UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 6 Examination in Engineering: December 2018

Module Number: CE6303 Module Name: Engineering Hydrology

[Three Hours]

[Answer **all questions**, each question carries 10 marks]

Q1

a) Evaporation from water surfaces are estimated through water and energy budget concepts. Briefly explain each method highlighting their associated limitations.

[02 Marks]

b) Water surface evaporation is also estimated through Mass Transfer Method which is based on the ability of water surface to transport vapour away from the surface. Transport rate depends on both humidity gradient in the air near the water surface and wind speed near the surface. The governing equation for this method is given in equation Q1.

$$E = \frac{0.622k^2 \rho_a u_2}{p\rho_w \left[\ln\left(\frac{z_2}{z_0}\right) \right]^2}(e_s - e_a) \qquad \text{Equation Q1}$$

Where,
E = Evaporation in mm/day
e_s = saturated vapour pressure
e_a = vapour pressure at z_2
k = 0.4; Von Karman constant
p = pressure
ρ_a = density of air
ρ_w = density of water
U_2 = velocity at z_2
Z_0 = roughness height

(i) Briefly explain rationale of Mass Transfer Method in determining evaporation from open water bodies by comparing with the two methods discussed in above part (a).

(ii) Using Mass Transfer Method, estimate the evaporation rate from an open water surface with air temperature 30°C, relative humidity 70%, air pressure 101.3 kPa, and wind speed 4 m/s, all measured at height 2 m above the water surface. Assume a roughness height Z_o = 0.03 cm. Figure Q1.1 and Table Q1.1 shall be used to extract related data.

[02 + 04 Marks]

c) Briefly explain how evapotranspiration differs from evaporation.

[02 Marks]

Q2

a) Annual maximum values of 10-minute-duration rainfall at a principal meteorological station point, from 2000 to 2010 are presented in Table Q2.1.

Estimate the probability of exceedance and return period of precipitation of 20 mm (2008 value) using the California formula.

[02 Marks]

b) (i) Develop a model for above dataset through rainfall frequency analysis using an appropriate probability distribution function selecting from Table Q2.2.

(ii) Calculate the 5-year, 10-year, and 50-year return period maximum values of 10-minute rainfall for the dataset.

[06 Marks]

c) Comment on the accuracy of answers of above part (b).

[02 Marks]

Q3

a) Distinguish between precipitation and rainfall.

[02 Marks]

b) List and explain three (03) types of precipitations available in global scale. What is/are the dominant type/s for Sri Lanka in general? Give reasons.

[03 Marks]

c) *"According to the* ***Germanwatch*** *Global Climate Risk Index, Haiti, Zimbabwe as well as Fiji were the most affected countries in 2016 followed by* ***Sri Lanka****, Vietnam and India."*

(i) What are the local evidences available to support above statement in relation to Sri Lanka's climatic conditions? Explain.

(ii) Briefly explain about climate change adaptation techniques in hydrological context that are applicable to Sri Lanka.

[02 + 03 Marks]

Q4

a) Using a stream flow hydrographs or otherwise, explain how the urbanization can cause flash floods.

[03 Marks]

b) What is meant by time of concentration? Does it change with the catchment characteristics? Explain

[01 + 02 Marks]

c) Rational formula is a widely used simple method to estimate the peak streamflow using the peak rainfall intensity.

(i) Briefly explain step-by-step procedure to be followed in determining peak streamflow discharge using rational formula.

(ii) What are the assumptions and limitations associated with this method?

[03 + 01 Marks]

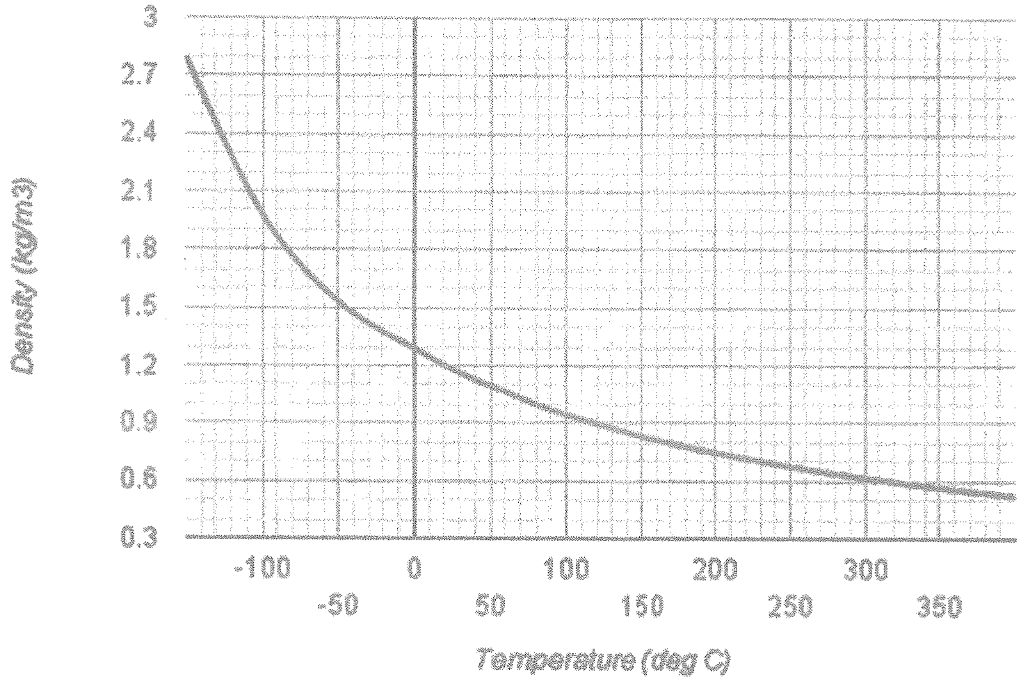

Figure Q1.1: Variation of air temperature and density at atmospheric pressure

Table Q1.1: Saturated vapor pressure of water vapor over liquid water

Temperature (^{0}C)	Saturated Vapor Pressure (Pa)
-20	125
-10	286
0	611
5	872
10	1227
15	1704
20	2337
25	3167
30	4243
35	5624
40	7378

Table Q2.1: Annual maximum 10-minutes rainfall 2000 - 2010

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Rain (mm)	13	17	10	15	11	12	19	14	20	15	21

Table Q2.2: Probability distributions for fitting hydrologic data

Distribution	Probability density function	Range	Equations for parameters in terms of the sample moments
Normal	$f(x) = \frac{1}{\sigma\sqrt{2\pi}} \exp\left(-\frac{(x-\mu)^2}{2\sigma^2}\right)$	$-\infty \le x \le \infty$	$\mu = \bar{x},\ \sigma = s_x$
Lognormal	$f(x) = \frac{1}{x\sigma\sqrt{2\pi}} \exp\left(-\frac{(y-\mu_y)^2}{2\sigma_y^2}\right)$ where $y = \log x$	$x > 0$	$\mu_y = \bar{y},\ \sigma_y = s_y$
Exponential	$f(x) = \lambda e^{-\lambda x}$	$x \ge 0$	$\lambda = \frac{1}{\bar{x}}$
Gamma	$f(x) = \frac{\lambda^\beta x^{\beta-1} e^{-\lambda x}}{\Gamma(\beta)}$ where Γ = gamma function	$x \ge 0$	$\lambda = \frac{\bar{x}}{s_x^2}$ $\beta = \frac{\bar{x}^2}{s_x^2} = \frac{1}{CV^2}$
Pearson Type III (three parameter gamma)	$f(x) = \frac{\lambda^\beta (x-\epsilon)^{\beta-1} e^{-\lambda(x-\epsilon)}}{\Gamma(\beta)}$	$x \ge \epsilon$	$\lambda = \frac{s_x}{\sqrt{\beta}},\ \beta = \left(\frac{2}{C_s}\right)^2$ $\epsilon = \bar{x} - s_x\sqrt{\beta}$
Log Pearson Type III	$f(x) = \frac{\lambda^\beta (y-\epsilon)^{\beta-1} e^{-\lambda(y-\epsilon)}}{x\Gamma(\beta)}$ where $y = \log x$	$\log x \ge \epsilon$	$\lambda = \frac{s_y}{\sqrt{\beta}}$, $\beta = \left[\frac{2}{C_s(y)}\right]^2$ $\epsilon = \bar{y} - s_y\sqrt{\beta}$ (assuming $C_s(y)$ is positive)
Extreme Value Type I	$f(x) = \frac{1}{\alpha} \exp\left[-\frac{x-u}{\alpha} - \exp\left(-\frac{x-u}{\alpha}\right)\right]$	$-\infty < x < \infty$	$\alpha = \frac{\sqrt{6}s_x}{\pi}$ $u = \bar{x} - 0.5772\alpha$