University of Tehran
School of Electrical and Computer Engineering

<table>
<tr><td>Course:</td><td colspan="10">8101581– Detection and Estimation Theory</td></tr>
<tr><td>Course type:</td><td colspan="9"><table>
<tr><td></td><td colspan="6">EE*</td><td colspan="3">CE*</td></tr>
<tr><td></td><td>Com</td><td>E</td><td>P</td><td>B</td><td>Con</td><td>D</td><td>SW</td><td>HW</td><td>IT</td></tr>
<tr><td>Required</td><td>☐</td><td>☐</td><td>☐</td><td>☐</td><td>☐</td><td>☐</td><td>☐</td><td>☐</td><td>☐</td></tr>
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</table></td><td>Credit: 3</td></tr>
<tr><td>Level:</td><td colspan="10">Undergraduate ☐
Graduate ■</td></tr>
<tr><td>Co-requisite(s):</td><td colspan="10">None</td></tr>
<tr><td>Prerequisite(s):</td><td colspan="10">Stochastic Processes (8101272)</td></tr>
<tr><td>Prerequisite by topic:</td><td colspan="10">Probability and random processes</td></tr>
<tr><td>Textbook(s):</td><td colspan="10">[1] H. V. Poor, An Introduction to Signal Detection and Estimation, Springer, 2nd edition, 1994.</td></tr>
<tr><td>Coordinator:</td><td colspan="10">A. Olfat, Associate Professor, School of ECE</td></tr>
<tr><td>Goals:</td><td colspan="10">The first part of the course presents the mathematical framework for hypothesis testing and different optimality criteria for hypothesis testing will be introduced. In this part upper bounds for probability of error for optimal and suboptimal detectors will be introduced. The second part of the course introduces different estimation methods for parameter estimation problem and then the optimal mean square error filters for dynamical estimation problems is formulated and optimal recursive estimators known as kalman filters are derived.</td></tr>
<tr><td>Outcome:</td><td colspan="10">Upon successful completion of the course, students will be able
1. To formulate detection problem as a hypothesis testing problem,
2. To apply different optimality methods for hypothesis testing,
3. To learn different estimation methods for both random and nonrandom parameters,
4. To obtain global lower bound for variance of estimators,
5. To derive state space models for stochastic processes,
6. To develop and implement optimal linear MMSE estimators for random processes.</td></tr>
<tr><td>Topics:</td><td colspan="10">1) Hypothesis Testing (Bayesian hypothesis testing, Minimax hypothesis testing, Neyman-Pearson hypothesis testing, Composite hypothesis testing, UMP and LMP tests, generalized likelihood ratio</td></tr>
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	testing). 2) **Signal Detection in Discrete Time** (Models and detector structures, Performance evaluation, Chernoff and related bounds, Sequential detection). **3) Parameter Estimation** (Bayesian estimation, random parameter estimation, Minimum mean square error estimation (MMSE), MAE method, Maximum a priori estimation (MAP), vector parameter estimation, Nonrandom parameter estimation, Maximum likelihood estimation (ML), Minimum variance unbiased estimation (MVUB), Cramer-Rao lower bound (CRLB). **4) Linear Minimum Mean Square Error Estimation and Kalman Filtering** (General linear estimation theory, State-space models and Kalman Filtering, Time-Invariant Kalman filters, Kalman Filtering for prediction, Optimal smoothers).
Computer usage:	MATLAB
Assignments:	9 to 11 assignments
Projects:	Term project on a related topic
Grading:	Assignments: 15% Project: 15% Midterm exams: 35% Final exam: 35%
Further readings:	[1] B. Levy, *Principles of Signal Detection and Parameter Estimation*, Springer, 2008. [2] M. S. Grewal and A. P. Andrews, *Kalman Filtering: Theory and Practicce*, Wiley, 4th Edition, 2015. [3] H. L. VanTrees, K. Bell and Z. Tian, *Detection, Estimation and Modulation Theory: Part I,* 2nd Edition, Wiley, 2013. [4] B. D. O. Anderson and J. B. Moore, *Optimal Filtering,* Prentice-Hall, 1979.
Prepared by:	Ali Olfat
Date:	December 9, 2017.

*EE: Electrical Engineering		CE: Computer Engineering	
Com	Communications	SW	Software
E	Electronics	HW	Hardware
P	Power	IT	Information Technology
B	Bioelectronics		
Con	Control		
D	Digital System		