks at a distance of 20m from the test barrier. If the testing ground is a flat surface paved with asphalt concrete that has a longitudinal friction coefficient of 0.65, calculate the impact speed of the vehicle when it hits the barrier.	[04]
	ii)	A racetrack has a side friction coefficient of 1.2 and a superelevation of 30%. If the top speed of race cars is 254km/h, estimate a suitable radius of curvature (R) for this racetrack.	[03]
		A Policy on Geometric Design of Highways and Streets 5th edition, 2004 published by American Association of State Highway and Transportation Officials (AASHTO) is the preferred standard when answering questions Q4-iii and Q4-iv.	
	iii)	Considering the stopping sight distance (SSD), determine the length of the crest curve that is required to connect the two grades: G1 = 3.5% and G2 = -2.5%. Assume the design speed of the road as 70km/h. For a passenger car, the height of eye above roadway surface is typically 1080mm and the height of object above roadway surface has to be 600mm.	[04]
	iv)	The answer obtained in Q4-iii is suitable for passenger cars. However, for heavy vehicles such as trucks, buses, and large lorries, this curve length may not be adequate as they require comparatively more time to stop the vehicle (due to inertia and low deceleration rate). Hence, their SSD requirement is also high. If	[03]

		the vertical curves are designed using 'passenger car' as the base, how do the roads still be safe with respect to such heavy vehicles? Discuss		
	v)	A traffic survey was conducted to propose a design for the pavement in a road rehabilitation project. The traffic volumes and Equivalent Single Axel Load factors (ESAL) are provided in Table 2. The engineers have recommended a typical asphalt surface with suitable sub-layers for the pavement structure. The soil tests carried out on the subgrade produced a CBR value of 8.5%. The traffic growth in this area is expected to be approximately 3% per annum		
		a)	What is the most appropriate design life period for this highway?	[02]
		b)	Propose a suitable structural design for the pavement using an empirical approach (preferred standard: TRL Road Note 31)	[07]
		c)	Justify why the lightweight vehicles (e.g.: Motorcycle, Three-wheeler, Car, SUV, and Van) were not considered in the design	[02]
			Total	**[25]**

Table 1 – Survey data of the highway section

License plate number	Spot speed at P (km/h)	Observed time at P (AM)	Observed time at Q (AM)
KM-6548	55	11:45:35	11:48:07
CAB-9871	42	11:46:12	11:48:51
BK-5498	38	11:46:36	11:49:20
BO-3211	54	11:47:25	11:49:34
NJ-3251	36	11:48:55	11:50:51

Table 2 – Traffic volumes and ESAL factors

Vehicle type	Direction 01		Direction 02	
	Daily volume	ESAL factor	Daily volume	ESAL factor
Motorcycle	1834	-	1932	-
Three-wheeler	1442	-	1610	-
Car and SUV	1372	-	994	-
Van	546	-	546	-
Large Bus	175	0.400	225	0.400
Light Goods Vehicle	200	0.325	280	0.325

Medium Goods Vehicle	285	3.200	150	3.200
Heavy Goods Vehicle	14	8.000	7	8.000

End of the Question Paper