

Week 5 Functional Dependency

nment Project Exam Help
Alice: Your model reduces the most interesting information

to something flat and boring.

Vittorio: You're right, and this causes a lot of problems.

pesiphing that Chema to Q Emplex application is tough, and it is easy to make mistakes when updat-

ing a database.

Riccardo: Also, the system knows so little about the data that it

is hard to obtain good penjangance. Are you telling me that the model is bad?

Vittorio: No, wait, we are going to fix it!

(Foundations of Databases, S. Abiteboul, R. Hull, V. Vianu, Addison-Wesley, 1995)



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Assisting equation of the percentage as a decimal (round to two decimal places) \rightarrow

represent the percentage as a proportion of 1, to 2 decimal places (not 11.29%, not 0.1129, just 0.11).

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A SSA SUMMENT EN TOUR 1500 1 COUNTY OF THE PORT OF THE

- (not 11.29%, not 0.1129, just 0.11).

 Pay attention to which attributes you need to list, whether you need to cool the uples, systax issues etc. (Partial malks may be awarded)
- Do not wait until the last minute to check/submit your solution. (Refer to the instructions in the assignment specification.)



A SSA SUMMED TO THE PIECE OF 2012, X am Help List the percentage as a decimal (round to two decimal places) of 1, to 2 decimal places (not 11.29%, not 0.1129, just 0.11).

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- Drap in sessions before Assignment 1 CSUUTOTCS
 - Aug 30 (Tue) 5-7 pm



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(not 11.29%, not 0.1129, just 0.11).

- Aug 30 (Tue) 5-7 pm
- Anonymous Survey 1 (under Week 5 in Wattle)
 - Feedback on online and on-campus lectures
 - Feedback on labs and tutors



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	Name <u>StudentID</u>		DoB	<u>CourseNo</u>	Semester	Unit
	Tom 123456		25/01/1989	COMP2400	2010 S2	6
1	4 Tom	12/84/56	25/01/1989	COMP8740	2011 S2	12
I	Michie	1/23/458	21/01/1985	COMP2/00	2009 S2	6
	Michael	123458	21/04/1985	COMP8740	2011 S2	12
	Fran	123457	11/09/1987	COMP2400	2009 S2	6



Assignment Project Exam? Help

	Name	StudentID	DoB	<u>CourseNo</u> <u>Semester</u>		Unit
	Tom	123456	25/01/1989	COMP2400	2010 S2	6
1	↓ Tom	12/84/56	25/01/1989	COMP8740	2011 S2	12
I	Mich e	123458	21/0 // 1985	COMP 2400	2009 S2	6
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	Fran	123457	11/09/1987	COMP2400	2009 S2	6

Vection at omalies: If inserting a new course COMP3000, then ...



Assignment in Project Exam? Help

	Name <u>StudentID</u>		DoB	<u>CourseNo</u>	Semester	Unit
	Tom 123456 25/0		25/01/1989	01/1989 COMP2400		6
1	4 Tom	12/84/56	25/01/1989	COMP8740	2011 S2	12
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	Fran	123457	11/09/1987	COMP2400	2009 S2	6

Insertion aromalies: If inserting a new course COMP3000, then ... (Ne. Cannot heart light values jute to be cause of the entity integrity constraint).



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	Tom	123456	25/01/1989	COMP2400	400 2010 S2	
1	4 Tom	12/84/56	25/01/1989	COMP8740	2011 S2	12
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	Fran	123457	11/09/1987	COMP2400	2009 S2	6

- Insertion aromalies: If inserting a new course COMP3000, then ... (Ne. Cannot insert bull called into Course occause of the entity integrity constraint).
- Deletion anomalies: If deleting the enrolled course COMP2400 of Fran, then ...



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	Name	StudentID	DoB	<u>CourseNo</u>	Semester	Unit
	Tom	123456	25/01/1989	COMP2400	2010 S2	6
1	4 Tom	12/84/56	25/01/1989	COMP8740	2011 S2	12
I	Michie	123458	21/0 // 1985	COMP2/00	2009 S2	6
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	Fran	123457	11/09/1987	COMP2400	2009 S2	6

- Insertion aromalies: If inserting a new course COMP3000, then ... (Ne. Cannot insert bull called into Course occause of the entity integrity constraint).
- Deletion anomalies: If deleting the enrolled course COMP2400 of Fran, then ... the personal information of Fran, such as DoB, will be lost as well.



Assignment Project Exam? Help

	Name	StudentID	DoB	<u>CourseNo</u>	Semester	Unit
	Tom 123456		25/01/1989	COMP2400	2010 S2	6
1	4 Tom	12/84/56	25/01/1989	COMP8740	2011 S2	12
I	Michie	123458	21/0 // 1985	COMP2/00	2009 S2	6
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- insertion aromalies: If inserting a new course COMP3000, then ... (Ne. Cannot Insert Lull Calus jutte Course occause of the entity integrity constraint).
- Deletion anomalies: If deleting the enrolled course COMP2400 of Fran, then ... the personal information of Fran, such as DoB, will be lost as well.
- Modification anomalies: If changing the DoB of Michael, then ...



Assignment in the trade and update operations? Help

	Name	StudentID	DoB	<u>CourseNo</u>	Semester	Unit
	Tom 123456		25/01/1989	COMP2400	2010 S2	6
1	4 Tom	12/84/56	25/01/1989	COMP8740	2011 S2	12
I	Michie	123458	21/0 // 1985	COMP2/00	2009 S2	6
	Michael	123458	21/04/1985	COMP8740	2011 S2	12
	Fran	123457	11/09/1987	COMP2400	2009 S2	6

- nsertion aromalies: If inserting a new course COMP3000, then ... (No. Cannot next bull alvoy jute Course occause of the entity integrity constraint).
- Deletion anomalies: If deleting the enrolled course COMP2400 of Fran, then ... the personal information of Fran, such as DoB, will be lost as well.
- Modification anomalies: If changing the DoB of Michael, then ... update every tuple that records the DoB of this student.



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	Tom	123456	25/01/1988	COMP2400	2010 S2	6	
	Tom	123456	25/01/1988	COMP8740	2011 S2	12	
	Michael	123458	21/04/1985	COMP2400	2009 S2	6	
	Michael	12345/8/4	21/04/1985	COMP8740	2011 S2	12	
	Fran	234/57	11/09/1087	OM P2400	2009 S2	6	

STUDENT							
Name	StudentID	DoB					
Tom	(2 3 156	250 T/1988					
Michael	123458	21/04/1985					
Fran	123457	11/09/1987					

Course					
<u>CourseNo</u>	Unit				
COMP2400	6				
COMP8740	12				

		- Funci								
۲	ENROL									
L	Stilden II D	<u>SourseNo</u>	<u>Semester</u>							
	123456	COMP2400	2010 S2							
	123456	COMP8740	2011 S2							
	123458	COMP2400	2009 S2							
	123458	COMP8740	2011 S2							
	123457	COMP2400	2009 S2							



Why Functional Dependencies?

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FDs tell us "relationship between and among attributes"!

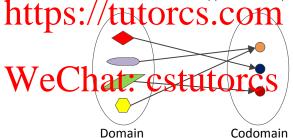
- FDs are developed to define the goodness and badhess of (relational) database design in a formal way.
 - Top down: start with a relation schema and FDs, and produce smaller value conscient certain command for m (rate conormalisation).
 - **Bottom up**: start with attributes and FDs, and produce relation schemas (*not popular in practice*).



What is "Functional" about Functional Dependencies?

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A (total) function f: X → Y describes a relationship between two sets X and Y such that each element of X is mapped to a unique element of Y.

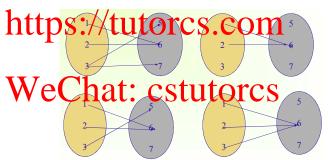




What is "Functional" about Functional Dependencies?

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• Exercise: which of them represent a function?

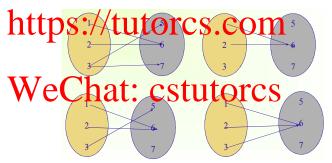




What is "Functional" about Functional Dependencies?

$Assa(pa) \text{ unique} \text{ (pa)} \rightarrow \text{Pascrips a clation ship very earning between the part of x is mapped to a unique element of x.$

• Exercise: which of them represent a function?

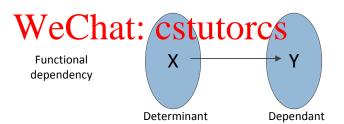


Answer: The ones at the bottom.



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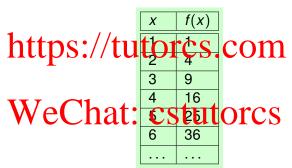


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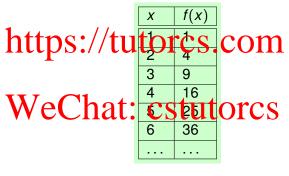


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$$X \rightarrow f(x)$$



Formal Definition

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A relation r(R) satisfies $X \to Y$ on R if, for any two tuples $t_1, t_2 \in r(R)$, whenever the tuples t_1 and t_2 coincide on values of X, they also coincide on values of Y.

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$$t_1[Y] = t_2[Y]$$

- A FW tree (if it carativays to satstart 1910S
 - $\bullet \ \{A,B\} \to \{A\}$
 - $\{A, B, C\} \rightarrow \{A, B, C\}$
- Syntactical convention: (1) Instead of $\{A, B, C\}$, we may use ABC. (2) A, B, \ldots for individual attributes and X, Y, \ldots for sets of attributes.



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 Consider the following relation with attributes {A,B,C,D,E}. Do they satisfy the given FDs?

https://t	u	to	1 (A)	S	.C	om
•	Α	В	С	D	E	
	1	2	3	4	5	
XX / (1)	1	2	2	2	2	
WeCha	1 1•	P	CB -	141	3	rcs
,, cerra	2	2	2	4	4	



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 Consider the following relation with attributes {A,B,C,D,E}. Do they satisfy the given FDs?

https://1	u	to	TA	S	.C	om
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	1	2	3	4	5	
XX / (1)	1	2	2	2	2	
WeCha	111	E	CBL	21	3	rcs
*	2		20	4	4	

 \bigcirc ABC \rightarrow AB



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	1	2	3	4	5	
WeCha	1	2	2	2	2	
We('ha	110	2	C3 -	121	3	rcs
*	2	<u> </u>	2	4	4	

Yes.



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https://1	tu	to	TA	S	.C	om
1	Α	В	C	D	E	
	1	2	3	4	5	
WeCha	1	2	2	2	2	
WeCha	1 1 1	P	CB -	141	3	rcs
	2	2	2	4	4	

 \bigcirc ABC \rightarrow AB

Yes.

2 $ABC \rightarrow D$



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ı	Α	В	C	D	E	
	1	2	3	4	5	
WeCha	1	2	2	2	2	
Wellha	110	P	CB	141	3	rcs
VV CCII	2	<u> </u>	20	4	4	

lacktriangle ABC ightarrow AB

Yes.

2 $ABC \rightarrow D$

No.



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1	Α	В	C	D	E	
	1	2	3	4	5	
TT 7 (1)	1	2	2	2	2	
WeCha	110	2	CBL	141	3	rcs
VV CCIIu	2	2	20	4	4	

lacktriangle ABC ightarrow AB

Yes.

2 ABC \rightarrow D

No.

 \bigcirc E → ABCD



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1	Α	В	C	D	E	
	1	2	3	4	5	
WeCha	, 1	2	2	2	2	
Wel ha	110	2	CB	2 1	3	rcs
,, cella	2	2	2	4	4	

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WeCha	, 1	2	2	2	2	
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Yes.

2 ABC \rightarrow D

No.

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Yes.



Assignment Project Exam Help A functional dependency specifies a constraint on the relation schema that

A functional dependency specifies a constraint on the relation schema that must hold at all times.

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Assignment Project Exam Help A functional dependency specifies a constraint on the relation schema that

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• In real tite applications twenty must the following approaches:



Assignment Project Exam Help A functional dependency specifies a constraint on the relation schema that

- A functional dependency specifies econstraint on the relation schema that must hold at all times.
- In real-tite inputations twent must the following approaches:
 - (1) Analyse data requirements

 Can be provided in the form of discussion with application users

 Analyse data requirements of discussion with application users

 Analyse data requirements



Assignment Project Exam Help A functional dependency specifies a constraint on the relation schema that

- A functional dependency specifies a constraint on the relation schema that must hold at all times.
- In real tite applications we of must the following approaches:
 - (1) Analyse data requirements

Can be provided in the form of discussion with application users

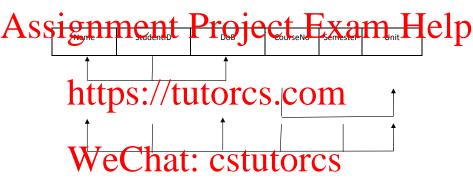
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(2) Analyse sample data

Useful when application users are unavailable for consultation and/or the document is incomplete.



(1) Analyse Data Requirements and FD Diagram



- StudentID → Name, DoB;
- CourseNo → Unit;
- StudentID, CourseNo, Semester → Name, DoB, Unit.



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	Name	<u>StudentID</u>	DoB	<u>CourseNo</u>	<u>Semester</u>	Unit
	Tom	123456	25/01/1988	COMP2400	2010 S2	6
1	Tom	128456	25/01/1988	COMP8740	2011 S2	12
ľ	I lich te	123458	27/07/1985	COMF 2400	2009 S2	6
î	Mich tel	123458	21/04/1985	COMP8740	2011 S2	12
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	Name	<u>StudentID</u>	DoB	<u>CourseNo</u>	<u>Semester</u>	Unit
	Tom	123456	25/01/1988	COMP2400	2010 S2	6
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Ť	Mich lel	123458	21/04/1985	COMP8740	2011 S2	12
	Fran	123457	11/09/1987	COMP2400	2009 S2	6

• Wermay have: With the till have, 65 tutores



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	Name	<u>StudentID</u>	DoB	<u>CourseNo</u>	<u>Semester</u>	Unit
	Tom	123456	25/01/1988	COMP2400	2010 S2	6
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Ť	Mich lel	123458	21/04/1985	COMP8740	2011 S2	12
	Fran	123457	11/09/1987	COMP2400	2009 S2	6

We may have: We true (tip) A a time, 6 Stutores

{StudentID, Name} → {DoB};



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	Name	<u>StudentID</u>	DoB	<u>CourseNo</u>	<u>Semester</u>	Unit
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Ť	Mich lel	123458	21/04/1985	COMP8740	2011 S2	12
	Fran	123457	11/09/1987	COMP2400	2009 S2	6

- We may have the tile have e. 65 tutores
 - {StudentID, Name} → {DoB};
 - $\{Name\} \rightarrow \{StudentID\} \times;$
 -



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	Name	<u>StudentID</u>	DoB	<u>CourseNo</u>	<u>Semester</u>	Unit
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	Fran	123457	11/09/1987	COMP2400	2009 S2	6

We may have: We may have: A stutores

- {StudentID, Name} \rightarrow {DoB};
- $\{Name\} \rightarrow \{StudentID\} \times;$
-

Limitations:

- (1) Sample data needs to be a true representation of all possible values in the database.
- (2) Do we need all FDs?



Inference?

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Example:

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If S interposition of S o
```



Inference?

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Example:

If each student works on one project and each project has one supervisor, then each student must have green piper supervisor.



Inference?

Assignments Project de Examp Help

Example:

If each student works on one project and each project has one supervisor, ther each student must have encomplet supervisor.

Can we systematically infer all possible FDs?





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The Armstrong's inference rules consist of the following three rules:

• Augmentation rule: $\{X \rightarrow Y\} \models XZ \rightarrow YZ$

$${X \rightarrow Y} \models XZ \rightarrow YZ$$

Wasterhat: Cstutores x - z

• We use the notation $\Sigma \models X \rightarrow Y$ to denote that $X \rightarrow Y$ is **inferred** from the set Σ of functional dependencies.



Rule 1 - Reflexive Rule

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	ENROLMENT					
	Name	StudentID	DoB	<u>CourseNo</u>	<u>Semester</u>	Unit
1	Tom	123456	25/01/1988	COMP2400	2010 S2	6
ľ	Ton)	12/3/45	25/01/1988	COMP8740	2011 S2	12
•	Mich tel	123458	21/04/1985	COMP2400	¹ 2009 S2	6
	Michael	123458	21/04/1985	COMP8740	2011 S2	12
	Fran	123457	11/09/1987	COMP2400	2009 S2	6

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 $\{StudentID, CourseNo, Semester\} \rightarrow \{CourseNo, Semester\},\$ where

- X={StudentID};
- Y={CourseNo, Semester}.



Rule 2 – Augmentation Rule

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			LINHOLIV	ILINI		
	Name	StudentID	DoB	<u>CourseNo</u>	<u>Semester</u>	Unit
1	Tom	123456	25/01/1988	COMP2400	2010 S2	6
ľ		12/34/55	25/01/1988	COMP8740Y	2011 S2	12
_	Michael	123458	21/04/1985	COMP2400	[▲] 2009 S2	6
	Michael	123458	21/04/1985	COMP8740	2011 S2	12
	Fran	123457	11/09/1987	COMP2400	2009 S2	6

- X={CourseNo};
- Y={Unit};
- Z={Semester}.



Rule 3 - Transitive Rule

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		LINGUMENT				
	Name	StudentID	DoB	<u>CourseNo</u>	<u>Semester</u>	Unit
1	Tom	123456	25/01/1988	COMP2400	2010 S2	6
ľ		12/34/55	25/01/1988	COMP8740Y	2011 S2	12
1	-Mich tel	123458	21/04/1985	COMP2400	¹ 2009 S2	6
	Michael	123458	21/04/1985	COMP8740	2011 S2	12
	Fran	123457	11/09/1987	COMP2400	2009 S2	6

Wample: {StudentilD, CourseNo} → {Unit} | StudentilD, CourseNo} → {Unit}, where

- X={StudentID, CourseNo};
- Y={CourseNo};
- Z={Unit}.



Other Derived Rules

Assignmentation and existing rules. Profesive augmentation, mansitive rules of p

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Other Derived Rules

Assign Amenton and raiding in the following rules:

- Union rule: If $X \to Y$ and $X \to Z$, then $X \to YZ$
- **Example:** If StudentID \rightarrow Name and StudentID \rightarrow DoB hold, then we have StudentID \rightarrow The Name and StudentID \rightarrow DoB hold, then we have StudentID \rightarrow DoB hold, then we
 - X=StudentID;
 - Y=Name;
 - Z=DoB.



Other Derived Rules

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- Union rule: If $X \to Y$ and $X \to Z$, then $X \to YZ$
- Example: If StudentID → Name and StudentID → DoB hold, then we have Suspent/D/- Name, Diff (Nere CO)
 - X=StudentID;
 - Y=Name;
 - Z=DoB.

We concess in that it is X = X . It is the $X \to Z$

- ullet Example: If StudentID o Name, DoB holds, then we have StudentID
 - \rightarrow Name and StudentID \rightarrow DoB, where
 - X=StudentID;
 - Y=Name;
 - Z=DoB.



Assignment Project Exam Help

• If each student works on one project and each project has one supervisor, does each student have one project supervisor?

```
\begin{array}{ll} & \text{Nttps://tutorcs.com} \\ & \{\{\text{StudentID}\} \rightarrow \{\text{ProjectNo}\}, \\ & \{\text{ProjectNo}\} \rightarrow \{\text{Supervisor}\} \} \end{array} \models \quad \{\text{StudentID}\} \rightarrow \{\text{Supervisor}\} \end{array}
```

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Assignment Project Exam Help

• If each student works on one project and each project has one supervisor, does each student have one project supervisor?

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```

```
{StudentID} \rightarrow {ProjectNo}, 

{ProjectNo} \rightarrow {Supervisor}  \models {StudentID} \rightarrow {Supervisor}
```

This can be proven by using the Translive rule:

$$\{X \to Y, Y \to Z\} \models X \to Z$$



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Yes, using the Augmentation rule.

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Yes, using the Augmentation rule.

https://tutorcs.com



Assignment Projecte. Examt? Help

Yes, using the Augmentation rule.



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Yes, using the Augmentation rule.

(https://tutorcs.com)

Wechat. cstutorcs

$$\{x \rightarrow y\} \models y \rightarrow x$$



$Assign {\color{red} Project. Exam? Help} \\ ({\color{red} Project. Exam. Exam$

Yes, using the Augmentation rule.

 $(3) \quad \{X \to Y\} \models Y \to X$

No. See the counter-example below:

X	Y
0	2
1	2



Assignment Project Exam Help Two questions:

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Assignment Project Exam Help

• Two questions:

Are all the FDs inferred using the Armstrong's inference rules correct?



Assignment Project Exam Help

- Two questions:
 - Are all the FDs inferred using the Armstrong's inference rules correct?
 - Can we use the Armstrong's inference rules to infer all possible FDs?
 completeness (you can prove anything that is right)



Assignment Project Exam Help

- Two questions:
 - Are all the FDs inferred using the Armstrong's inference rules correct?
 - Can we use the Armstrong's inference rules to infer all possible FDs?
 completeness (you can prove anything that is right)
- The Trim Charletting, 628 tutores
 - The Armstrong's inference rules are both sound and complete.



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Assignment Project Exam Help

ullet Σ^* can be computed using the Armstrong's inference rules.





Assignment Project Exam Help

Σ* can be computed using the Armstrong's inference rules.



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• Why can we compute Σ* using the Armstrong's inference rules?



Assignment Project Exam Help

Σ* can be computed using the Armstrong's inference rules.



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• Why can we compute Σ* using the Armstrong's inference rules?

Because the Armstrong's inference rules are both **sound** and **complete**.



Assignment Project Exam Help

Σ* can be computed using the Armstrong's inference rules.



- WeChat: cstutorcs

 Why can we compute Σ* using the Armstrong's inference rules?
 - Because the Armstrong's inference rules are both **sound** and **complete**.
- Nonetheless, computing Σ* using the Armstrong's inference rules is not efficient.



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Example: Consider a relation schema $R = \{A, B, C, D, E\}$ and a set of FDs $\Sigma = \{AB \to CD, B \to E, DE \to A\}$. How can we use the Armstrong rules to show that $DB \to A \notin \Sigma^*$?



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Example: Consider a relation schema $R = \{A, B, C, D, E\}$ and a set of FDs $\Sigma = \{AB \to CD, B \to E, DE \to A\}$. How can we use the Armstrong rules to show that $DB \rightarrow A \notin \Sigma$

WeChat: estutores

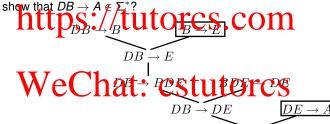




Assignment Project ExameHelp

Example: Consider a relation schema $R = \{A, B, C, D, E\}$ and a set of FDs $\Sigma = \{AB \to CD, B \to E, DE \to A\}$. How can we use the Armstrong rules to

 $DB \rightarrow A$



• How can we derive the proof more efficiently?



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² See Algorithm 15.1 on Page 538 in [Elmasri & Navathe, 7th edition] or Algorithm 1 on Page 555 in [Elmasri & Navathe, 6th edition]



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² See Algorithm 15.1 on Page 538 in [Elmasri & Navathe, 7th edition] or Algorithm 1 on Page 555 in [Elmasri & Navathe, 6th edition]



Assignation of the property of Exams? Help

1 Compute **the set of all attributes** that are dependent on X, which is called the **closure** of X under Σ and is denoted by X^+ .

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² See Algorithm 15.1 on Page 538 in [Elmasri & Navathe, 7th edition] or Algorithm 1 on Page 555 in [Elmasri & Navathe, 6th edition]



Assistant Project Exams Help

- **1** Compute **the set of all attributes** that are dependent on X, which is called the **closure** of X under Σ and is denoted by X^+ .
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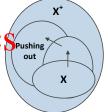
² See Algorithm 15.1 on Page 538 in [Elmasri & Navathe, 7th edition] or Algorithm 1 on Page 555 in [Elmasri & Navathe, 6th edition]



Assignation of Problem Exams? Help

- Ompute the set of all attributes that are dependent on X, which is called the closure of X under Σ and is denoted by X^+ .
- Algorithm S. // tutores.com
 - X+ := X;

 The entil large change tutore Spushing
 - for each $Y \to Z \in \Sigma$ with $Y \subseteq X^+$, add all the attributes in Z to X^+ , i.e., replace X^+ by $X^+ \cup Z$.



² See Algorithm 15.1 on Page 538 in [Elmasri & Navathe, 7th edition] or Algorithm 1 on Page 555 in [Elmasri & Navathe, 6th edition]



Assign property Office te, Examp Help

• Decide whether or not $\Sigma \models AC \rightarrow DE$ holds.

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Assign property Help

• Decide whether or not $\Sigma \models AC \rightarrow DE$ holds.

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$$CS.Com$$
 $(AC)^+ \supseteq AC$ initialisation



Assign property Help

• Decide whether or not $\Sigma \models AC \rightarrow DE$ holds.

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 $(A\overline{C})^+ \supseteq AC$ $\supset ACB$ initialisation using $AC \rightarrow B$



SSORGE THE PROPERTY HELP

• Decide whether or not $\Sigma \models AC \rightarrow DE$ holds.

https://tutorcs.com

 $\supset AC$

⊃ *ACB*

initialisation using $AC \rightarrow B$



Assign in the Project Examp Help

• Decide whether or not $\Sigma \models AC \rightarrow DE$ holds.

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Assign in the Project Examp Help

• Decide whether or not $\Sigma \models AC \rightarrow DE$ holds.





Assign in the Project Examp Help

• Decide whether or not $\Sigma \models AC \rightarrow DE$ holds.

Matip Sild the tult orcs. Com initialisation
$$(AC)^+ \supseteq AC$$
 initialisation using $AC \to B$ using $B \to CD$ using $B \to CD$ CSTUTION CS

2 Then we check that $DE \subseteq (AC)^+$. Hence $\Sigma \models AC \rightarrow DE$.



Assign in the Project Examp Help

• Decide whether or not $\Sigma \models AC \rightarrow DE$ holds.

$$\begin{array}{ccc} \textbf{MtipSid} & \textbf{MtipSid$$

- 2 Then we check that $DE \subseteq (AC)^+$. Hence $\Sigma \models AC \rightarrow DE$.
- Can you quickly tell whether or not $\Sigma \models AC \rightarrow EF$ holds?



Assign in the Project Examp Help

• Decide whether or not $\Sigma \models AC \rightarrow DE$ holds.

$$\begin{array}{ccc} \mathbf{M} & \mathbf{M} &$$

- 2 Then we check that $DE \subseteq (AC)^+$. Hence $\Sigma \models AC \rightarrow DE$.
- Can you quickly tell whether or not $\Sigma \models AC \rightarrow EF$ holds?

 $\Sigma \models AC \rightarrow EF$ does not hold because $EF \nsubseteq (AC)^+$



Exercise – Implied Functional Dependencies

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Decide whether or not

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Exercise – Implied Functional Dependencies

A SSO GREEN REPORT OF LOCATION AND A SSO GREEN REPORT OF LANGE TO A SECOND TO BE A SECOND TO BE

Decide whether or not

https://tutorcs.com

- $\Sigma \models BD \rightarrow AC \text{ holds}$
- We wild the closure for the set of attributes and check:
 - (AD)⁺ = $(ACD)^+$ = $(ACDE)^+$ = ACDE and $CE \subseteq (AD)^+$, hence $\Sigma \models AD \rightarrow CE$.
 - ② $(BD)^+ = (BCD)^+ = (BCDE)^+ = BCDE$ and $AC \not\subseteq (BD)^+$, hence $\Sigma \not\models BD \rightarrow AC$.



Assignment Project Exam Help

https://tutores.com \(\sigma_2^*\)



Assignment Project Exam Help



• Let $Y_1 = C$ Late; arcstuto C, $X \to Z$. Note $\Sigma_1 \neq \Sigma_2$ but $\Sigma_1^* = \Sigma_2^* = \{X \to Y, Y \to Z, X \to Z\}$ (Σ_1 and Σ_2 are equivalent)



Assignment Project Exam Help



- Let $X_1 = \{C, X_2\}$ are $\{C, X_3\}$ and $\{C, X_4\}$ but $\{C, X_4\}$ are equivalent)
- If $\Sigma_1 \models \Sigma_2$ and $\Sigma_2 \models \Sigma_1$, are Σ_1 and Σ_2 equivalent?



Assignment Project Exam Help



- Let Y_1 = Chat; arcstutorc, $X \to Z$. Note $\Sigma_1 \neq \Sigma_2$ but $\Sigma_1^* = \Sigma_2^* = \{X \to Y, Y \to Z, X \to Z\}$ (Σ_1 and Σ_2 are equivalent)
- If $\Sigma_1 \models \Sigma_2$ and $\Sigma_2 \models \Sigma_1$, are Σ_1 and Σ_2 equivalent? Yes.



Assignment Project Exam Help



- Let $Y_1 = C$ Lat; arcstutorc, $X, X \to Z$. Note $\Sigma_1 \neq \Sigma_2$ but $\Sigma_1^* = \Sigma_2^* = \{X \to Y, Y \to Z, X \to Z\}$ (Σ_1 and Σ_2 are equivalent)
- If $\Sigma_1 \models \Sigma_2$ and $\Sigma_2 \models \Sigma_1$, are Σ_1 and Σ_2 equivalent? Yes.
- Questions: Can we find the minimal one among equivalent sets of FDs?



Minimal Cover - The Hard Part!

Assignment Project Exam Help

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Minimal Cover – The Hard Part!

Assignment Project Exam Help

 $\begin{array}{l} \Sigma_{\it m} \text{ is equivalent, to } \Sigma, \text{ i.e., start with } \Sigma_{\it m} = \Sigma; \\ \textbf{https://tutorcs.com} \end{array}$



Minimal Cover – The Hard Part!

Assignment Project Exam Help

- Σ_m is equivalent to Σ , i.e., start with $\Sigma_m = \Sigma$;
 - **Dependent:** each FD in Σ_m has only a single attribute on its right hand side, i.e., replace each FD $X \to \{A_1, \ldots, A_k\}$ in Σ_m with $X \to A_1, \ldots, X \to A_k$;



Minimal Cover - The Hard Part!

Assignment Project Exam Help Let Doe a set of FDs. A minimal ouver Σ_m of Σ is a set of FDs such that

- Σ_m is equivalent to Σ , i.e., start with $\Sigma_m = \Sigma$;

 Department: each FD in Σ_m has only a single attribute on its right hand side, i.e., replace each FD $X \to \{A_1, \ldots, A_k\}$ in Σ_m with $X \to A_1, \ldots, X \to A_k$;
 - possible, i.e., for each FD $X \to A$ in Σ_m , check each attribute B of X to see if we can replace $X \to A$ with $(X B) \to A$ in Σ_m ;



Minimal Cover - The Hard Part!

Assignment Project Exam Help Let Doe a set of FDs. A minimal ouver Σ_m of Σ is a set of FDs such that

- \bigcirc Σ_m is equivalent, to Σ , i.e., start with $\Sigma_m = \Sigma$;
- hand side, i.e., replace each FD $X o \{A_1, \ldots, A_k\}$ in Σ_m with $X o A_1, \ldots, X o A_k$;
 - **Neterolinary:** each FD (as Gs few attribute) The left hand side as possible, i.e., for each FD $X \to A$ in Σ_m , check each attribute B of X to see if we can replace $X \to A$ with $(X B) \to A$ in Σ_m ;
- **a** Remove a FD from Σ_m if it is redundant.



Assignment Project Exame Help minimal cover of Σ as follows:

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Assignment Broject Exame Help minimal cover of Σ as follows:

 \bigcirc start from Σ ;

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Assignment Project Exame Help minimal cover of Σ as follows:

 \bigcirc start from Σ ;

check rykether allfthe FDs in E have only one attribute on the right hand side (look good);



Assignment Project Exame Help

- \bigcirc start from Σ ;
- check ryhether allfthe FDs in Σ have only one attribute on the right hand side (look good);
- **3** check if $AB \rightarrow D$ can be replaced by $A \rightarrow D$?



Assignment Project Examulatelp
minimal cover of Σ as follows:

- \bigcirc start from Σ ;
- check whether allfthe FDs in Σ have only one attribute on the right hand side (look good);
- **3** check if $AB \rightarrow D$ can be replaced by $A \rightarrow D$?

$$\begin{array}{c} \Sigma = \{ \text{$B \to A$, $D \to A$, $AB \to D$} \}, \ \Sigma_1 = \{ \text{$B \to A$, $D \to A$, $A \to D$} \} \\ \text{WeChat: cstutorcs} \end{array}$$



Assignment Project Examellelp

- start from Σ;
- check yhether allfthe FDs in Σ have only one attribute on the right hand side (look good);
- **3** check if $AB \rightarrow D$ can be replaced by $A \rightarrow D$?

$$\Sigma = \{B \rightarrow A, D \rightarrow A, \textbf{AB} \rightarrow \textbf{D}\}, \Sigma_1 = \{B \rightarrow A, D \rightarrow A, \textbf{A} \rightarrow \textbf{D}\}$$
 whether Σ^* Σ^* 11101CS



Assignment Project Examulatelp

- \bigcirc start from Σ ;
- check sylvether allfthe FDs in E have only one attribute on the right hand side (look good);
- **3** check if $AB \rightarrow D$ can be replaced by $A \rightarrow D$?

$$\Sigma = \{B \to A, D \to A, \mathbf{AB} \to \mathbf{D}\}, \Sigma_1 = \{B \to A, D \to A, \mathbf{A} \to \mathbf{D}\}$$
Therefore
$$\Sigma = \{B \to A, D \to A, \mathbf{A} \to \mathbf{D}\}$$
The property of t



Assignment Project Examulatelp

- \bigcirc start from Σ ;
- check ykether allfthe FDs in Σ have only one attribute on the right hand side (look good);
- **3** check if $AB \rightarrow D$ can be replaced by $A \rightarrow D$?

$$\Sigma = \{B \to A, D \to A, \mathbf{AB} \to \mathbf{D}\}, \Sigma_1 = \{B \to A, D \to A, \mathbf{A} \to \mathbf{D}\}$$
check whether $\Sigma^* = \Sigma^*$ (vertex) but $\Sigma \models \Sigma_1$?)



Assignment Project Examultelp

- \bigcirc start from Σ ;
- check ykether allfthe FDs in Σ have only one attribute on the right hand side (look good);
- **3** check if $AB \rightarrow D$ can be replaced by $A \rightarrow D$?

$$\Sigma = \{B \rightarrow A, D \rightarrow A, \mathbf{AB} \rightarrow \mathbf{D}\}, \Sigma_1 = \{B \rightarrow A, D \rightarrow A, \mathbf{A} \rightarrow \mathbf{D}\}$$

$$Check \Sigma = \mathbf{A} \rightarrow \mathbf{D}$$

$$\Sigma_1 = \{B \rightarrow A, D \rightarrow A, \mathbf{A} \rightarrow \mathbf{D}\}$$

$$\Sigma_2 = \{B \rightarrow A, D \rightarrow A, \mathbf{AB} \rightarrow \mathbf{D}\}, \Sigma_1 = \{B \rightarrow A, D \rightarrow A, \mathbf{A} \rightarrow \mathbf{D}\}$$

$$\Sigma_1 = \{B \rightarrow A, D \rightarrow A, \mathbf{AB} \rightarrow \mathbf{D}\}, \Sigma_2 = \{B \rightarrow A, D \rightarrow A, \mathbf{A} \rightarrow \mathbf{D}\}$$

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$$\Sigma_1 = \{B \rightarrow A, D \rightarrow A, \mathbf{AB} \rightarrow \mathbf{D}\}, \Sigma_2 = \{B \rightarrow A, D \rightarrow A, \mathbf{A} \rightarrow \mathbf{D}\}$$

If $\Sigma \models A \to D$, then $\Sigma \models \Sigma_1$ and $\Sigma_1 \models \Sigma$, indicating $\Sigma^* = \Sigma_1^*$.



Assignment Project Examultelp

- \bigcirc start from Σ ;
- check whether all the FDs in Σ have only one attribute on the right hand side (look good);
- **3** check if $AB \rightarrow D$ can be replaced by $A \rightarrow D$?

$$\Sigma = \{B \rightarrow A, D \rightarrow A, \mathbf{AB} \rightarrow \mathbf{D}\}, \Sigma_1 = \{B \rightarrow A, D \rightarrow A, \mathbf{A} \rightarrow \mathbf{D}\}$$

$$\mathsf{Check} \ \Sigma = \mathbf{A} \rightarrow \mathbf{D}, \ \Sigma = \{B \rightarrow A, D \rightarrow A, \mathbf{A} \rightarrow \mathbf{D}\}$$

$$\mathsf{Check} \ \Sigma = \mathbf{A} \rightarrow \mathbf{D}, \ \Sigma = \{B \rightarrow A, D \rightarrow A, \mathbf{A} \rightarrow \mathbf{D}\}$$

If $\Sigma \models \mathbf{A} \to \mathbf{D}$, then $\Sigma \models \Sigma_1$ and $\Sigma_1 \models \Sigma$, indicating $\Sigma^* = \Sigma_1^*$. If $\Sigma \nvDash \mathbf{A} \to \mathbf{D}$, then $\Sigma^* \neq \Sigma_1^*$.



Assignment Broject Exame Help

- \bigcirc start from Σ ;
- check whether all the FDs in Σ have only one attribute on the right hand side (look good);
- **3** check if $AB \rightarrow D$ can be replaced by $A \rightarrow D$?

$$\Sigma = \{B \rightarrow A, D \rightarrow A, \mathbf{AB} \rightarrow \mathbf{D}\}, \Sigma_1 = \{B \rightarrow A, D \rightarrow A, \mathbf{A} \rightarrow \mathbf{D}\}$$

$$\mathsf{Check} \ \Sigma = \mathbf{A} \rightarrow \mathbf{D}, \ \Sigma^{\mathsf{P}} \ \mathsf{Theorem } \Sigma^{\mathsf{P}}, \ \mathsf{but} \ \Sigma \models \Sigma_1 ?)$$

If $\Sigma \models A \to D$, then $\Sigma \models \Sigma_1$ and $\Sigma_1 \models \Sigma$, indicating $\Sigma^* = \Sigma_1^*$. If $\Sigma \nvDash A \to D$, then $\Sigma^* \neq \Sigma_1^*$.

• $\Sigma \nvDash A \rightarrow D$ because $D \not\subseteq (A)^+$.

No. $AB \rightarrow D$ cannot be replaced by $A \rightarrow D$.



Assignment Project Exame Help minimal cover of Σ as follows:

- start from Σ;
- check ryhether allfthe FDs in Σ have only one attribute on the right hand side (look good);
- 3 check if $AB \rightarrow D$ can be replaced by $B \rightarrow D$?



Assignment Project Exame Help

minimal cover of Σ as follows:

- \bigcirc start from Σ ;
- check yhether allfthe FDs in Σ have only one attribute on the right hand side (look good);
- **3** check if $AB \rightarrow D$ can be replaced by $B \rightarrow D$?

$$\begin{array}{c} \Sigma = \{ B \rightarrow A, D \rightarrow A, AB \rightarrow D \}, \ \Sigma_2 = \{ B \rightarrow A, D \rightarrow A, B \rightarrow D \} \\ \hline WeChat: \ Cstutorcs \end{array}$$



Assignment Project Examellelp

- \bigcirc start from Σ ;
- check yhether allfthe FDs in Σ have only one attribute on the right hand side (look good);
- **3** check if $AB \rightarrow D$ can be replaced by $B \rightarrow D$?

$$\Sigma = \{B \rightarrow A, D \rightarrow A, AB \rightarrow D\}, \Sigma_2 = \{B \rightarrow A, D \rightarrow A, B \rightarrow D\}$$
 whether Σ^* except that Σ^*



Assignment Project Examellelp

- \bigcirc start from Σ ;
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- **3** check if $AB \rightarrow D$ can be replaced by $B \rightarrow D$?

$$\Sigma = \{B \rightarrow A, D \rightarrow A, AB \rightarrow D\}, \Sigma_2 = \{B \rightarrow A, D \rightarrow A, B \rightarrow D\}$$
 whether Σ^* except that Σ^*



Assignment Project Examulatelp

- \bigcirc start from Σ ;
- check yhether allfthe FDs in Σ have only one attribute on the right hand side (look good);
- **3** check if $AB \rightarrow D$ can be replaced by $B \rightarrow D$?

$$\Sigma = \{B \rightarrow A, D \rightarrow A, \mathbf{AB} \rightarrow \mathbf{D}\}, \Sigma_2 = \{B \rightarrow A, D \rightarrow A, \mathbf{B} \rightarrow \mathbf{D}\}$$
 whether Σ^* and Σ^* are travely Σ^* , but $\Sigma \models \Sigma_2$?



Assignment Project Examulatelp

- start from Σ;
- check whether all the FiDs in Σ have only one attribute on the right hand side (look good);
- **3** check if $AB \rightarrow D$ can be replaced by $B \rightarrow D$?

$$\Sigma = \{B \to A, D \to A, \mathbf{AB} \to \mathbf{D}\}, \Sigma_2 = \{B \to A, D \to A, \mathbf{B} \to \mathbf{D}\}$$
check
$$\Sigma^* = \{B \to A, D \to A, \mathbf{B} \to \mathbf{D}\}$$
check
$$\Sigma^* = \{B \to A, D \to A, \mathbf{B} \to \mathbf{D}\}$$



Assignment-Project Examellelp minimal cover of Σ as follows:

- \bigcirc start from Σ ;
- check ykether allfthe FDs in Σ have only one attribute on the right hand side (look good);
- **3** check if $AB \rightarrow D$ can be replaced by $B \rightarrow D$?

$$\Sigma = \{B \rightarrow A, D \rightarrow A, \textbf{AB} \rightarrow \textbf{D}\}, \Sigma_2 = \{B \rightarrow A, D \rightarrow A, \textbf{B} \rightarrow \textbf{D}\}$$

$$\text{Check } \Sigma = \{B \rightarrow A, D \rightarrow A, \textbf{AB} \rightarrow \textbf{D}\}$$

$$\text{Check } \Sigma = \{B \rightarrow A, D \rightarrow A, \textbf{AB} \rightarrow \textbf{D}\}$$

$$\text{Check } \Sigma = \{B \rightarrow A, D \rightarrow A, \textbf{AB} \rightarrow \textbf{D}\}$$

If $\Sigma \models \mathbf{B} \to \mathbf{D}$, then $\Sigma \models \Sigma_2$ and $\Sigma_2 \models \Sigma$, indicating $\Sigma^* = \Sigma_2^*$.



Assignment Project Examellelp minimal cover of Σ as follows:

- \bigcirc start from Σ ;
- check whether all the FDs in Σ have only one attribute on the right hand side (look good);
- **3** check if $AB \rightarrow D$ can be replaced by $B \rightarrow D$?

$$\Sigma = \{B \rightarrow A, D \rightarrow A, \textbf{AB} \rightarrow \textbf{D}\}, \Sigma_2 = \{B \rightarrow A, D \rightarrow A, \textbf{B} \rightarrow \textbf{D}\}$$

$$\text{Check } \Sigma = B \rightarrow D; \Sigma \text{(vertage } \Sigma, \text{ but } \Sigma \models \Sigma_2 \text{?)}$$

If $\Sigma \models \mathbf{B} \to \mathbf{D}$, then $\Sigma \models \Sigma_2$ and $\Sigma_2 \models \Sigma$, indicating $\Sigma^* = \Sigma_2^*$. If $\Sigma \nvDash \mathbf{B} \to \mathbf{D}$, then $\Sigma^* \neq \Sigma_2^*$



Assignment_Project Exame Help

- \bigcirc start from Σ ;
- check whether all the FDs in Σ have only one attribute on the right hand side (look good);
- **3** check if $AB \rightarrow D$ can be replaced by $B \rightarrow D$?

$$\Sigma = \{B \rightarrow A, D \rightarrow A, \textbf{AB} \rightarrow \textbf{D}\}, \Sigma_2 = \{B \rightarrow A, D \rightarrow A, \textbf{B} \rightarrow \textbf{D}\}$$

$$\text{Check } \Sigma = \{B \rightarrow A, D \rightarrow A, \textbf{AB} \rightarrow \textbf{D}\}, \Sigma_2 = \{B \rightarrow A, D \rightarrow A, \textbf{B} \rightarrow \textbf{D}\}$$

$$\text{Check } \Sigma = \{B \rightarrow A, D \rightarrow A, \textbf{AB} \rightarrow \textbf{D}\}, \Sigma_2 = \{B \rightarrow A, D \rightarrow A, \textbf{B} \rightarrow \textbf{D}\}$$

If $\Sigma \models \mathbf{B} \to \mathbf{D}$, then $\Sigma \models \Sigma_2$ and $\Sigma_2 \models \Sigma$, indicating $\Sigma^* = \Sigma_2^*$. If $\Sigma \nvDash \mathbf{B} \to \mathbf{D}$, then $\Sigma^* \neq \Sigma_2^*$

• $\Sigma \models \mathbf{B} \to \mathbf{D}$ because $D \subseteq (B)^+$.

Yes. $AB \rightarrow D$ can be replaced by $B \rightarrow D$.



Assignment Project Exam Help minimal cover of Σ as follows:

start from Σ ;

hand side (look good);

 \bullet $AB \rightarrow D$ can be replaced by $B \rightarrow D$; WeChat: cstutorcs



Assignment Project Exam Help minimal cover of Σ as follows:

- start from Σ;

 Clack Difficult (Included Description of the right hand side (look good):
- 3 $AB \rightarrow D$ can be replaced by $B \rightarrow D$; 3 $AB \rightarrow D$ can be replaced by $B \rightarrow D$; 4 $AB \rightarrow D$ can be replaced by $B \rightarrow D$;



Assignment Project Exam Help minimal cover of Σ as follows:

- start from Σ;

 Clack Distribute all the FDS has only ore attribute on the right hand side (look good):
- ③ $AB \rightarrow D$ can be replaced by $B \rightarrow D$;
- Michael Catators
 - check whether $B \rightarrow A$ is redundant?



Assignment Project Exam Help minimal cover of Σ as follows:

- start from Σ ;

 Check that all the FDS has only ore attribute on the right hand side (look good):
- ③ $AB \rightarrow D$ can be replaced by $B \rightarrow D$;
- Moked remark to a stutore-SD)
 - check whether $B \rightarrow A$ is redundant?
 - $B \rightarrow A$ is redundant because $\{D \rightarrow A, B \rightarrow D\} \models B \rightarrow A$;

Assignment Project Exam Help minimal cover of Σ as follows:

- \bigcirc start from Σ ;
- hand side (look good);
- **3** $AB \rightarrow D$ can be replaced by $B \rightarrow D$;
- Michary Matton (Stytones)
 - check whether $B \rightarrow A$ is redundant?
 - $B \rightarrow A$ is redundant because $\{D \rightarrow A, B \rightarrow D\} \models B \rightarrow A$;

Therefore, the minimal cover of Σ is $\{D \to A, B \to D\}$.



Assignment Project Exam Help

The minimal cover of a set of functional dependencies $\boldsymbol{\Sigma}$ always exists but is not necessarily unique.

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Assignment Project Exam Help

The minimal cover of a set of functional dependencies $\boldsymbol{\Sigma}$ always exists but is not necessarily unique.

https://tutorcs.com

• **Examples:** Consider the following set of functional dependencies:

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Assignment Project Exam Help

The minimal cover of a set of functional dependencies $\boldsymbol{\Sigma}$ always exists but is not necessarily unique.

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• Examples: Consider the following set of functional dependencies:

WeChat: *estatoresab}

 Σ has two different minimal covers:

$$\bullet \ \Sigma_1 = \{A \to B, B \to C, C \to A\}$$

•
$$\Sigma_2 = \{A \rightarrow C, C \rightarrow B, B \rightarrow A\}$$



Assignment Project Exam Help

The minimal cover of a set of functional dependencies $\boldsymbol{\Sigma}$ always exists but is not necessarily unique.

https://tutorcs.com

• Examples: Consider the following set of functional dependencies:

WeChat: *estatoresab}

 Σ has two different minimal covers:

•
$$\Sigma_1 = \{A \rightarrow B, B \rightarrow C, C \rightarrow A\}$$

•
$$\Sigma_2 = \{A \rightarrow C, C \rightarrow B, B \rightarrow A\}$$

ullet The algorithm in the previous slide can find one, but not all minimal covers of a set of functional dependencies Σ .



Assignment Project Exam Help

• Given a set Σ of FDs on a relation R, the question is:





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 $^{^3}$ It extends Algorithm 15.2(a) in [Elmasri & Navathe, 7th edition, pp. 542], or Algorithm 2(a) or in Algorithm 2(a) in [Elmasri & Navathe, 6th edition pp. 558] to finding all keys of R



Assignment Project Exam Help

• Algorithm³:

Output: the set of All keys of A. COM

 $^{^3}$ It extends Algorithm 15.2(a) in [Elmasri & Navathe, 7th edition, pp. 542], or Algorithm 2(a) or in Algorithm 2(a) in [Elmasri & Navathe, 6th edition pp. 558] to finding all keys of R



Assignment Project Exam Help

• Algorithm³:

Output: the set of All keys of A. COM

 $^{^3}$ It extends Algorithm 15.2(a) in [Elmasri & Navathe, 7th edition, pp. 542], or Algorithm 2(a) or in Algorithm 2(a) in [Elmasri & Navathe, 6th edition pp. 558] to finding all keys of R



Assignment Project Exam Help

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for every subset X of the relation R, compute its closure X⁺

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Assignment Project Exam Help

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 $W^{+} = R$, then X is a superkey. CStutorcs

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Assignment Project Exam Help

• Algorithm³:

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```
if X^+ = B, then X is a superkey.

Vinno proper subset Y of X with X = B then X is a key.
```

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Assignment v. Retroject RExam Help

• Algorithm³:

Output: the set of All keys of A. COM

for every subset X of the relation R, compute its closure X⁺

if $X^+ = B$, then X is a superkey.

Vinno proper subset Y of X with X = B then X is a key.

 A prime attribute is an attribute occurring in a key, and a non-prime attribute is an attribute that is not a prime attribute.

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A Soscion properties, equal energy and energy and energy following set Σ of FDs:

- $\{CustID\} \rightarrow \{CustName\}$
- {CustID, StartDate} → {PropertyNo}

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- Questions:
 - What are the keys of RENTAL?
 - 2 What is a minimal cover of Σ ?



A Sosoperde Protection, edginante Projection, Datestage woners and the 1 p

• R={C, N, P, D, O}, and https://tutores.com}

What are the keys of RENTAL?



A Soscieta France | Quitid, edginary | expertino, Dutestag oner; | and the 1 p

- R={C, N, P, D, O}, and https.\/\phitttore\s.com}
- What are the keys of RENTAL?
- Solution: Check (X)⁺ for every subset of {C, N, P, D, O}.

 Appeared the dependent of any F Comust be part of each key.



A S'Schog of Phre-Putil, edgrand exective, but start whire and the 1p

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 - $(O)^+ = OP$



A S'Scherde Prime PutilD. Polyrand Properties. Delegating Many and the 1p

- R={C, N, P, D, O}, and https://tutores.com}
- What are the keys of RENTAL?
- Solution: Check (X)⁺ for every subset of {C, N, P, D, O}.

 Appeared the dependent of any F Comust be part of each key.
 - $(O)^+ = OP$
 - $(CO)^+ = CPNDO, (DO)^+ = CPNDO...$
 - Thus, {CustID, Owner} and {Owner, DateStart} are the keys.



ASSEDS: httle abbreviated form as O EcopertyNo. DateStart Chapt? and its 1 p

- $R=\{C, N, P, D, O\}$, and
- whittps://tutorcs.com



ASSEDS: httle abbreviated form as O EcopertyNo. DateStart Chapt? and its 1 p

- $R=\{C, N, P, D, O\}$, and
- $\underline{ \bullet} \ \ \Sigma = \{\textit{C} \rightarrow \textit{N}, \, \textit{PD} \rightarrow \textit{C}, \, \textit{CP} \rightarrow \textit{D}, \, \textit{CD} \rightarrow \textit{P}, \, \textit{O} \rightarrow \textit{P} \}$
- white said the ores. com
- Solution:



A SSEDS in the abbreviated form as O PropertyNo. Date Start Owner } and its 1 p

- $R=\{C, N, P, D, O\}$, and
- $\Sigma = \{\textit{C} \rightarrow \textit{N}, \textit{PD} \rightarrow \textit{C}, \textit{CP} \rightarrow \textit{D}, \textit{CD} \rightarrow \textit{P}, \textit{O} \rightarrow \textit{P} \}$
- whittps://tutorcs.com
- Solution:
 - I that the FDC in the colly one attribute on the right hand side (look good);



Exercises - Keys and Minimal Cover

ASSEDS in the abbreviated form as Decretive Date Start Owner and its 1p

- R={C, N, P, D, O}, and
- $\underline{\bullet} \ \Sigma = \{\textit{C} \rightarrow \textit{N}, \, PP \rightarrow \textit{C}, \, \textit{CP} \rightarrow \textit{D}, \, \textit{CD} \rightarrow \textit{P}, \, \textit{O} \rightarrow \textit{P} \}$
- whittps://tutorcs.com
- Solution:
 - what from the FDC in the control of the attribute on the right hand side (look good);
 - 3 determine if PD \rightarrow C, CP \rightarrow D and CD \rightarrow P have any redundant attribute on the left hand side (look good);



Exercises - Keys and Minimal Cover

A SSEDS in the abbreviated form as O PropertyNo. Date Start Owner } and its 1 p

- $R=\{C, N, P, D, O\}$, and
- whittps://tutorcs.com
- Solution:
 - tart from 1 constitute FDC in 2 have only one attribute on the right hand side (look good);
 - Odetermine if PD → C, CP → D and CD → P have any redundant attribute on the left hand side (look good);
 - **4** look for a redundant FD in Σ (none of FDs in Σ are redundant);



Exercises - Keys and Minimal Cover

ASSEDS in the abbreviated form as Decretive Date Start Owner and its 1p

- $R=\{C, N, P, D, O\}$, and
- whittps://tutorcs.com
- Solution:
 - what from 2 the FDC in 2 the ball broat ribute on the right hand side (look good);
 - 3 determine if PD → C, CP → D and CD → P have any redundant attribute on the left hand side (look good);
 - 4 look for a redundant FD in Σ (none of FDs in Σ are redundant);

Therefore, Σ is a minimal cover itself.



Accommodation Database

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- ROOM(roomNo, hotelNo, type, price) with PK {roomNo, hotelNo}
- GUEST(guestNo, guestName, guestAddress) with PK {guestNo}

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Accommodation Database

- ROOM(roomNo, hotelNo, type, price) with PK {roomNo, hotelNo}
- GUEST(guestNo, guestName, guestAddress) with PK {guestNo}
- We have some requirements on BOOKING:
 - Rt tooking can be made for one day only.
 - R2/A/guest can make several bookings in a hotel for different days.
 - R3 A guest cannot make two or more bookings in the same hotel for the same day.
 - R4 A guest can make two or more bookings in different hotels for the same day.
 - **R5** A room in any hotel can only be booked by one guest on the same date, i.e., no *double-booking*.



Assignment Project Exam Help HOTEL(hotelNo, hotelName, city) with PK {hotelNo}

- ROOM(roomNo, hotelNo, type, price) with PK {roomNo, hotelNo}
- GUEST (guestNo, guestName, guestAddress) with PK {guestNo}

 Book GuestNo, bate No, date, book No) with PK {?}
- Which functional dependency does the following requirement imply?





Assignment Project Exam Help HOTEL(hotelNo, hotelName, city) with PK {hotelNo}

- ROOM(roomNo, hotelNo, type, price) with PK {roomNo, hotelNo}
- GUEST(guestNo, guestName, guestAddress) with PK {guestNo}
- Which functional dependency does the following requirement imply?
 - Rivering conventate or Stratem TCS

 \hookrightarrow {guestNo, hotelNo, roomNo} \rightarrow {date}?



Assignment Project Exam Help HOTEL (hotelNo, hotelName, city) with PK {hotelNo}

- ROOM(roomNo, hotelNo, type, price) with PK {roomNo, hotelNo}
- GUEST(guestNo, guestName, guestAddress) with PK {guestNo}
- Which functional dependency does the following requirement imply?
 - RWood chatate ost utorcs

 $\hookrightarrow \{\text{guestNo, hotelNo, roomNo}\} \rightarrow \{\text{date}\} \text{? No}$



Assignment Project Exam Help HOTEL(hotelNo, hotelName, city) with PK {hotelNo}

ROOM(roomNo, hotelNo, type, price) with PK {roomNo, hotelNo}

GUEST (guestNo, guestName, guestAddress) with PK {guestNo}

Which functional dependency does the following requirement imply?

Rivering constate or she tay to or CS

 \hookrightarrow {guestNo, hotelNo, roomNo} \rightarrow {date}? No

guestNo	hotelNo	roomNo	Date
001	H1	R101	28/08/2020
001	H1	R101	29/08/2020



- Consider the following:
 - HOTEL(hotelNo, hotelName, city) with PK {hotelNo}
 - PropyregomNo, hotelNo, type, price) with PK-frepmNo, hotelNo}
 - GUEST (guestNo, guestName, guestAddress) with PK {guestNo}
 - BOOKING(guestNo, hotelNo, date, roomNo) with PK {?}
- Which furcional dependency does the playing eapirement imply?
 - R2 A guest can make several bookings in a hotel for different days.



Assignment Project Exam Help

- Consider the following:
 - HOTEL(hotelNo, hotelName, city) with PK {hotelNo}
 - Propyr(roomNo/hotelNo, type, price) with PK-froomNo, hotelNo}
 - GUEST (guestNo, guestName, guestAddress) with PK {guestNo}
 - BOOKING(guestNo, hotelNo, date, roomNo) with PK {?}
- Whith furcional dependency does the plawn general imply?
 - R2 A guest can make several bookings in a hotel for different days.

None



- ROOM(roomNo, hotelNo, type, price) with PK {roomNo, hotelNo}
- GUEST(guestNo, guestName, guestAddress) with PK {guestNo}
- Which functional dependency does the following requirement imply?
 - RT A guest cannot make two or more bookings in the same hotel for the Same day. 131. CSUULOICS



Assignment Project Fixam Help

- ROOM(roomNo, hotelNo, type, price) with PK {roomNo, hotelNo}
- GUEST(guestNo, guestName, guestAddress) with PK {guestNo}
- Which functional dependency does the following requirement imply?

RITA guest cannot make two or more bookings in the same hotel for the Same day. Πat CSUULOICS

 \hookrightarrow {guestNo, hotelNo, date} \rightarrow {roomNo}?



Assignment Project Exam Help

- ROOM(roomNo, hotelNo, type, price) with PK {roomNo, hotelNo}
- GUEST(guestNo, guestName, guestAddress) with PK {guestNo}

https://shtptotes.onom.k {?}

Which functional dependency does the following requirement imply?

RITA guest cannot make two or more bookings in the same hotel for the Same day. Πat CSUULOICS

 \hookrightarrow {guestNo, hotelNo, date} \rightarrow {roomNo}? **Yes**

guestNo	hotelNo	roomNo	Date
001	H1	R101	29/08/2020
001	H1	R102 ×	29/08/2020



- HOTEL(hotelNo, hotelName, city) with PK {hotelNo}
- BOOM(roomNø, hotelNo, type, price) with PK {roomNo, hotelNo}
- BOOKING(guestNo, hotelNo, date, roomNo) with PK {?}
- Which functional dependency does the prowing requirement imply?
 - R4 A guest can make two or more bookings in different hotels for the same day.



Assignment Project Exam Help

- HOTEL(hotelNo, hotelName, city) with PK {hotelNo}
- BOOM(roomNø, hotelNo, type, price) with PK {roomNo, hotelNo}
- BOOKING(guestNo, hotelNo, date, roomNo) with PK {?}
- Which functional dependency does the prowing requirement imply?
 - R4 A guest can make two or more bookings in different hotels for the same day.

None



Assignment Project Exam Help

- ROOM(roomNo, hotelNo, type, price) with PK {roomNo, hotelNo}
- GUEST(guestNo, guestName, guestAddress) with PK {guestNo}
- Which functional dependency does the following requirement imply?

Ray in journ any hotel can only be booked by one guest on the same volted and be booking. UULOTCS

 \hookrightarrow {hotelNo, date, roomNo} \rightarrow {guestNo}



Assignment Project Fixam Help

- ROOM(roomNo, hotelNo, type, price) with PK {roomNo, hotelNo}
- GUEST(guestNo, guestName, guestAddress) with PK {guestNo}
- Which functional dependency does the following requirement imply?

RS A room in any hotel can only be booked by one guest on the same volted in any hotel can only be booked by one guest on the same

 \hookrightarrow {hotelNo, date, roomNo} \rightarrow {guestNo} Yes

guestNo	hotelNo	roomNo	Date
001	H1	R101	29/08/2020
002 ×	H1	R101	29/08/2020



How to Find Candidate Keys?

Assignment Project Exam Help HotelNo, hotelName, city) with PK {hotelNo}

- ROOM(roomNo, hotelNo, type, price) with PK {roomNo, hotelNo}
- GUEST(guestNo, guestName, guestAddress) with PK {guestNo}
- FDs on BOOKING

 $\begin{tabular}{ll} \hline \label{table_stable} VguestNo, here | Note | Not$



How to Find Candidate Keys?

Assignment Project Exam Help HOTEL(hotelNo, hotelName, oily) with PK {hotelNo}

- ROOM(roomNo, hotelNo, type, price) with PK {roomNo, hotelNo}
- GUEST(guestNo, guestName, guestAddress) with PK {guestNo}
- FDs on BOOKING

- Candidate keys on BOOKING
 - {guestNo, hotelNo, date}
 - {hotelNo, date, roomNo}



changes:

How to Identify FDs?

Assignment Project Exam Help Consider BOOKING(guestNo, hotelNo, date, roomNo) and the following

- R1 A booking carybe made for one day only.
- RIA gues can make several beokings in a rote for different days.
- R3 A guest cannot make two or more bookings in the same hotel for the same day.
- R4 A guest can make two or more bookings in different hotels for the
- R5 A room in any field can only be blocked by one guest on the same date, i.e., no double-booking.
- **R6** A guest is not allowed to make more than one booking for the same day even in the different hotels.



- HOTEL(hotelNo, hotelName, city) with PK {hotelNo}
- ROOM(roomNø, hotelNo, type, price) with PK {roomNo, hotelNo} westAddress) With PK {guestNo}
- BOOKING(guestNo, hotelNo, date, roomNo) with PK {?}
- Which functional dependency does the proving requirement imply?
 - **R6** A guest is not allowed to make more than one booking for the same day even in the different hotels.



- HOTEL(hotelNo, hotelName, city) with PK {hotelNo}
- ROOM(roomNø, hotelNo, type, price) with PK {roomNo, hotelNo} westAddress) With PK {guestNo}
- BOOKING(guestNo, hotelNo, date, roomNo) with PK {?}
- Which functional dependency does the iptowing requirement imply?
 - **R6** A guest is not allowed to make more than one booking for the same day even in the different hotels.
 - \hookrightarrow {guestNo, date} \rightarrow {hotelNo, roomNo}



How to Find Candidate Keys?

Assignment Project Exam Help HotelNo, hotelName, city) with PK {hotelNo}

- ROOM(roomNo, hotelNo, type, price) with PK {roomNo, hotelNo}
- GUEST(guestNo, guestName, guestAddress) with PK {guestNo}
- FDs on BOOKING





How to Find Candidate Keys?

Assignment Project Exam Help HotelNo, hotelName, city) with PK {hotelNo}

- ROOM(roomNo, hotelNo, type, price) with PK {roomNo, hotelNo}
- GUEST(guestNo, guestName, guestAddress) with PK {guestNo}
- FDs on BOOKING



- Candidate keys on BOOKING
 - {hotelNo, date, roomNo}
 - {guestNo, date}



Assignment Project Exam Help



Kurt Gödel (1906-1978)



Armstrong's Inference Rules

- Two questions:
 - Are all the FDs inferred using the Armstrong's inference rules correct?

 Are all the FDs inferred using the Armstrong's inference rules correct?

 Supply and the FDs inferred using the Armstrong's inference rules correct?

 Are all the FDs inferred using the Armstrong's inference rules correct?

 Are all the FDs inferred using the Armstrong's inference rules correct?
 - Can we use the Armstrong's inference rules to infer all possible FDs?
 completeness (you can prove anything that is right)
- Theorem (W. Amistrong) cstutorcs
 - The Armstrong's inference rules are both sound and complete.



Hilbert's program (1920s)

- A SS completeness all true mathematical statements of proved TEIP
 - Consistency: no contradiction can be obtained in the formalism
 - Decidability: decide the truth or falsity of any mathematical statement.

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Hilbert's program (1920s)

A SS completeness all true mathematical statements dan be proved TEIP

- Consistency: no contradiction can be obtained in the formalism
- Decidability: decide the truth or falsity of any mathematical statement.

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David Hilbert (1862-1943)

We must know. We will know.



Kurt Gödel and Incompleteness Theorem

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 Theorem (Kurt Gödel, 1931)
 For any computable axiomatic system that is powerful enough to describe the arithmetic of the natural numbers, there will always be at least one true but unprovable statement.



Kurt Gödel and Gödel Prize

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Kurt Gödel John von Neumann CStut (DPC 957)

Kurt Gödel's achievement in modern logic is singular and monumental –
indeed it is more than a monument, it is a landmark which will remain visible
far in space and time. — John von Neumann



Kurt Gödel and Gödel Prize

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- Kurt Gödel's achievement in modern logic is singular and monumental –
 indeed it is more than a monument, it is a landmark which will remain visible
 far in space and time. John von Neumann
- The **Gödel prize** became an annual prize for outstanding papers in the area of theoretical computer science since 1993.