

OLLSCOIL NA hÉIREANN, GAILLIMH
NATIONAL UNIVERSITY OF IRELAND, GALWAY

EH 305 – Hydrology and Hydrogeology

SUMMER EXAMINATIONS 2005
THIRD SCIENCE (3ER, 3EV, 3BSc, 4ER, 4EV)

Examiners: Professor K.J. Beven
 Professor C. Cunnane

Time allowed: three hours

Attempt five questions with at least two from each section

Separate answer books are not required

SECTION A

1. (a) Identify and explain the roles played by water vapour in the atmosphere. [5 marks]
- (b) By means of a small numerical example compare and contrast the specific heat capacity and the latent heat of vapourisation of water. [5 marks]
- (c) Outline the factors involved in the evolution of rainwater quality [5 marks]
- (d) Distinguish between the processes of absorption and adsorption of water in soils and explain the process in each case.
2. (a) Explain the functioning of a current meter and how it is calibrated. [5 marks]

A current meter was used to measure velocity at 4 depths in a river as follows:

Location above bed level, m	Revolutions per minute
0.3	160
0.6	210
0.9	240
1.2	260

Total depth of water is 1.2 m and the current meter calibration relation is $v = 0.27n$ where v is in m/s and n is current meter revolutions per second.

- (i) Plot the vertical velocity profile [5marks]
- (ii) Calculate the discharge per unit width of river and hence the average velocity $V = Q/A$. [5 marks]

- (iii) Estimate from the graph the quantities $V_{0.6d}$ and $(V_{0.2d} + V_{0.8d})/2$, where d = depth from water surface and hence comment on whether these commonly used methods of determining average velocity are satisfactory in this case or not. [5 marks]
3. (a) Describe two ways in which the global hydrological and global energy cycles interact. [5 marks]
- (b) The total global average evaporation from the entire surface of the earth amounts to approximately $0.5 \times 10^6 \text{ km}^3$ of water per year. Estimate the amount of energy required for this purpose. [5 marks]
- (c) Explain what is meant by the term "water balance".
If 1100 mm rainfall fell on a catchment of area 1600 km^2 in a year and the average runoff during the year was $35 \text{ m}^3/\text{s}$ estimate the total evapotranspiration for that year. What assumptions are made in your answer? [5 marks]
- (d) Flow in a small stream is measured by a rectangular sharp crested weir, of width 0.7m. If upstream water level is 0.5 m above the weir crest determine the flow rate in m^3/s . Adopt $c_d = 0.63$.
4. (a) (i) What are the main factors which cause and control infiltration of water into the ground? [3 marks]
- (ii) What is meant by soil moisture tension? If soil moisture tension is 60 cm what is the corresponding pF value. [4 marks]
- (iii) Explain what is meant by a soil moisture characteristic and explain the difference between the characteristics for sandy and clayey soils. [3 marks]
- (b) (i) If $9000 \text{ kJ/m}^2/\text{day}$ were available as latent heat of vapourisation what depth of water would be evaporated? [3 marks]
- (ii) On a day when average temperature is 16°C , average wind speed $u_2 = 1.5 \text{ m/s}$ and relative humidity is 70% what is the Dalton or Aerodynamic estimate of evaporation? [5 marks]
- (iii) Explain the meaning of the terms Δ , H , γ , E_a in the Penman open water evaporation equation. [2 marks]

SECTION B

5. (a) Define the terms aquifer, aquitard and aquifuge. Distinguish between an aquifer and an ideal aquifer. [5 marks]

- (b) In a confined aquifer Point A is 200 m above sea level and Point B is 230 m above it. In a piezometer well located at A the water level reaches an elevation of 245 m above sea level. A pressure measuring device installed at B indicates that the pressure there is 35000 Pa. Draw a sketch showing the above information and any other relevant information obtained from it and hence determine the direction of flow between A and B. [5 marks]

- (c) Define what is meant by

- Hydraulic Conductivity
- Transmissivity
- Specific Storage
- Storativity
- Specific Storativity

[5 marks]

- (d) An unconfined aquifer has areal extent 10 km^2 and a storativity value of 0.29. If the water table falls by 0.6 m owing to drainage towards the sea, what volume of water leaves the aquifer during this time during a time of no recharge?

If recharge of 100 mm occurred during this time by how much would the water table have fallen? [5 marks]

6. (a) Explain what is meant by the Principle of Conservation of Mass. [4 marks]

Explain, in general terms, how this is applied to a control volume in order to derive a groundwater flow equation. [4 marks]

- (b) What primary quantity/quantities are obtained when a groundwater model is run? How are these usually displayed? [4 marks]
What can be deduced from this output? [2 marks]

- (c) In the following form of the general groundwater flow equation, state whether
- (i) the flow is steady or unsteady
 - (ii) the medium is homogeneous or not
 - (iii) the medium is isotropic or not. [3 marks]

$$\frac{\partial}{\partial x} \left(K \frac{\partial h}{\partial x} \right) + \frac{\partial}{\partial y} \left(K \frac{\partial h}{\partial y} \right) + \frac{\partial}{\partial z} \left(K \frac{\partial h}{\partial z} \right) = S_s \frac{\partial h}{\partial t}$$

Question 6 continued overleaf.../

- (d) For steady groundwater flow in one dimension in a homogeneous, isotropic medium the 1-D Laplace equation applies. State what this is and what solution can be derived from it? [3 marks]

- 7.(a) List the main categories of groundwater contamination and the main sources of groundwater pollution. [4 marks]

Give recent examples of incidents in Ireland which either caused groundwater pollution or had a high possibility of doing so. [4 marks]

- (b) Describe the main components of the current Irish Groundwater Protection schemes. [8 marks]
- (c) Show, with the help of sketches, some possible ways of preventing pollution of an unconfined aquifer over which a historical land-fill site is located. [4 marks]

- 8.(a) A well which fully penetrates an ideal confined aquifer is pumped at a rate of $2000\text{m}^3/\text{day}$. The aquifer thickness is 50 m and its hydraulic conductivity and storativity are 7 m/day and 0.00034 respectively. Calculate the drawdown at a radial distance 60 m from the well after 2 days of pumping. [6 marks]

Without performing any further calculation assess the impact on the drawdown of

- (i) halving the pumping rate
(ii) doubling the hydraulic conductivity. [4 marks]

- (b) In the confined aquifer described in (a) above, two wells located 800 m apart, display water levels of 125 m and 124.2 m above sea level respectively. Determine the hydraulic gradient and hence calculate the volume of water, in m^3/day , which flows through a 1 km wide section of the aquifer. [5 marks]

- (c) Groundwater contours, in m above sea level, in an unconfined aquifer are shown on a 1 km x 0.75 km portion of a map. The base of the aquifer is horizontal and at 60m above sea level and the aquifer's hydraulic conductivity is 60m/day. What is the approximate rate of groundwater flow, per m width of aquifer

- (i) between A and C
(ii) between D and B? [5 marks]

