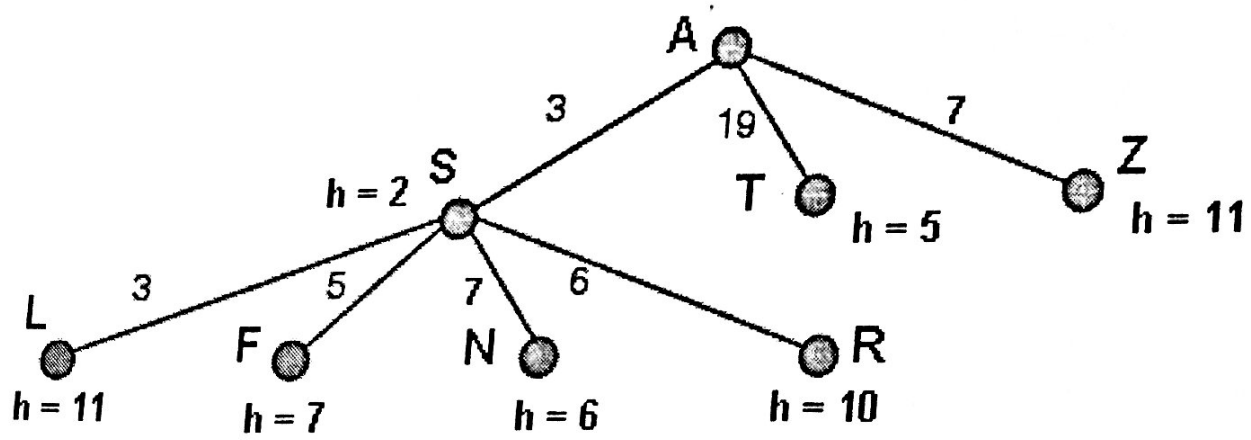
**1.** *(3 pts)* Explain the difference between the state space and the search tree through an example. PL: LABIRINTUS

ÁLLAPOTTÉRE: Az összes bejárható útvonal "egysége"

KERESŐFA: egy adott bejárása az állapottérnek. Nem lehet tetszőleges sorrendben bejárni pl: falak miatt.

**2.** *(6 pts)* The following figure contains a partially expanded search tree. For each of the search strategies listed below, give the node to be expanded next. For non-informed methods nodes are returned from left to right. Justify your answers.




a.) *(1p)* breadth-first search ASTZLFNR

A szélességi bejárás egy adott mélységben (itt: jobbról balra) bejárja a node-ot.

b.) *(1p)* depth-first search

ASLFNRTZ

c.) (*1p*) greedy search

d.) (*1p*) uniform cost search

e.) (*1p*) A* search

f.) (*1p*) recursive best first search

3. (*5 pts*) Convert the following sentences to first order predicate logic form.

a.) (*2pts*) There is no cannibal that eats another cannibal, except if it has blue eyes. (predicates: CANNIBAL($x$), EATS($x, y$), HAS_BLUE_EYES($x$))

$\forall x$ CANNIBAL($x$)

b.) (*3pts*) Each general assembly has a member that already had a proposal not supported by any other member of the assembly. (GENERAL_ASSEMBLY($x$), MEMBER_OF($x, y$), PROPOSAL_OF($x, y$), SUPPORT($x, y$))

4. (*6 pts*) For each group of sentences below, provide a domain and an interpretation that makes the sentences true, or show that it is impossible!

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a.) $\forall x.\exists y.f(x,y)$
$\forall x.\neg f(x,x)$
$\forall x,y,z.f(x,y) \wedge f(y,z) \rightarrow f(x,z)$

$I(x)=$
$I(y)=$
$I(z)=$

$f = \{\langle A,B\rangle, \langle B,A\rangle$

| x | y | z |
|---|---|---|
| A | A | A |
| A | B | A |
| A | B | B |
| A | A | B |
| B | B | B |
| B | B | A |
| B | A | B |
| B | A | A |

b.) $\forall x.\exists y.f(x,y)$
$\forall x.\neg f(x,x)$
$\forall x.(g(x) \rightarrow \exists y.f(y,x))$
$\exists x.g(x)$

5. (*6 pts*) For each pair of literals below, specify a most general unifier, or indicate that they are not unifiable

a.) $k(x, h(x,y), h(y, h(x,y)))$ and $k(x, w, h(w, z))$

$z = h(x,y)$
$w = h(x,y)$
$y = h(x,y)$
$k(x, h(x,y), h(y, h(x,y)))$
$k(x, h(x,y), h(h(x,y), z))$

$k(x, h(x,y), h(h(x,y), h(x,y)))$

b.) $k(a, x, g(h(y, A)))$ and $k(z, g(z), g(w))$

6. (*12 pts*) There are three boxes with a label on each of them:

| | |
|---|---|
| Box **A**: | This box is empty |
| Box **B**: | This box is empty |
| Box **C**: | There is money in Box **B** |

The only thing we know is that at most one label is true.

a.) (*2pts*) Give a logic formula expressing the fact that at most one variable is tr
out of three. *Hint*: Try to avoid using Disjunctive Normal Form (this wou
make your work much harder), rather use the fact that two variables cann
be true.

**6.** *(12 pts)* There are three boxes with a label on each of them:

| | | |
|---|---|---|
| Box **A**: | This box is empty | (1) |
| Box **B**: | This box is empty | (2) |
| Box **C**: | There is money in Box **B** | (3) |

(4)

The only thing we know is that at most one label is true.

a.) *(2pts)* Give a logic formula expressing the fact that at most one variable is true out of three. *Hint*: Try to avoid using Disjunctive Normal Form (this would make your work much harder), rather use the fact that two variables cannot be true.

b.) *(4pts)* Axiomatize the domain by defining a knowledge base (KB) such that the interpretation above is a model of the KB. Use the following variables:

$B_n$: box $n$ covers the money;
$L_n$: the label on box $n$ is true.

c.) *(2pts)* Convert the statements in the KB to Conjunctive Normal Form (CNF).

d.) (*4pts*) If you can have one of the boxes without opening any of them, which one would you take? Explain your choice using a resolution refutation proof.

7. (*4 pts*) Formulate the effect axiom in situation calculus of the CLOSE operator (applicable to doors) using the CLOSED predicate.

8. (*10 pts*) An agent uses forward checking for solving a constraint satisfaction problem

a.) (*1pt*) In what decisions (choices) can the agent use a heuristic?

b.) (*2pts*) Fill the gaps in the following sentences:

According to the minimum remaining values heuristic the ..... constrained ..... should be instantiated to bring dead ends upper in ..... .

(*10 pts*) An agent uses forward checking for solving a constraint satisfaction problem.

a.) (*1pt*) In what decisions (choices) can the agent use a heuristic?

b.) (*2pts*) Fill the gaps in the following sentences:

According to the minimum remaining values heuristic the ..... constrained ..... should be instantiated to bring dead ends upper in the ..... .

A good heuristic when choosing a ..... is to pick the one that rules ou the ..... values in the remaining variables.

c.) (*7pts*) Simulate the agent on the following cryptarithmetic problem by ha using backtracking, forward checking, and the heuristics stated abo Indicate where forward checking and each of the heuristics comes into pla

```
   PIN
+  PIN
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  KNOT
```

**10.** *(8 pts)* We would like to compute the conditional probability value $P(a, b \mid c, d)$, having only the following values are available:

$P(a)$, $P(b)$, $P(c)$,
$P(a \mid d)$, $P(b \mid d)$, $P(c \mid d)$,
$P(d \mid a)$,
$P(a, b)$, $P(c, d)$,
$P(a \mid c, d)$, $P(b \mid c, d)$,
$P(c \mid a, b)$, $P(d \mid a, b)$.

For each of the following assumptions decide if $P(a, b \mid c, d)$ can be computed, and the formula to calculate it if it is possible.

a.) $a$ and $b$ are conditionally independent given $c$ and $d$.

b.) $c$ and $d$ are conditionally independent given $a$ and $b$.

c.) $a$ and $b$ are independent.

d.) $a$, $b$, and $c$ are conditionally independent given $d$.

9. *(6 pts)* Give a Bayesian network that satisfies the following conditions:

(i) A is independent of B
(ii) A depends on B given C
(iii) A depends on D
(iv) A is independent of D given C

**11.** (*10 pts*) Decide whether the following statements are true or false and justify your answer. Points are only given for the justification.

a.) If the premises are consistent, first-order resolution terminates without a contradiction.

b.) If first-order resolution terminates without a contradiction, the premises are consistent.

c.) If A and B are independent, then A and B are conditionally independent given C.

d.) The variable elimination algorithm runs in time polynomial in the size of the conditional probability tables in the network.

e.) Using the Bayesian correction in parameter estimation means that we no longer get the model that maximizes the likelihood of the data.