PRIFYSGOL ABERYSTWYTH UNIVERSITY

SEMESTER ONE 2026

COMPUTER SCIENCE

CS33020 : SYSTEMS ENGINEERING

Time allowed: **2 HOURS**

Answer **TWO** from **THREE** questions.

All questions carry equal marks.

YOU MAY BRING THE FOLLOWING INTO THE EXAMINATION:
UP TO 3 SHEETS OF NOTES ON A4 PAPER (WHICH MAY BE DOUBLE-SIDED). THERE ARE NO ADDITIONAL RESTRICTIONS ON CONTENT OR FORMATTING OF THESE NOTES.
NO ELECTRONIC DEVICES.

CALCULATORS ARE NOT PERMITTED.

STUDENTS MAY SUBMIT ANSWERS TO THIS PAPER IN EITHER WELSH OR ENGLISH

Once seated, students may complete the front cover of the answer book(s) and the attendance slip ONLY.

DO NOT TURN THE EXAMINATION QUESTION PAPER OVER UNTIL INSTRUCTED TO DO SO.

1. RoDoc is a two-armed robot surgeon that has been developed to perform basic operations. A key safety feature of the device is a real-time state tracking system that verifies whether the robot is performing a correct behaviour. A camera system tracks the robot movements and classifies these against a list of behaviours. If RoDoc ever exhibits a state that is incorrect for a given scenario, or exhibits movements that are outside of any known behaviours, RoDoc freezes, and a red warning light flashes, letting people in the operating theatre know to take over.

Medical staff report incidents where RoDoc freezes, but no warning light is shown. RoDoc developers insist RoDoc has been thoroughly tested, and there is no way that the system can freeze without the warning light being turned on, therefore any reported freezes must be inaccurate, or part of normal operation.

You are a systems engineer recruited to determine if RoDoc is operating appropriately.

Figure 1 is the reliability diagram for RoDoc. The developers state that the Robot Behaviour Detector and Warning Lights are separate elements to the other system sensors and actuators, and that while the system interfaces with the control system, this is needed to stop RoDoc from moving.

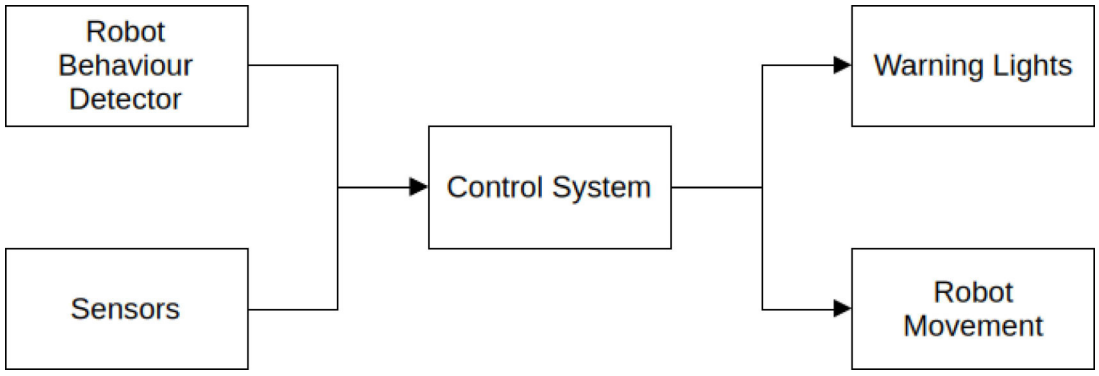


Figure 1: A high-level reliability diagram for the RoDoc system.

a) Explain why the developers are wrong to state that the Robot Behaviour Detector system is independent of the main system and also explain how this design flaw could lead to undesirable behaviours in the system. [8 marks]

b) What design modification would you propose in order to ensure independence? Provide the rationale behind your design choices. [8 marks]

While reviewing the project implementation plan, you notice that AI has been used to write the control system source code and that code was validated using a set of test cases. A reinforcement learning approach was used, and the AI coder looped until the code was able to pass all the tests. This was all performed using software, with no physical or virtual model of the RoDoc involved.

c) In your opinion, is this an appropriate approach to validating the system? Explain your answer. [8 marks]

You ask the developers to review the AI written code and produce a detailed design for the internal workings of the control system. The developers state that the code is massively complex and mapping it would be impossible. They state that this is the nature of their AI approach to writing code and their lack of documentation is inline with industry practices.

d) What is the advantage of having a detailed design of the control system, and how would this help in the current situation? [6 marks]

e) Would you recommend the future use of AI in this manner? [2 marks]

You advise the RoDoc team to redevelop the code and it transpires that AI was used to develop the control system because the RoDoc development team lacked the experience to write the code themselves. The RoDoc team agree to loop the project back to the Implementation stage of the product life-cycle, but ask you on how best to develop the code without in-house expertise.

The RoDoc team have two options to implement the system without the use of AI: hire a developer with the necessary experience; and outsource the development to a third party.

f) What are the advantages and disadvantages of both options, and which option would you recommend and why? [8 marks]

RoDoc decide to outsource the development to a team abroad and ask you to plan the management of the implementation to ensure that the new development team work well with the RoDoc developers, and that the code delivered meets the needs of the RoDoc project.

g) Describe ONE activity/process that would help plan for the outsourcing of the development. Give your answer in terms of ONE input, ONE process, ONE output, ONE enabler and ONE constraint. [10 marks]

2. SimUlator is an advanced modelling and simulation system for the optimisation of room booking and energy usage for university teaching buildings.

At the centre of the system is a state machine that labels rooms in either a Heating On state, or an Heating Off state. When a room is in use, the heating is automatically turned on. If the room is not in use, then the heating is turned off.

To save money, the design focused on minimising the number of required system elements needed to meet the core requirements.

a) In addition to saving money, why might a low number of system elements improve the system in terms of its maintainability and the diagnosis of system faults?

[4 marks]

The state machine for the system is depicted in Figure 2. It shows the two states of Heating On and Heating Off, and the resultant behaviours for each state.

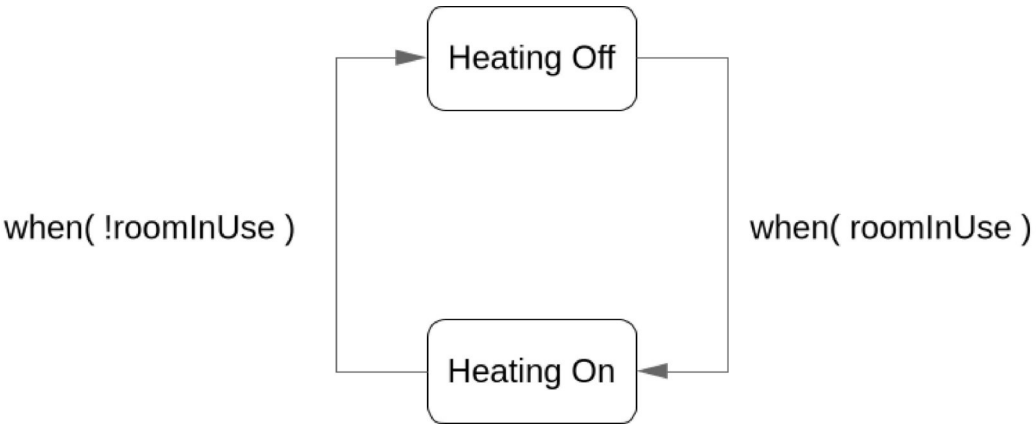


Figure 2: The state machine for the SimUlator system.

In day-to-day operation, room users complain that rooms are cold at the beginning of a class, and can be too hot by the end of the class.

b) What single additional state could you add to the state machine to ensure that the rooms are warm at the beginning of a class? Explain how your answer addresses the issue. [4 marks]

Room users state that rooms do not stay at a constant comfortable temperature, and the temperature continues to increase to an uncomfortable level. A stock-flow diagram depicting the design for the heating system is shown Figure 3.

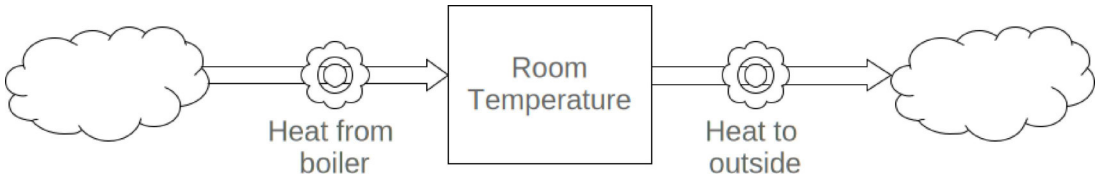


Figure 3: A stock-flow diagram for the SimUlator system.

c) What is missing from the stock-flow diagram to enable the system to produce a steady temperature? Explain your answer. [4 marks]

d) What SINGLE new system element would be needed to deliver a constant temperature? Explain your answer and include a description of how this new system element would interface with the existing system. [4 marks]

After taking into account all the design changes needed to develop a system that meets the requirements of room users, a systems engineer on the project states that the cost implications of the changes are too high, and that they should just re-start the project from the beginning.

e) Considering the cost involved, state why you think that this Systems Engineer may be correct in his assertion? [6 marks]

SimUlator decide to retrofit a large number of new system elements (including software) to the existing system. The changes resulted in a tightly coupled system.

During testing of the system, it was discovered that the system exhibits some undesirable behaviours that cause the entire system to fail. The developers struggle to find the root causes of these issues.

f) Why might this be the case? Give your answer in terms of tightly and loosely coupled systems. [8 marks]

Having failed to improve the system design while in the in-use stage of the product life-cycle, SimUlator decide to retire the system and focus on the development of SimUlator 2.0.

The SimUlator CEO would like to know who was responsible for the decision to minimise the number of system elements in the design.

g) In a well run systems engineering project, how would find out who made this decision? [4 marks]

h) As a systems engineer, what would you suggest that SimUlator do with all these documents now that they are designing SimUlator 2.0? [6 marks]

Having decided to retire SimUlator 1.0, SimUlator ask you to advise on the planning of the retirement of the system.

i) Describe ONE activity/process that would help plan for the retirement of the system. Give your answer in terms of ONE input, ONE process, ONE output, ONE enabler and ONE constraint [10 marks]

3. PD is a university spin-off who developed a system that uses image recognition to detect and identify plant diseases. A 3D virtual model of a plant, and a real-time simulation of the disease growing on the plant was developed. The system was used to generate a large number of simulated images of the diseases, and an AI system was trained to identify both the presence of a disease, and the stages of progression of the disease through the plant.

In a real-world evaluation of the system, it is discovered that the system will only work during very particular conditions – on dry afternoons where most of the sky is covered in cloud, and there is no wind. As a systems engineer, you are recruited to investigate and advise on how to improve the system performance.

a) How could the use of images from the simulated environment have caused the system to only detect issues under these conditions? Give your answer in terms of virtual versus physical modelling and simulation. [8 marks]

b) Give three reasons why PD might have selected to use virtual modelling over physical modelling? [6 marks]

When reviewing the requirements for the virtual environment, you discover the following set of requirements:

R1: The plant disease identifier AI shall be trained using images from a virtual environment.

R1.1: The virtual environment shall model aspects of the physical world, e.g. plant disease growth.

R1.2: The virtual environment shall use NVIDIA Isaac Sim™.

c) How could requirement R1.1 have led to the issues discovered in the real-world evaluation? [6 marks]

d) Explain how you would re-write requirement R1.1 to mitigate the issues with the images. Use an example of a well-written requirement for the virtual environment to help explain your answer. [8 marks]

The CEO of the company decides that the system should be launched to the public under an early access agreement with users. Under this agreement, users would accept that the system is still under development, and that they should report issues when they notice the system isn't working correctly.

The plan to correct the behaviour is to use data collected by the end users to modify the virtual environment to match the situations provided by the users and train the AI on images from the updated virtual environment. A computer scientist on the project says that they should just use the real-world images provided by the end users, rather than images from the virtual environment.

e) What are the benefits of using the images to improve the virtual environment compared to using the real-world images directly. Explain your answer. [8 marks]

The plan to improve the system relies on software updates and new software-based features being developed and pushed to the system while they are being used. The hardware engineers involved in the development are concerned that new behaviours shouldn't be added to the live system, and improvements should only happen in future releases of the product.

f) Do you agree with the hardware engineers? Explain your answer. [4 marks]

After deciding to go ahead with the launch of the system under an early access agreement, you are asked to give advice on how best to proceed.

g) Describe ONE activity/process that would help support system users. Give your answer in terms of ONE input, ONE process, ONE output, ONE enabler and ONE constraint [10 marks]

END OF PAPER