Second Semester Examination
2020/2021 Academic Session

July/August 2021

EAH316 – Hydraulic Structure

Duration : 1 hour

Please ensure that this examination paper contains **EIGHT (8)** printed pages before you begin the examination.

Instructions: This paper contains **THREE (3)** questions. Answer **ANY TWO (2)** questions.

All questions **MUST BE** answered on a new page.

1. (a). A pump is installed in an 18 cm diameter, 400 m long pipeline to pump 0.09 m^3/s of water at 26°C from a supply reservoir to the receiving reservoir. The elevation difference between the supply reservoir and the receiving reservoir is 18 m. If the pump has a 20 cm impeller intake diameter, a cavitation parameter of $\sigma = 0.13$, and experiences a total head loss of 1.5 m on the suction side, determine the maximum allowable distance between the pump intake and the water surface elevation in the supply tank. Assume the pipeline has C = 100 and please refer to Moody Chart in **Appendix 1** to aid your calculation.

[18 marks]

(b). A centrifugal pump delivers 30 L/s of water against a head of 12 meters and running at 1500 rpm which requires 12 kW of power. Determine the discharge, head of the pump and power required if the pump runs at 2000 rpm.

[12 marks]

(c). **Figure 1** illustrates a standard water pumping station with a minimum flowrate of 90 gpm from a reservoir to an elevated storage tank. The tanks are connected through a 40 cm diameter of wrought-iron pipe, 1800 m long with elevations difference of 20 m. By selecting the type of pumps from the set given in **Appendix 2**, calculate the discharge and total head at which the pumps operate.

[20 marks]

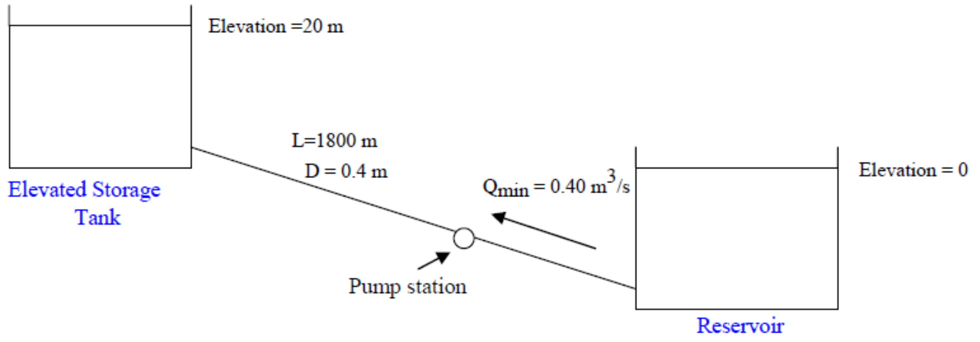


Figure 1: Typical water pumping station

2. (a). A 5 m wide spillway chute is designed to carry a maximum discharge of 20 m^3/s. A hydraulic jump is formed downstream of the chute where the pre-jump flow depth is 0.5 m. Determine the post-jump depth, Froude number and energy loss in the jump.

[15 marks]

(b). For a maximum discharge of 5500 m^3/s and a maximum total head on the spillway crest of 25 m, determine the crest length and the discharge at the design head of the standard ogee spillway.

[20 marks]

(c). Sedimentation in reservoirs is a naturally occurring process. Without sustainable management, sedimentation deposits will gradually displace the volume of water over a period of time. Discuss:

i) the advantages and disadvantages of reservoir sediment,
ii) the methods for measuring and monitoring sedimentation; and
iii) the potential sediment management strategies and its applicability

[15 marks]

3. (a). The outlet structure of a monsoon drain discharges water into the river via orifices of 150 mm, 300 mm and 500 mm diameter. The center of the 150 mm and 300 mm diameter orifices are both located at 47 m LSD while the center of 500 mm orifice is located at 46 m LSD. The invert level of the monsoon drain is located at 45.5 m LSD. The water depth in the monsoon drain is 3.5 m. Determine discharge from the monsoon drain to the river. Assume a free fall flow and C_d = 0.6.

[25 marks]

(b). A mini emergency spillway used a broad-crested overflow weir cut through original ground next to embankment. The transverse cross-section of the weir cut is trapezoidal in shape. The overflow weir is used to safely convey a 6 m^3/s flood. The weir coefficient is given in **Table 1 (Appendix 4)**. Determine the following (Use n = 0.01 and H_p = 1.0 m):

i) Spillway base width.
ii) Critical velocity at the control section of the weir.
iii) Critical slope at the control section of the weir.
iv) Sketch the cross-section at the control section of the weir.

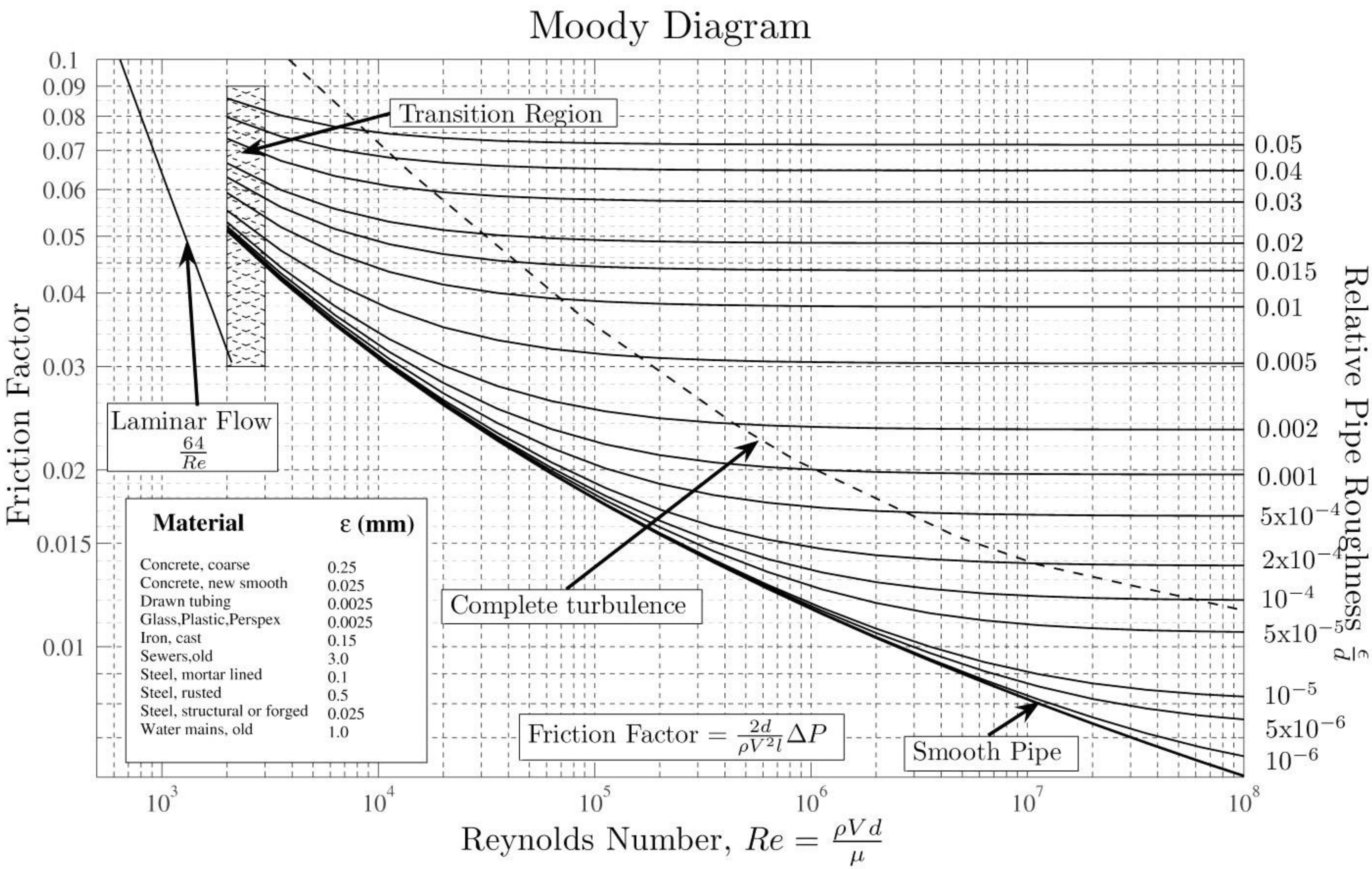
Given that,

$$V_C = 2.14\left(\frac{Q}{B}\right)^{0.33}$$

$$S_C = 9.84n^2\left(\frac{V_C B}{Q}\right)^{0.33}$$

[25 marks]

Appendix 1


Moody Diagram
Friction Factor
Relative Pipe Roughness $\frac{\epsilon}{d}$
Reynolds Number, $Re = \frac{\rho V d}{\mu}$
Transition Region
Laminar Flow $\frac{64}{Re}$
Complete turbulence
Smooth Pipe
Friction Factor $= \frac{2d}{\rho V^2 l} \Delta P$
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.015
0.01
10^3
10^4
10^5
10^6
10^7
10^8
0.05
0.04
0.03
0.02
0.015
0.01
0.005
0.002
0.001
$5x10^{-4}$
$2x10^{-4}$
10^{-4}
$5x10^{-5}$
10^{-5}
$5x10^{-6}$
10^{-6}
Material ε (mm)
Concrete, coarse 0.25
Concrete, new smooth 0.025
Drawn tubing 0.0025
Glass,Plastic,Perspex 0.0025
Iron, cast 0.15
Sewers,old 3.0
Steel, mortar lined 0.1
Steel, rusted 0.5
Steel, structural or forged 0.025
Water mains, old 1.0

Appendix 2

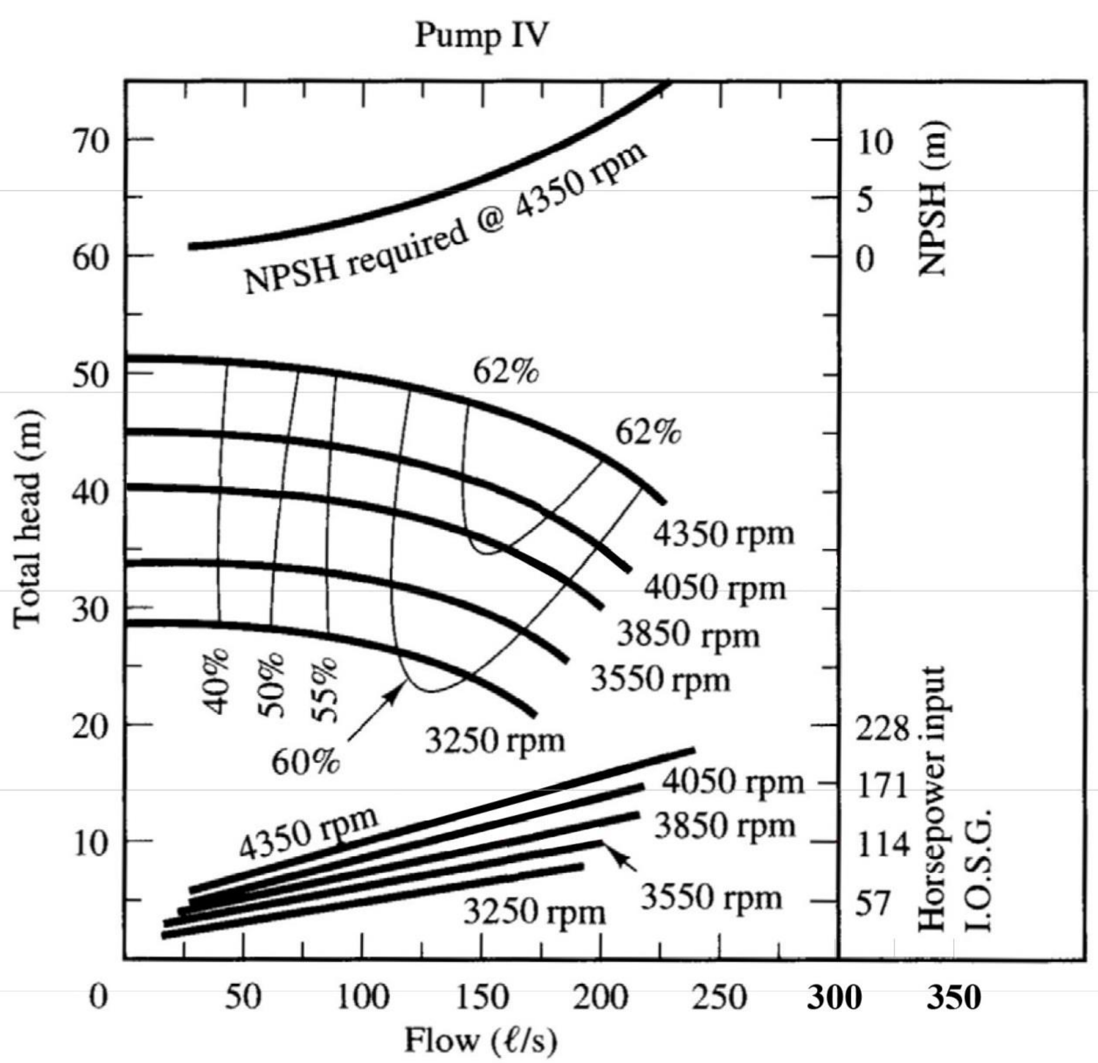


Figure 2: Pump performance curve type IV

Appendix 3

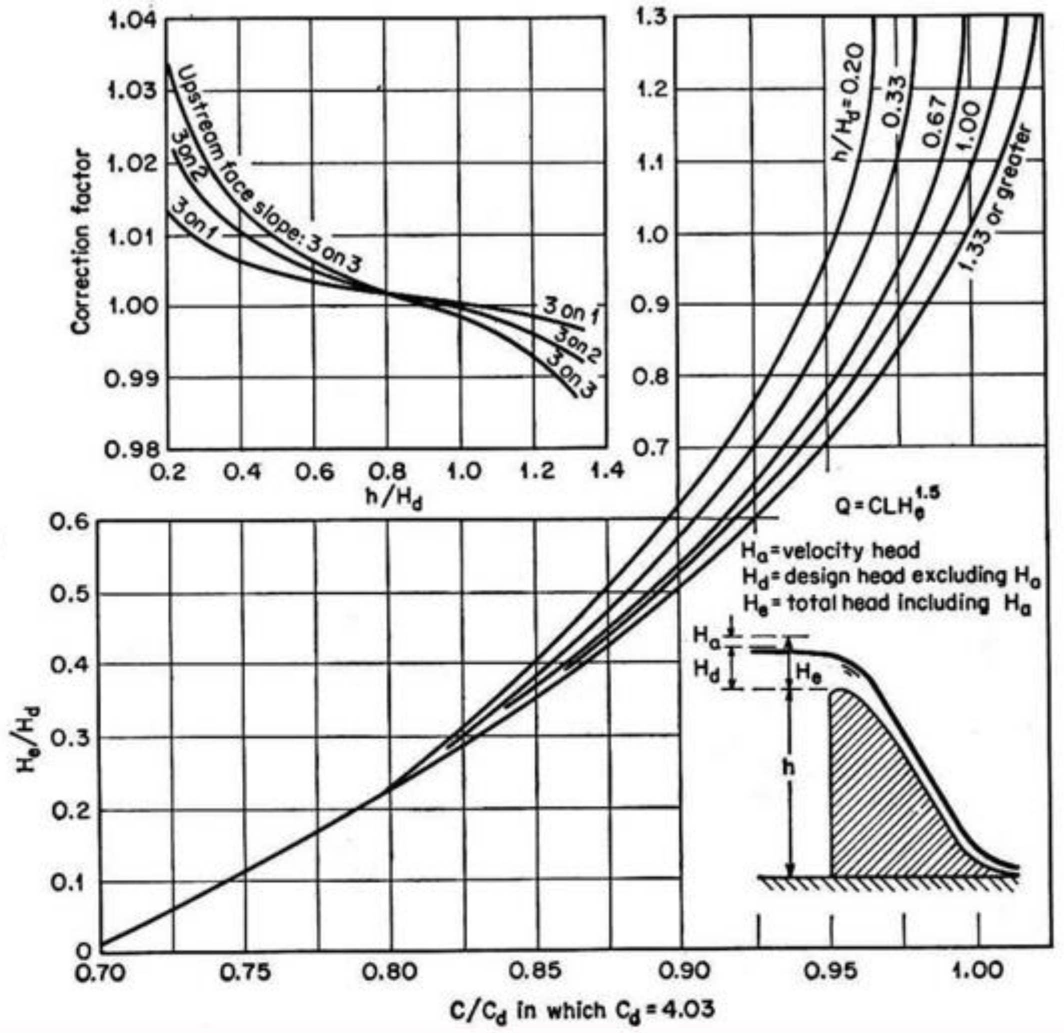


Figure 3: Discharge coefficient for the WES standard Spillway

Appendix 4

Table 1 Broad-crested weir coefficient C_{SP} values as a function of weir base width and head

Head H_p(m) [1]	Weir Base Width B (m)														
	0.15	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00	1.25	1.50	2.00	3.00	4.00
0.10	1.59	1.56	1.50	1.47	1.45	1.43	1.42	1.41	1.40	1.39	1.37	1.35	1.36	1.40	1.45
0.15	1.65	1.60	1.51	1.48	1.45	1.44	1.44	1.44	1.45	1.45	1.44	1.43	1.44	1.45	1.45
0.20	1.73	1.66	1.54	1.49	1.46	1.44	1.44	1.45	1.46	1.48	1.48	1.49	1.49	1.49	1.45
0.30	1.83	1.77	1.64	1.56	1.50	1.47	1.46	1.46	1.46	1.47	1.47	1.48	1.48	1.48	1.45
0.40	1.83	1.80	1.74	1.65	1.57	1.52	1.49	1.47	1.46	1.46	1.47	1.47	1.47	1.48	1.45
0.50	1.83	1.82	1.81	1.74	1.67	1.60	1.55	1.51	1.48	1.48	1.47	1.46	1.46	1.46	1.45
0.60	1.83	1.83	1.82	1.73	1.65	1.58	1.54	1.46	1.31	1.34	1.48	1.46	1.46	1.46	1.45
0.70	1.83	1.83	1.83	1.78	1.72	1.65	1.60	1.53	1.44	1.45	1.49	1.47	1.47	1.46	1.45
0.80	1.83	1.83	1.83	1.82	1.79	1.72	1.66	1.60	1.57	1.55	1.50	1.47	1.47	1.46	1.45
0.90	1.83	1.83	1.83	1.83	1.81	1.76	1.71	1.66	1.61	1.58	1.50	1.47	1.47	1.46	1.45
1.00	1.83	1.83	1.83	1.83	1.82	1.81	1.76	1.70	1.64	1.60	1.51	1.48	1.47	1.46	1.45
1.10	1.83	1.83	1.83	1.83	1.83	1.83	1.80	1.75	1.66	1.62	1.52	1.49	1.47	1.46	1.45
1.20	1.83	1.83	1.83	1.83	1.83	1.83	1.83	1.79	1.70	1.65	1.53	1.49	1.48	1.46	1.45
1.30	1.83	1.83	1.83	1.83	1.83	1.83	1.83	1.82	1.77	1.71	1.56	1.51	1.49	1.46	1.45
1.40	1.83	1.83	1.83	1.83	1.83	1.83	1.83	1.83	1.83	1.77	1.60	1.52	1.50	1.46	1.45
1.50	1.83	1.83	1.83	1.83	1.83	1.83	1.83	1.83	1.83	1.79	1.66	1.55	1.51	1.46	1.45
1.60	1.83	1.83	1.83	1.83	1.83	1.83	1.83	1.83	1.83	1.81	1.74	1.58	1.53	1.46	1.45

[1] Measured at least 2.5H upstream of the weir

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$$\frac{y_2}{y_1} = \frac{1}{2}\sqrt{1 - 8Fr^2} - 1$$

$$\Delta E = \frac{(y_2 - y_1)^3}{4y_1 y_2}$$

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