THIS QUESTION PAPER MUST BE HANDED-IN TO THE INVIGILATOR AT THE END OF THE EXAMINATION

CRANFIELD UNIVERSITY

Examination

SCHOOL OF ENERGY, ENVIRONMENT AND AGRIFOOD
WATER & WASTEWATER ENGINEERING
MSc / PgD / PgC
MTech IN WATER PROCESSES

HYDRAULICS AND PUMPS

Wednesday 6 January 2016: 09.00 – 11.30

Open Notes

INSTRUCTIONS TO CANDIDATES:

Attempt **all** questions in Section A.

Attempt **one question only** from Section B.

Attempt **one question only** from Section C

Start each answer on a separate page.

Candidates are allowed a non-programmable calculator and 1 x A4 file of material and personal notes.

Candidates may also have a copy of Hamill.

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SECTION A (COMPULSORY)

Question A-1 – Compulsory

A rectangular channel with a breadth of 2.3 m is to be used to deliver water at a constant discharge rate of 2.5 m^3/s. The hydraulic depth in the channel can range up to a maximum depth of 3.2 m dependent upon flow conditions upstream. Comment on the energy profile of the channel, whilst also specifically highlighting whether the process is supercritical or subcritical, and what might present the most appropriate operating depth for the proposed channel.

[10 Marks]

A rectangular concrete lined channel is required to provide a discharge rate of 6 m^3/s with a nominal slope of 1:235. Calculate the depth and breadth of the channel that will result in the optimum hydraulic section.

[10 Marks]

What is the mean velocity and discharge of an open [rectangular] channel whose dimensions are: width 4m; depth 1.5m; slope, 1:450; Chezy coefficient 53 $m^{1/2}/s$?

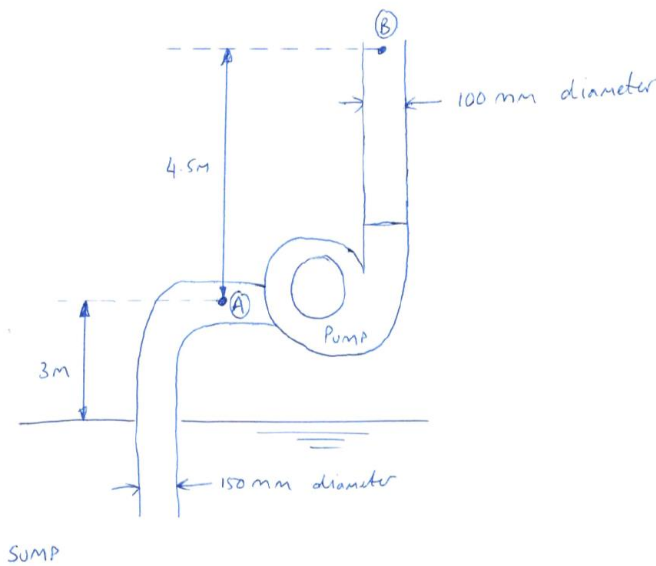
[5 marks]

Question A-2 – Compulsory

Part 1

Water is pumped from a sump using a pump. The pump operates as following:

- Flow rate: 6.9 m^3/min
- Power supplied by pump: 25 kW



i) Determine the pressure at A and B neglecting all losses from the system.

[10 marks]

ii) If the actual pressure at B is 25 kN/m^2, what is the total energy loss in m between the sump and point B?

[5 marks]

Part 2

A 500 mm diameter siphon discharges water from a large reservoir. Determine the maximum possible elevation of the top of the siphon relative to the surface of the reservoir in order to achieve a discharge of 2.15 m^3/s without the pressure becoming less than 20 kN/m^2 ABSOLUTE pressure.

[5 marks]

What is the corresponding elevation at the discharge end relative to the reservoir surface?

[5 marks]

SECTION B

Attempt <u>one</u> question from Section B

Question B-1

Part 1

Water is separated by a lock gate. The lock gate is 3.3 m wide and rectangular. On one side of the lock the water is 2.5 m high. On the other side the water is 1.9 m high.

i) Calculate the forces acting on each side of the gate

[6 marks]

ii) What is the magnitude of the overall hydrostatic force on the gate and at what height does it act?

[9 marks]

Part 2

i) Describe what happens when water flows over a solid boundary layer under conditions of: a) turbulent flow and b) laminar flow.

In your answer, explain how the boundary layer influences flow in a pipe for both flow conditions.

[10 marks]

Attempt <u>one</u> question from Section B

Question B-2

Part 1

A circular pipe of 1.2 m diameter discharges treated sewage to a river. At the end of the pipe is a circular flap gate that stops the discharge when the river is in flood. If the flood water reaches 2.3 m above the top of the flap gate calculate:

1) The pressure at the bottom of the flap gate
2) The force acting on the gate
3) The depth at which the resultant force acts.

[15 marks]

Part 2

A large tank discharges water through a 0.3m diameter horizontal pipe which terminates at a valve 25m below the water level in the tank. If the pipe is 1550 m long with a λ of 0.015 how long will it take for the velocity to reach 99% of its final steady state value? Ignore minor losses.

[10 marks]

SECTION C

Attempt <u>one</u> question from Section C

Question C-1

Water is pumped from reservoir A to reservoir B. The surface of reservoir B is 9.1 m above the surface of reservoir A.

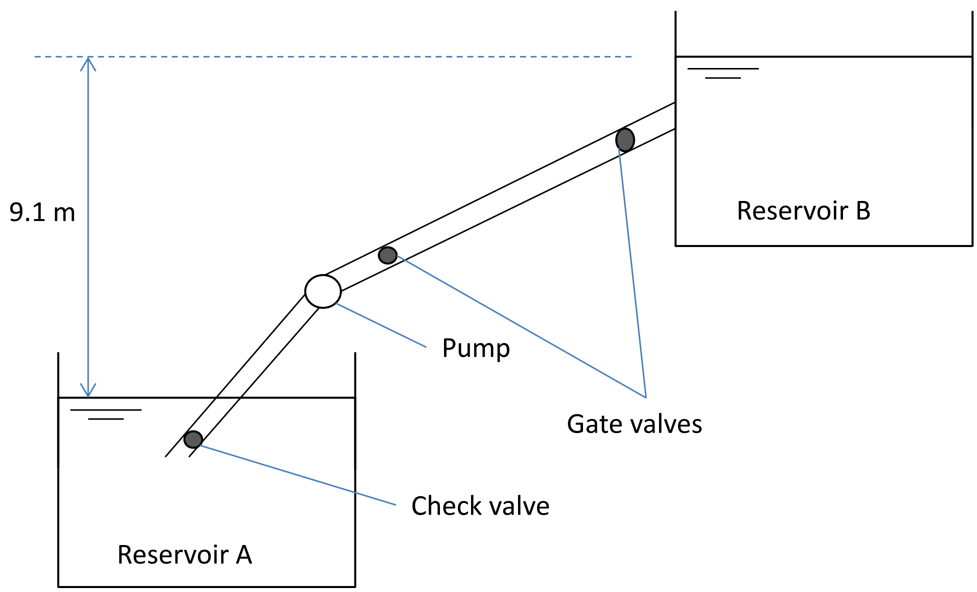
The suction pipe is of diameter 0.3 m and is 33.5 m long.

The discharge pipe from the pump to reservoir B is of 0.25 m diameter and 457 m long.

Assume that the friction factor for each pipe is 0.015.

The suction pipe has an entrance loss co-efficient, K_e, of 1.0 and a check valve loss co-efficient, K_v, of 2.5.

The discharge pipe has two gate valves each with a coefficient, Kgv, of 0.2.



The pump head/discharge curve is shown over page - see Figure.

The pump is operated at 1800 rpm.

At the operating point, the pump is 74% efficient.

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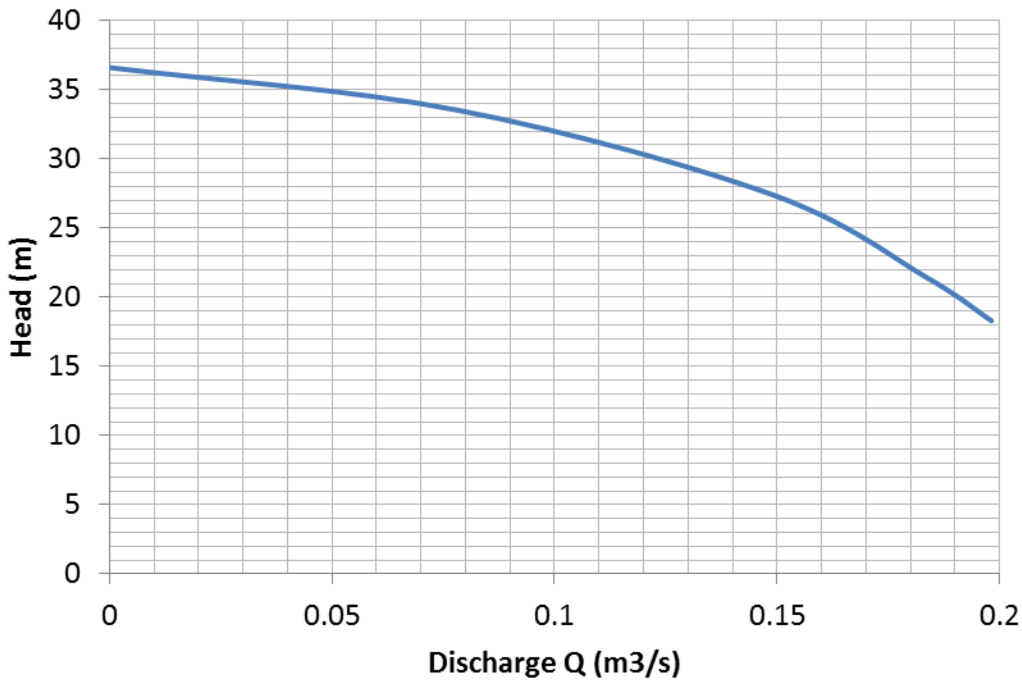
i) What is the flow rate from reservoir A to reservoir B?

ii) What is the power required to drive the pump?

[25 marks]



Attempt <u>one</u> question from Section C

Question C-2

Two reservoirs, A and B, are connected by a long pipe. The headloss in the pipe is expressed as:

$$h_L = 42.5(Q)^2$$

A single pump is used to pump the water from reservoir A to reservoir B. The pump operates at 1800 rpm and has the following characteristics:

Head (m)	Flow rate (m^3/min)
30.5	0
27.4	0.42
24.4	0.68
18.3	0.95
12.2	1.14
6.1	1.29

For the single pump, plot a series of curves showing the pump delivery (discharge rate) for differences in elevation between the reservoirs of -10, 0, 10, 20 and 25 m.

Repeat for a pump speed of 2160 rpm (assume the same impeller diameter).

[25 marks]