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reviewer3@nptel.iitm.ac.in ▼

Courses » Applied Optimization for Wireless, Machine Learning, Big-Data

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## Unit 14 - Week 12: Application: Convex optimization for Big Data Analytics, Recommender systems, User Rating Prediction and Optimization for Finance

### Course outline

How to access the portal

Week 1 :  
Introduction to properties of Vectors, Norms, Positive Semi-Definite matrices and Gaussian Random Vectors

DOWNLOAD VIDEOS

Week 2:  
Introduction to Convex Optimization – Convex sets, Hyperplanes/ Half-spaces etc. Application: Power constraints in Wireless Systems

Week 3 :  
Convex/ Concave Functions, Examples, Conditions for

### Assignment-12

The due date for submitting this assignment has passed.

As per our records you have not submitted this assignment. **Due on 2018-10-24, 23:59 IST.**

1) Let the Lagrangian of an optimization problem be denoted by  $L(\bar{\mathbf{x}}, \bar{\boldsymbol{\lambda}}, \bar{\boldsymbol{\nu}})$ . The Lagrange dual function for the optimization problem is given by **1 point**



$$g_d(\bar{\boldsymbol{\lambda}}, \bar{\boldsymbol{\nu}}) = \max_{\bar{\mathbf{x}}} L(\bar{\mathbf{x}}, \bar{\boldsymbol{\lambda}}, \bar{\boldsymbol{\nu}})$$



$$g_d(\bar{\mathbf{x}}, \bar{\boldsymbol{\nu}}) = \min_{\bar{\boldsymbol{\lambda}}} L(\bar{\mathbf{x}}, \bar{\boldsymbol{\lambda}}, \bar{\boldsymbol{\nu}})$$



$$g_d(\bar{\boldsymbol{\lambda}}, \bar{\boldsymbol{\nu}}) = \min_{\bar{\mathbf{x}}} L(\bar{\mathbf{x}}, \bar{\boldsymbol{\lambda}}, \bar{\boldsymbol{\nu}})$$



$$g_d(\bar{\mathbf{x}}, \bar{\boldsymbol{\lambda}}) = \min_{\bar{\boldsymbol{\nu}}} L(\bar{\mathbf{x}}, \bar{\boldsymbol{\lambda}}, \bar{\boldsymbol{\nu}})$$

**No, the answer is incorrect.**

**Score: 0**

**Accepted Answers:**

$$g_d(\bar{\boldsymbol{\lambda}}, \bar{\boldsymbol{\nu}}) = \min_{\bar{\mathbf{x}}} L(\bar{\mathbf{x}}, \bar{\boldsymbol{\lambda}}, \bar{\boldsymbol{\nu}})$$

2) Let  $g_d(\bar{\boldsymbol{\lambda}}, \bar{\boldsymbol{\nu}})$  denote the Lagrange dual function for an optimization problem. The dual optimization problem for the given optimization problem is **1 point**



$$\max g_d(\bar{\boldsymbol{\lambda}}, \bar{\boldsymbol{\nu}})$$



$$\max g_d(\bar{\boldsymbol{\lambda}}, \bar{\boldsymbol{\nu}})$$

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## Cognitive Radio Systems

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No, the answer is incorrect.

Score: 0

Accepted Answers:

$$\max g_d(\bar{\lambda}, \bar{\nu})$$

$$\text{s.t. } \bar{\lambda} \succeq 0$$

Week 4 : Convex Optimization problems, Linear Program, Application: Power allocation in Multi-cell cooperative OFDM

3) Let  $p^*$ ,  $d^*$  denote the optimal values of the primal and dual optimization problems, respectively. Then

1 point

$$p^* \geq d^*$$

$$p^* \leq d^*$$

$$p^* < d^*$$

$$p^* > d^*$$

No, the answer is incorrect.

Score: 0

Accepted Answers:

$$p^* \geq d^*$$

Week 5: Jensen's Inequality, Operations that preserve Convexity, Examples, Beamforming in Multi-antenna Wireless Communication

4) Consider the min norm optimization problem  $\min \|\bar{\mathbf{x}}\|$ , s.t.  $\mathbf{A}\bar{\mathbf{x}} = \bar{\mathbf{b}}$ . The corresponding dual optimization problem is given as

1 point

$$\max -\frac{1}{4} \bar{\nu}^T \mathbf{A} \mathbf{A}^T \bar{\nu} - \bar{\nu}^T \bar{\mathbf{b}}$$

$$\max -\frac{1}{4} \bar{\nu}^T \mathbf{A} \mathbf{A}^T \bar{\nu} - \bar{\lambda}^T \bar{\mathbf{b}}, \bar{\lambda} \succeq 0$$

$$\max -\frac{1}{4} \bar{\lambda}^T \mathbf{A} \mathbf{A}^T \bar{\lambda} - \bar{\lambda}^T \bar{\mathbf{b}}, \bar{\lambda} \succeq 0$$

$$\max -\frac{1}{4} \bar{\lambda}^T \mathbf{A} \mathbf{A}^T \bar{\lambda} - \bar{\nu}^T \bar{\mathbf{b}}, \bar{\lambda} \succeq 0$$

Week-6: Maximal Ratio Combiner (MRC), Multi-antenna Beamforming with Interfering User, Zero-Forcing (ZF) beamforming, Robust beamformer Design

Week-7: Optimization for signal estimation, LS, WLS, Regularization. Application: Wireless channel estimation, Image Reconstruction- Deblurring, Representative of Convex Optimization problem

No, the answer is incorrect.

Score: 0

Accepted Answers:

$$\max -\frac{1}{4} \bar{\nu}^T \mathbf{A} \mathbf{A}^T \bar{\nu} - \bar{\nu}^T \bar{\mathbf{b}}$$

Week 8 : Application: Convex optimization for Machine Learning, Principal Component Analysis (PCA), Support Vector Machines

5) Consider the standard form of the optimization problem given below

1 point

$$\min g_0(\bar{\mathbf{x}})$$

$$\text{s.t. } \min g_i(\bar{\mathbf{x}}) \leq 0, i = 1, 2, \dots, l$$

$$\tilde{g}_j(\bar{\mathbf{x}}) = 0, j = 1, 2, \dots, m$$

The KKT conditions for the above problem are

i.  $g_i(\bar{\mathbf{x}}) \leq 0, i = 1, 2, \dots, l, \tilde{g}_j(\bar{\mathbf{x}}) = 0, j = 1, 2, \dots, m$

ii.  $\bar{\lambda} \succeq 0$

iii.  $\lambda_i g_i(\bar{\mathbf{x}}) = 0$

iv.  $\nabla_{\bar{\mathbf{x}}} L(\bar{\mathbf{x}}, \bar{\lambda}, \bar{\nu}) = 0$

Week 9- Application: Compressive Sensing, Sparse

Signal Processing, OMP (Orthogonal Matching Pursuit), LASSO (Least Absolute Shrinkage and Selection Operator) for signal estimation, SVM

Week 10- Application: Compressive Sensing, Sparse Signal Processing, OMP (Orthogonal Matching Pursuit), LASSO (Least Absolute Shrinkage and Selection Operator) for signal estimation

Week 11 : Application: Radar for target detection, Array Processing, MUSIC, MIMO-Radar Schemes for Enhanced Target Detection

Week 12: Application: Convex optimization for Big Data Analytics, Recommender systems, User Rating Prediction and Optimization for Finance

- Lec 74- Examples on Duality: Min-Max problem, Analytic Centering
- Lec 75- Semi Definite Program(SDP) and its application: MIMO symbol vector decoding
- Lec 76-

- i, ii, iii only
- ii, iii, iv only
- i, iii, iv only
- i, ii, iii, iv

No, the answer is incorrect.

Score: 0

Accepted Answers:  
i, ii, iii, iv

6) Consider the set of  $n$  parallel communication channels with power gain of the  $i^{th}$  channel given by  $\alpha_i$ . If the noise power for each channel is  $\sigma^2$ , what is the optimal power to be allocated to each channel to maximize the sum rate, given a total transmit power of  $P$  1 point

- $\frac{1}{\nu} - \frac{\sigma^2}{\alpha_i}$
- $\left( \frac{1}{\nu} - \frac{\sigma^2}{\alpha_i} \right)^+$
- $\left( \frac{1}{\nu} - \frac{\alpha_i}{\sigma^2} \right)^+$
- $\frac{1}{\nu} - \frac{1}{\alpha_i \sigma^2}$

No, the answer is incorrect.

Score: 0

Accepted Answers:  
 $\left( \frac{1}{\nu} - \frac{\sigma^2}{\alpha_i} \right)^+$

7) Consider a MIMO channel matrix with singular values 2, 1, 1. If the noise power for each channel is  $\sigma^2 = 3dB$ , what are the optimal powers to be allocated to the respective channels to maximize the sum rate, given a total transmit power of 0 dB ? 1 point

- $\frac{1}{2}, \frac{1}{4}, \frac{1}{4}$
- $\frac{1}{3}, \frac{1}{3}, \frac{1}{3}$
- 1, 0, 0
- 0,  $\frac{1}{2}, \frac{1}{2}$

No, the answer is incorrect.

Score: 0

Application:SDP for MIMO Maximum Likelihood(ML) Detection

- Lec 77- Introduction to big Data: Online Recommender System(Netflix)
- Lec 78- Matrix Completion Problem in Big Data: Netflix-I
- Lec 79- Matrix Completion Problem in Big Data: Netflix-II
- Quiz : Assignment-12
- Assignment-12 Solution

**Transcripts**

**Accepted Answers:**

1, 0, 0

8) The dual norm of the  $l_1$  norm is

1 point

- $l_0$  norm
- $l_1$  norm
- $l_2$  norm
- $l_\infty$  norm

No, the answer is incorrect.

Score: 0

**Accepted Answers:**

$l_\infty$  norm

9) Consider the linear program given below

1 point

$$\min \bar{\mathbf{c}}^T \bar{\mathbf{x}} \text{ s.t. } \mathbf{G}\bar{\mathbf{x}} \preceq \bar{\mathbf{h}}, \mathbf{A}\bar{\mathbf{x}} = \bar{\mathbf{b}}$$

The dual of this optimization problem is

- $\max \bar{\mathbf{b}}^T \bar{\boldsymbol{\lambda}} + \bar{\mathbf{h}}^T \bar{\boldsymbol{\nu}} \text{ s.t. } \bar{\mathbf{c}} + \mathbf{G}\bar{\boldsymbol{\lambda}} + \mathbf{A}\bar{\boldsymbol{\nu}} = 0, \bar{\boldsymbol{\lambda}} \succeq 0$
- $\max \bar{\mathbf{b}}^T \bar{\boldsymbol{\nu}} + \bar{\mathbf{h}}^T \bar{\boldsymbol{\lambda}} \text{ s.t. } \bar{\mathbf{c}} + \mathbf{A}^T \bar{\boldsymbol{\lambda}} + \mathbf{G}^T \bar{\boldsymbol{\nu}} = 0, \bar{\boldsymbol{\nu}} \succeq 0$
- $\min -\bar{\mathbf{b}}^T \bar{\boldsymbol{\nu}} - \bar{\mathbf{h}}^T \bar{\boldsymbol{\lambda}} \text{ s.t. } \bar{\mathbf{c}}^T \bar{\boldsymbol{\lambda}} + \mathbf{G}^T \bar{\boldsymbol{\nu}} = 0, \bar{\boldsymbol{\nu}} \succeq 0$
- $\max -\bar{\mathbf{b}}^T \bar{\boldsymbol{\nu}} - \bar{\mathbf{h}}^T \bar{\boldsymbol{\lambda}} \text{ s.t. } \bar{\mathbf{c}} + \mathbf{G}^T \bar{\boldsymbol{\lambda}} + \mathbf{A}^T \bar{\boldsymbol{\nu}} = 0, \bar{\boldsymbol{\lambda}} \succeq 0$

No, the answer is incorrect.

Score: 0

**Accepted Answers:**

$$\max -\bar{\mathbf{b}}^T \bar{\boldsymbol{\nu}} - \bar{\mathbf{h}}^T \bar{\boldsymbol{\lambda}} \text{ s.t. } \bar{\mathbf{c}} + \mathbf{G}^T \bar{\boldsymbol{\lambda}} + \mathbf{A}^T \bar{\boldsymbol{\nu}} = 0, \bar{\boldsymbol{\lambda}} \succeq 0$$

10) Consider the ML decoder  $\| \mathbf{y} - \mathbf{H}\mathbf{x} \|^2$  for the MIMO channel matrix  $\mathbf{H}$  where symbols in  $\bar{\mathbf{x}}$  are drawn from the BPSK constellation  $\{+1, -1\}$ . The relaxed SDP for the same is given as

1 point

- $\min \text{Tr}(\mathbf{S}) \text{ s.t. } \text{diag}(\mathbf{S}) = \bar{\mathbf{1}}, \mathbf{S} \succeq 0$
- $\min \text{Tr}(\mathbf{L}\mathbf{S}) \text{ s.t. } \text{diag}(\mathbf{S}) = \bar{\mathbf{1}}, \mathbf{S} \succeq 0 \text{ where } \mathbf{L} = \begin{bmatrix} \mathbf{H}^T \mathbf{H} & -\mathbf{H}^T \bar{\mathbf{y}} \\ -\bar{\mathbf{y}}^T \mathbf{H} & \bar{\mathbf{y}}^T \bar{\mathbf{y}} \end{bmatrix}$
- $\min \text{Tr}(\mathbf{L}\mathbf{S}) \text{ s.t. } \mathbf{S} \succeq 0 \text{ where } \mathbf{L} = \begin{bmatrix} \mathbf{H}\mathbf{H}^T & -\mathbf{H}^T \bar{\mathbf{y}} \\ -\bar{\mathbf{y}}^T \mathbf{H} & \bar{\mathbf{y}}^T \bar{\mathbf{y}} \end{bmatrix}$
- $\min \text{Tr}(\mathbf{L}\mathbf{S}) \text{ s.t. } \text{diag}(\mathbf{S}) = \bar{\mathbf{1}}, \mathbf{S} \succeq 0 \text{ where } \mathbf{L} = \begin{bmatrix} \bar{\mathbf{y}}\bar{\mathbf{y}}^T & -\mathbf{H}^T \bar{\mathbf{y}} \\ -\bar{\mathbf{y}}^T \mathbf{H} & -\bar{\mathbf{y}}^T \bar{\mathbf{y}} \end{bmatrix}$

No, the answer is incorrect.

Score: 0

Accepted Answers:

$$\min \text{Tr}(\mathbf{L}\mathbf{S}) \text{ s.t. } \text{diag}(\mathbf{S}) = \bar{\mathbf{1}}, \mathbf{S} \succeq 0 \text{ where } \mathbf{L} = \begin{bmatrix} \mathbf{H}^T \mathbf{H} & -\mathbf{H}^T \bar{\mathbf{y}} \\ -\bar{\mathbf{y}}^T \mathbf{H} & \bar{\mathbf{y}}^T \bar{\mathbf{y}} \end{bmatrix}$$

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