PRIFYSGOL ABERYSTWYTH UNIVERSITY

SEMESTER TWO 2025-2026

COMPUTER SCIENCE

CS26020 : ROBOTICS AND EMBEDDED SYSTEMS

Time allowed: **2 HOURS**

Answer all **THREE** questions

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 PERMITTED (CASIO FX991, FX83 OR FX85 MODELS ONLY)

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.

All questions of this paper use the following scenario. Please read the scenario carefully and refer to it as necessary.

> You work for a company that designs bespoke robots for specific problems. You are working on a new product: an autonomous robot that searches for people trapped in buildings after disasters, such as after an earthquake. The robot must be able to explore multi-storey buildings while avoiding obstacles (such as walls, chairs, tables, etc., as well as those created by the disaster), build a representation of the environment that has been explored, detect survivors and save their location in the map. The robot needs to be able to go back to its starting location to recharge and to relay all the information it gathered to the search and rescue team for them to rescue the people. Obviously this needs to be done as fast as possible.

The questions starting on the next page explore several aspects of the system you are working on.

1. This question is about the hardware of the robot. Several aspects need to be considered when designing the robot. We will look at locomotion, sensors and power, which could all influence each other.

a) You need to explore which locomotion system to use.

(i) Which locomotion system would you use for this robot? Justify your choice by comparing options covered in lectures, making sure you cover stability of the robot, ease of control, power consumption and capability in moving in the environment of the task. [10 marks]

(ii) It is suggested that the robot might, in a future version, have to carry food and drinks to the people it finds. In what way(s) does this change your answer to the part above? Explain. [4 marks]

b) The robot needs to use sensors to perform its task.

(i) In the context of the application, suggest and discuss any sensors the robot could use to get some *absolute* information about its pose. If there are no applicable absolute sensors, explain why. [8 marks]

(ii) If absolute sensors are not possible, briefly describe the process by which the pose of the robot can be calculated using *relative* sensors. Describe the main drawback of such an approach. [6 marks]

(iii) What type of sensor would you use to detect survivors? Explain how this would work and the limitations of your approach. [5 marks]

c) The final aspect to consider at this stage is the power system.

(i) Given your decision of locomotion system in part 1.a) above, which battery chemistry would you select for your robot? Compare and contrast **three** different chemistries in terms of their applicability for the application. [9 marks]

(ii) After having selected various components for your robot (motors, sensors, computers, etc.), you estimate that an average current consumption of the whole system is approximately 10A, with a peak consumption of 20A. You explore possible battery sizes and consider one that has a nominal voltage of 22.2V and a capacity of 10,000mAh. For how long would your robot operate with this battery? State any assumptions you make and explain your reasoning. [6 marks]

2. This question is about mapping strategies.

a) In lectures, we have seen grid-based maps, vector-based maps and topological maps.

(i) Briefly describe each of the three types. [6 marks]

(ii) Explain how each type could be used in the search and rescue application. Discuss how useful each type is, considering all the requirements of the application and pre-existing knowledge of the environment. In particular, consider the human aspects of the application (human rescuers using the maps). [15 marks]

b) You are exploring different ways of representing the world, since none of the standard methods are really appropriate. Considering that (1) small specific parts of the environment need to be represented in detail for the robot to navigate them while others don't need to and that (2) spatial relationships between these areas might be enough for the robot and human beings to navigate, how else could you represent the building in which the robot needs to navigate? Discuss your approach and how such a map could be built from sensors. [Hint: combine 2 or 3 of the map types.] [10 marks]

3. This question is about control architectures.

a) Are all types of map suitable for a deliberative approach? Justify your answer. [6 marks]

b) Is a deliberative approach appropriate for this application? Justify your answer. [5 marks]

c) Is a hybrid (reactive and deliberative) approach more or less appropriate than a deliberative approach? Justify your answer. Make sure you discuss all aspects of the task. Describe the reactive and deliberative parts of the control system you would need to implement to achieve the task. [10 marks]

END OF PAPER