23MPC123

Automotive Crash Protection

Semester 1 2023/24 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 only. Each question carries 20 marks.

1. (a) An essential requirement for seatbelt effectiveness is the elimination of slack from the webbing during a crash. On the other hand, a belt which is too tight can be detrimental to occupant safety. Explain the concept of Intrinsic Compliance and describe why it is an essential part of seatbelt design. [6 marks]

   (b) You are supplied with an occupant restraint system that keeps dummy measures below legal limits when an average frontal crash pulse of 25 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) A Vauxhall Astra of mass 1395 kg and travelling at 65 km/h collides head-on with a Vauxhall Corsa of mass 980 kg also travelling at 65 km/h from the opposite direction. Calculate the velocity change of each vehicle after impact. You may assume that the collision is inelastic and that external forces are negligible. [6 marks]

   (d) In relation to Crash Compatibility, discuss the effect of car mass and stiffness on the frontal crash protection of European cars. [4 marks]

2. (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. [2 marks]

   (b) 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]

   (c) Describe the differences between U.S. and European frontal airbags and explain why they are different. [6 marks]

   (d) European and US vehicles use different restraint system deployment parameters for frontal crash protection. In relation to European and US frontal compliance crash tests, explain why the seatbelt systems are configured differently. [6 marks]

3. (a) On a sketch of a safety steering system, show the location of its major components and describe how they help to reduce driver injury in a frontal crash. [6 marks]

   (b) Describe the function of each of the five major components of a steering wheel mounted driver airbag system. [5 marks]

   (c) Describe four types of sensor which can be used to modify the deployment behaviour of frontal crash airbags and for each sensor type describe how the information supplied is beneficial. [8 marks]

   (d) Part of the side impact protection system consists of foam pusher blocks placed in the front doors of cars in line with the occupant's pelvis. Describe how these devices can reduce injury. [1 mark]

4. (a) State Newton's three laws of motion. [3 marks]

(b) In relation to the laws stated in part a, explain why an unbelted driver is injured in a frontal crash. [3 marks]

(c) Discuss four factors which may compromise the performance of seat belts in a frontal crash. [4 marks]

(d) With reference to the issue of Optimisation and with the aid of a risk – exposure diagram, discuss the reasons why it may be unwise to continually increase frontal crash test speeds. [4 marks]

(e) An elderly female front seat passenger in a modern car is in a 64 km/h head on crash with another car. Her vehicle is fully overlapped with the opposing car. Describe what issues should be considered when deciding how to protect this occupant from serious injury and describe how you would adapt the restraint system to reduce injury risk. [6 marks]

END OF PAPER

Dr RJ Frampton