

**Ollscoil na hÉireann, Gaillimh**  
**NATIONAL UNIVERSITY OF IRELAND, GALWAY**

**SUMMER EXAMINATIONS 2000**

**THIRD SCIENCE EXAMINATION - EH 305 HYDROLOGY AND HYDROGEOLOGY**

Examiners:      Professor P.E. O'Connell  
                          Professor C. Cunnane  
                          Mr. T. Henry

Time allowed is *three* hours.

Attempt *five* questions with at least two from each section  
 Use separate answer books for each section.

**SECTION A.**

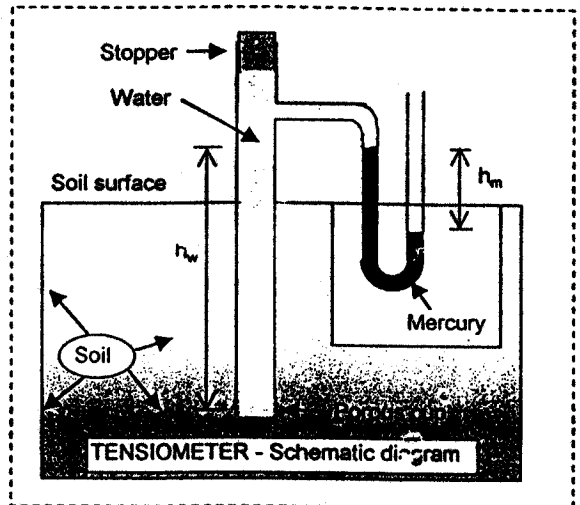
1. (a) Hydrology is concerned with water, a substance with its own special properties. Discuss these properties and outline how they relate to our natural environment. [8 marks]
- (b) Distinguish between the processes of absorption and adsorption of water in the natural environment, explaining each of them briefly. [4 marks]
- (c) Write a note about water quality in Irish rivers during the past 25 years [8 marks]
2. (a) Explain briefly how either a Dines tilting siphon or a tipping bucket raingauge operates. [6 marks]
- (b) What are the principle deficiencies involved in measuring rainfall over an area such as a river catchment. [4 marks]
- (c) The following water levels were measured upstream of a sharp crested rectangular weir, whose crest elevation is at 50 m above sea level and whose width is 0.9 m.  
 [Weir equation is  $Q = C_d \frac{2}{3} B \sqrt{2g} (H - H_c)^{3/2}$  where  $H_c$  = crest elevation,  $B$  is weir width and  $C_d$  = coefficient of discharge = 0.66]

Time, hours	0.00	06.00	12.00	18.00	24.00
Water level H,m	50.2	50.8	51.2	50.9	50.4

Calculate the corresponding discharge values and display them on a graph.  
 Calculate also the mean daily flow and display it on the same graph. [10 marks]

3. (a) Describe the principal hydrological features encountered in the unsaturated soil zone beneath the ground surface [5 marks]
- (b) State and illustrate the main components of a neutron probe soil moisture measuring device. What are its advantages and disadvantages? [7 marks]

- (c) A tensiometer is installed beneath the soil surface as shown. If  $h_m = 0.12\text{m}$ , determine the soil water pressure in Pa and the corresponding value of pF. The meniscus of the mercury in the suction limb is  $0.20\text{ m}$  above ground level while the centre of the porous cup is  $0.25\text{ m}$  below ground level. The expression  $P = \rho_w g h_w - \rho_m g h_m$  in the usual class notation, may be useful, where  $\rho_w = 1000\text{ kg/m}^3$  and  $\rho_m = 13600\text{ kg/m}^3$ . [8 marks]



4. (a) Explain the terms : wet and dry bulb temperatures [2 marks]  
saturated vapour pressure [2 marks]  
psychrometric constant [2 marks]
- (b) If wet and dry bulb temperatures are  $10^\circ\text{C}$  and  $13^\circ\text{C}$  respectively determine the relative humidity of the air. [4 marks]
- (c) Using the equations and tables provided determine the Penman open water evaporation for a location at  $50^\circ\text{N}$  during the month of August assuming that air temperature is  $16^\circ\text{C}$ , wind speed is  $0.8\text{ m/s}$ , relative humidity is  $65\%$  and duration of bright sunshine is  $6\text{ hours}$ . [10 marks]

## SECTION B

5. Answer any eight of the following. Please keep your answers brief.
- Cooper and Jacob modified the Theis Method for the analysis of pumping test results. What field conditions determine the use of their two methods?
  - Is the potentiometric surface the same as the water table? Briefly explain your answer.
  - Are permeability and hydraulic conductivity affected by a change in groundwater temperature? Briefly explain your answer.
  - What is Hubbert's definition of potential?
  - There are six basic properties of fluids and porous media that must be known to properly describe groundwater flow. List the six properties.
  - An aquifer is described as being homogeneous and isotropic. Briefly explain what this means, in relation to the distribution of hydraulic conductivity.
  - The drawdown at an observation well located some distance from a pumping well is a function of what three variables?
  - Is the Transmissivity of an unconfined aquifer constant through time? Briefly explain your answer.
  - What is an aquifer?
  - What is the difference between the porosity and moisture content of a porous medium? [2.5 marks each]

continued overleaf.../

6. Answer (a) or (b) or (c).

- (a) Write an essay on karst hydrology, using specific examples from County Galway and County Clare.

[20 marks]

or

- (b) Write an essay on aquifer protection schemes in Ireland.

[20 marks]

or

- (c) Should fresh water be free, or should it be treated like other resources (such as oil, gas, timber) and be a charged commodity?

[20 marks]

7. Answer part (a) and (b) below.

- (a) Answer *all* parts of the question.

- (i) When dealing with bounded aquifers, *two* major boundary conditions can be defined. What are they?

[2 marks]

- (ii) What effect will the proximity of these boundaries to a pumping well have on drawdown?

[2 marks]

- (iii) A production well is installed in an aquifer, and pumped at a rate of 1100 m<sup>3</sup>/day. The aquifer is 12.5 metres thick, and has a hydraulic conductivity of 10 m/day. The storativity is estimated to be 0.001. A reservoir is located 50 metres from the well.

What would the drawdown be at a monitoring well located midway between the pumping well and the reservoir, after pumping had proceeded for all of the months of May and June?

[6 marks]

- (b) Answer *all* parts of the question.

A well is cased into a confined aquifer and is pumped at a constant rate of 500 m<sup>3</sup>/day. Five observation wells are installed in the area around the pumping well, at radial distances of 10, 25, 50, 100 and 200 metres. Drawdowns were recorded against time at each observation well. The drawdowns after two days of pumping were plotted against distance, as shown on the accompanying graph.

- (i) Draw the best-fit line through the data points and determine the value of  $r_0$  and a value for  $\Delta s$ .

[4 marks]

- (ii) Determine values of *transmissivity* and *storativity* for the aquifer.

[6 marks]

*Remember to write your name and examination number on the graph, and enclose the graph with your answer script.*

## 8. Answer part (a) and (b) below

- (a) Two rivers run parallel to each other, at a distance of 600 metres. The rivers fully penetrate an unconfined (water-table) aquifer. The hydraulic conductivity of the aquifer is 0.5 m/day. Rainfall in the area averages 0.1 m/year and evaporation averages 0.05 m/year. The elevation of the water in River One is 25 metres above datum, and the elevation of the water in River Two is 23 metres above datum.

- (i) Determine the *location* of the water table divide. [2 marks]  
 (ii) Determine the *elevation* of the water table divide (the maximum water table elevation). [4 marks]  
 (iii) Determine the daily discharge per metre width into *River Two*. [4 marks]

- (b) Four wells are installed in an aquifer.

Well 2 is located exactly 100 metres north of Well 1.

Well 3 is located exactly 100 metres east of Well 2.

Well 4 is located exactly 100 metres east of Well 1.

Details of each well are in the table below.

Well No.	Elevation of Well (m ASL)	Depth of Well (m)	Depth to Water (m)
1	100	60	12
2	98	40	15
3	103	55	20
4	90	30	2

- (i) Determine the values of total head, elevation head and pressure head for each well. [6 marks]  
 (ii) Draw a map view of the area indicating direction groundwater flow in this area. [2 marks]  
 (iii) What is the hydraulic gradient between Well 1 and Well 2? [2 marks]