For this exam, consider the following schema and instances of the relations. Feel free to remove this page from the exam.

This a product database. It is composed of three relations: *Parts*, *Suppliers* and *Catalog* (indicating what Parts are offer by which Suppliers. Empty values represent NULL.

```
Parts(pid: integer, pname character(40), color character(20));
```

Primary key: *pid*.

pid	*pname*	*color*
6	Anti-Gravity Turbine Generator	Cyan
7	Anti-Gravity Turbine Generator	Magenta
8	Fire Hydrant Cap	Red
9	7 Segment Display	Green
10	SQL queries	Green

```
Suppliers(sid: character(10), sname: character(40), address: char(50));
```

Primary key: *sid*.

sid	*sname*	*address*
acme	Acme Widget Suppliers	1 Grub St., Potemkin Village, IL 61801
bigRed	Big Red Tool and Die	4 My Way, Bermuda Shorts, OR 90305
per	Perfunctory Parts	99999 Short Pier, Terra Del Fuego, TX 41299
alien	Alien Aircaft Inc.	2 Groom Lake, Rachel, NV 51902

```
Catalog(sid character(10), pid integer, cost real);
```

Primary key: *(sid,pid)*.

sid	*pid*	*cost*
acme	8	11.7
bigRed	8	7.95
per	8	12.5
per	9	1
acme	10	10.5
acme	9	

1. Writing queries (SQL and Relation Algebra

For each of the following questions, provide a relational algebra expression that solves it, and its corresponding SQL statement. You can refer to Parts as P, Suppliers are S, and Catalog as C.

(a) [4] Find the **pid** of all the parts that are color *red*.

(b) [4] Find **sid** of suppliers who supply at least one *red* and at least one *blue* part.

(c) [4] Find the **address** of the suppliers who supply the part with **pname** *Fire Hydrant Cap*.

(d) [4] Find the **pid** of parts in the catalog that that do not have a price (price is not null).

(e) [4] Find out how many tuples in the catalog have a price.

(f) [4] Find out the number of parts that are in the relations Parts (how many tuples are in the relation Parts).

(g) [4] For each part in the Parts relation, list its **pid**, and the number of suppliers that sell that part.

(h) [4] For each part in the Catalog relation, list its **pid**, its most expensive price, and the **sid** of the supplier which sells it at that price.

(i) [4] List the **pid** of parts that are sold by exactly 2 suppliers.

(j) [4] List the *pname* of the parts that are not in the catalog relation.

2. Normalization

(a) [5] Consider a relation $R(A, B, C, D)$ with the following functional dependencies (FDs): $A \rightarrow B$, $BC \rightarrow D$. Which of the following FDs can be derived from them? Show all your work.

- $AC \rightarrow D$

- $B \rightarrow D$

(b) [5] Given the relation $R(A, B, C)$ and the set of functional dependencies $F = \{AB \rightarrow C, B \rightarrow A, C \rightarrow B\}$. Find all the keys of this relation. Show all your work.

(c) [5] Consider the relation $R(A, B, C, D)$, with the following functional dependencies: $AB \rightarrow D$, $B \rightarrow C$, $C \rightarrow B$. Its candidate keys are AB and AC. Is R in BCNF? Is R in 3NF? Show all your work.

(d) [5] Let relation $R = (A, B, C)$, and assume the following set of FDs: $A \rightarrow B$, $B \rightarrow C$, $C \rightarrow A$. Compute the projection of its set of FDS into the subrelation $R_1 = (A, B)$. Show all your work.

(e) [5] Consider the relation $R(A, B, C, D, E)$ with set of functional dependencies $F = \{AB \rightarrow C, AB \rightarrow E, E \rightarrow A, E \rightarrow B, C \rightarrow D\}$. F is minimal, and the keys of the relation are AB, and E. This table is not 3NF. Decompose it, using synthesis, into a set of relations that are loss-less join and dependency preserving (you do not have to demonstrate that the resulting relations satisfy these last two properties). Show all your work.

End of examination
Total pages: 6
Total marks: 65