تالتة تحكم

University: *Menoufia* **Faculty:** *Electronic Engineering* **Department:** *Industrial Electronics and Control Engineering* **Academic level:** *3rd Year* **Course Name:** *Elective-2 "Advanced control systems-2"* **Course Code:** *ACE 326* **Academic Year:** *2018/2019*	جامعة المنوفية	**Date:** *24/06/2019* **Time:** *3 Hours* **No. of pages:** *2* **No. of Questions:** *5* **Full Mark:** *70 Marks* **Exam:** *Final Exam* **Examiner:** *Dr. Lamiaa M. Elshenawy*

Achieved ILOS :

Question No		Q.1	Q.2	Q.3	Q.4	Q.5
Achieved ILOs	A- Knowledge & Understanding	a1,a19	a1,a5,a16,a19	a1,a5,a19	a1,a5,a16, a20	a1,a5,a16, a20
	B- Intellectual skills	b4	b1,b2,b4,b5	b1,b2,b5	b1,b2,b3,b5	b1,b2,b4,b5
	C- Professional and practical skills	c1	c1,c7,c20,c24	c1,c7,c20,c24	c1,c3,c7,c20, c24	c1,c3,c7, c20,c24

Q.1. Answer *True or False* (20 Marks)

1. All design problems have only linear inequality constraints.
2. A function cannot have more than one global minimum point.
3. The Hessian matrix of a continuously differentiable function can be asymmetric.
4. If there is an equality constraint in the design problem, the optimum solution must satisfy it.
5. At the optimum point, the Lagrange multiplier for an equality constraint can be negative.
6. A matrix is positive semidefinite if some of its eigenvalues are negative and others are non-negative.
7. A point satisfying necessary conditions for an unconstrained function may not be a local minimum point.
8. A "≤ type" constraint expressed in the standard form is active at a design point if it has zero value there.
9. Taylor series expansion can be written at a point where the function is discontinuous.
10. The value of the function having a global minimum at several points must be the same.
11. The Hessian matrix for a function is calculated using only the first derivatives of the function.
12. A quadratic form can have first-order terms in the variables.
13. A symmetric matrix is positive definite if its eigenvalues are non-negative.
14. If a point satisfies suffcient conditions for an unconstrained function, it should be an optimum point.
15. At the optimum point, Lagrange multipliers for the "≤ type" inequality constraints must be non-negative.
16. While solving an optimum design problem by KKT conditions, each case defined by the switching conditions can have multiple solutions.

17. All eigenvalues of a negative definite matrix are strictly negative.
18. In optimum design problem formulation, "≥ type" constraints cannot be treated.
19. The slack variable s_j for the "≤ type" inequality constraints can be negative.
20. A function defined on an open set satisfies Weierstrass theorem.

Q.2.

(10 Marks)

a. What is the necessary condition according to the Lagrange multiplier theorem for equality constraints? Derive it.

b. Find the local minimum points for the following function:

$$f(x_1, x_2) = 2{x_1}^2 + 3{x_2}^2 + x_1 - 2x_2.$$

Q.3.

(10 Marks)

Find the candidate local minimum points using KKT necessary conditions for the following cost functions:

a. Maximize $f(x_1, x_2) = 4{x_1}^2 + 3{x_2}^2 - 5x_1x_2 - 8$,
   Subject to $x_1 + x_2 = 4$.

b. Minimize $f(x_1, x_2) = (x_1 - 1)^2 + (x_2 - 1)^2$,
   Subject to $x_1 + x_2 \le 4$.

Q.4.

(20 Marks)

A system is described by the following state equations:

$$\dot{x}_1(t) = 4x_2(t), \qquad \dot{x}_2(t) = 3u(t),$$

with the boundary conditions $x(0) = [1 \;\; 0]^T; x(2) = [0 \;\; 2]^T$.

Design an optimal control that minimize the cost function, $J = \int_0^2 2u^2(t)\, dt$, by using

a. Euler-Lagrange multiplier theorem.

b. Pontryagin maximum principle.

Q.5.

(10 Marks)

The state equations of a system are:

$$\dot{x}_1(t) = 2x_2(t), \qquad \dot{x}_2(t) = -x_1(t) + x_2(t) + u(t).$$

Design a linear quadratic regulator (LQR) that minimize the following cost function:

$$J = \frac{1}{2}\int_0^\infty [{x_1}^2(t) + 3x_1(t)x_2(t) + {x_2}^2(t) + u^2(t)]\, dt,$$

$$\text{with } Q = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \text{ and } R = 1.$$

GOOD LUCK