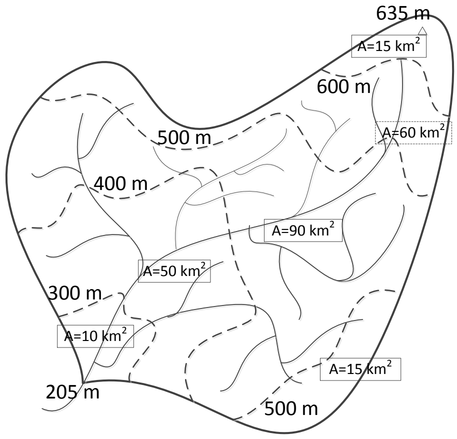
INSTITUTO SUPERIOR TÉCNICO
MESTRADO INTEGRADO EM ENGENHARIA DO AMBIENTE
Hidrologia, Ambiente e Recursos Hídricos
Ano lectivo de 2014/15 – Exame 1 – Duração total: 2 horas

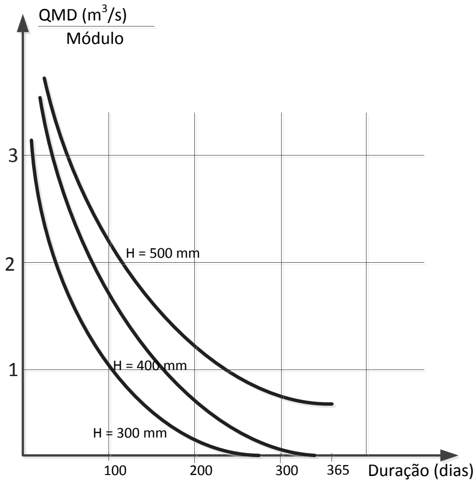
(Cada pergunta vale 2 valores)

1. The Tagus rive catchment of the River Tagus has 80'600 km^2 distributed over 24'800 km^2 in Portugal and in Spain 55’800 km2. The average annual precipitation in Portugal and Spain is, respectively, 875 mm and 655 mm; the evapotranspiration in Portugal and Spain is, respectively, 340 mm and 500 mm. Compute the watershed runoff, in mm, and the module at the mouth of Tagus River, in m^3/s, for natural conditions.



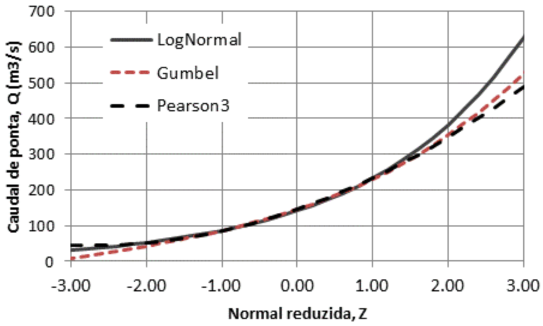
2. The figure shows a watershed with its river network and contour lines. The area between contour lines is also presented. Sketch the watershed hypsometric curve (showing the table that supports your graph), as well as the median height of the watershed, in meters.

3. The Turc formula to estimate runoff deficit depends on two meteorological variables. Define these two variables and draw a graph describing the relationship between runoff deficit and these variables, explaining why and how are the three variable related. Mark on the graph the most significant points of the curves.



4. The figure shows the average annual duration curves of the daily average flow of three watersheds in mainland Portugal. Consider a watershed with 250 km^2 which generates an average annual flow volume of 125 hm^3. There are plans to install at its mouth a mini power plant with an operating range of 0.5 to 1.5 m^3/s. If the minimum flow assigned to ecological needs is 0.7 m^3/s, how many days on average will the plant operate and what is the average annual volume that is available for power production?

5. The figure shoes the log-Normal, Gumbel and Pearson3 probability distribution functions estimated from the record of annual maximum discharge of a hydrometric station. Assuming the annual maximum flow distribution can be described by a log-Pearson distribution with skewness equal to zero, what is the maximum annual discharge for a return period of 100 years?

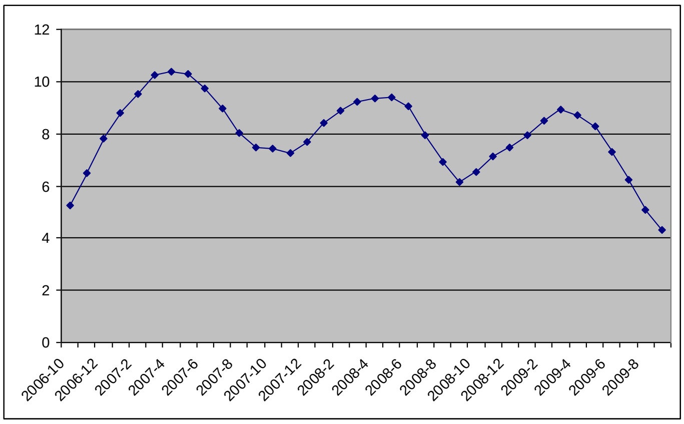


6. Consider a soil with the characteristics shown in the table. In a given day, when the soil saturation level is 30%, an intense precipitation event occurs that leads to 100 mm of infiltration. What is the soil saturation level, in %, and what is the soil water content, in mm, at the end of the precipitation event? What can you say about the values these parameters assume a few hours after the end of the event?

Parâmetro	Valor
Profundidade do solo, h(m)	0,4
Porosidade, n	0,50
Teor de humidade dos solo saturado, θs	0,45
Capacidade de campo, θcc	0,35
Ponto de emurchecimento, θe	0,15
Cond. hid. quando saturado, Ks (mm/h)	30,0
Sucção na frente humedecim., Ψf (mm)	-10,0

7. Consider the soil described in the previous problem. When the soil water content is 0.25, an event occurs during 30 min and generates runoff 10 min after the beginning of the event. Estimate the cumulative infiltration at 10 min and 20 min after the beginning of the precipitation event.

8. Consider the piezometric (values in meters) time series observed in well 595/1028 (fig.1) located in aquifer Querença Silves (Algarve). Calculate the mean recharge rate for the first two hydrological years using the water table fluctuation method. The value of specific yield is 0.15.



9. Consider the watershed described in Problem 2 and its main watercourse with 18 km of length. The rainfall depth-duration-frequency curve for a return period of 100 years is $\mathrm{P(mm)} = 30 \cdot \mathrm{D(min)}^{0{,}35}$. Compute the peak flow from a non-uniform precipitation, assuming an infiltration rate of 30% and a flow peak attenuation of 5%, due to temporary water storage in the watershed. Use the Kirpich formula and the rational formula.

10. Consider a watershed where a net precipitation of 32 mm during 40 min generates the following hydrograph.
    a. What is the watershed's time of concentration, in hours?
    b. Determine the flood hydrograph produced by a rinfall evento f 16 mm with a duration of 20 min.

T (min)	0	10	20	30	40	50	60	70
Q (m3/s)	0	40	56	64	64	24	8	0

Fórmulas:

Standard normal distributin:

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

Pearson3 probability factor:

$$k = \frac{C_a}{6} \quad K_p = z_p + \left(z_p^2 - 1\right) \cdot k + \frac{1}{3}\left(z_p^2 - 6 \cdot z_p\right) \cdot k^2 - \left(z_p^2 - 1\right) \cdot k^3 + \frac{1}{3} \cdot k^5$$

Green e Ampt equation:

$$f = K_s - \frac{K_s \cdot \Psi_f \cdot (\Theta_s - \Theta_i)}{F} \qquad F = K_s \cdot t + \frac{b}{K_s} ln\left(1 + \frac{K_s \cdot F}{b}\right) \qquad b = -K_s \cdot \Psi_f \cdot (\Theta_s - \Theta_i)$$

$$t_e = \frac{-\Psi_f \cdot (\Theta_s - \Theta_i)}{p \cdot \left(\frac{p}{K_s} - 1\right)}; \quad p > K_s$$

Kirpich formula:

$T_c = 0{,}3 \cdot \left(\frac{L}{d^{0{,}3}}\right)^{0{,}76}$, Tc in hours, L in km, d no units.

Rational formula majoration factor:

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