University of Tehran
School of Electrical and Computer Engineering

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<tr><td>Course</td><td>8101821 –Electromagnetic Compatibility (EMC)</td></tr>
<tr><td>Course type</td><td>
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<tr><td></td><td colspan="6">EE*</td><td colspan="3">CE*</td><td rowspan="2">Credit: 3</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><td></td></tr>
<tr><td>Elective</td><td>☒</td><td>☐</td><td>☐</td><td>☐</td><td>☐</td><td>☐</td><td>☐</td><td>☐</td><td>☐</td><td></td></tr>
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<tr><td>Level</td><td>Undergraduate ☐
Graduate ■</td></tr>
<tr><td>Co requisite(s)</td><td>-</td></tr>
<tr><td>Prerequisite(s):</td><td>Fields and Waves</td></tr>
<tr><td>Prerequisite by topic:</td><td>Maxwell’s equations, Fields & waves, Fundamentals of electronics and Digital Systems</td></tr>
<tr><td>Textbook(s)</td><td>[1] Paul, Clayton R., Introduction to Electromagnetic Compatibility, 2nd edition, John Wiley & Sons, 2006
[2] Class notes handouts and journal articles.</td></tr>
<tr><td>Coordinator</td><td>J. Rashed-Mohassel, Professor, School of ECE</td></tr>
<tr><td>Goals</td><td>The course provides electrical engineering students with the required background to understand and design electromagnetically compatible systems. These designs meet the requirements of: not interference with other systems, and not susceptible to emissions from other systems. Students upon completion of the course will have a comprehensive and advanced knowledge of topics stated in the course description for EMC/EMI system design.</td></tr>
<tr><td>Outcome</td><td>Upon successful completion of the course, students will be able to
1. analyze and design electronic and digital systems for EMC/EMI
2. understand concepts of signal integrity and non ideal behavior of components
3. understand the concepts of conducted emission, radiated emission and susceptibility
4. consider and analyze crosstalk, coupling and shielding in transmission lines, PCB lands, and wires
5. understand grounding, shielding, shielding effectiveness, magnetic field shielding, effect of apertures,
6. perform system configuration and design for EMC/EMI
7. obtain a comprehensive and advanced knowledge of topics stated in the course description</td></tr>
<tr><td>Topics</td><td>Introduction to EMC/EMI: Noise and interference, fundamental behavior of electrical systems, EMC requirements for electronic systems, review of Maxwell 's equations, radiation mechanism, definition of resistance, capacitance, and inductance, KVL & KCL from a field point of view, transmission lines, analysis of lossy lines, transients on lossy lines, step response, delay time, rise time, skin effect in transmission lines, time</td></tr>
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	domain reflectometry (TDR), low pass filter as a delay line, Iterative transfer function, step response of a ladder network, signal integrity, bandwidth of digital waveforms. **Electromagnetic spectrum**: signal spectrum, Fourier series, impulse functions, periodic functions, trapezoidal waveforms, rise/fall time, effect of repetition rate and duty cycle, Fourier transform and non-periodic signals, modulation and signal spectrum, **Limitations of Kirchhoff's laws**: RLC circuits, coupled circuits, coupling coefficients and induced voltages, non-ideal behavior of circuit components, internal impedance in low and high frequency limits, self and mutual inductance of two circuits, radiation resistance of a planar circuit, equivalent circuit for a resistor, capacitor, and inductor, ferromagnetic materials, electromechanical devices, mechanical switches, arcing, **Antennas and radiation mechanism**: Hertzian dipole, Near-zone field, Far-zone field, radiation from a loop antenna, broadband antennas, aperture antennas, receiving/transmitting, **EMC regulations**: Radiation emission, class A and class B digital devices, differential and common mode currents, radiation from common modes, emission modes for common mode currents, current probes, **Radiated immunity**: Shielded cables, conducted emissions and susceptibility, power supply filters, conducted immunity, **Network analysis**: Spectrometers, cabling, capacitive coupling, inductive coupling, radiation coupling, cross-talk, shielding against magnetic radiation, shielding against electromagnetic fields, shielding effectiveness, reflection from and transmission through conductors, apertures, **System design for EMC**: Printed circuit boards (PCBs), digital circuits, internal noise sources, TTL examples, digital circuit radiation, **Electrostatic discharge**: Dielectric breakdown, static charge generation, human body models, static discharge,
Computer usage	MATLAB, Related Software (MININEC, AWAS, PSPICE,)
Assignments	8 to 10 homework assignments (15%)
Projects:	One final project (15%)
Grading	Assignments & Project 30 % Midterm exam: 35 % Final exam: 35 %
Further readings	[1] Sengupta, Dipak, L., Liepa, Valdis V., *Applied Electromagnetics and Electromagnetic Compatibility,* John Wiley & Sons, 2006. [2] Weston, David A., *Electromagnetic Compatibility, Principles and Applications*, 2nd ed., Revised and Expanded, Marcel Dekker, New York, 2001 [3] Kodali, W. Prasad, *Engineering Electromagnetic Compatibility*, 2nd ed.: *Principles, Measurement, Technologies, and Computer Models*, IEEE Press, 2001, [4] Morrison, Ralf, *Grounding and Shielding Techniques*, 4th ed., John Wiley, 1998, [5] Ott, Henry W., *Noise Reduction Techniques in Electromagnetic Systems*, 2nd ed., John Wiley & Sons, 1988 [6] Williams, Tim, *EMC for Product Designers*, 2nd ed., Red Educational and Professional Publishing Ltd (Newnes), 1996 [7] Philip C. Magnusson, Gerald C. Alexander, Vijai K. Tripathi, Andreas Weisshaar, *Transmission Lines and Wave Propagation*, 4th ed., CRC press, 2001 [8] Ronald Kitchen, *RF and Microwave Radiation Safety, 2nd ed.,* Newnes, 2001,
Prepared by	Jalil Rashed-Mohassel
Date	Jan., 26, 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		