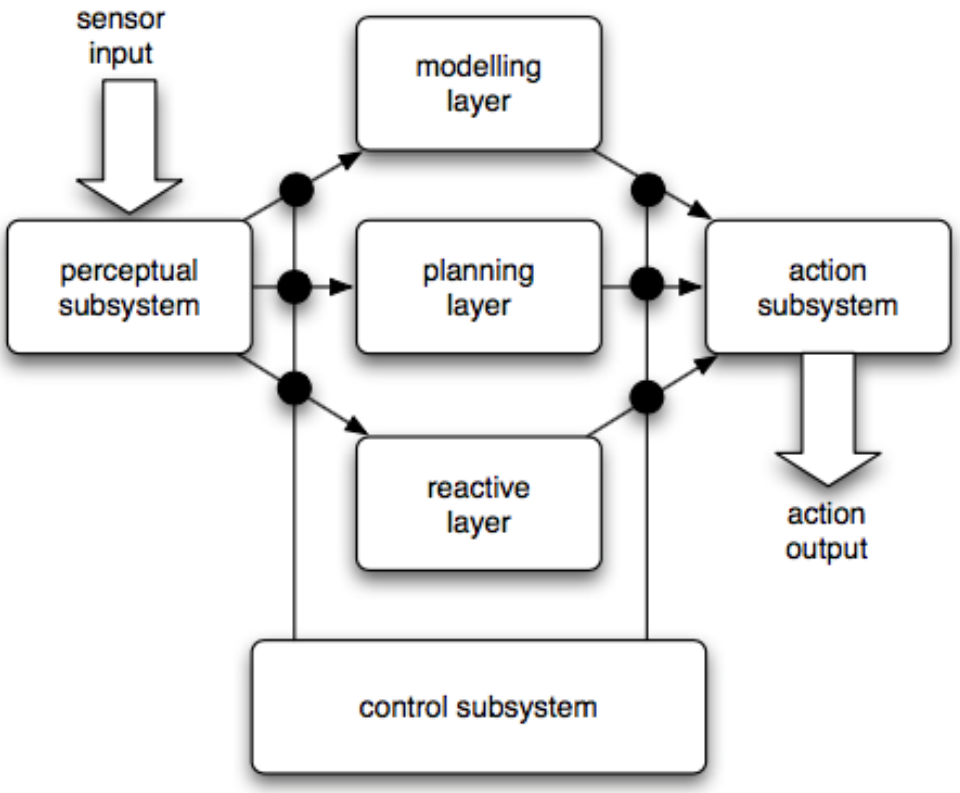
Reactive and hybrid agents
a) Describe two key difficulties with constructing agents based on classical deductive/symbolic reasoning agent architectures.

b) Brooks' subsumption architecture attempts to avoid altogether explicit representations and explicit reasoning in decision making. Explain how it achieves this.

c) The following diagram illustrates the key subsystems of the TOURINGMACHINES agent architecture:



Describe the overall operation of the architecture, making sure you explain how the three decision layers achieve the goal of providing both reactive and pro-active behaviour.

Communication and ontologies
a) Give two advantages of using an ontology in a multi-agent system.

b) It is often recommended to reuse ontologies where possible. Discuss the advantages and disadvantages of this.

c) State the meaning of the following in FIPA SL:

- Predicates
- Concepts
- Agent actions

d) Consider the following ACL message:

```
(inform
:sender (agent-identifier :name i)
:receiver (set (agent-identifier :name j))
:content ((price good2 150))
:language fipa-sl
:ontology SET10111-pc-auction
)
```

Identify the following in the message:

- The FIPA performative
- The predicate
- The content language

e) Write an ACL message in which agent i asks agent j to move box 17 to location 12. Be sure to show the FIPA performative, sender, receiver, and content fields. You should use FIPA SL syntax for the content field.

Working together

a) "The CONTRACT NET protocol takes inspiration from the way in which contracts are put out to tender in human organisations." With reference to the way in which the CONTRACT NET works, and the key issues that must be addressed in implementing it, explain what you understand by this statement.

b) Explain how the CONTRACT NET protocol may be implemented in terms of the FIPA agent communication language.

Game theory

a) Define the prisoner's dilemma, and in particular explain why it is a "dilemma".

b) Define the notion of Nash equilibrium, and identify and explain the single Nash equilibrium in the prisoner's dilemma.

c) Consider the following payoff matrix:

	Agent *j* cooperates	Agent *j* defects
Agent *i* cooperates	2 2	3 1
Agent *i* defects	1 3	0 0

State which outcomes maximise social welfare, and explain under what circumstances we would be interested in social welfare.

d) Explain how the game in c) is different from a Prisoner's Dilemma.

Agent-based modelling

a) Discuss the benefits of agent-based modelling compared to traditional analytical modelling.

b) Discuss the disadvantages of agent-based modelling compared to traditional analytical modelling.

c) Describe an example of an agent-based model used to address a question in economics.