**2023 Syllabus of**

**Fundamentals of Automotive Crash Safety**

**(Shortened as FACS)**

**Basic Information**

Course Title: Fundamentals of Automotive Crash Safety

中文课程名称:《汽车碰撞安全基础》

Course Number: 80150193-0

Class Hours: 48

Credits: 3

Language: English

**Prerequisite and Prospective Students**

Engineering mechanics, engineering mathematics, numerical methods

Graduate students; International students; Under-graduate students

**The Teaching Team**

Lecturer: Prof. ZHOU Qing (zhouqing@tsinghua.edu.cn)

Co-Lecturer: Prof. NIE Bingbing (nbb@tsinghua.edu.cn)

Co-Lecturer: Prof. XIA Yong (xiayong@tsinghua.edu.cn)

Teaching Assistant: Mr. FANG Tuo (ft22@mails.tsinghua.edu.cn)

Teaching Assistant: Mr. LIU Siyuan (siyuan-l22@mails.tsinghua.edu.cn)

Teaching Assistant: Mr. SHEN Wenxuan (shenwx21@mails.tsinghua.edu.cn)

**Course Description and Requirements**

In this course we systematically teach fundamental knowledge and theory and the state-of-the-art technologies of vehicle crash safety and human body impact protection. Main contents include safety characteristics of vehicle body structure, kinematics and dynamics of vehicle responses and occupant responses in vehicle crash, human body injuries in vehicle collision accidents, crash dummies and crash tests for crash safety assessment, occupant restraint systems, smart occupant protection for autonomous vehicles, pedestrian impact protection, lightweight vehicle and safety, characterization and modeling of vehicle materials and structures under impact loading, impact failures and safety risks of battery of electric vehicles, etc.

This course will help students to (a) comprehend the critical role of vehicle safety in vehicle product and design and the design constraints of vehicle crash protection from the requirements of lightweighting and packaging; (b) learn the mechanisms of human body injuries under impact loading as well as the protection principles; and (c) understand the evolution and limitations of vehicle safety technologies and how the new technologies can integrate the pre-crash maneuver, warning and preparation all the way to in-crash restraint to provide individualized protection that is adaptive to the conditions of human body stature and state as well as the crash scenario.

In addition to attending classes, students are required to participate in discussions in class and complete homework sets after class. There are three in-class quizzes and a final examination. Each quiz takes about 20 minutes in class. Quiz and final exam will be open book. Final grade is based on student’s performance in homework, in-class quizzes, examination, class discussions and class attendance.

The course videos we recorded last year are already online: https://www.xuetangx.com/course/thu08021000357intl/14314101  
Taking advantage of these videos, we might try the method of flipped class for teaching some contents. We will see when and how we use the method.

**List of Lectures**

**Module 1 – Crash Mechanics and Safety Assessment**

Lecture 1 – Fundamentals of Vehicle Crash Safety

Lecture 2 – Vehicle Frontal Impact Response and Occupant Ride-Down

Lecture 3 – Human Body Injuries in Vehicle Collisions

Lecture 4 – Vehicle Crash Safety Assessment (Crash Dummy and Crash Test)

**Module 2 – Occupant Restraint Systems**

Lecture 5 – Seatbelt and Airbag

Lecture 6 – Seat as Occupant Impact Protection Device

Lecture 7 – Protection of Child Passengers (optional)

Lecture 8 – Adaptive Protection for Autonomous Vehicle

**Module 3 – Interactions between Human Body and Structure**

Lecture 9 – Side Impact Protection

Lecture 10 – Occupant Head Impact Protection (optional)

Lecture 11 – Pedestrian Impact Protection

**Module 4 – Vehicle Structures and Materials under Impact**

Lecture 12 – Impact Mechanics of Thin-Walled Tubes

Lecture 13 – Impact Failures of Vehicle Materials (a short version)

Lecture 14 – Small Lightweight Vehicle and Crash Safety

Lecture 15 – Impact Safety of Battery

**Optional Lectures**

* Crash sensing

**Biographies of Lecturers**

**Dr. ZHOU Qing** joined the faculty of Tsinghua University in 2003 as a full professor in the Department of Automotive Engineering. He was appointed as Volkswagen Endowed Chair Professor of Vehicle Safety in 2016 (term ended 2021). Prof. Zhou is also a Member of Academic Committee of Tsinghua University since 2014, the Director of Vehicle Safety Committee of Chinese Society of Automotive Engineers since 2005, an Associate Editor of International Journal of Impact Engineering (IJIE) since 2012, and a Council Member of International Research Council on Biomechanics of Injury (IRCOBI) since 2016. Prof. Zhou’s research interests include vehicle crash safety, structural and material failures under impact loading, battery crash safety, lightweight vehicle, occupant and pedestrian impact protection, and injury biomechanics.

Prior to joining Tsinghua University, Dr. Zhou worked as a technical specialist from 1999 to 2003 in the Volpe National Transportation Systems Center, a research unit in the US Department of Transportation in Cambridge, Massachusetts, USA. From 1994 to 1999, Dr. Zhou worked as a research engineer in R&D Center of General Motors in Warren, Michigan, USA. Dr. Zhou received B.S. degree in mechanics from Peking University in 1985 and Ph.D. degree in applied mechanics from Massachusetts Institute of Technology in 1994.

**Dr. NIE Bingbing** is an Associate Professor at School of Vehicle and Mobility, Tsinghua University, China. Dr. Nie received her BSc (2007) from Tsinghua University, MSc (2009) from RWTH-Aachen, Germany and PhD (2013) from Tsinghua University. Prior to joining Tsinghua University in 2016, Dr. Nie worked as a Visiting Scholar in General Motors R&D (2012-2013), and as a Research Associate at University of Virginia (2013-2016). Her research areas include applied biomechanics, vehicle safety, human-vehicle interaction and human body modeling. She has authored/co-authored more than 40 technical papers and 3 patents. She has also served as Session Organizer of Pedestrian and Cyclist Safety of SAE World Congress, IRCOBI Scientific Review Committee Member, AAAM Scientific Program Committee Member and China-Sweden CTS Scientific Committee Member.

**Dr. XIA Yong** is an Associate Professor in the School of Vehicle and Mobility of Tsinghua University. He leads the Vehicle Safety and Lightweight Group together with Prof. Zhou and Prof. Nie. Dr. Xia joined the faculty of Tsinghua since 2006, and once worked as a visiting scholar at MIT in 2013-2014. He received PhD degree in Solid Mechanics in 2004, and BS degree in Polymer Physics in 1998, both from University of Science and Technology of China. Dr. Xia is also a member of the Expert Committee of Automotive Lightweight Technology Innovation Alliance in China, a member of Editorial Advisory Board of International Journal of Impact Engineering (IJIE), the deputy secretary of Safety Technology Committee of SAE-China, and a member of SAE International. He has published more than 100 research papers and more than 20 patents in the areas of mechanical characterization and failure analysis of materials and joints, battery crash safety and pedestrian protection.