Version JMC/4

EGT2
ENGINEERING TRIPOS PART IIA
EGT3
ENGINEERING TRIPOS PART IIB

Wednesday 4 May 2022 2.00 to 3.40

Module 4C4

DESIGN METHODS

*Answer not more than **three** questions.*

All questions carry the same number of marks.

*The **approximate** percentage of marks allocated to each part of a question is indicated in the right margin.*

*Write your candidate number **not** your name on the cover sheet.*

STATIONERY REQUIREMENTS
Single-sided script paper

SPECIAL REQUIREMENTS TO BE SUPPLIED FOR THIS EXAM
CUED approved calculator allowed
Engineering Data Book

10 minutes reading time is allowed for this paper at the start of the exam.

You may not start to read the questions printed on the subsequent pages of this question paper until instructed to do so.

You may not remove any stationery from the Examination Room.

1 Your company has been asked to design a pair of glasses equipped with an internal camera. The glasses are controlled using a bespoke smartwatch that communicates with the glasses wirelessly. The purpose of the system is to allow the user to take photographs at any moment by interacting with the smartwatch. The smartwatch also allows the user to browse previously taken photographs, apply a series of filters, delete photographs and email them to a contact.

(a) Identify the overall function of the system and its main subfunctions. [10%]

(b) Identify and draw the overall function structures, including their functional elements and the flow of signals. Briefly explain the functions represented by each function structure. [30%]

(c) Create a modular product architecture for the system by modularising the function structures identified in (b). Describe the motivation for your product architecture and explain its potential advantages and disadvantages. [30%]

(d) Identify performance and user risks in the system, including the product architecture identified in (c). Propose a cohesive strategy to manage these risks. [30%]

2 You have been asked to design a numeric keypad for a machine that delivers medicine to a patient. The numeric keypad allows nurses to input the exact doses of medicine to be administered. The keypad must provide the following 13 keys: `0`–`9`, `Set Dose`, `Administer Dose` and `Reset`. To provide a dose to a patient, the nurse is meant to first input `Set Dose` and then use the number keys `0`–`9` to input a number in the range $[1, 999]$. Thereafter the nurse can administer the dose by inputting `Administer Dose`. If the nurse makes an input mistake, the nurse can reset the process by inputting `Reset`, which allows the nurse to start over by first inputting `Set Dose` again.

(a) Derive a solution-neutral problem statement for the proposed system. [10%]

(b) Identify the overall function of the system and identify its system boundary. Briefly explain the choice of system boundary. [10%]

(c) Identify three sources of human error permitted by the system. [30%]

(d) Briefly discuss how the system can be augmented to mitigate these sources of human error. [30%]

(e) Propose a verification and validation strategy to ensure the three sources of human error have been mitigated. Ensure the distinct roles of verification and validation are made clear. [20%]

3 Figure 1 shows a visual representation of the global aluminium production system in 2007, where the thickness of each line is proportional to the flow of aluminium.

(a) Provide a definition of a *system* and describe the benefits of taking an holistic approach when designing systems. [10%]

(b) Describe three insights which emerge from visualising the global aluminium production system as a single diagram, providing examples to support each insight. [30%]

(c) Calculate the overall yield of the aluminium production system, as a mass ratio of end-use products to the liquid aluminium input to the recasting processes. Suggest options for improving the yield of the rolling, forming, casting and fabrication processes. [20%]

(d) Use your knowledge of rework to explain the inefficiencies present in the system related to the scrap generated in the rolling, forming, casting and fabrication processes. [20%]

(e) Most cast aluminium is used in vehicles, mainly in engine blocks and gearboxes, with high fractions of alloys such as silicon used to aid casting processes. Comment on the implications of a shift in vehicle production towards electric vehicles for the aluminium production system. [20%]

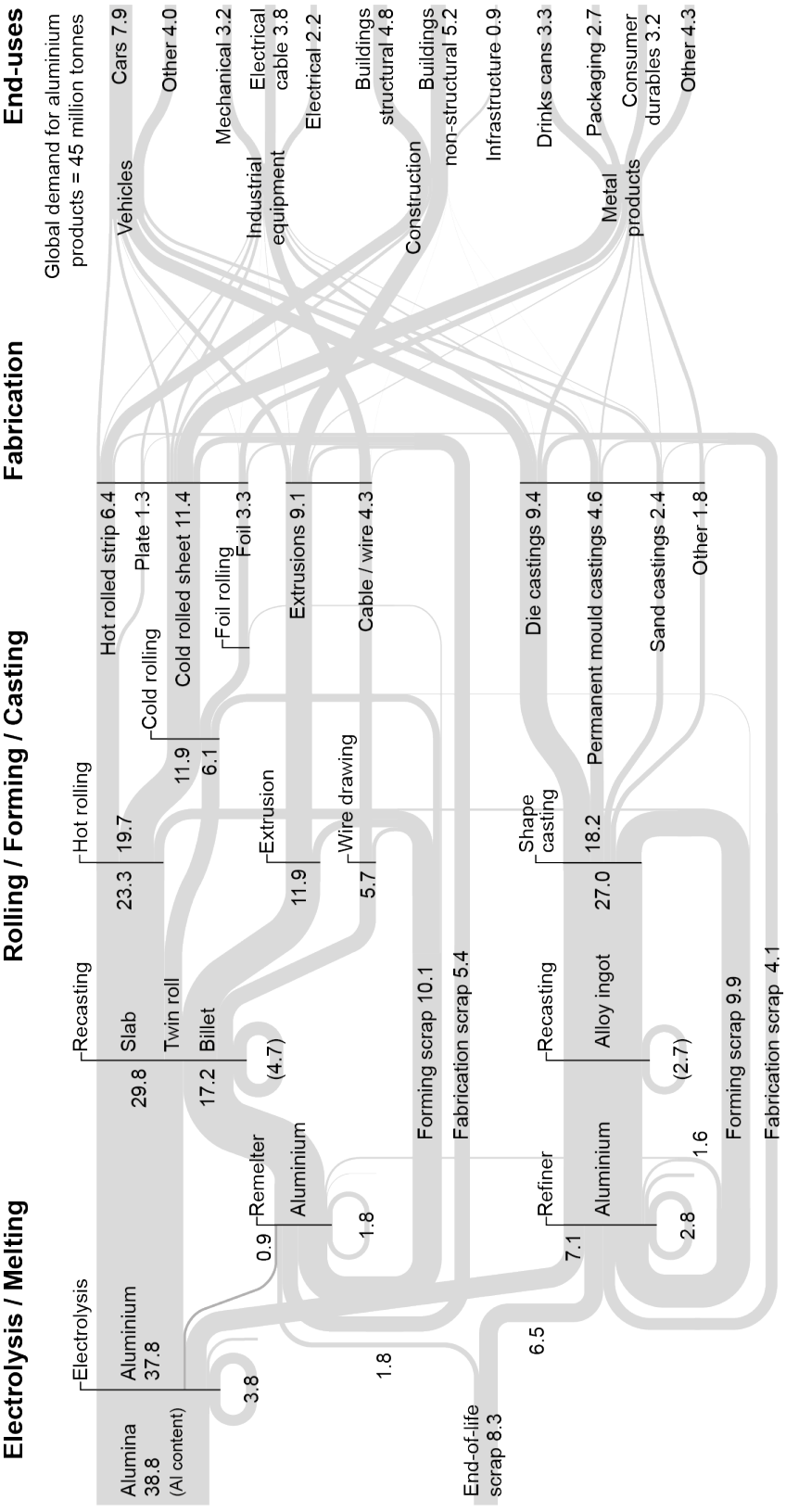

Fig. 1: Global aluminium production system (2007). Flows shown in million tonnes (Mt).

4 A university plans to establish a remote campus in another country within five years. The remote campus will offer a limited range of undergraduate level courses to up to 100 fee-paying students per year. A number of teaching staff will be seconded to the new campus to establish the courses, train local teaching staff and ensure the delivery of high quality teaching.

(a) Provide definitions of risk management and risk analysis and outline the differences between the two approaches. [20%]

(b) Create a list of ten risks associated with the establishment of the remote campus. [20%]

(c) Define suitable descriptive scales for measuring the likelihood and the impact of the risks identified in (b) using a scoring system from 1 (low) to 5 (high). Score each risk and create a ranked list of the ten risks. Plot the ten risks on a risk matrix. [30%]

(d) Suggest actions for mitigating the risk for the top five risks in your ranking. Rescore these five risks assuming that the suggested actions have been taken and plot the new risk scores on the risk matrix from (c). [20%]

(e) Describe two alternative risk assessment tools which might be useful for identifying and assessing risks, and prioritising actions. [10%]

END OF PAPER