Theoretical Assignment	DATABASE SYSTEMS

For problems 1–4, we use the following relational schema:

- `Product(maker, model, category)`
- `PC(model, speed, ram, hd, price)`
- `Laptop(model, speed, ram, hd, screen, price)`
- `Printer(model, color, type, price)`

where attribute names should be self-explanatory. The constraints are as follows:

- `model` is the key for all relations.
- The only possible values of `category` are "PC", "laptop", and "printer".
- The only possible values of `type` are "laser" and "ink-jet".
- Every PC, laptop or printer must be referenced in relation `Product`.

Problem 1 (10 marks) Write an assertion statement for the following constraint: *Products of different kinds cannot have the same model number. For example, a PC and a laptop cannot have the same model number, nor can a printer and a laptop, etc.*

Problem 2 (10 marks) Write an assertion statement for the following constraint: *For every PC, there is a laser printer, and a color ink-jet printer, by the same maker.*

Problem 3 (15 marks). Write the following query in *relational algebra* (you may use $\pi, \sigma, \bowtie, \times, \cup, -$ and renaming of attributes. Renaming of relations, and the linear notation from the text are **not** allowed).

Find PCs that are faster and have more ram than all the laptops by the same manufacturer (maker).

Do *not* assume that the assertions of the first two problems are valid.

Problem 4 (15 marks). Write a *relational algebra* query that finds manufacturers (makers) whose laptops ought to be avoided. That is, for every laptop they make, there is another one, by a different manufacturer, that has a faster processor, more ram, a larger screen, and costs less.

The rules stated in Problem 3 apply.

Problem 5 (10 marks) Is the following schedule conflict serializable? Explain why. If it is, give an equivalent serial schedule.

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

Problem 6 (20 marks) Consider the following database schema. Its attributes are

$$A, B, C, D, E, F, G$$

and FDs are

$$\begin{aligned} AB &\rightarrow CF \\ BG &\rightarrow C \\ AEF &\rightarrow C \\ ABG &\rightarrow ED \\ CF &\rightarrow AE \\ A &\rightarrow CG \\ AD &\rightarrow FEG \\ AC &\rightarrow B \end{aligned}$$

Each of the questions is worth 5 marks.

1. Find the candidate keys and the prime attributes of this schema.
2. Compute the minimum cover of this schema.
3. Produce a 3NF decomposition.
4. Produce a BCNF decomposition of this schema. Is it dependency-preserving? Explain why.

Problem 7 (20 marks) A set X of attributes is an *antikey* if it is not a key, but every proper superset Y of X is a key (recall that Y is a proper superset of X if $X \subset Y$ and $Y \neq X$). Is the following true: an attribute is prime if and only if it does not belong to at least one antikey.

If it is true, provide a proof; if it is false, give a counterexample. The **maximum length** of your answer is 13 lines in at least 11pt font, if you type, or equivalent for handwritten assignments. Longer answers will automatically receive 0 marks.