DATABASE SYSTEMS

Theoretical Assignment

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Before you begin, please read carefully the policy on Late coursework and Academic misconduct and related links, in particular the Guidelines on plagiarism.

Submission instructions: Hand in your paper (handwritten or typed) to the ITO by the stated deadline. If you do not type, please make sure that your handwriting is legible.

Problem 1 (15 marks). Let R be a relation with two attributes, A and B, and let S be a relation with a single attribute, C. Express the relational calculus query $\{x \mid \exists y\, R(x,y) \wedge \forall z\, (S(z) \rightarrow R(x,z))\}$ in relational algebra.

Problem 2 (10 marks). What is the answer to the query of Problem 1 when $R = \{(a_1,b_1),(a_1,c_1),(a_2,c_1),(a_1,b_2),(a_3,b_1),(a_2,b_1),(a_3,b_2)\}$ and $S = \{b_1,b_2\}$? Justify your answer (correct solutions without an appropriate explanation will get zero marks).

Problem 3 (20 marks). Are the following schedules conflict serializable? Justify your answers. For those that are, give an equivalent serial schedule.

T_1	T_2	T_3	T_4
read(A)			
		read(B)	
	read(A)		
			read(B)
read(C)			
		read(A)	
			write(B)
	read(B)		
	read(C)		
		read(C)	
write(C)			
		write(C)	

T_1	T_2	T_3	T_4	T_5
	read(X)			
write(X)				
		read(X)		
	read(Y)			
write(Y)				
	read(Z)			
		write(Z)		
				read(Z)
				write(Z)
			write(Y)	

Problem 4 (20 marks). Consider a database schema over attributes A, B, C, D, E, F, G with the following functional dependencies:

$$BD \rightarrow C\,,\ BC \rightarrow DG\,,\ BFG \rightarrow D\,,\ CA \rightarrow D\,,\ BCA \rightarrow FE\,,\ B \rightarrow DA\,,\ DG \rightarrow BF\,,\ BE \rightarrow GFA$$

Each of the following questions is worth 5 marks:

(a) Find the candidate keys and the prime attributes of this schema.
(b) Compute a minimal cover of this schema.
(c) Produce a 3NF decomposition.
(d) Produce a BCNF decomposition of this schema. Is it dependency-preserving? Justify your answer.

Problem 5 (15 marks). Consider a relation R with two attributes, A and B, and a relation S with a single attribute, B. Can the relational algebra query $\pi_A(R) \times \big(\pi_B(R) \cap S\big)$ be expressed in terms of $\pi, \sigma, \times, \rho$? If yes, produce an equivalent expression using only the given operators; otherwise, explain why it is so (answers without appropriate justification will get zero marks).

Problem 6 (20 marks). Prove that the algorithm below returns the closure $C_F(X)$ of X w.r.t. F and that its running time is $O(n^2)$, where n is the size (i.e., number of attributes) of the schema.

INPUT: a set F of FDs, and a set X of attributes
OUTPUT: $C_F(X)$
Initialize *unused* to F
Initialize *closure* to X
repeat
  if $Y \to Z \in$ *unused* and $Y \in$ *closure* **then**
    Remove $Y \to Z$ from *unused*
    Add Z to *closure*
  end if
until no more changes
return *closure*

TOTAL: 100 marks.