Loughborough University

24MPC123
Automotive Crash Protection

Semester 1 2024/25 | In-Person Exam paper

This examination is to take place in-person at a central University venue under exam conditions. The standard length of time for this paper is **2 hours**.

You will not be able to leave the exam hall for the first 30 or final 15 minutes of your exam. Your invigilator will collect your exam paper when you have finished.

Help during the exam

Invigilators are not able to answer queries about the content of your exam paper. Instead, please make a note of your query in your answer script to be considered during the marking process.

If you feel unwell, please raise your hand so that an invigilator can assist you.

You may use a calculator for this exam. It must comply with the University's Calculator Policy for In-Person exams, in particular that it must not be able to transmit or receive information (e.g. mobile devices and smart watches are **not** allowed).

Answer **THREE** questions

1. (a) Explain the purpose of each of the structural components used to dissipate crash energy in the frontal impact of a current European vehicle. [6 marks]

   (b) Optimising frontal crash protection for high-speed offset tests can compromise occupant safety in some real-world frontal crashes. Explain why this happens by considering the issues of intrusion, crash structure design, exposure to crash speeds and crash compatibility. [4 marks]

   (c) Discuss four reasons why seatbelt performance can be compromised in a frontal crash, and for each reason, give one example of a resultant injury. [4 marks]

   (d) Discuss the reasons why "non struck side occupants" are injured in side impacts and describe possible countermeasures that could be employed to reduce injury. [6 marks]

2. (a) In 2020, EuroNCAP changed its frontal impact test procedure from a fixed deformable barrier impact at 64 km/h to a moving deformable barrier impact, where the test vehicle and a 1400 kg barrier approach each other from opposite directions, each travelling at 50 km/h. Calculate the velocity change of a 1844 kg Ford Kuga plug-in hybrid undergoing the revised impact procedure and briefly state the effect of the new test on the frontal crash structures of large cars. [5 marks]

(b) Most frontal crash tests specify performance requirements for the steering system. Explain how the components of a Safety Steering Column help to reduce driver injury in a frontal crash. [3 marks]

(c) The Wayne State head injury tolerance curve shows how human tolerance to head injury is based on the relationship between magnitude of acceleration and the time over which it is applied. The curve was used as the basis for the Head Injury Criterion (HIC) which defines limits on head loads in most crash test procedures. Describe the biomechanical research tests conducted to define the Wayne State head injury tolerance curve and describe the three main criticisms of the HIC as a predictor of head injury. [6 marks]

(d) Describe the types of indirect loading injuries that can occur to belted occupants in frontal crashes. [6 marks]

3. (a) Using Newton's laws of motion as a basis, explain why an unbelted driver is injured in a frontal crash. [3 marks]

(b) European and US vehicles are tested with different legal frontal crash test procedures and thus have different frontal restraint systems. Explain how and why those restraint systems are calibrated differently and suggest what might happen if an unmodified EU vehicle was put through a US frontal crash test. [8 marks]

(c) Discuss ways in which the restraint system could be used to counteract the effects of increased structural stiffness in frontal crashes. [6 marks]

(d) In relation to seatbelt load limiting in frontal crashes, explain why protecting the oldest and weakest occupants would not result in improved frontal protection for the full range of occupant ages. [3 marks]

4. (a) Explain why side impacts are so much more dangerous than frontal crashes. [3 marks]

(b) The Viscous Criterion (VC) uses both thorax deflection depth and thorax deflection velocity to predict chest injury risk in frontal impact testing with dummies. Discuss the types of chest injury predicted with different combinations of deflection and velocity. [3 marks]

(c) A car manufacturer has failed to design their side impact structure well. Consequently, in a 35 km/h side impact into a lamp post, the side door intrudes and strikes the driver’s thorax at 32 km/h, compressing the chest by 100 mm. Calculate the time taken to maximum chest compression and calculate the acceleration in g, experienced by the chest. [4 marks]

(d) Side airbags are commonly used to protect occupants in side crashes, but the door design itself is also important. Explain how the features of door design can help reduce crash forces on the occupant in a side impact. [4 marks]

(e) In the US, frontal airbag deployment characteristics can be modified to prevent injury from the bag itself. Name three types of sensor which can be used to inform the deployment behaviour of frontal airbags, and describe how each sensor type works. [6 marks]

END OF PAPER

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