Birla Institute of Technology & Science, Pilani
Work Integrated Learning Programmes Division
M. Tech Automotive Electronics
I Semester 2019-20

Course Title	Automotive Control Systems
Course No(s)	AEL ZG510
Credit Units	5
Credit Model	Instruction + Student Preparation
Instructor-In-Charge	

Course Description
Introduction to vehicle electronics, semiconductor diodes, FETs, rectifiers, small signal amplifiers, circuit models, automotive applications and case studies, automotive micro controllers, auto sensors and actuators, vehicle electronics, feedback control, control strategy, analog and digital controllers, expert systems and neural networks, advanced topics in EMC, vehicle communication networks, automotive control system design, transmission and powertrain, brake, traction, suspension, active safety and supplementary restraint systems, intelligent vehicle systems and ADAS..

COURSE OBJECTIVES	
CO1	Learn the working of various components, sensors and actuators used by control systems
CO2	Educate about various automotive micro controllers, control systems and control strategy
CO3	Introduce the CAN network and various systems built around the CAN network

LEARNING OUTCOMES	
LO1	Comfortable selecting, designing and working with electronic components and systems
LO2	Able to design and develop simple control systems for automotive mechatronics
LO3	Understand the strategy and working of various automotive systems like ABS, EBD etc.,
LO4	Understand and analyze connected car technlogy and ADAS systems
LO5	Apply the concepts using Ricardo Ignite and MATLAB.

Text Book(s):

T1	U Kiencke, L Nielsen, “Automotive Control Systems for Engine, Driveline, and Vehicle”, Springer.
T2	Ronald K. Jurgen, “Automotive Electronics Handbook”, McGraw-Hill, Inc.

Reference Book(s) & other resources:

R1	Allan W.M. Bonnick, “Automotive Computer Controlled systems, Diagnostic tools and techniques”
R2	Bechfold, Understanding Automotive electronics, SAE, 1998.
R3	William, B. Ribbens, Understanding Automotive electronics, ButterWorth Heinemann 1998.
R4	Robert N. Brandy, Automotive computers and Digital Instrumentation, Prentice Hall Eaglewood Cliffs, New Jersey, 1988.

Content Structure: Current

Session	Area	Topic	Reference
1	**Vehicle Electronics1**	Semiconductor diodes, FETs, Rectifiers, Small signal amplifiers	
2		Circuit models, Automotive applications and case studies	
3	**Automotive Microcontrollers**	Introduction to modern computer logic Programming inputs and Outputs	
4		Interrupts and system design. Typical controllers used	
5	**Auto Sensors and Actuators**	Types of sensors, Sensors calibration	
6		Signal attenuation, Shielding	
7	**Vehicle Electronics2**	Feedback control, Control strategy	
8		Analog and digital controllers, Expert systems and neural networks	
9	**Advanced Topics in EMC**	Basics of EMC, Component segregation, cable routing, Grounding, Shielding, common impedance coupling	
10		Classification of EMC environments, EMC test methods	
11	**Vehicle Communication Networks**	Various networks used, topology, basic architecture of CAN	
12		Security protocols, Vulnerabilities	
13	**Automotive Control Systems**	Engine, Transmission, Powertrain, Brake control systems	
14		Traction, Suspension control systems, active safety systems	
15	**Intelligent Vehicle Systems and ADAS**	In vehicle electronic sensors, connected cars and application Collision avoidance systems	
16		Active cruise control, Self-driving applications	

Revised Objectives

COURSE OBJECTIVES	
CO1	Learn the fundamentals of control strategy development for automotive systems
CO2	Understand the various functional requirements of automotive applications
CO3	Introduce the concept of model based control development and testing

LEARNING OUTCOMES	
LO1	Develop control strategy for ICE and other automotive sub systems
LO2	Able to design and develop control systems for automotive applications
LO3	Develop plant models for evaluating control strategies
LO4	Develop MIL and HIL testing frameworks and analyse results
LO5	Gain proficiency in use tools like Ricardo Wave, Ricardo Ignite and Simulink

Content Structure: Revised

Mode – Class Room Discussions

Topic No	Topic Title	Reference
1.1	Introduction to control systems, examples and need. Concepts of control system design, development process	
1.2	Over-View of course structure, defining pre-requisites, supplementary study material and time lines	
1.3	Introduction to Automotive IC Engines and Electronic Fuel Control, Fundamentals of ICE control	

Topic No	Topic Title	Reference
2.1	SI Engine Modelling – Fundamental Equations and their significance	
2.2	Air-fuel Ratio & Flame Propagation	
2.3	Emissions Formation & Control	

Topic No	Topic Title	Reference
3.1	CI Engine Modelling – Comparison with SI Engine	
3.2	Direct Injection and Lean Burn – CI vs GDI	
3.3	Emissions Formation & Control	

Topic No	Topic Title	Reference
4.1	SI Engine Control Requirements	
4.2	Lambda Control Circuit & Engine Model for Lambda Control	
4.3	Adaptive Lambda Control	

Topic No	Topic Title	Reference
5.1	Knock Control in SI Engines	
5.2	Knock Sensor, Conditioning & Control	
5.3	Cylinder Balancing & Adaptation of injection map	

Topic No	Topic Title	Reference
6.1	Engine Mis-Fire Detection	
6.2	Kalman Filter Design	
6.3	Crankshaft Torque Balance	

Topic No	Topic Title	Reference
7.1	Power Train Modelling – Manual and Automatic Gearboxes	
7.2	Drive Cycles and Significance of Gear Ratios	
7.3	Testing methodology, statutory requirements and standards	

Topic No	Topic Title	Reference
8.1	Steer by Wire – EPS control development	
8.2	Drive by Wire – Electronic Throttle Control	
8.3	Brake by Wire – Electronic Brake Control	

Topic No	Topic Title	Reference
9.1	Plant Modelling, Requirements and Applications	
9.2	Plant Modelling using Simulink and Simscape	
9.3	Data Driven vs Mathematical Models	
9.4	Data Extraction Methods – Testing vs Simulation	

Topic No	Topic Title	Reference
10.1	1D Model using Ricardo Wave – Design of Experiments and Data Collection	
10.2	Full System simulation using Ricardo Ignite – MIL Testing	
10.3	Co-Simulation of Wave & Simulink Models – MIL Testing	

Topic No	Topic Title	Reference
11.1	HIL Testing fundamentals, applications and use cases	
11.2	Developing HIL testing frame-work for control strategy evaluation	
11.3	Automating HIL Test Scripts – Pass / Fail Scenarios	

Evaluation Scheme:

Legend: EC = Evaluation Component; AN = After Noon Session; FN = Fore Noon Session

No	Name	Type	Duration	Weight	Day, Date, Session, Time
EC-1	Quiz	online	2 weeks	10%	
	Assignments / Experiential lab	Virtual / Remote	2 weeks	20%	
EC-2	Mid-Semester Test	Closed Book	2 hours	30%	
EC-3	Comprehensive Exam	Open Book	3 hours	40%	

Elearn portal: https://elearn.bits-pilani.ac.in.
Students are expected to visit the Elearn portal on a regular basis and stay up to date with the latest announcements and deadlines.

Contact sessions: Students should attend the online contact sessions as per the schedule provided on the Elearn portal.

Evaluation Guidelines:

1. EC-1 consists of Quizzes, assignments, project
2. For Closed Book tests: No books or reference material of any kind will be permitted.
3. For Open Book exams: Use of books and any printed / written reference material (filed or bound) is permitted. However, loose sheets of paper will not be allowed. Use of calculators is permitted in all exams. Laptops/Mobiles of any kind are not allowed. Exchange of any material is not allowed.
4. If a student is unable to appear for the Regular Test/Exam due to genuine exigencies, the student should follow the procedure to apply for the Make-Up Test/Exam which will be made available on the Elearn portal. The Make-Up Test/Exam will be conducted only at selected exam centres on the dates to be announced later.
5. Syllabus for Mid-Semester Test (Closed Book): Contact Hours 1 to 8
6. Syllabus for Comprehensive Exam (Open Book): Contact Hours 1 to 16

It shall be the responsibility of the individual student to be regular in maintaining the self-study schedule as given in the course handout, attend the online lectures, and take all the prescribed evaluation components such as Quizzes, Assignments, Project, Mid-Semester Test and Comprehensive Examination according to the evaluation scheme provided in the handout.

Instructor-in-charge
(AEL ZG510)