Version JMC/4

EGT2
ENGINEERING TRIPOS PART IIA
EGT3
ENGINEERING TRIPOS PART IIB

Wednesday 1 May 2024 14:00 to 15:40

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 The diagram in Fig. 1 shows a process decomposed as a series of tasks T1–T6, with dependencies indicated as arrows.

(a) Draw a dependency structure matrix for the process depicted in Fig. 1a, with the rows and columns in the order of the tasks. [10%]

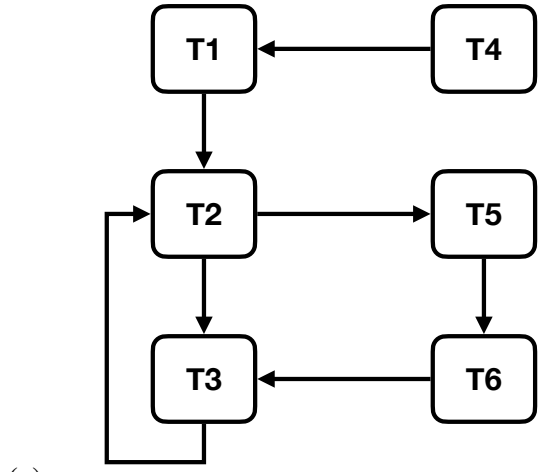
(b) It is later discovered that task T2 can be decomposed into two subtasks T2a and T2b, where only T2b is dependent on T3, and no task is dependent on T2b. Reduce rework as much as possible by manipulating the dependency structure matrix arrived at in (a). Explain your reasoning. [20%]

(c) Worker W1 is assigned T1–T3, Worker W2 is assigned T4–T6, and Worker W3 is assigned T3 and T6. Draw a multiple domain matrix of this system with the rows and columns in the original order of the tasks (i.e. using the diagram in Fig. 1a). [30%]

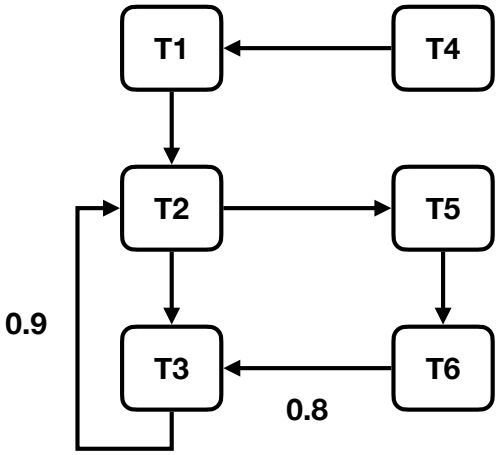
(d) The quality of the work is indicated in two transitions in Fig. 1b. Assume rework discovery time for the transition T3 $\rightarrow$ T2 is one week and rework discovery time for the transition T6 $\rightarrow$ T3 is two weeks. Each transition needs to achieve an overall 99% work completion and it is only possible to proceed to T5 once T2 has no rework. By how much time will the process overrun? [20%]

(e) The ability of worker W3 to monitor the quality of the work in T3 and T6 is modelled by a Beta distribution with mean $\mu = \frac{\alpha}{\alpha+\beta}$ and variance $\sigma^2 = \frac{\alpha\beta}{(\alpha+\beta+1)(\alpha+\beta)^2}$, where α and β are the parameters of the Beta distribution. Data reveals that the mean failure of monitoring the quality of the work is 4% with a standard deviation of 6% for both tasks. Derive expressions for the α and β parameters and hence determine their values. Briefly discuss how rework is affected by the worker's ability to monitor the uncertainty around the quality of the work. [20%]

(cont.



(a)



(b)

Fig. 1

2 Push to exit buttons are designed to prevent unauthorised individuals from entering a building while providing a quick and easy way for people to exit a building in an emergency. Push to exit buttons are usually placed near exit doors. Pushing the button unlocks and opens the door.

Your company is tasked with creating a touch-free exit system to minimise coronavirus transmission.

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

(b) Draw a diagram of the overall function indicating the system boundary and flows. Draw a second diagram showing the function structures, including their functional elements and the flow of signals. Briefly explain the functions represented by each function structure. [40%]

(c) Create a modular product architecture for the system by modularising the function structures and indicating these on your diagram from (b). Compare this modular approach to an integral product architecture, explaining the potential advantages and disadvantages. [30%]

(d) During the design process, the client requests an additional function to notify the building control system and log each time the door is opened and closed. Update the function structures from (b) to reflect this requirement. Briefly explain the reasoning behind your revised design. [20%]

3 A low-volume manufacturing plant is producing specialised control panels with multiple design variations using a complex moulding process. The plant is reliant on skilled individual workers for the manual production of the control panel.

(a) Explain what is meant by *quality* in the context of rework. [10%]

(b) Give three reasons why rework is likely to occur and relate each to the control panel fabrication task. [30%]

(c) The plant manager is investigating the use of augmented reality glasses to provide live fabrication instructions to novice workers. Novice workers on the shop floor will receive instructions through the headset on how to carry out the steps necessary to complete the production of the control panel. The headset uses computer vision to assess the current state of the fabrication process. Use the rework cycle model to explain how the proposed system may affect quality and productivity. [20%]

(d) Explain the difference between verification and validation, and describe how the system in (c) could succeed in verification but fail in validation. [20%]

(e) It is later discovered that the use of the system in (c) results in too many control panels that fail quality assurance. To rectify this problem, the novice workers will now be supervised by an experienced worker who is tasked with both monitoring the quality of the control panel and providing guidance to the novice workers upon request. Describe how quality and rework discovery time can be used to explain whether this change in process reduces the quality assurance problem. [20%]

4 Your company is exploring the use of artificial intelligence (AI) tools to generate design concepts for clothing in a fast-moving fashion market. This new design process has the potential to broaden the range of clothing designs while reducing the amount of design input required, leading to more appealing designs with higher profit margins.

(a) Derive a solution-neutral problem statement for the new design process. [10%]

(b) List key requirements for the new design process. [20%]

(c) Outline the six principles for integrated system design and describe in detail how each principle relates to the implementation of the new design process. [30%]

(d) A risk review affords an assessment of the nature and extent of potential risks. Discuss key factors of good risk management practice that will enable the successful delivery of the new design process. [20%]

(e) Sketch a fault tree highlighting events that may lead to the unsuccessful operation of the new design process. [20%]

END OF PAPER