Loughborough University

22MPC123
Automotive Crash Protection

Semester 1 2022/23 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 why, in 1996, Europe changed its frontal safety compliance test from a 50 km/h full overlap rigid barrier to a 56 km/h frontal offset deformable barrier. [3 marks]

   (b) You are supplied with an occupant restraint system that keeps dummy measures below legal limits when an average frontal crash pulse of 18 g is applied. For a 1200 kg car in a European frontal offset compliance test, calculate the crash structure crush time needed to achieve the pulse and calculate the energy that the structure needs to dissipate. [4 marks]

   (c) 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]

   (d) A Ford Focus of mass 1408 kg and travelling at 65 km/h collides head-on with a Ford Fiesta of mass 1064 kg also travelling at 65 km/h from the opposite direction. Calculate the velocity change of each vehicle after impact and discuss the effect of car mass on occupant safety. For the calculation you may assume that momentum is conserved and external forces are negligible. [7 marks]

2. (a) With reference to Newton's three laws of motion, explain why an unbelted driver is injured in a frontal crash. [6 marks]

   (b) Describe four reasons why seatbelt performance can be compromised in a frontal crash, and for each reason, discuss one example of a resultant injury and its cause. [4 marks]

   (c) 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]

   (d) 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]

3. (a) Human tolerance to head injury demonstrates a relationship between magnitude of acceleration and the time over which it is applied. Describe what biomechanical research tests were conducted to define the Wayne State head injury tolerance curve and describe the three main criticisms of the head injury tolerance criterion (HIC) as a predictor of head injury. [6 marks]

   (b) In 2020, EuroNCAP changed its frontal impact fixed offset barrier test procedure to one which uses a moving barrier and a new crash test dummy. Discuss the reasoning behind the changes. [4 marks]

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

   (d) Discuss ways in which the restraint system can be used to reduce indirect loading injuries in frontal crashes. [4 marks]

4. (a) Describe three reasons why seatbelts can help to reduce injury in a frontal crash.

[3 marks]

(b) Apart from seat belts, take three other restraint components used to protect drivers in a frontal crash and describe how they help to reduce injury. [3 marks]

(c) Discuss three reasons why the injury risk to car occupants in side crashes is greater than the risk in frontal impacts. [6 marks]

(d) A manufacturer has failed to design their side impact structure well. In a side impact into a crash barrier, the side door intrudes and strikes the driver's thorax at 28 km/h, compressing it by 100 mm. Calculate the time taken to maximum thoracic compression and calculate the acceleration in g, experienced by the thorax.

[4 marks]

(e) 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]

END OF PAPER

RJ Frampton