Name: ____________________________ Roll No.: ___________________

UNIVERSITY OF PETROLEUM & ENERGY STUDIES

End Semester Examination: May 2018

Program:	**B. Tech. Chemical Engg. (RP); CE-RP**	**Semester:**	**II**
Subject (Course):	**Process Optimization (Elective)**	**Max. Marks:**	**100**
Course Code:	**CHEG 455**	**Duration:**	**3 Hrs**
No. of page/s:	**0 + 5**		

In this **OPEN BOOKS and NOTES EXAM**, you are allowed to have the textbook (Manojkumar C. Ramteke, D. N. Saraf and S. K. Gupta, *Optimization for Engineers*) ***as well as any other set of books***, ***all*** handouts provided, ***your own class-notes*** and your solutions to assignment problems, ***etc.***

Please return the Question Paper at the end of the exam (and work on it as much as possible)

1. Please show **all** ***intermediate steps*** of your answers (and not just the final answers) to earn marks
2. ***Please answer the questions in the sequence: 1, 2, 3.*** You can do this by assigning, *a priori*, a few pages to each question, in the correct sequence. You may then answer the questions in whatever sequence you wish to, ***all parts in one place***
3. No student is allowed to leave the examination hall in the first hour of the exam

Sections A and B: XXX

No questions here

Continued . . .

Section C: ALL THE THREE QUESTIONS ARE COMPULSORY [Total 100 Marks]

Q.1 We wish to solve:

$$Min\ f(x_1, x_2) \equiv -3x_1^2 + 2x_2 \quad \text{(i)}$$

$$s.t.: h(x_1, x_2) \equiv 2x_1 + x_2 - 4 = 0 \quad \text{(ii)}$$

$$g_1(x_1, x_2) \equiv -x_1^2 - x_2^2 + 16.0 \geq 0 \quad \text{(iii)}$$

$$g_2(x_1, x_2) \equiv x_1 \geq 0 \quad \text{(iv)}$$

using the KKT (Karoush-Kuhn Tucker) procedure.

(a) Introduce slack variables, x_3^2 *and* x_4^2, in eqns. (iii) and (iv), respectively, and re-write ***these*** two equations **(6)**

(b) Now, write the expression for the Lagrangian function, $L(\boldsymbol{x}, \boldsymbol{u})$, using u_i as the Lagrangian variables **(6)**

(c) Differentiate L and give ***all*** the relevant equations **(2 × 7 = 14)**

(d) ***CHECK*** if $x_1 = 0$, $x_2 = 4$ satisfy your equations ***if the minimum lies at the bounds*** **(4)**

(*30 Points*)

NOTE for later on, during the vacations: A multi-variable Newton Raphson code in MATLAB (to solve for the seven variables in the seven equations in part (c) above, with a starting guess of all the seven variables as 1.0, will give the converged solution.

Q.2 We wish to solve the following Single Objective Optimization (SOO) problem using Particle Swarm Optimization (PSO):

$$Min\ f(x_1, x_2) \equiv 4x_1^2 + 5x_2^2$$

$1 \leq x_1 \leq 3$ and $2 \leq x_2 \leq 4$.

Use: $w = 0.6$; $c_1 = 5$, $c_2 = 5$ and 2 particles. Do only the computations indicated in the Table (with calculations in your answer-script) but ***please fill up the Table given***. ***Continued . . .***

Particle No.	$x_{1,j}^{(0)}$	$x_{2,j}^{(0)}$	$I_j^{(0)}$	$P_{best,1,j}^{(0)}$	$P_{best,2,j}^{(0)}$	$G_{best,1}^{(0)}$	$G_{best,2}^{(0)}$	$V_{1,j}^{(0)}$	$V_{2,j}^{(0)}$	$V_1^{(1)}$	$V_2^{(1)}$
1								0	0		
2								0	0		

(12)

Particle No.	$x_{1,j}^{(1)}$	$x_{2,j}^{(1)}$	$I_j^{(1)}$	$P_{best,1,j}^{(1)}$	$P_{best,2,j}^{(1)}$	$G_{best,1}^{(1)}$	$G_{best,2}^{(1)}$
1							
2							

(18) (*30 Points*)

Continued . . .

Q.3 [Courtesy: Dr. Manojkumar C. Ramteke, Chem. Engg. Dept., IIT Delhi]

A variant of GA is ***genetic programming***. In this technique, the four bases in the DNA strand, Adenine (A), Thymine (T), Guanine (G) and Cytosine (C), are mimicked (using the four quarternaries, 0, 1, 2, and 3) as:

A = 0; B = 1, C = 2 and D = 3

This is an alternative of the binary system, involving 0 and 1 (as in the GA discussed in the class/books).

Note the mapping for ***binaries*** for, say, four *binaries*, involves a base of 2 and may be written for the representation of x_i as S_3, S_2, S_1, S_0 as:

$$x_i = 2^3 \times S_3 + 2^2 \times S_2 + 2^1 \times S_1 + 2^0 \times S_0$$

(a) Write a similar mapping for the quarternary system with a base of 4 (instead of 2) for x_i represented as S_3, S_2, S_1, S_0

$$x_i = (??) \times S_3 + (??) \times S_2 + (??) \times S_1 + (??) \times S_0$$

[Hint: The smallest number with four quarternaries will be 0 0 0 0 and the highest number will be 3 3 3 3] .

Make a Table of four quarternaries starting with 0 0 0 0 and extending to 0 1 0 0 (not the full Table ending in 3 3 3 3) with the corresponding (quarternary values of x_i)

Quarternary	**Value (quarternary) of x_i**
0 0 0 0	0.0
etc.	

(10)

Continued . . .

(b) Now, consider the following minimization problem:

Min $f(x_1, x_2) \equiv (x_1 - 10)^2 + (x_2 - 5)^2 - 36$

s.t.: $5 \leq x_1 \leq 10$ and $5 \leq x_2 \leq 10$

Use the sequence of random numbers, *R*, in Table 4.1 of your textbook and fill up the following Table with three chromosomes (Nos. 1 – 3), ***each*** involving four ***quaternaries***, 0, 1, 2 and 3 (give details of how you choose 0, 1, 2 and 3 from the *R*, in your answer script) **(15)**

Chromosome No.	x_1 (***Quaternary representation***)				x_2 (***Quaternary representation***)			
	S_3	S_2	S_1	S_0	S_3	S_2	S_1	S_0
1								
2								
3								

(c) Map these three chromosomes into ***real*** numbers (explain how in your answer script) and evaluate *f* **(15)**

Chromosome No., *i*	**Real x_1**	**Real x_2**	f_i
1			
2			
3			

(***40 Points***)

We will stop at this point and not worry about selection, crossover, mutation, JG, elitism, etc. (You may like to do these during the summer break).

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