汽车系研究生英文授课课程大纲汇编

2012 年 7 月

序号	课程名	英文课程名	课程号	学分	授课教师
1	汽车碰撞安全基础	Fundamentals of Automotive Crash Safety	80150193	3	周青
2	轻量化设计基础	Fundamentals of Lightweight Design	70150133	3	侯之超 危银涛
3	机械设计中的材料选择	Materials Selection in Mechanical Design	80150122	2	危银涛
4	汽车工程 1	Automotive Engineering I	70150153	3	王霄锋
5	车辆新型驱动系统	Alternative Vehicle Propulsion System	80150162	2	张俊智
6	车辆控制工程	Vehicle Control Engineering	70150113	3	李克强
7	汽车 NVH	Vehicle NVH	80150173	3	郑四发
8	汽车工程Ⅱ	Automotive Engineering II	70150333	3	郑四发
9	汽车机电系统	Mechatronic Systems in Automotive Engineering	70150163	3	李建秋
10	内燃机Ⅰ	Internal Combustion Engines I	70150203	3	马凡华
11	内燃机Ⅱ	Internal Combustion Engine II	80150183	3	王志

Fundamentals of Automotive Crash Safety (Shortened as FACS)

汽车碰撞安全基础

Basic Information

Course Number: 80150193
Class Hours: 48
Course Credits: 3

Lecturers: ZHOU Qing (zhouqing@tsinghua.edu.cn)
XIA Yong (xiayong@tsinghua.edu.cn)
Intended Students: Graduate students, foreign students

Prerequisite: Engineering Mathematics and Engineering Mechanics. Knowledge of the following courses is helpful but not set as prerequisite: finite element method, and automobile body structure.

Biography of Professor ZHOU Qing

Professor ZHOU Qing joined the faculty of Tsinghua University in 2003 as a professor in the Department of Automotive Engineering. He also serves as the Director of Vehicle Safety Committee of the Chinese Society of Automotive Engineers. Prior to joining Tsinghua University, Dr. Zhou worked as a technical specialist from 1999 to 2003 in the Volpe Transportation Systems Center, a research unit in the US Department of Transportation in Cambridge, Massachusetts, USA. From 1994 to 1999, he worked in the R&D Center of General Motors in Warren, Michigan, USA, first as a senior research engineer and later as a staff research engineer. Dr. Zhou's research interests include vehicle crashworthiness, structural and material failure under impact loading, lightweight vehicle body design, occupant and pedestrian impact protection, and impact biomechanics. Dr. Zhou received his bachelor degree in mechanics from Peking University in 1985, and his Ph.D. degree in applied mechanics from Massachusetts Institute of Technology in 1994.

Course Abstract

In this course, fundamental knowledge and theory and current technologies and research methods in the area of vehicle crashworthiness and occupant/pedestrian impact protection will be systematically lectured and discussed. The fundamental contents include safety characteristics of vehicle body structure, design and analysis of major crash energy absorbing components, crash characterization, kinematics and dynamics of occupant in vehicle crash, human body injuries in vehicle accidents and injury assessment methods, and occupant restraint systems such as seat, seatbelt and airbag. The advanced contents include pedestrian impact protection, vehicle crash compatibility, lightweight vehicle and crash safety, structural failures under impact loading, etc.

In addition to attending the lectures of about 48 class hours, students are required to participate in discussions in class and complete about 4-5 homework sets after class. There will also be 3-4 in-class quizzes and each will take no more than 20 minutes. In the final course grade, student's

performance in the homework and the class attendance will be accounted for about 75%, and student's performance in the quizzes will be accounted for about 25%. The course language is English.

Course Outline

Notes:

- The lecture sequence in actual teaching could be slightly adjusted.
- The number in the parenthesis after each lecture title represents approximate class hours.

Lecture 0 – Course Organization (0.5)
- Basic information
- Arrangement of lectures, references, problem sets and final examination
- Grading policy
- Lecture topics

Unit 1 – Vehicle Structure and Crash Pulse

Lecture 1 – Fundamentals of Crash Safety (2)
- Vehicle crash process
- Definition of crash safety
- Types of collisions
- Crashworthiness requirements
- Design process and performance target

Lecture 2 – Critical Body Structures for Crash Safety (3)
- Main body structures and their safety requirements
- Packaging of engine compartment
- Front bumper
- Front rail and crash box
- Design for oblique and offset impacts
- Load path for frontal crash

Lecture 3 – Large Deformation Mechanics of Thin-Wall Tubes (3)

Lecture 4 – Crash Pulse and Occupant Ride-Down Analysis (5)
- Vehicle crash pulse
- Vehicle and occupant kinematics
- Occupant ride-down analysis
- Crash pulse characterization
- Design considerations

Unit 2 – Human Body Injuries and Crash Assessment

Lecture 5 – Human Body Injuries in Motor Vehicle Accidents (3)
- Injury mechanisms under impact loading
- Mechanical responses of human body to impact loading
- Human injury tolerances

Lecture 6 – Crash Test Dummy (2)

Requirements of crash test dummies
Historical developments of dummies
Hybrid III frontal impact dummy
Other dummies

Lecture 7 – Introduction of Vehicle Crash Test Methods (2)
Main elements of vehicle crash test laboratory
Typical procedure of crash test
Types of crash tests

Unit 3 – Occupant Restraint Systems

Lecture 8 – Seat System (2)
Structure
Seat strength requirements
Anti-whiplash techniques
Advanced seats

Lecture 9 – Seatbelt System (3)
Seatbelt benefits and history
Components and working principals
Seatbelt regulations
Advanced seatbelts

Lecture 10 – Airbag System (2)
Airbag benefits and history
Airbag components and working principals
Types of airbags
Airbag hazards
Depowered and advanced airbags

Lecture 11 – Design and Analysis for Occupant Head Impact Protection (3)
Background of occupant head impact problem
The mechanics model and the rationales for the model
How the findings lead to the protection countermeasure design

Lecture 12 – Protection of Child Passengers (2)
Characteristics child body
Child injury criteria
Child passenger protection

Unit 4 – Protection for Side Impact and Pedestrian Impact

Lecture 13 – Side Impact Protection (3)
Challenges and requirements of side impact protection
Analysis of side impact process
Design and countermeasures for side impact protection

Lecture 14 – Pedestrian Impact Protection (3)
Characteristics of car-to-pedestrian impact accidents
Injuries in car-to-pedestrian collisions
Assessment methods and test devices for pedestrian impact

Pedestrian protection measures
Vehicle design considerations

Unit 5 – Crash Safety of Lightweight Vehicles and Impact Failures

Lecture 15 – Vehicle Weight Reduction and Crash Compatibility (3)
Reality problems, vehicle size and safety
Influencing factors of crash compatibility
Compatibility problems in real world accidents
Assessment of compatibility
Lightweight and safety

Lecture16 – Study on Failure of Materials and Spot Welds for Vehicle Crash Application (3)
Body materials for lightweight vehicle
Material and structural failures in vehicle crash
Challenges in material failure characterization for vehicle crash application
Modeling of material failure
Joining methods in vehicle bodies
Structure of spot welds
Mechanical test methods of spot welds
Failure modes of spot welds
Modeling of spot weld failure

Fundamentals of Lightweight Design

轻量化设计基础

Basic Information

Course Number: 70150133
Class Hours: 48
Course Credits: 3

Lecturers: HOU Zhichao, WEI Yintao
Intended Students: Graduate students, foreign students

Course Outline

Chapter 1 Introduction (3 class hours)
- motivation of structural lightweight design
- concepts and approaches of lightweight design
- main methods for vehicle lightweight design
- contents and schedule of the classes

Chapter 2 Fundamentals (4.5)
- Typical structures and their models
- Structural elements and their failure modes

Chapter 3 Material Selection for Lightweight Design (7.5)
- Materials for lightweight design
- Indices for material lightweight design
- Structural elements and typical material indices
- Tutorial: Application of a special software for material selection

Chapter 4 Truss and Solid Beams (14)
- Truss
- Engineering beam theory
- Basics of plastic beam
- Tutorial

Chapter 5 Thin-walled Beam and Stiffened Shear Web (16)
- Bending of thin-walled beams
- Torsion of thin-walled beams
- Stiffened shear web
- Tutorial

Chapter 6 Typical Applications of Lightweight Design (3)
- USA and EU: ULSAB program
- Vehicle lightweight design in Japan and South Korea
- Other examples

Materials Selection in Mechanical Design

机械设计中的材料选择

Basic Information

Course Number: 80150122
Class Hours: 32
Course Credits: 2

Lecturers: WEI Yintao
Intended Students: Graduate students, foreign students

Course Abstract

The primary goal of this course will be for students to learn to identify, based on previously-defined design requirements, the basic function of an engineering object, the parameters to be optimized and the best material(s) to meet the design requirements. Students should also become aware of the breadth and range of material properties associated with different material classes, the basic processes available for processing materials and how to relate the shape of a component to its mechanical response.As the application of the materials selection theory the materials for automobile bodies will be introduced in the second part of the lectures.The practical objects includes

- Developing students' ability to select and optimize materials for a given engineering application, especially for vehicle structures, with due consideration to functional requirements, cost, availability, manufacturability, etc.
- Learn basic criteria for materials selection.
- Derive the performance indices for materials.
- Select materials with lightweight design and energy-safety.
- Select materials with good toughness and impact properties.
- Familiar with materials of automotive bodies

After this course, the students should have

- Talent of systematic selection of materials for a variety of structural designs, especially for vehicle/component
- Capability of identifing the basic function of an engineering object, the parameters to be optimized and the best material(s) to meet the design requirements

Application of the material selection theory to the automobile bodies

Automotive Engineering I (Shortened as AE I)

汽车工程 I

Basic Information

Course Number: 70150153
Class Hours: 48
Course Credits: 3

Lecturers: WANG XiaoFeng (wangxf60@tsinghua.edu.cn)
Intended Students: Graduate Students

Prerequisite: Engineering Mathematics and Engineering Mechanics.
Lecture semester: Fall Semester

Course Abstract

Automotive engineering 1 or Longitudinal dynamics of vehicles focuses on dealing with vehicle performances in their longitudinal direction, i.e., driving and braking performances. The main contents of the course are as follows:

1. The resistance forces to the motion of vehicle, including rolling resistance, aerodynamic drag, upgrade resistance force, and acceleration resistance.
2. The designs and structures of the engines, clutches, hydrodynamic couplings, hydrodynamic torque converters, transmissions, transfercases, driveshafts, differentials, brakes and brake circuits
3. Determination of the vehicle performances, including maximum velocity, maximum slope angle which can be overcome, maximum acceleration.
4. Determination of the fuel consumption of the vehicle.
5. determination of the brake performances of the vehicle.

The students are required to do exercises.

Course Outline

1 Introduction
1.1 Dawn of the motor vehicle age
1.2 Ways of transportation
1.3 Energy demand
1.4 Influence on environment

2 Road loads
2.1 Rolling resistance
2.2 Aerodynamic drag and lift
2.3 Climbing and upgrade resistance

2.4 Acceleration resistance
2.5 Overall resistance

3 Drivetrain
3.1 Energy storage devices
3.2 Engines
3.3 Clutches: speed converters
3.4 Transmissions: torque converters
3.5 Differentials
3.6 Vibrations

4 Driving performance and fuel economy
4.1 Power-limited performance(Maximum velocity, acceleration performance, gradeability and influences of transmission layout)
4.2 Fuel economy
4.3 Propulsion concepts
4.4 Traction-limited performance(acceleration performance and gradeability)

6 Braking performance
6.1 brake systems
6.2 Legal requirements
6.3 Wheel brakes
6.4 Brake circuit division
6.5 Hydraulic service brake systems
6.6 Air brake system
6.7 Hybrid brake system
6.8 Electric brake system
6.9 Continuous service brake system
6.10 Parking brake system
6.11 Basic equations for braking performance
6.12 Braking forces
6.13 Tire-road friction
6.14 Vertical loads and maximum braking forces on the axles
6.15 Braking capacity due to adhesion
6.16 Brake force distribution
6.17 Pedal force gain

Alternative Vehicle Propulsion System

车辆新型驱动系统

Basic Information

Course Number: 80150162
Class Hours: 48
Course Credits: 3

Lecturers: ZHANG Junzhi
Intended Students: Graduate students, foreign students

Course Abstract

The subject of this lecture series is alternative concepts for vehicle drive-trains. These lectures deal with the different alternative drive systems, such as unconventional types of combustion engines with the consideration of alternative fuels (alcohol, natural gas, hydrogen), gas turbines, Stirling engines and fuel cells. Furthermore, these lectures discuss the different types of variable transmissions and power split drive trains. Regenerative drives e.g. electric, flywheel and hybrid drives are a main topic of these lectures. Beside the discussion of the different components (hydraulic machines, electric motors, hydraulic pressure accumulators, batteries, flywheels), possible control strategies (integrated engine-transmission management) are deducted, according to the various drive concepts.

- **1.** Introduction
  - 1.1 Definition
  - 1.2 Motivation
  - 1.3 Classification of alternative propulsion systems

- 2. Energy sources and properties
  - 2.1 Properties of fuels
  - 2.2 Production of alternative fuels
  - 2.3 Alternative fuels and applications

- 3. Energy conversion cycles and their realization
  - 3.1 Thermodynamical energy conversion
    - 3.1.1 Thermodynamical ideal cycles
    - 3.1.2 Alternative processes
    - 3.1.3 Realization of alternative processes
  - 3.2 Electrochemical energy conversion: fuel cell
    - 3.2.1 Definition and History
    - 3.2.2 Classification
    - 3.2.3 Basics of cell and stack
    - 3.2.4 Fuel cell systems

- 4. Storage of alternative fuels

- 4.1 Hydrogen storage
- 4.2 Electrical accumulators
- 4.3 Flywheels
- 4.4 Hydraulic accumulators
- 4.5 Comparison of storage concepts

◆ 5. Regenerative energy converters
- 5.1 Electric machines
- 5.2 Hydraulic machines
- 5.3 Comparison of conversion systems

◆ 6. Torque converter (transmission)
- 6.1 Mechanical transmission
- 6.2 Torque conversion via regenerative energy conversion
- 6.3 Comparison of torque converters

◆ 7. Structures of alternative propulsion systems (morphology)
- 7.1 Single propulsion systems
- 7.2 Hybrid concepts
- 7.3 Comparison of morphologies

Vehicle Control Engineering

车辆控制工程

Basic Information

Course Number: 70150113
Class Hours: 48
Course Credits: 3

Lecturers: LI Keqiang
Intended Students: Graduate students, foreign students

Course Abstract

Based on Control Theory and Vehicle Dynamics, this course will present the control strategies, system design and evaluation method to develop vehicle electronic control devices, and introduce the state of the art and perspectives of vehicle control technology. To introduce the concepts and terminology, the stateof-the-art development, and basic principles of various vehicle control systems. Principles， Rather Than Specifics Will be Emphasized Upon completion of this course, students should be able to follow the literature on these subjects and perform independent design, research and development work in this field.

Course Outline

Chapter 1 Introduction to Vehicle Control Technology

Chapter 2 Fundamentals of Vehicle Dynamics and Control

Chapter 3 Engine/Drivetrain Control

– – Emission Control
– – Fuel Economics & Dynamic Performance Control
– AT/AMT/CVT
– Chapter 4, Chassis Control
– ABS & TCS
– – Vehicle Dynamics Control / ESP
– Active Suspension / ANC

Chapter 5, Intelligent Vehicle/Intelligent Transportation Systems

- ITS/AVCSS

- FCW/CAS、ACC

Vehicle Acoustics (NVH)

汽车 NVH

Basic Information

Course Number: 80150173
Class Hours: 48
Course Credits: 3

Lecturers: ZHENG Sifa
Intended Students: Graduate students, foreign students

Course Abstract

The first part of the lecture deals with the physical and audiological groundings of automotive acoustics. Further subjects are noise emission standards and measurement regulations and procedures. Based on that the specific vehicle noise sources e.g. power train, brakes and tyres are discussed as far as noise generation and technical reduction potentials are concerned. The influences of manufacturer, customer and legislation on the reduction of traffic noise are investigated for the current traffic situation. Beyond the theoretical background the subjects are put into practice by demonstrations of measurement techniques, noise reduced vehicle parts and sound level measurements in the anechoic chamber or on the test track.

Course Outline

0 Introduction

1 Fundamentals

1.1Acoustics
1.1.1 Sound characteristics
1.1.2 Sound level
1.1.3 Sound wave propagation
1.1.4 Reflection and transmission of sound waves
1.2Audiology
1.2.1 The anatomy of the human ear
1.2.2 Threshold of audibility and auditory area
1.2.3 Spaciousness

2 Measuring Equipment

2.1Sensors,measuringdevices
2.1.1Airborne sound
2.1.2 Structure borne sound
2.2Test chambers
2.2.1Anechoic chamber
2.2.2Reverberation room
2.3Signal Analysis

3 Legislation, Measuring regulations and limiting values

3.1 Applicabe regulations
3.2 Noise measurement procedures
3.2.1interior noise
3.2.2Exterior noise
3.3Exterior noise limit values
3.3.1 Accelerated passage
3.3.2 tire noise in constant driving
3.3.3 low noise road vehicles
3.3.4 conformity of production
3.4 Critical remarks on road-vehicle noise legislation
3.5 Partial sound source analysis
3.5.1Measurement with encapsulated vehicles
3.5.2Simulation calculations
3.5.3 Simulation examples of level-reduction measures

4 Drive train and chassis

4.1 Set up
4.2 Combustion engine
4.2.1 indirect noise(combustion noise, mechanical noise)
4.2.2 Direct noise(Intake and exhaust system, radiator and generator)
4.2.3 Noise level of vehicle engines
4.2.4 Possibilities of noise reduction(Active measures, passive measures)
4.3 Transmission
4.3.1 Design
4.3.2 Noise generation and remedial measure
4.3.3 Noise level of gear transmission
4.4 Joints
4.4.1 Designs
4.4.2 Vibration excitation and influence possibilities
4.5 Vibration system “Drive train”
4.5.1Vibration excitation and NVH phenomena
4.5.2Remidies
4.6 Alternative vehicle drives
4.6.1 Electric drive
4.6.2 Hybrid drives
4.7 Tires
4.7.1Tire structure
4.7.2Origin of noise
4.7.3Influcing variables and measurements of noise reduction
4.7.4Roll noise level of motor vehicles
4.8 Brake systems
4.8.1 Brake Squeak
4.8.2 Brake Judder
4.9 Steering system

5 Body

5.1Sound Sources

5.1.1 Vibration excitation by drivetrain and tires

5.1.2 Noise generation by wind

5.2 Analysis of sound sources and transfer

5.2.1 Experiment method

5.2.2 Calculation methods(FEM/BEM/SEA)

5.3 Methods for interior Noise reduction

5.3.1 Body Noise

5.3.2 Airbourn Sound

6 Psychoacoustics

6.1 indices

6.2 Criteriaof perception

6.3 Measuring technology and analysis methods

Vehicle Engineering II (Vertical and lateral dynamics)

汽车工程 II

Basic Information

Course Number: 70150333
Class Hours: 48
Course Credits: 3

Lecturers: ZHENG Sifa
Intended Students: Graduate students, foreign students

Course Abstract

In this lecture the student becomes acquainted with the basic knowledge and analysis of suspension systems. During the first part of the lecture the main point of interest is in the subject "vertical dynamics" not only the different requirements regarding the suspension itself, but also various other components of the vibration-system car, especially the tires, springs, dampers and the car seats, are introduced to the student. With the help of several mathematical models the basic parameter of influence are discussed and the subject will be closed with an introduction of the various analysing methods.

The second part of the lecture discusses the subject "lateral dynamics". the basic structure of the tires, the suspension and steering system are explained. Simple simulation models allow basic examinations of the stability conditions of the vehicle. Examinations with consideration of the non-linear tire characteristics require a transition from the simple simulation model to a complex three dimensional four wheel vehicle model.

Course Outline

Mechatronic Systems in Automotive Engineering

汽车机电系统

Basic Information

Course Number: 70150163
Class Hours: 48
Course Credits: 3

Lecturers: LI Jianqiu
Intended Students: Graduate students, foreign students

Course Outline

I Chapter 1 Introduction
1.1 Development of the terminology
1.2 Demand on a Mechatronic Engineer
1.3 Education of a Mechatronics Engineer
1.4 Examples of a Mechatronic System in Vehicle Construction
1.5 Design Process of Mechatronic Systems

II Chapter 2 Sensors
2.1 Requirements and Degree of Integration
2.2 Properties of Sensors
2.3 Principles for the Measurement of Kinematic and Dynamic
2.4 Displacement and Angle Measurement
2.5 Velocity and Rotational Speed Measurement
2.6 Acceleration Measurement Systems
2.7 Measurement of Force and Moment
2.8 Measurement of Temperature
2.9 Optical Sensors
2.10 Gas Sensors
2.11 Sensor in Fluid Technology
2.12 Measurement of Electrical Parameters

III Chapter 3 Signal Processing
3.1 Analogue Signal Processing
3.2 Digital Signal Processing

IV Chapter 4 Signals Output
4.1 Microcontroller Interface
4.2 Power Switches
4.3 Digital Signal Outputs
4.4 Analogue Signal Outputs
4.5 Motor Control

V Chapter 4 Signals Output

5.1 Conduction-bound Disturbance
5.2 Irradiated Disturbance

VI Bus System

6.1 Bus Systems: Overview
6.2 SAE J1850 Protocol
6.3 LIN (Local Interconnect Network)
6.4 CAN (Controller Area Network)
6.5 MVB & LON
6.6 TTP/C (Time Triggered Protocol)/ Class C
6.7 Byteflight (Optimal Fiber Network)
6.8 Flexray
6.9 MOST (Media Oriented Systems Transport)
6.10 TTCAN (Time Triggered CAN)
6.11 Bluetooth (Wireless Network)
6.12 Bussystems Summary

VII Actuators

7.1 Overview of Actuators
7.2 Fluid Actuators
7.3 Electric Actuator

VIII Power System

8.1 Power System Introduction
8.2 Alternator/Starter
8.3 DC/DC
8.4 Battery
8.5 42V System

Internal Combustion Engines 1

内燃机 1

Basic Information

Course Number: 70150203
Class Hours: 48
Course Credits: 3

Lecturers: MA Fanhua
Intended Students: Graduate students, foreign students

Course Abstract

This course will focus introduce the working process and the design of the internal combustion engines. This course includes the introduction and the properties of the fuels for internal combustion engines, and the energy efficiency （thermodynamic fundamentals）of internal combustion engines, together with heat transfer in combustion engines which are three of the key chapters. Design of combustion engines, valve train and design elements of combustion engines are the important contents of the combustion engines' design.

Course Outline

1. Fuels
1.1 Fuels and power industry
1.2 Mineral-oil-based fuels
1.3 Alternatives to mineral-oil-based fuels
1.4 Properties of fuels

2. Energy efficiency of the internal combustion engine
2.1 Ideal combustion cycles
2.2 Loss dissipation of the real combustion process
2.3 Analysis of the rate of heat release
2.4 Energy and exergy balance

3. Heat transfer in the internal combustion engine
3.1 Heat transfer of the combustion chamber
3.2 Component temperatures
3.3 Thermal strain
3.4 Thermal similarity

4. Design of the internal combustion engine
4.1 Similarity rules
4.2 Characteristic values and mechanical power limit
4.3 Basic data and design
4.4 Development plan

5. Valve train
5.1 Valve train versions
5.2 Dynamic of valve train
5.3 Design of valve train

6. Design elements of the internal combustion engine
6.1 Crank shaft
6.2 Connecting rod
6.3 Bearings
6.4 Piston, rings and pin
6.4 Cylinder liner
6.5 Cylinder head
6.6 Crank case
6.7 Coolant and lubrication system

Internal Combustion Engines II

内燃机II

Basic Information

Course Number: 80150183
Class Hours: 48
Course Credits: 3

Lecturers: WANG Zhi
Intended Students: Graduate students, foreign students

Course Abstract

This course is suitable for the postgraduate students majored in Vehicle Engineering and Power machinery Engineering. The course mainly focuses on the working process of internal combustion engines, including gas exchange in internal combustion engine, gasoline engine and diesel engine combustion process, special combustion processes, supercharging for internal combustion engine, as well as the generation of pollutants formation and emission control.

Course Objectives

The objectives are to extend the professional knowledge in advanced ICE technologies, to have a deep understanding of the ICE, and to make transition from learn to research.

Course Outline

1. Gas Exchange and Flow in the Combustion Chamber
    1.1 Four Stroke Reciprocating Engine
    1.2 Rotary Engine
    1.3 Two Stroke Engine
    1.4 Wave Processes in Pipes

2. The Process in Gasoline Engines
    2.1 Combustion Process
    2.2 Ignition
    2.3 Formation of the Mixture
    2.4 Direct Injection Gasoline Engines

3. The Process in Diesel Engines
    3.1 Injection
    3.2 Combustion in Diesel Engine
    3.3 Mixture Formation
    3.4 Comparison of Diesel and Gasoline Engines
4. Special Process
    4.1 Homogeneous Charge Compression Ignition (HCCI)
    4.2 Homogeneous Charge Induced Ignition (HCII)

5. Supercharging
    5.1 Supercharging Techniques
    5.2 Increasing Performance by Supercharging
    5.3 Exhaust Gas Turbocharging

6. Pollutants
    6.1 Pollutant Development
    6.2 Pollutant formation from ICE
    6.3 Emission Control Regulations
    6.4 Exhaust-Emission Control in Gasoline Engines
    6.5 Exhaust Emission Control for Diesel Engines

Appendix:
Experiment: Combustion visualization of Diesel engine
Exercise: 1D Engine Cycle Simulation