UNIVERSITY OF RUHUNA

Faculty of Engineering

Mid-Semester 8 Examination in Engineering: October 2014

Module Number: CE8240 Module Name: Water Resources Planning and Management

[Two Hours]

[Answer all questions]

Q1. Briefly distinguish between simulation and optimization techniques used in water resources systems modelling. Use examples to elaborate your explanation.

[4.0 Marks]

Q2. Releases from a reservoir are used for water supply and hydropower. The benefits per unit of water allocated to hydropower and water supply are B_h and B_w, respectively. For any given release the difference between the allocations to the two users cannot exceed 50% of the total amount of available water.

a) Formulate an optimization model for estimating the water allocations. The model should clearly indicate the decision variables, objective function, and constraints.

[2.0 Marks]

b) Show graphically how to determine the most profitable allocation of the water for some assumed values of B_h and B_w. Graphically identify the possible optimal solutions and binding constraints.

[4.0 Marks]

Q3. a) Consider a general constrained optimization problem.

Maximize (or minimize) F(X)

Subject to constraints

$g_i(X) = b_i; i = 1,2,3, \ldots\ldots, m$

where X is the vector of all decision variables x_j (j=1,2,….n).

Write the corresponding Lagrange function L(X,λ) and show that each Lagrangian multiplier is equal to the marginal change in the original objective function F(X) with respect to change in the constant associated with the corresponding constraint.

[4.0 Marks]

b) Consider the water allocation problem illustrated in Figure Q3. There are j (j =1, 2,…,j) water users along the river. Each user receives an actual allocation of water x_j and has a desired or known target allocation T_j. If a user receives an excess of water $x_j>T_j$ or deficit of water $x_j<T_j$, then the user incurs a penalty (reduced benefit).

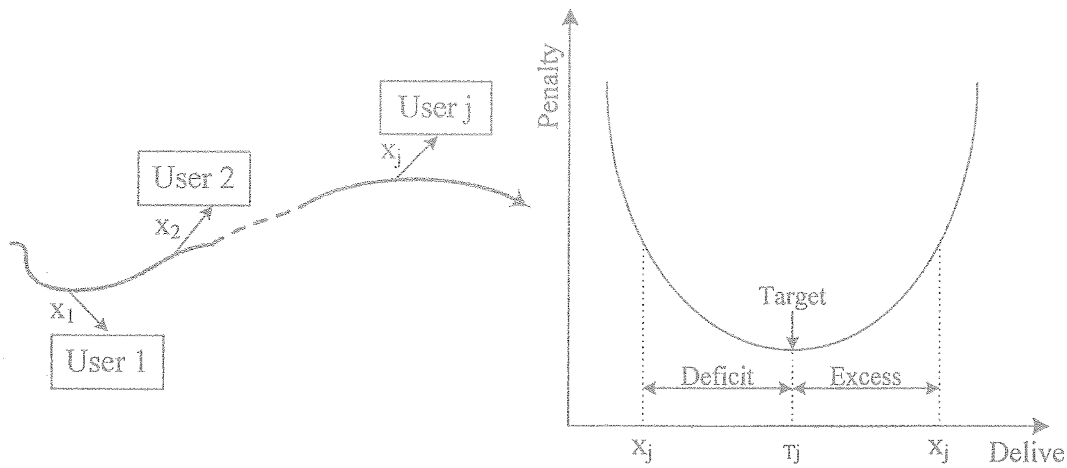

Figure Q3

All water users want to minimize their penalties; that is their objective. The objective is to minimize the sum of squared deviations of the actual allocations from the target allocations. Given a supply of water Q, you are to write an optimization model for this problem.

(i) For a given supply of water Q, structure an optimization model for the above problem.

[2.0 Marks]

ii) Write the corresponding Lagrange function for this problem and solve for the optimal values of x_j.

[4.0 Marks]

SECTION II

Q1. a) What are the key layers of the International Standard Atmosphere (ISA)? Draw the temperature variation pattern within the ISA from sea level to 100 km altitude (Accurate temperature values are not required).

[1.0 Marks]

b) Show that (with usual notation) the static pressure (P) and goepotential height (H) within the Troposphere are related as:

$$P = P_b\left(1+\frac{a}{T_b}H\right)^{-\frac{g_0}{aR}}$$

[1.5 Marks]

c) Derive an expression for pressure variation with the altitude for the first sub-layer of the stratosphere.

[1.5 Marks]

d) Estimate the temperature and pressure at an altitude of 16.5 km within the ISA?

[1.0 Marks]

Q2. a) Show that for a steady, adiabatic and isentropic flow, the static pressure (P), the total pressure (P_T), and the Mach number (M) are related by:

$$P_T = P\left[1+\frac{\gamma-1}{2}M^2\right]^{\frac{\gamma}{\gamma-1}}.$$

Hence deduce an expression for true air-speed of an aircraft.

[1.5 Marks]

b) Explain why a boundary layer tends to separate when it is subjected to an adverse pressure gradient. Discuss two methods that could be used to minimize the boundary layer separation on an airfoil.

[1.5 Marks]

c) An airplane is cruising at a velocity of 870 km/h at an altitude of 10,400 m. The mass and the wings planform area of the plane are 6700 kg and 35 m^2, respectively. The drag coefficient at the cruise is 0.018. Calculate the followings during the cruise.

i) Flight Mach number.
ii) Lift coefficient.
iii) Lift to drag ratio.
iv) Power required by the aircraft.

[2.0 Marks]

Data and Formulae sheet for Aerospace Engineering – ME8336

a.) For sea-level atmospheric conditions use followings:

Static pressure (P_0)	=	101325 Pa
Temperature (T_0)	=	288.15 K
Density (ρ_0)	=	1.225 kg.m^{-3}
Acceleration due to gravity (g_0)	=	9.81 m.s^{-2}
Specific heat ratio (γ)	=	1.4
Real gas constant (R_g)	=	287 J.kg^{-1}.K^{-1}

b.) In an ISA below 11 km; the static pressure (P) and the temperature (T) are given by,

$P = P_0\left(1 - 2.2558\times10^{-5}h\right)^{5.2559}$ N.m^{-2},

$T = T_0 - 0.0065h$ K.

Where h is measured in meters, note 1 ft = 0.3048 m.

c.) For a steady, adiabatic, isentropic and inviscid flow, the total pressure (P_T), free stream pressure (P_∞) and free stream Mach number (M_∞) are related as,

$$P_T = P_\infty\left[1 + \frac{\gamma - 1}{2}M_\infty^2\right]^{\frac{\gamma}{\gamma-1}}$$

d.) Atmospheric air can be treated as a perfect gas,

$P = \rho R_g T$

Speed of sound $a = \sqrt{\gamma RT}$.

e.) 1 Knot = 0.5144 ms^{-1}