ME 260: Structural Optimization: Size, Shape, and Topology		
Assigned: Oct. 30, 2020	Sample Quiz 1	Due: Not applicable

This is a do-it-home examination and you are permitted to refer to my class-notes, books, reference material, and internet resources. Please also sign this honor code given below and submit it along with your answer script that may be hand-written or typed. A single pdf file should be sent by email to suresh@iisc.ac.in with a cc to priyabratam@iisc.ac.in within 3 h from the time it is sent to you by email. We will be emailing the question paper at 10 AM. The deadline to receive your answer script is Nov. 2nd, 1 PM.

This examination will be graded for 15 points. So, **answer any three problems.**

Honor code

"I have neither consulted nor sought help from any living person, directly or indirectly, in answering the questions in the first quiz of ME 260. I understand the general guidelines given by the instructor with regard to the code of conduct of this examination."

Name:

Signature:

Place:

Date:

Problem 1 (5 points)

(a) There are four towns with (x, y) coordinates (in km) give as: (0,0), (3,0), (1,4), and (4,5). Pose a problem in finite variable optimization framework to lay roads of minimum total length so that we can travel from any town to the others. Write necessary and sufficient conditions for the problem you have posed. You need not solve the problem.

(b) What if there is a circular pond of radius 0.25 km with centre at the centroid of the quadrilateral formed by the four towns? Pose this problem and write necessary and sufficient conditions but you need not solve the problem.

Problem 2 (5 points)

$$\underset{a,b}{\text{Min}}\ f = \frac{Gabnpd^4}{8WLD^3}$$

Subject to

$$g_1 = \frac{8WLDk_w\sqrt{a^2+b^2}}{\pi abnd^3} - 345E6 \le 0$$

$$g_2 = \frac{80WLD^3\sqrt{a^2+b^2}}{Gabnpd^4} - 7 \le 0$$

$$g_3 = \frac{Gd^4abn}{8WLD^3} - 100 \le 0$$

Data: $W = 30\times 9.81, G = 79E9, L = 0.15, n = 3$

$d = 3\text{E-}3, D = 27\text{E-}3, p = 4\text{E-}3$

$$k_w = \frac{4c-1}{4c-4} + \frac{0.615}{c}; c = \frac{D}{d}$$

Consider a practical optimization from an engineering application.

(a) Solve the optimization problem shown on the left side, graphically, analytically, and computationally (fmincon).

(b) What if $n = 2$? Comment on what happens to the solution now?

(c) If you are allowed to change d, D, and n, find suitable values for them so that the aforementioned optimization problem has a minimum but the constraint qualification is not satisfied.

Problem 3 (5 points)

The problem of minimization of the volume of material of a statically determinate truss is stated ahead with a constraint on strain energy and a displacement constraint on one degree of freedom. Comment on what the symbols stand for.

(a) Solve for the areas of cross section analytically. Argue which constraint should be active? When do you think both constraints should be active?

(b) Pose a dual of the primal problem and solve it.

$$\underset{A_{i=1,2,\cdots N}}{\text{Min}} \quad \sum_{i=1}^{N} A_i l_i$$

Subject to

$$\mu: \quad \sum_{i=1}^{N} \frac{T_i t_i l_i}{A_i E} - \Delta^* \le 0$$

$$\lambda: \quad \frac{1}{2}\sum_{i=1}^{N} \frac{T_i^2 l_i}{A_i E} - SE^* \le 0$$

Data: $N, \mathrm{E}, \Delta^*, SE^*, l_i, T_i, t_i$ with $i = 1, 2.\cdots, N$

Problem 4 (5 points)

For the specifications shown in the adjacent figure, obtain a single stiffest topology of a truss using Truss Optimization Matalb code provided to you, for two separate load cases (red and blue) that do not act simultaneously.