94-Agric-A4
Fluid Flow

National Exams May 2004

98-Agric-A4, Fluid Flow

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper a clear statement of any assumptions made.

2. Any non-communicating calculator is permitted. This is an Open Book exam. Note to candidates you must indicate the type of calculator being used, i.e. write the name and model designation of the calculator, on the first inside left-hand sheet, of the exam work book.

3. Any **four (4)** questions constitute a complete paper. Only the first four questions as they appear in your answer book will be marked.

4. All questions are of equal value.

Included Materials: Graph Paper, Moody Diagram, Table of roughness factors

1. (25 Marks)

A simple rectangular concrete channel is used to convey water from a farm field tile drainage system to a downstream water body. The channel has a width of 1.0 m and a height of 0.5 m and a uniform downward slope of 0.5%. The channel carries 0.45 m^3/s of clean water.

a) What depth of flow would you expect under uniform flow conditions?

b) What is uniform flow and under what conditions would you expect it to occur?

c) A small rise in the base of the channel is constructed to help monitor the flow in the channel. The height of the rise is 10% of the depth determined in part (a) above (if you were not able to complete part (a), you may use a height equal to 10% of the height of the channel.) The rise extends the full width of the channel, has a length of 0.5 m and has a smooth transition. What depth of flow would you expect over the rise? Comment on its suitability to measure the flow in the channel from a practical point of view.

d) Recommend a sharp crested weir (shape and dimensions) for installation in the channel to help monitor the discharge in the channel. It should be capable of measuring at least twice the flow in the original question without overtopping the channel. It will be installed at the end of the channel. For at least one discharge, calculate the depth over the weir and the upstream depth in the channel for that discharge.

2. (25 Marks)

A 1.5 m wide rectangular channel has a depth upstream of an undershot gate of $y_1 = 2.5$ m. The undershot gate is open 0.5 m allowing water to exit under the gate producing a downstream depth (y_2) of 0.5 m. Some distance downstream of this a hydraulic jump occurs producing a depth of y_3. You may assume no losses between points 1 and 2 and that the channel slope is essentially 0. What is:

a) The discharge through the gate?
b) The depth downstream of the hydraulic jump?
c) The losses associated with the hydraulic jump?
d) The length of the hydraulic jump?

3. (25 Marks)

Liquid manure (3% solids) needs to be pumped from an open tank to a sprinkler for irrigation purposes. The manure in the tank is at an elevation of 100 m, the pump is at an elevation of 101 m and the sprinkler head is at an elevation of 110 m. The sprinkler requires a pressure in the pipe just before the sprinkler of 74 kPa to work properly at a discharge of 20 L/s. The pump draws liquid manure from the tank through a 3 m long hose and delivers it to the sprinkler through a 100 m long hose. Both hoses are 100 mm in diameter made of flexible, smooth, material.

a) What are the losses in the 200 m long supply line from the discharge side of the pump to the sprinkler?
b) What pressure is required on the discharge side of the pump?
c) What overall head must be supplied by the pump?
d) What power of pump is required?
e) What is the Net Positive Suction Head for this installation?
f) What additional requirements would you specify for this pump?

4. (25 Marks)
Two plates, each 0.2 m^2 in area are parallel to each other and separated by a fluid-filled gap 0.1 mm thick. An experiment is conducted in which the plates are moved relative to each other at a steady speed and the force required to move it is then recorded. A table of values for two fluids is given below.

a) Which of the fluids is a Newtonian fluid and which a non-Newtonian fluid?
b) Fill in the required force for each fluid in the blank space in the table
c) Cite two examples of Newtonian fluids and two examples of non-Newtonian fluids.

Speed (m/s)	Force (N)	
	Fluid 1	Fluid 2
0	0	0
0.01	0.02	0.001
0.02	0.04	0.004
0.05	0.10	0.025
0.10	0.20	0.100
0.20	0.40	0.400
0.50	?	?

5. (25 Marks)

A single pipe is used to carry irrigation water from one pond to another under the influence of gravity alone. The pipe is a 15 cm diameter concrete pipe with a uniform downward slope of 1% for a distance of 500 m. The two ponds have water surface elevations that differ by 3.0 m. The entrance into the pipe in the first pond is through a vertical concrete wall with the pipe flush with the wall. The exit into the lower pond is directly out of the pipe into the water. Both ends are fully submerged.

a. What discharge would you estimate this pipe to carry under these conditions?
b. If a second pipe were added in parallel to the first one, with the same diameter, slope and length, only constructed with plastic, what would the total discharge be in the two pipes?
c. If the original pipe were to be replaced with a plastic pipe such that the discharge was double that determined in part (a), what diameter pipe would be required, to the nearest 5 mm? (Note, if you could not answer part (a), you may assume the answer to part (a) is 25 L/s.)

Appendix

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	n	Average roughness height ϵ	
		ft	mm
Artificial lined channels:			
Glass	0.010 ± 0.002	0.0011	0.3
Brass	0.011 ± 0.002	0.0019	0.6
Steel, smooth	0.012 ± 0.002	0.0032	1.0
Painted	0.014 ± 0.003	0.0080	2.4
Riveted	0.015 ± 0.002	0.012	3.7
Cast iron	0.013 ± 0.003	0.0051	1.6
Cement, finished	0.012 ± 0.002	0.0032	1.0
Unfinished	0.014 ± 0.002	0.0080	2.4
Planed wood	0.012 ± 0.002	0.0032	1.0
Clay tile	0.014 ± 0.003	0.0080	2.4
Brickwork	0.015 ± 0.002	0.012	3.7
Asphalt	0.016 ± 0.003	0.018	5.4
Corrugated metal	0.022 ± 0.005	0.12	37
Rubble masonry	0.025 ± 0.005	0.26	80
Excavated earth channels:			
Clean	0.022 ± 0.004	0.12	37
Gravelly	0.025 ± 0.005	0.26	80
Weedy	0.030 ± 0.005	0.8	240
Stony, cobbles	0.035 ± 0.010	1.5	500
Natural channels:			
Clean and straight	0.030 ± 0.005	0.8	240
Sluggish, deep pools	0.040 ± 0.010	3	900
Major rivers	0.035 ± 0.010	1.5	500
Floodplains:			
Pasture, farmland	0.035 ± 0.010	1.5	500
Light brush	0.05 ± 0.02	6	2000
Heavy brush	0.075 ± 0.025	15	5000
Trees	0.15 ± 0.05	?	?

* A more complete list is given in Ref. 3, pp. 110–113.

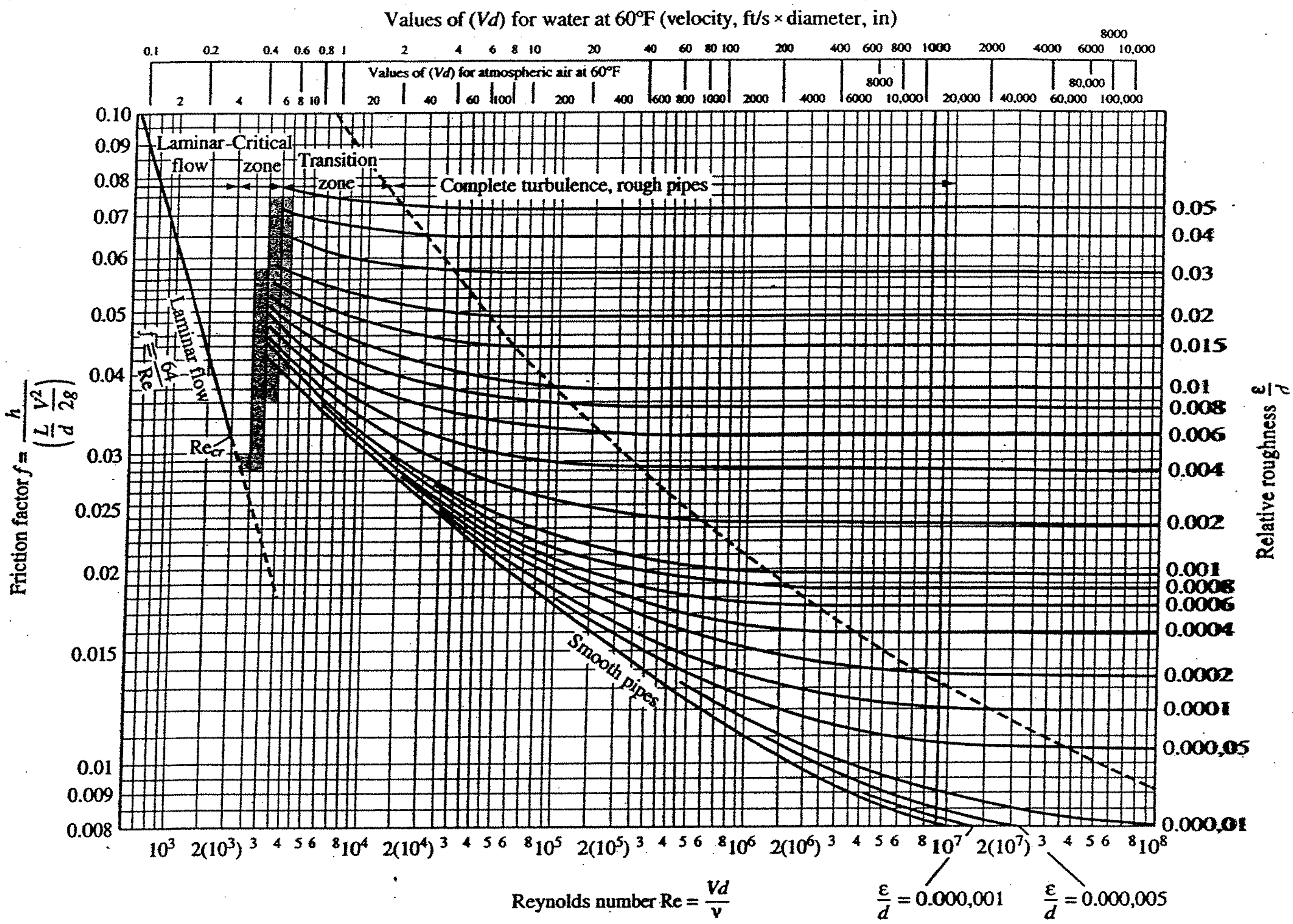

Fig. 6.13 The Moody chart for pipe friction with smooth and rough walls. This chart is identical to Eq. (6.64) for turbulent flow. (*From Ref. 8, by permission of the ASME.*)

From tests with commercial pipes Moody gave the values for average pipe roughness listed in Table 6.1.

Table 6.1 Average Roughness of Commercial Pipes

Material (new)	ϵ ft	ϵ mm
Riveted steel	0.003–0.03	0.9–9.0
Concrete	0.001–0.01	0.3–3.0
Wood stave	0.0006–0.003	0.18–0.9
Cast iron	0.00085	0.26
Galvanized iron	0.0005	0.15
Asphalted cast iron	0.0004	0.12
Commercial steel or wrought iron	0.00015	0.046
Drawn tubing	0.000005	0.0015
Glass	"Smooth"	"Smooth"