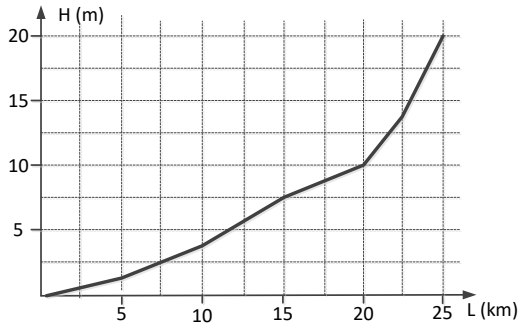
INSTITUTO SUPERIOR TÉCNICO
Hydrology, Environment and Water Resources
School year 2015/16 – 2nd exam – Duration: 2 hours

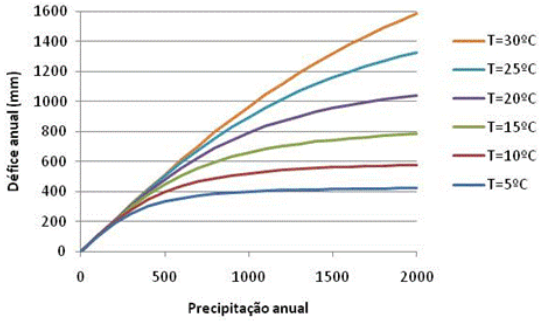
(Each question is graded 2/20)

1. The area of Earth is 510 000 000 km^2, with 70% corresponding to oceans and 30% to continents. Knowing that the average annual precipitation over oceans and continents is 1270 mm and 805 mm, respectively, and that the average annual evaporation from oceans and continents is 1400 mm and 485 mm, respectively, estimate the flow from continents to oceans, in km^3/year, and the flow through the atmosphere from oceans to continents, in km^3/year.



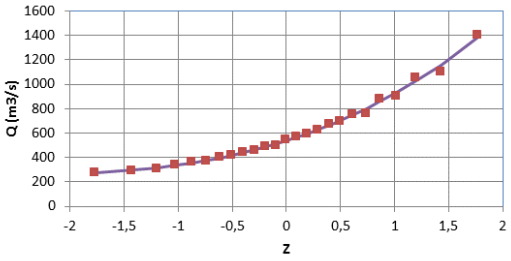
2. The figure on the right shows the profile of a river. Determine the average slope, the equivalent slope and slope 10,85.

3. Explain what is the role of the crop coefficient when estimating evapotranspiration and briefly discuss what factors influence this coefficient and why.



4. The figure on the right shows the graphical representation of the Turc formula. Justify the location and shape of each curve in the graph and explain how the graph can be used to estimate annual runoff.

5. The record of annual maxima discharges from a hydrometric station located upstream of a small town follows a Pearson 3 probability distribution function, as shown in the graph. Estimate the discharge value for T=20 years.



6. Consider a soil with the characteristics shown in the table. At the given moment, when the degree of saturation of the soil is 40%, a rainstorm occurs during one hour leading to an infiltration equal to 50 mm. Under these conditions, what is the moisture content at the end of the rainstorm (in m/m) and 5 hours after the end of the rainstorm (in m/m)? Justify your answer.

7. Consider the soil of the previous exercise. Assuming that at the beginning of the above mentioned rainstorm event the infiltration capacity was 60 mm/h, estimate the Horton model constant.

Parameter	Value
Soil depth, h (m)	0,60
Porosity, n	0,50
Saturated soil water content, θs (m/m)	0,46
Field capacity, θcc (m/m)	0,25
Wilting point, θe (m/m)	0,12
Hydraulic conductivity when saturated, Ks (mm/h)	5,0

8. Beja (Alentejo, Portugal) has a mediterranean climate with dry hot summers and mild winters and annual average rainfall around 578 mm/year. In the region, chloride concentration has been monitored monthly in rainfall and groundwater bodies for the last 5 years. Using the monitoring information summarized in following Tables 1 & 2 calculate groundwater recharge rate.

Table 1. Groundwater chloride concentration in mg/l for the "*Gabros de Beja*" groundwater body.

No Samples	Min	Q1	Median	Average	Q3	Max.	Standard deviation
60	13.0	22.0	32.5	48.2	59.4	235.0	39.8

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Table 2. Rainfall chloride concentration in mg/l for the Beja region

No Samples	Min	Q1	Median	Average	Q3	Max	Standard deviation
60	0.4	2.2	3.4	4.2	5.5	13.4	3.3

9. Consider a basin situated in a region for which the following rainfall depth-duration-frequency curve for a return period of 50 years $P = 45 \cdot D^{0,65}$, with P in mm and D hours with the 15-min unit hydrograph shown in the table. Determine the flood hydrograph generated by the most critical non-uniform precipitation event assuming a 20% infiltration rate.

T (min)	0	15	30	45	60
u (m3/s/mm)	0	50	25	10	0

10. Consider the basin of the previous exercise and use the rational formula to estimate the peak discharge for T = 50 years. Explain why the obtained value is different from the peak discharge obtained in exercise 9.

Useful formulas:

Standard normal:

p	0.01	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	0.95	0.99
z	-2.33	-1.64	-1.28	-0.84	-0.52	-0.25	0.00	0.25	0.52	0.84	1.28	1.64	2.33

Pearson 3 probability factor:

$$K_p = \frac{2}{\gamma} \cdot \left(1 + \frac{z_p \cdot \gamma}{6} - \frac{\gamma^2}{36}\right)^3 - \frac{2}{\gamma}$$

Horton model:

$$f = f_c + (f_0 - f_c)\, e^{-kt}$$

$$F = f_c \cdot t + \frac{f_o - f_c}{k} \cdot \left(1 - e^{-k \cdot t}\right)$$

Rational formula peak coeficient

$$f = 2 - \sqrt{n}$$