- *You have 90 minutes to answer the questions.*
- *Work on your own. Any form of communication will result in immediate disqualification.*
- *To receive full score you have to justify your answers, unless indicated otherwise.*
- *Exams with incomplete headers will not get evaluated.*

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	Σ
14	5	6	6	6	8	10	8	6	8	10	87
6	3.5	8	6	5	7	6	2	0	0	4	39.5

1. (*14 pts*) You are right next to a fountain. Given two water jugs of 5l and 3l respectively, you have to fill the 5l jug with 4l of water.

a.) (*3 pts*) Propose a good state representation for this search problem. Give the start and goal states in the chosen representation.

b.) (*6 pts*) Define the actions (operators) that are meaningful in this state space. Give the rules of the state transition function for this state space using the following table in the form

$$(\{state_0\}, action) \rightarrow state_1,$$

where $\{state_0\}$ represents the set of states where the given *action* can be executed, and $state_1$ is the resulting state of the *action*. If you can use parameters to define input state set of the operator, you can also you use it to define the resulting state.

$\{state_0\}$	action	$state_1$
3literes üres	feltöltjük félig	1.5 liter van benne
5 literes üres	feltöltjük félig	2.5 liter van benne
1.5 liter van benn	átöntjük a másikba	4 liter van benn
5l üres	teletölt	5l tele
3l üres	5l-esből feletölt	3l tele, 5l-ben 2l marad
3l tele	kiönt	3l üres
3l üres, 5l-ben 2l van	5l-esből feltölt	3l-ben 2l van, 5l üres
5l üres	teletölt	5l tele

c.) (*2 pts*) Propose a good state evaluation function for measuring proximity to the goal state.

d.) (*3 pts*) Perform hill climbing search without backtracking.

2. (5 *pts*) Compare A*, RBFS and SMA* in terms of memory usage and time requirement.

- SMA*: simplified memory bounded A*: korlátozott memória, minden kiadja, ha nem
- RBFS: rekurzív mivel mindig elölről kezdi a fát keresést, ha a korát nem jó
- A*: memóriaigényes, mivel tárolja a node-okat és nem dobja ki, ha nem kellenek

3 TP

3. (*6 pts*) Consider a world with objects **A**, **B**, and **C**! We will look at a logical language with constant symbols *X*, *Y*, and *Z*, predicate symbols *p*, *q*, and *r*, and function symbol *f*. Consider the following interpretation!

$I(X) = \mathbf{B}$, $I(Y) = \mathbf{B}$, $I(Z) = \mathbf{A}$
$I(f) = \{\langle \mathbf{A},\mathbf{B}\rangle, \langle \mathbf{B},\mathbf{C}\rangle, \langle \mathbf{C},\mathbf{C}\rangle\}$
$I(p) = \{\mathbf{A},\mathbf{B}\}$
$I(q) = \{\mathbf{C}\}$
$I(r) = \{\langle \mathbf{B},\mathbf{A}\rangle, \langle \mathbf{C},\mathbf{B}\rangle, \langle \mathbf{C},\mathbf{C}\rangle\}$

For each of the following sentences, decide whether it is true or false in the given interpretation!

a.) $r(f(Z),Z)$

hamis

b.) $q(f(f(f(Z))))$ igaz

c.) $\exists y\, f(y) = f(f(y))$

d.) $\forall y\, r(f(y),y)$

igaz

e.) $\forall u,v\ r(u,v) \rightarrow (\forall w\ r(u,w) \rightarrow v = w)$ hamis, nincs két olyan ~~[illegible]~~ ahol a második érték egyenlő

f.) $\forall u,v\ r(u,v) \rightarrow (\forall w\ r(w,v) \rightarrow u = w)$ igaz

de. eSpel előtt lehe igaz

c,B c,C fordítva

4. (*6 pts*) Show that the following sentences are equivalent by converting them to CNF.

$\forall x\, [\forall y\ P(x,y)] \rightarrow Q(x)$

$\forall x\, \exists y\, [P(x,y) \rightarrow Q(x)]$

6 p

$\forall x\, [\forall y\ P(x,y)] \rightarrow Q(x)$

$\forall x\, \neg [\forall y\ P(x,y)] \lor Q(x)$

$\forall x\, \exists y\, \neg P(x,y) \lor Q(x)$

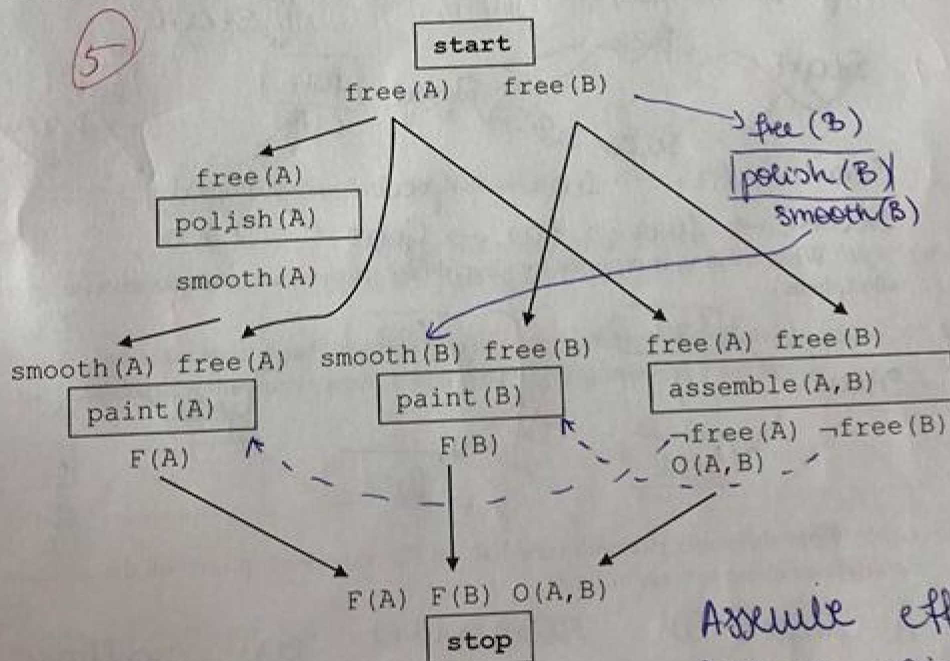
$\forall x\, \exists y\, [P(x,y) \rightarrow Q(x)]$

$\forall x\, \exists y\, \neg P(x,y) \lor Q(x)$

ekvivalens

5. (*6 pts*) Let us consider the following incomplete partially ordered plan. What steps are missing to complete the plan? Mark them in the graph.

5



Assemble effektje törölheti a paint(A) és paint(B) prekondícióját

6. (8 *pts*) Consider the following expression returned by a situation calculus planner:

RESULT(A, RESULT(F, RESULT(D, RESULT(Q, S_0))))

a.) (*2 pts*) What is the role of S_0 in the expression?

S_0 a kezdőállapot, ebből indul ki.

b.) (*2 pts*) What is the total number of situations the agent meets when executing the plan? Justify your answer.

$S_0 \xrightarrow{Res(Q,S_0)} S_1 \xrightarrow{Res(D,S_1)} S_2 \xrightarrow{Res(F,S_2)} S_3 \xrightarrow{Res(A,S_3)} S_4$

kezdőállapot + állapotok => 1+4=5

c.) (*4 pts*) Extract the plan in the form of a graph from the expression.

Q→D→F→A

$S_0 \longrightarrow Result(Q, S_0) \longrightarrow Result(D, Result(Q, S_0)) \longrightarrow Result(F, \ldots)$

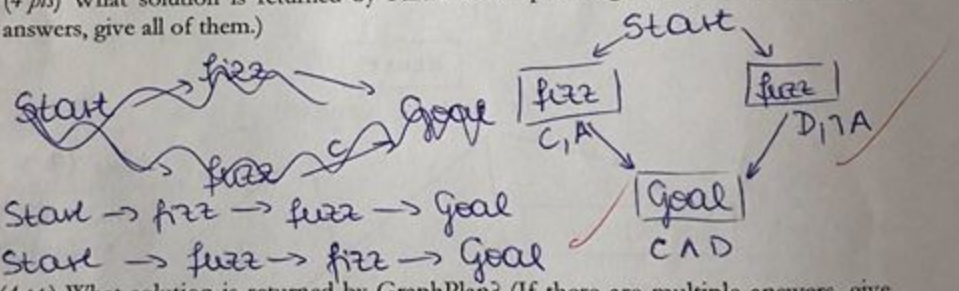
$\downarrow$

$Result(A, \ldots)$

7. (*10 pts*) Consider the following domain with the goal C ∧ D.

Op.: **fizz**	Precondition: -	Effect: C, A
Op.: **fuzz**	Precondition: -	Effect: D, ¬A

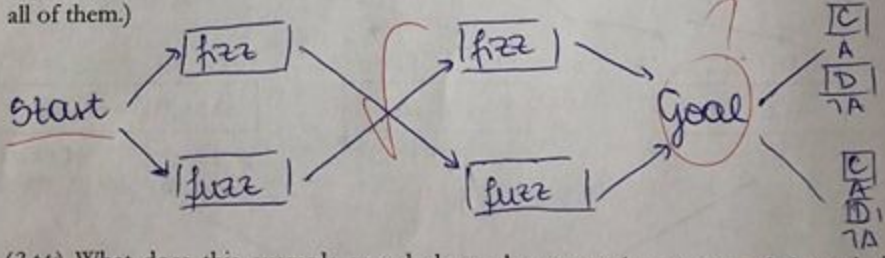
d.) (*4 pts*) What solution is returned by Partial order planning? (If there are multiple answers, give all of them.)



Start → fizz → fuzz → Goal

Start → fuzz → fizz → Goal

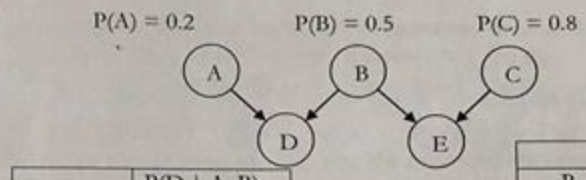
e.) (*4 pts*) What solution is returned by GraphPlan? (If there are multiple answers, give all of them.)



f.) (*2 pts*) What does this example reveal about the expressive power of the solution descriptions in the two algorithms?

A GraphPlan szemléletesi egy gráfban az összes lehetséges megoldást/útvonalat

8. *(8 pts)* Consider the following Bayesian network:



	P(D | A, B)
A, B	0.9
¬A, B	0.6
A, ¬B	0.5
¬A, ¬B	0.1

	P(E | B, C)
B, C	0.2
¬B, C	0.4
B, ¬C	0.8
¬B, ¬C	0.3

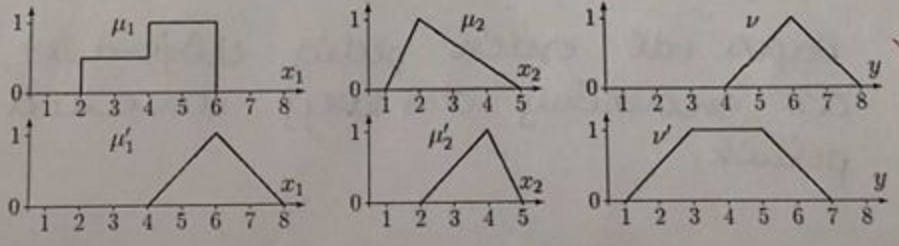
a.) *(4 pts)* Suppose we know the value of D. Are A and B d-separated given D? Are A and E d-separated given D?

b.) *(4 pts)* What is the probability of A being false, given that all other variables are true?

9. *(6 pts)* Consider the following fuzzy sets and rules:

(R_1) If x_1 is μ_1 and x_2 is μ_2, then y is ν.
(R_2) If x_1 is μ'_1 and x_2 is μ'_2, then y is ν'.

where x_1 and x_2 are input fuzzy variables, y is the output fuzzy variable, and μ_1, μ_2, μ'_1, μ'_2, ν, and ν' are predicates for the fuzzy variables with the following member functions:



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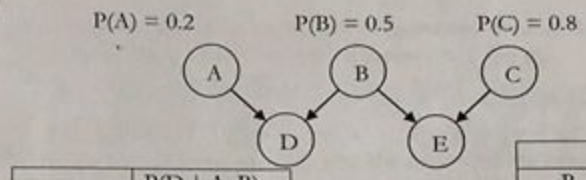

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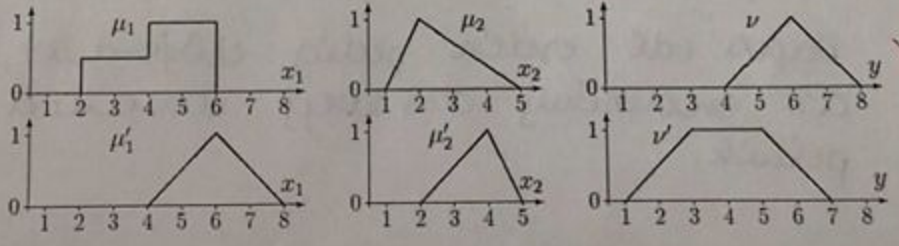
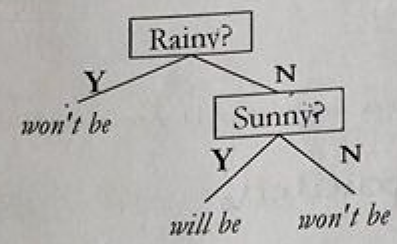


Based on these fuzzy sets and the rules, what output μ_{out} does a controller with Mamdani implication return for the input tuple (5, 2.5)?

10. (*8 pts*) Let us consider the following decision tree and the associated data set.



#	Rainy	Sunny	Hot	Summer	Sunday	Picnic	FP	FN
1.	Y	N	N	N	N	*won't be*	X	
2.	N	Y	N	N	Y	*will be*	X	
3.	N	Y	Y	Y	Y	*won't be*		X
4.	N	Y	Y	N	Y	*won't be*		X
5.	Y	N	N	N	Y	*won't be*	X	
6.	N	Y	N	N	Y	*won't be*		X

inverted model output?

a.) (*3 pts*) For each sample in the data set, indicate in the appropriate column if it is considered a false positive or a false negative with respect the answer given by the decision tree.

b.) (*5 pts*) Which terminal leave would be worth substituting for an attribute test and why? (Rainy = Y, Sunny = Y, Sunny = N?) Which attribute would result in the largest gain?

Ha az eső esik mindenképp elmarad a piknik.

Napos idő esetén pedig előfordult, hogy az eredmény az, hogy elmarad a piknik.

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

a.) Admissible heuristics are by nature optimistic, because they think the cost of solving the problem is usually less than it actually is.

igaz

A heurisztika akkor elfogadható, ha sosem becsüli túl a költséget.

b.) Alpha-beta pruning can only alter the computed minimax value of the root of a game search tree if the order of the terminal nodes is inconsistent.

Hamis

Az alpha-béta metszéssel csökkenthetjük a megvizsgálni kívánt ágakat.

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

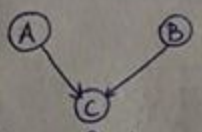
Hamis, akkor kontradikció kell legyen.

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

Hamis, a rezolúció végén az ellentmondás jelenti, hogy igaz volt a következtetés

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

igaz,



meg tudunk adni ilyen C-t.