English. Bokmål på side 7, nynorsk på side 11. I tilfelle du er usikker på betydningen av noen av begrepene (noen er ikke så letteå oversette), se på den engelske versjonen. Answers in red text. If the student gets portions of the answer correct, reward accordingly.

Problem 1

10 points total, 1 point each subtask. Answer each question with *True* or *False*.

(a) Artificial intelligence was born when Alan Turing formulated the Turing Test. False, the field is considered to be born in 1956 with the first AI workshop at Dartmouth College.

(b) Early advances in artificial intelligence were met with skepticism and doubt. False, people were over-enthusiastic.

(c) The agent function maps percept sequences to action. True

(d) The real world is fully observable. False

(e) A taxi driving from A to B in traffic operates in a deterministic environment. False

(f) A simple reflex agent has a small but limited short-term memory. False, a simple reflex agent has no memory.

(g) Goal-based agents often rely on search and planning to find their goal. True

(h) A utility-based agent is better suited in the real world than a learning agent, since it is able to estimate its own utility. False, a learning agent is better suited to deal with the real world.

(i) Learning is necessary for complex agent behaviour to arise in a multi-agent setting. False, complex behaviour can arise from very simple agents.

(j) Learning helps in a stochastic and continuous environment. True

Problem 2

10 points total, 1 point each subtask. Answer each question with *True* or *False*.

(a) Intelligent agents are supposed to optimize their performance measure. False, they are supposed to maximize their performance measure - to optimize the performance measure does not make sense.

(b) The vacuum world is not a toy problem. False, it is a toy problem since it is an overly simplistic problem, also categorized as such in section 3.2.1.

(c) Redundant paths in a search tree are impossible to avoid. False

(d) GRAPH-SEARCH is the same as TREE-SEARCH, only with history. True

(e) Time complexity and space complexity are the two best ways to evaluate the performance of an algorithm. False, you must also consider whether it is complete and optimal in addition to the two mentioned above.

(f) Blind search is also known as heuristic search. False

(g) A graph with branching factor *b* and depth *d* can be solved in most cases by uninformed search. False, since the time/space complexity will be exponential, it cannot be solved in most cases by uninformed search. It can be solved in a few cases where *b* and *d* are small.

(h) Bidirectional search reduces the time complexity with the square root. True

(i) An heuristic estimates the cheapest cost from one node to the goal node, even if the path is impossible to execute. True

(j) A* is the best known form of best-first search. True

Problem 3

10 points in total, points indicated for each subtask. Express tasks *a*, *b* and *e* using first-order logic, otherwise follow the instructions.

(a) (1 point) All lectures are fun. $\forall x Lecture(x) => Fun(x)$

(b) (1 point) There exists a lecture that is not fun. $\exists x Lecture(x) \land \neg Fun(x)$

(c) (2 points) Siblinghood is a symmetric relationship (i.e. write how to express this relationship in first-order logic). $\forall x,y Sibling(x,y) \Leftrightarrow Sibling(y,x)$

(d) (2 points) Express that "everyone dislikes vegetables" in two ways, using the "FOR ALL" quantifier in one sentence and "THERE EXISTS" quantifier in the other sentence, and the same predicate in both sentences.
$\forall x \neg Likes(x, Vegetables)$ is the same as $\neg \exists x Likes(x, Vegetables)$

(e) (4 points) Some siblings have di↵erent parents.
$\exists x, y Sibling(x,y) \land (\exists p Parent(p,x) \land \neg Parent(p,y))$

Problem 4

10 points in total, 2 points each subtask.

(a) What is another word for *unification*? Substitution. See 9.2.2 in AIMA, unification is described as $UNIFY(p,q) = \theta$ where $SUBST(\theta,p) = SUBST(\theta,q)$

(b) What is the purpose of *Universal Instantiation*? Infer any sentence obtained by substituting a ground term for the variable, it replaces a variable with a term to form a new sentence.

(c) *Existential Instantiation* is a special case of a more general process. What is the name of this general process? Skolemization.

(d) What is the best known programming language that builds on backward chaining? Prolog

(e) What is conjunctive normal form, and what is it used for? CNF is a conjunction of clauses where each clause is a disjunction of literals. It is used for first-order resolution.

Problem 5

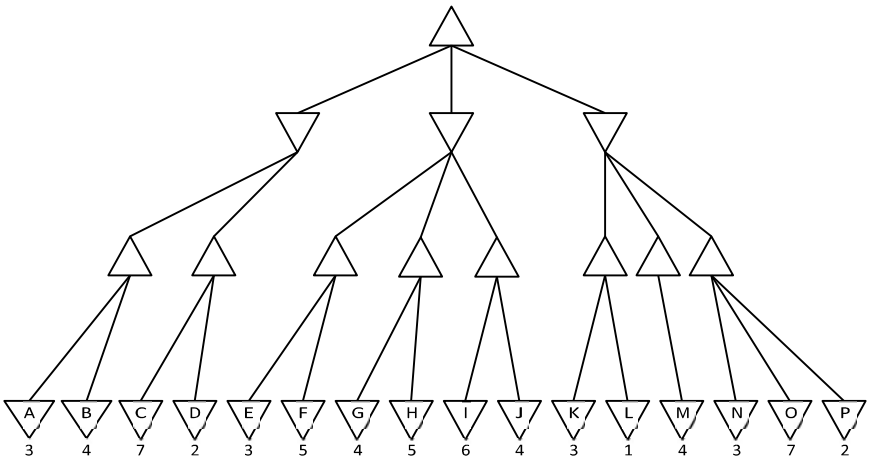
15 points. Points indicated in each subtask.

(a) (2 points) What is the name of the tree structure in the figure below? Minimax tree.

(b) (2 points) What does it represent? An adversarial game.

(c) (5 points) Write down the node values that are missing in a breadth-first manner. 5 4 5 3 4 7 5 5 6 3 4 7

(d) (6 points) Apply alpha-beta pruning and write down the leaf nodes that won't get expanded. D J M N O P



Problem 6

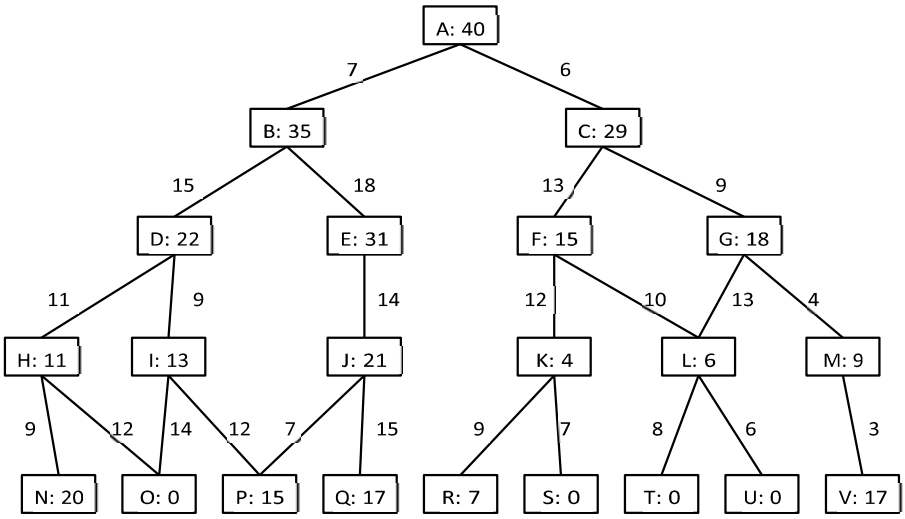
20 points. Points indicated in each subtask.

(a) (2 points) A* belongs to which class of search algorithms? Informed.

(b) (2 points) What is the worst-case time complexity of A*? Exponential, if the search space is unbounded. $O(b^d)$ It is sufficient to mention that it is exponential.

(c) (2 points) What does it mean to use an *admissible heuristic* in A* search? The heuristic must not overestimate the distance to the goal, i.e. it must be an optimistic estimate.

(d) (9 points) In the figure below, each node is labeled with the heuristic function for that node, e.g. node A has heuristic function value 40. Apply A* search to the tree and write down $f(n) = g(n)+h(n)$ for each node the algorithm visits (i.e. generates), e.g. the starting node would be written $A(40)$. Assume we visit child nodes from left to right. A(40) B(42) C(35) F(34) G(33) L(34) M(28) V(39) T(36) U(34) Note: if the student has included K(35) after V(39) this is also OK. UNIFORM-COST-SEARCH in Figure 3.14 of AIMA says that the algorithms pops a node from the frontier with the lowest cost, so this will depend on the implementation of the ordering when two nodes are of equal value.



(e) (2 points) List the nodes along the final path between the start state and the end state, using A* search. A C G L U

(f) (3 points) What is the biggest drawback of the A* algorithm? All the expanded nodes are kept in memory, so it will run out of space before it runs out of time. Therefore it does not scale well.

Problem 7

10 points. Points indicated in each subtask.

(a) (2 points) What are the best known examples of information retrieval systems? Web search engines.

(b) (3 points) What are the three essential elements in information retrieval? 1) A corpus of documents, 2) a query, 3) a result set of (ranked) relevant documents.

(c) (2 points) What separates information extraction from information retrieval? Information extraction is about acquiring knowledge from documents, whereas information retrieval is about finding the relevant documents given a query. The former builds upon the results of the latter.

(d) (3 points) What is the limiting factor in information extraction? The actual natural language processing, currently there does not exist an AI that understands text on a human level, in particular when it comes to ambiguity.