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UNIVERSITY OF EDINBURGH  
COLLEGE OF SCIENCE AND ENGINEERING  
SCHOOL OF INFORMATICS

**INFR10080 INTRODUCTION TO DATABASES**

**December 2020**

**13:00 to 15:00**

**INSTRUCTIONS TO CANDIDATES**

1. Note that **ALL QUESTIONS ARE COMPULSORY.**
2. **DIFFERENT QUESTIONS MAY HAVE DIFFERENT NUMBERS OF TOTAL MARKS.** Take note of this in allocating time to questions.
3. This is an **OPEN BOOK** examination.

Year 3 Courses

Convener: D.Armstrong

External Examiners: S.Rogers, H.Vandierendonck

**THIS EXAMINATION WILL BE MARKED ANONYMOUSLY**



**Question 1.** Consider the following set of functional dependencies:

$$\Sigma = \{AB \rightarrow C, B \rightarrow D, C \rightarrow A, AD \rightarrow E\}$$

Give a formal proof (written as a sequence of numbered and appropriately justified derivation steps) that:

(a)  $\Sigma \models CB \rightarrow E$  (n = 7) [6 marks]

(b)  $\Sigma \models AB \rightarrow EC$  (n = 8) [6 marks]

Marks are awarded as follows:

- 4 marks for a correct proof that may use the reflexivity, augmentation, transitivity, decomposition and union axioms;
- 5 marks if, in addition to the above requirements, the proof does *not* use the decomposition and union axioms;
- 6 marks if, in addition to the above requirements, the length (that is, number of steps) of the proof is at most  $n$ , where  $n$  is specified for each point above.

**Question 2.** Consider the following schedule:

	1	2	3	4	5	6	7	8	9	10	11
$T_1$					$r(B)$					$w(D)$	
$T_2$			$r(C)$				$w(C)$				
$T_3$	$r(A)$			$w(A)$							
$T_4$		$r(B)$							$w(B)$		$r(B)$
$T_5$						$r(D)$		$r(C)$			

where  $r$  denotes a read operation and  $w$  denotes a write operation.

(a) Draw the precedence graph of the schedule, and justify the presence of each edge. [6 marks]

(b) Is the schedule conflict-serializable? Justify your answer, and indicate all of the serial schedules that are equivalent to the given one (including the case when there are none). [2 marks]

**Question 3.** Given a schema consisting of a relation  $R$  over attributes  $A, B, C$  (in this order) and a relation  $S$  over attributes  $A, B, C, D$  (in this order), translate the following relational calculus query into an equivalent relational algebra expression (on sets):

$$\{x, x, y, w, z \mid S(x, y, w, z) \wedge \forall u \neg R(y, w, u)\}$$

You can use  $\text{Adom}_N$  (for any attribute name  $N$ ) to denote the relational algebra expression that computes the active domain, over attribute  $N$ . Only the translation rules presented in class are allowed. Detail all the steps of the translation. [10 marks]



✓ **Question 4.** Given a schema consisting of a relation  $R$  over attributes  $A, B, C$  (in this order), translate the following relational algebra expression (on sets) into an equivalent relational calculus query:

$$\pi_{A,B,C}(\sigma_{A=D \wedge B=E \wedge C \neq F}(R \times \rho_{A \rightarrow D, B \rightarrow E, C \rightarrow F}(R)))$$

Only the translation rules presented in class are allowed. Detail all the steps of the translation.

[8 marks]

✓ **Question 5.** Assuming set semantics, consider a database schema consisting of relations  $R$  over attributes  $A, B, C$  (in this order) and  $S$  over attributes  $A, B, C, D$  (in this order).

w/o  $\forall$

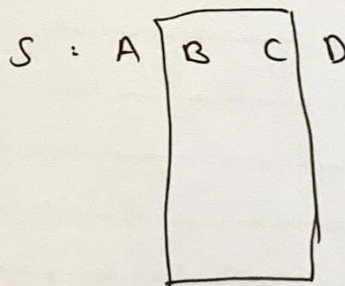
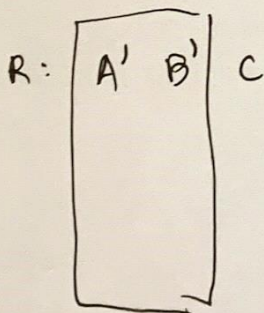
(a) Write a Boolean query in Relational Calculus, without universal quantifiers in its body, that returns true if and only if the functional dependency  $A, B \rightarrow C$  is satisfied by  $R$ .

[6 marks]

(b) Write a Relational Algebra query that, using only primitive operations, returns all of the tuples in  $S$  for which the inclusion dependency  $S[B, C] \subseteq R[A, B]$  is not satisfied.

[6 marks]

$$\sigma_{\substack{\text{B= A' } \wedge \text{ C= B' } \\ \text{B= A' } \wedge \text{ C= B' }}}(S \times \rho_{B \rightarrow B'}(R))$$



$\sigma$

$\pi_{A', B'}(R)$

$\pi_{B, C}(S)$

$\pi_{A', B'}(R) \times S$

$\pi_{A, B, C, D}(\sigma$