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KR 2020 exam Q and answers

Knowledge Representation (Vrije Universiteit Amsterdam)

Test KR2020 exam

Test ID: 50241
Folder: /Top/SIS/XM_0059
Folder description: Knowledge Representation
Version: 2.4
Randomised: No
Last modified: Tuesday, 20 october 2020 16:52:00
Number of questons: 24
Blocks: Fixed
Display questions once: No
Tools: Calculator extended
Test time: 195 minutes
Maximum score: 59 pt.
Chance score: 10.25 pt. / 17%
In test set with: -

Test instruction

Welcome to the exam of the course Knowledge Representation (XM_0059).

The exam was originally designed for 2 hours, but has been shortened given the proctoring constraints. You should be able to easily finish it within 90 minutes, but you will have plenty of time to finish it until 21.30.

The following tools are permitted:
- Calculator
- Scrap paper (nothing written or printed on it)
- Check here for the cheat sheet

There are 24 questions, including one open questions for which you can gain 10 points. In total you can earn 61 points.

For questions about the content of the test you can contact us **after the exam.** In case you believe a question is incorrect or vague, please answer according to your interpretation, and make a note of the question number and your assumption.
We can then later discuss these cases. Information about the review of the exam is provided via Canvas.

If you have **not** signed up for this exam, you will not receive a result. Through VUnet you can object to the fact that you can no longer sign up after the expiry of the registration deadline (and the fact that you will not receive a result for this exam). Submit your appeal online within one week after the exam. More information can be found at www.vu.nl/intekenen.

The official guideline of the proctored exam says that toilet visits are not allowed. In view of the long time slot of almost 3 hours, if needed, you can take such a short break. Please mention this in the camera.

Logic general

Question order: Fixed
Two short questions about Knowledge Engineering and Logics in general for 5 points in total.
Answering those questions should take about 5 minutes.

Question 1 − Proof by contradiction − 198701.1.0

Question type:	Multiple choice
Pre-test item:	No
Folder:	/Top/SIS/XM_0059
Folder description:	Knowledge Representation
Answer option order:	Random
Partial scoring:	No
Maximum score:	1
Chance score:	0.25 pt. / 25%
Status:	
Last modified:	17-10-2020 14:23
Attributes:	*Taxonomie/Taxonomy* 00 Onbekend/Unknown

In a proof by contradiction, such as DPLL or tableau, I can prove that a formula F is entailed by a knowledge base KB by showing that

A   the knowledge base KB and the formula F are together unsatisfiable.

B   the knowledge base is unsatisfiable, which implies that the formula F must be entailed.

C   the knowledge base KB and the negation of the formula are unsatisfiable.

D   the formula F is unsatisfiable, which implies that it must be entailed by the KB.

Question 2 − Logic Engineering − 198897.2.0

Question type:	Multiple choice
Pre-test item:	No
Folder:	/Top/SIS/XM_0059
Folder description:	Knowledge Representation
Answer option order:	Random
Partial scoring:	No
Maximum score:	4
Chance score:	1.00 pt. / 25%
Status:	
Last modified:	06-01-2021 23:11
Attributes:	*Taxonomie/Taxonomy* 00 Onbekend/Unknown

Consider a language L defined as follows

•Syntax
- $\{A,B,C\} \in L$
- If F1, F2, F3 $\in$ L then "(F1*F2*F3)" $\in$ L

•Semantics: let I be an interpretation function:
- I(A)=1, I(B)=2, I(C)=3
- I(F1*F2*F3) = I(F3).I(F1).I(F2)

What is I(A*B*(C*A*B))?

A   1.2.3.4.5

B   2.3.1.1.2

C   3.2.1.2.3

D   1.2.3.1.2

Propositional Logic

Question order: Fixed

7 questions on Propositional Logic, with 16 points in total. The 5th and 6th question of this block are a bit more complex and are worth 4 points each.

You will probably need 20 minutes for this block.

Question 3 − Semantics 2 − 98411.4.0

Question type:	Fill in (multiple)
Pre-test item:	No
Folder:	/Top/SIS/X_401086/Logical Agents
Answer option order:	Fixed
Partial scoring:	Yes
Maximum score:	2
Chance score:	0.00 pt. / 0%
Status:	
Last modified:	20-10-2020 09:47
Attributes:	*Taxonomie/Taxonomy* 00 Onbekend/Unknown

Fill in the truth value of the following formulas under the assumption that A,B,C and D are all false. Fill in the truth values of the formulas (use the words "True, False").

(A & B) v -C v -D is [True]

(A & B) v (-C & D) is [False]

(A->B) v (C->D) is [True]

(-A->B) v (-C->D) is [False]

[Alphanumeric]	[Alphanumeric]	[Alphanumeric]	[Alphanumeric]
True	**False**	**True**	**False**
true	false		
T	F		

Question 4 − PL semantics example − 198702.3.0

Question type:	Multiple choice
Pre-test item:	No
Folder:	/Top/SIS/XM_0059
Folder description:	Knowledge Representation
Answer option order:	Random
Partial scoring:	No
Maximum score:	2
Chance score:	0.50 pt. / 25%
Status:	
Last modified:	06-01-2021 23:21
Attributes:	*Taxonomie/Taxonomy* 00 Onbekend/Unknown

Which of the following is true?
The propositional statement (PvQ) -> (P&Q)

A is satisfiable, but not valid

B is valid

C is a contradiction

D neither valid, satisfiable nor a contradiction

Question 5 − Automated Reasoning as search − 83998.2.1

Question type: Multiple choice
Pre-test item: No
Folder: /Top/SIS/X_401086/Logical Agents
Answer option order: Random
Partial scoring: No
Maximum score: 2
Chance score: 0.50 pt. / 25%
Status:
Last modified: 17-10-2020 14:19
Attributes: *Taxonomie/Taxonomy* 00 Onbekend/Unknown

(2 points) Automated reasoning can often be seen as search procedure, that tries to find an order of rules to formulas in a knowledge base. Which of the following statements about the DPLL (Davis−Putnam−Logemann−Loveland) Algorithm and Search is correct?

A DPLL recursively searches through all possible variable assignments for a model, i.e. an interpretation that satisfies all the clauses.

B DPLL iteratively searches through the set of all clauses for one that is satisfied by a given interpretation.

C DPLL exhaustively applies a set of transformation rules to produce a contradiction

D DPLL cannot be seen as a search procedure, it only randomly assigns values to propositions until it finds an assignment that satisfies all the clauses.

Question 6 − DPLL properties − 198733.1.1

Question type: Multiple choice
Pre-test item: No
Folder: /Top/SIS/XM_0059
Folder description: Knowledge Representation
Answer option order: Random
Partial scoring: No
Maximum score: 1
Chance score: 0.50 pt. / 50%
Status:
Last modified: 06-01-2021 23:23
Attributes: *Taxonomie/Taxonomy* 00 Onbekend/Unknown

In DPLL, in each step of the algorithm more variables get assigned a truth value "true or false".

Is this statement true or false?

A True

B False

Question type:	Fill in (multiple)
Pre-test item:	No
Folder:	/Top/SIS/X_401086/Logical Agents
Answer option order:	Fixed
Partial scoring:	Yes
Maximum score:	4
Chance score:	0.00 pt. / 0%
Status:	
Last modified:	18-10-2020 17:56
Attributes:	*Taxonomie/Taxonomy* 00 Onbekend/Unknown

Given a clause set
{ AvB,
-AvBv-C,
-Av-BvC,
-AvBvC,
Av-B}

Fill in the gaps to prove satisfiability or unsatisfiability with DPLL. Hereby apply an alphabetical order (startng with A), and assing False before True to the variables. Please keep the clauses in the order given above and do not leave spaces before, between or after propositions. .

Assigning the value False to variable A results in the clause set:

B

-B

which is a contradiction. So we need to backtrack and assign the value True to A .
This results in the knowledge base:

Bv-C

-BvC

BvC

Assign the value False to variable B , which results in the clause set:

-C

C

which is again a contradition. So, after this we backtrack on B and give it the value True , which results in a single clause

C

This means that the knowledge base is satisfiable with an assignment A= True , B= False and C= True .

[Alphanumeric]	[Alphanumeric]	[Alphanumeric]	[Alphanumeric]	[Alphanumeric]	
B	**-B**	**True**	**A**	**Bv-C**	
[Alphanumeric]	[Alphanumeric]	[Alphanumeric]	[Alphanumeric]	[Alphanumeric]	[Alphanumeric]
-BvC	**BvC**	**False**	**B**	**-C**	**C**
[Alphanumeric]	[Alphanumeric]	[Alphanumeric]	[Alphanumeric]	[Alphanumeric]	[Alphanumeric]
B	**True**	**C**	**satisfiable**	**True**	**False**
			consistent		

[Alphanumeric]
True

Question type:	Fill in (multiple)
Pre-test item:	No
Folder:	/Prullenbak
Answer option order:	Fixed
Partial scoring:	Yes
Maximum score:	4
Chance score:	0.00 pt. / 0%
Status:	
Last modified:	06-01-2021 22:54
Attributes:	*Taxonomie/Taxonomy* 00 Onbekend/Unknown

Consider the following knowledge base (set of clauses):

1: ¬ p ∨ q ∨ r
2: p ∨ ¬ q ∨ ¬ r
3: ¬ p ∨ ¬ q ∨ ¬ r
4: p ∨ q
5: p ∨ r
6: ¬ p ∨ ¬ q ∨ r

and show whether the knowledge base is satisfiable or not using DPLL.

Use the following order: unit, pure, split alphabetic with a positive value.

According to the MOMs heuristics, one choses the variable $\boxed{p}$ to assign the value True first. This produces the following clause-set:
1': q ∨ r
3': ¬ q ∨ ¬ r
4': q
5': r
6': ¬ q ∨ r
Now there are two $\boxed{\text{unit}}$ -clauses,which means that the alphabetically first one has to be set to True. This gives the following set of new clauses:
3": $\boxed{¬\,r}$
5": $\boxed{r}$ and
6': $\boxed{r}$.
This leads to a contradiction, so hat we need to backtrack. This means we have to assign the value $\boxed{\text{False}}$ to the variable $\boxed{p}$.
Now we get the following clauses:
2''': $\boxed{¬\,q\,∨\,¬\,r}$
4''': $\boxed{q}$
5''': $\boxed{r}$
After two more steps we can decide that the clause set is $\boxed{\text{unsatisfiabile}}$, as there is $\boxed{\text{no}}$ model.

[Alphanumeric]	[Alphanumeric]	[Alphanumeric]	[Alphanumeric]	[Alphanumeric]	
p	**unit**	**¬ r**	**r**	**r**	
P	Unit	¬r			

[Alphanumeric]	[Alphanumeric]	[Alphanumeric]	[Alphanumeric]	[Alphanumeric]	[Alphanumeric]
False	**p**	**¬ q ∨ ¬ r**	**q**	**r**	**unsatisfiabile**
		¬q ∨ ¬q			

[Alphanumeric]
no

Question 9 − GSAT soundness − 198734.3.0

Question type:	Multiple choice
Pre-test item:	No
Folder:	/Top/SIS/XM_0059
Folder description:	Knowledge Representation
Answer option order:	Random
Partial scoring:	No
Maximum score:	1
Chance score:	0.50 pt. / 50%
Status:	
Last modified:	06-01-2021 23:25
Attributes:	*Taxonomie/Taxonomy* 00 Onbekend/Unknown

GSAT is complete w.r.t Propositional Logic satisfiability True or false?

A   True

B   False

Description Logics

Question order: Fixed

5 questions on Description Logics worth 20 points. The third question takes a bit more time (and is worth 5 points), the last one is the only open question of the exam and is worth 10 points. The entire block should take about 20 minutes.

Question 10 − DL in English 2 − 198715.3.1

Question type:	Multiple choice
Pre-test item:	No
Folder:	/Prullenbak
Answer option order:	Random
Partial scoring:	No
Maximum score:	2
Chance score:	0.50 pt. / 25%
Status:	
Last modified:	06-01-2021 23:05
Attributes:	*Taxonomie/Taxonomy* 00 Onbekend/Unknown

Which of the following English sentences is a faithful paraphrase of the following formula:

HappyParent = Parent $\sqcap$ $\exists$ hasChild.(Doctor $\sqcap$ $\forall$ hasChild.Doctor)

A   Happy parents are precisely those parents all of whose children are either doctors or have a child who is a doctor

B   Parents of doctors who also have children who have a doctor as a child, are happy parents

C   All happy parents have a child that is a doctor, or the parent of a doctor

D   Happy parents are precisely those parents who have a chlld that is a doctors and this doctor's children are doctors as well.

Question 11 − Model ENglish in DL − 198818.2.1

Question type:	Multiple choice
Pre-test item:	No
Folder:	/Top/SIS/XM_0059
Folder description:	Knowledge Representation
Answer option order:	Random
Partial scoring:	No
Maximum score:	2
Chance score:	0.50 pt. / 25%
Status:	
Last modified:	06-01-2021 23:30
Attributes:	*Taxonomie/Taxonomy* 00 Onbekend/Unknown

Which of the following ALC statements corresponds to the English statement
GrandGrandparents are people who have at least one child that has at least one child with a child

A   Grandparents= people⊓∃Child.∃Child.∃Child.⊤

B   Grandparents= people ⊓ ∀Child.∀Child. ∃Child.⊤

C   Grandparents= people ⊔ ∃Child.∃Child.∃Child ⊤

D   Grandparents⊓ people = ∃Child.∃Child.∃Child ⊤

Question 12 − DL model − 198724.2.5

Question type:	Fill in (multiple)
Pre-test item:	No
Folder:	/Top/SIS/XM_0059
Folder description:	Knowledge Representation
Answer option order:	Fixed
Partial scoring:	Yes
Maximum score:	5
Chance score:	0.00 pt. / 0%
Status:	
Last modified:	07-01-2021 17:26
Attributes:	*Taxonomie/Taxonomy* 00 Onbekend/Unknown

Given the following interpretation with domain {alice, bob, clair, c1, b1, l1} and a table that clarifies who and what are in the interpretation of the owns relation.

alice	bob	clair
c1	c1	c1
	b1	b1
		l1

Here c1 is in the interpretation of the concept **cars**, b1 in the interpretation of the concept **bicycles** and l1 in the interpretation of concept **lion**.

We also have information that cars, bikes and lions are disjoint classes.

Give the value of the interpretation (set of persons) of each of the following formulas. Write the full names with commas (but not spaces) in alphabetic order:

a) ∃ loves.cars $\boxed{\text{{alice,bob,clair}}}$
b) ∀ loves.cars $\boxed{\text{{alice}}}$
c) ¬ ∃ loves.cars $\boxed{\text{{}}}$
d) ¬ ∀ loves. ¬ cars $\boxed{\text{{bob,clair}}}$
e) ∀ loves.¬ (lion ⊔ bikes) $\boxed{\text{{alice}}}$

[Alphanumeric]	[Alphanumeric]	[Alphanumeric]	[Alphanumeric]	[Alphanumeric]
{alice,bob,clair}	**{alice}**	**{}**	**{bob,clair}**	**{alice}**
alice,bob,clair	alice		bob,clair	alice

Question 13 − Reduction of reasoning − 198821.2.1

Question type:	Multiple choice
Pre-test item:	No
Folder:	/Top/SIS/XM_0059
Folder description:	Knowledge Representation
Answer option order:	Random
Partial scoring:	No
Maximum score:	1
Chance score:	0.50 pt. / 50%
Status:	
Last modified:	07-01-2021 17:26
Attributes:	*Taxonomie/Taxonomy* 00 Onbekend/Unknown

ALC subsumption checking is reducible to ABox consistency. True or false?

A   True

B   False

Question 14 – Tableau calculus – 198710.3.0

Question type:	Open-ended
Pre-test item:	No
Folder:	/Top/SIS/XM_0059
Folder description:	Knowledge Representation
Answer option order:	Fixed
Partial scoring:	Yes
Maximum score:	8
Chance score:	0.00 pt. / 0%
Status:	
Last modified:	06-01-2021 23:35
Attributes:	*Taxonomie/Taxonomy* 00 Onbekend/Unknown
Word count:	1
Word count:	No

Use a tableau algorithm to test whether $\exists s.(C \sqcup D) \sqcap \forall s.\neg C \sqsubseteq \exists s.D$ (where $\sqsubseteq$ stands for DL subsumption)

Describe all the necessary steps in detail.

In case you have trouble typing the symbols use E for $\exists$, V for $\forall$, v, &, - for disjunction, conjunction and negation as usual.

Grading instruction

Criterion 1 (Number of points: 1)

Adding the negated implication to the left hand side of the formula

Criterion 2 (Number of points: 1)

Transform the formula into NNF

Criterion 3 (Number of points: 1)

Apply Existential rule correctly

Criterion 4 (Number of points: 1)

Apply Universal rule correctly

Criterion 5 (Number of points: 1)

Branching correctly

Criterion 6 (Number of points: 1)

Correct conclusion (there is an open branch, thus satisfiable).

Criterion 7 (Number of points: 1)

Correct conclusion: No subsumption relation.

Criterion 8 (Number of points: 1)

General idea is understood

PGMs

Question order: Fixed

10 questions on Probabilistic Graphical Models. These questions come in 4 blocks,
1. three knowledge questions (1 point each),
2. four questions with (2 points each)
3. one question with 4 parts about d-separation for 4 points
4. 2 questions calculating with Bayesian networks.(2 and 3 points)

Question 15 − PGM1: True false 1 − 198898.1.1

Question type:	Multiple choice
Pre-test item:	No
Folder:	/Top/SIS/XM_0059/PGM
Answer option order:	Random
Partial scoring:	No
Maximum score:	1
Chance score:	0.50 pt. / 50%
Status:	
Last modified:	18-10-2020 12:40
Attributes:	*Taxonomie/Taxonomy* 00 Onbekend/Unknown

If $I_{Pr}(X,W,Y)$ and $I_{Pr}(X,W,Z)$, then $I_{Pr}(X,W,Z \cup Y)$. True or false?

A   True

B   False

Question 16 − PGM: convergent valve − 198899.1.0

Question type:	Multiple choice
Pre-test item:	No
Folder:	/Top/SIS/XM_0059/PGM
Answer option order:	Random
Partial scoring:	No
Maximum score:	1
Chance score:	0.50 pt. / 50%
Status:	
Last modified:	18-10-2020 12:44
Attributes:	*Taxonomie/Taxonomy* 00 Onbekend/Unknown

A convergent valve ($\rightarrow W \leftarrow$) is open iff either variable W or any of its descendants appears in Z. True or false?

A   True

B   False

Question 17 − PGM: MAP queries − 198900.1.0

Question type:	Multiple choice
Pre-test item:	No
Folder:	/Top/SIS/XM_0059/PGM
Answer option order:	Random
Partial scoring:	No
Maximum score:	1
Chance score:	0.50 pt. / 50%
Status:	
Last modified:	18-10-2020 12:45
Attributes:	*Taxonomie/Taxonomy* 00 Onbekend/Unknown

In case of MAP-queries, the basic idea is that, we first sum-out all the non-MAP variables, and then maximise-out the MAP variables. True or false?

A   True

B   False

Question 18 − PGM: semantics − 198901.2.0

Question type: Multiple choice
Pre-test item: No
Folder: /Top/SIS/XM_0059/PGM
Answer option order: Random
Partial scoring: No
Maximum score: 2
Chance score: 1.00 pt. / 50%
Status:
Last modified: 20-10-2020 10:11
Attributes: *Taxonomie/Taxonomy* 00 Onbekend/Unknown

If $\alpha \models \beta$ and $Pr(\beta)=0$, then $Pr(\alpha)=0$. True or False?

A True

B False

Question 19 − PGMs: semantics 2 − 198902.2.0

Question type: Multiple choice
Pre-test item: No
Folder: /Top/SIS/XM_0059/PGM
Answer option order: Random
Partial scoring: No
Maximum score: 2
Chance score: 1.00 pt. / 50%
Status:
Last modified: 20-10-2020 10:12
Attributes: *Taxonomie/Taxonomy* 00 Onbekend/Unknown

If $\alpha \models \alpha \wedge \beta$, then $Pr(\alpha \vee \beta) \leq Pr(\alpha)$. True or false?

A True

B False

Question 20 − PGM corresponding interaction graph − 198995.2.0

Question type: Multiple choice
Pre-test item: No
Folder: /Top/SIS/XM_0059/PGM
Answer option order: Random
Partial scoring: No
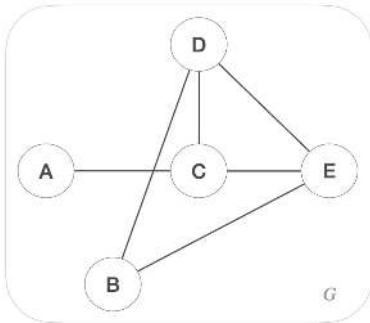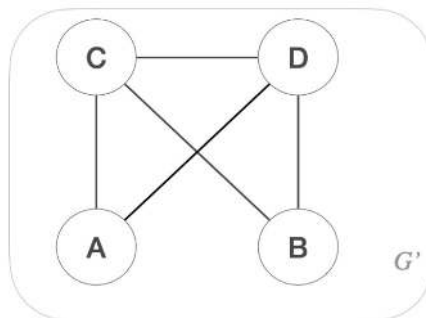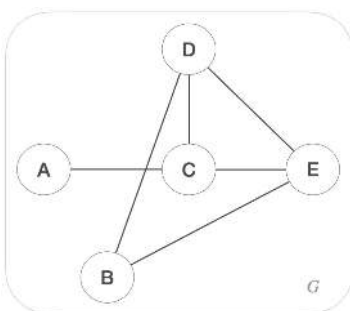**Maximum score:** 2
Chance score: 1.00 pt. / 50%
Status:
Last modified: 20-10-2020 10:12
Attributes: *Taxonomie/Taxonomy*   00 Onbekend/Unknown

The following corresponding interaction graph G corresponds to the set of factors: {f(A,C),f(D,E),f(B,D,E),f(C,E),f(C,D,E),f(A,E),f(B,D)} . True or false?

A   True

B   False

Question 21 − PGM eliminate node from interaction graph − 198996.2.0

Question type: Multiple choice
Pre-test item: No
Folder: /Top/SIS/XM_0059/PGM
Answer option order: Random
Partial scoring: No
Maximum score: 2
Chance score: 1.00 pt. / 50%
Status:
Last modified: 20-10-2020 10:12
Attributes: *Taxonomie/Taxonomy*   00 Onbekend/Unknown

If we eliminate node E from graph G, we get the interaction graph G'. True or false?

A   True

B   False

Question type:	Fill in (multiple)
Pre-test item:	No
Folder:	/Top/SIS/XM_0059/PGM
Answer option order:	Fixed
Partial scoring:	Yes
Maximum score:	4
Chance score:	0.00 pt. / 0%
Status:	
Last modified:	20-10-2020 10:13
Attributes:	*Taxonomie/Taxonomy* 00 Onbekend/Unknown

Consider the following Bayesian network, below. (Recall that dsep(X, Z, Y) denotes "X and Y are d-separated by Z").
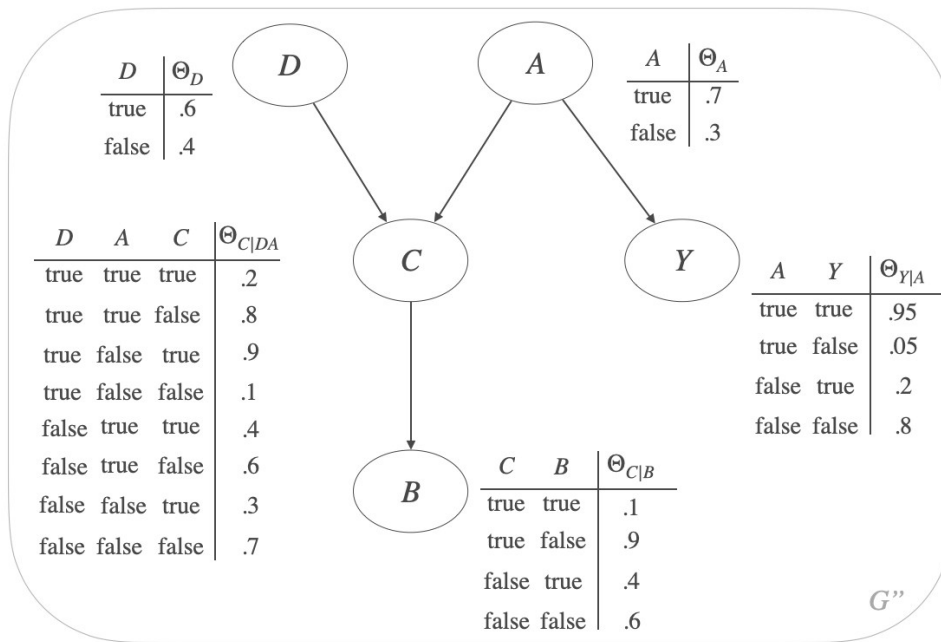
Label each of the following as True or False

a) dsep(B,C,A) True
b) dsep(Y,C,D) False
c) dsep(D,B,A) False
d) dsep(Y,C,B) True

[Alphanumeric]   [Alphanumeric]   [Alphanumeric]   [Alphanumeric]
True   **False**   **False**   **True**

Question 23 − PGM Bayesial chain rule − 199000.2.1

Question type: Fill in (multiple)
Pre-test item: No
Folder: /Top/SIS/XM_0059/PGM
Answer option order: Fixed
Partial scoring: No
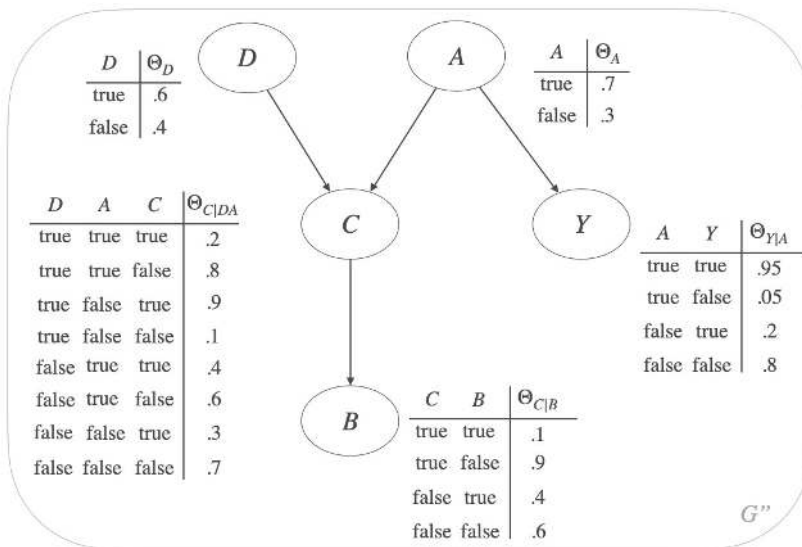**Maximum score:** 2
Chance score: 0.00 pt. / 0%
Status:
Last modified: 18-10-2020 22:18
Attributes: *Taxonomie/Taxonomy* 00 Onbekend/Unknown

Given the Bayesian network in the previous questiona) Write out the formula that calculates Pr(C=true, Y=false | D=false, A=true) using the chain rule.

You can use the following way of writing up your result but we will check for the correct answers manually...

(Typing hint: For any variable Y,
"Y = true" denoted as "y"
"Y = false" denoted as "-y" .
Sum is "sum", multiplication is "times" and division is /.
Parentheses can be used as in usual arithmetic.
Example: $(\sum_{XY} \Theta_X \cdot \Theta_{Y|ZW} \cdot \Theta_{b|\bar{c}})/\Theta_A$ can be typed as
"(sum_XY theta_X times theta_Y | ZW times theta`b|-c)/theta_A)"

Please write the formula here: | Θ_\overline{d} · Θ_a · Θ_\overline{y}|a · Θ_c|da |

[Alphanumeric]

Θ_\overline{d} · Θ_a · Θ_\overline{y}|a · Θ_c|da

Θ_{\overline{y} | a} · \Θ_{c|\overline{d}a} Σ_B

Question type:	Fill in (numerical)
Pre-test item:	No
Folder:	/Top/SIS/XM_0059/PGM
Answer option order:	Fixed
Partial scoring:	No
Maximum score:	3
Chance score:	0.00 pt. / 0%
Status:	
Last modified:	18-10-2020 17:47
Attributes:	*Taxonomie/Taxonomy* 00 Onbekend/Unknown

Given the Bayesian network from the previous question

What is the result of Pr(C=true, Y=false | D=false, A=true) ?

0.02