

No aiding devices allowed.

**Task 1.**

Describe the behaviour of depth-first, breadth-first and uniform-cost search, and compare their relative advantages and disadvantages. (3 points)

How does "informed search" try to improve on "uninformed search"? (3 points)

**Task 2.**

- (a) Describe the principles of the A\* -search procedure.
- (b) Apply the A\* -search procedure to a problem, where the following state transitions are possible:

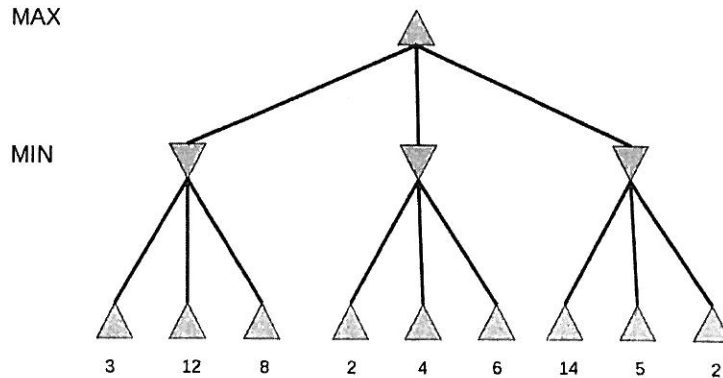
Transition	Its cost
S → A	2
S → B	1
S → C	2
A → D	2
B → E	1
C → F	1
D → H	2
E → H	8
E → I	7
F → I	2
H → G	1
I → G	2

The problem is to find a path from the state  $S$  to the state  $G$  and the values of the function  $h$  in the different states are the following  $h(A) = 3, h(B) = 3, h(C) = 3, h(D) = 2, h(E) = 2, h(F) = 2, h(H) = 1,$  and  $h(I) = 1$ . Which one of the two paths giving the minimum costs your algorithm will find and why?

(evaluation: point a) max. 3 points, point b) max. 3 points)

**Task 3.**

We have the two-ply game tree:



Explain the game setting. (2p.)

Describe how *minimax* -algorithm progresses in finding the optimal play in this game. (2p.)

Describe how *alpha-beta* - pruning works with this game. (2p.)

#### Task 4.

Inspector Palmu is a master of resolutive reasoning. He knows the following:

If a person has a motive to murder someone and possesses a murder weapon, then that person murders that someone. Inheriting someone is a motive to murder that someone, and hate is also in the same way a murdering motive. Old Madame and Bruno belong to the Rygseck-family. Bruno inherits Madame. The butler hates the old Madame. If you are crazy and also a Rygseck then you hate everybody. Blunt objects are the umbrella and the tennis racquet. Old Madame is crazy. Airi owns a tennis racquet. Bruno owns a scarf. The butler owns a hat and old Madame an umbrella. A person possesses a murder-weapon when the possessed object is owned by that person and the object is blunt.

( Use predicate- and constant symbols: murder= $k$ , motiv to murder= $m$ , possess a murder weapon= $p$ , to be Rygseck= $r$ , blunt object= $bl$ , own an object= $o$ , to be crazy= $c$ , inherit= $i$ , Bruno = Br, Butler = Bu, madame=M, Airi=A, umbrella=U, hat=H, tennis racquet=T, scarf=S , etc. if needed)

(a) Represent the knowledge of Inspector Palmu in first-order logic. (1 p)

- (b) Transform the knowledge to conjunctive normal form. (2 p)
- (c) Show by resolution using refutation that someone has murdered someone. Who murdered whom? (3 p)

### Task 5.

Let us consider the following planning problem. In the start state Rocket1, Parcel1, and Parcel2 are on the Earth. In the goal state Parcel1 and Parcel2 are on the Moon and Rocket1 is on the Earth. We have at our disposal three operators Load(parcel, rocket), Unload (parcel, rocket), and Fly(rocket, starting-point, destination), which may be divided into two operators (for flying loaded and flying unloaded), if needed. The capacity of Rocket1 is one parcel, i.e. only one parcel can be carried at a time - not two parcels. Define the operators as STRIPS- operator schemas, code the problem using these STRIPS-operators, and solve the problem in the POP-planner style. (You do not need to write down the POP (Partial-Order Planner) code, only to show, e.g. through pictures, how the solving of this problem goes.)