CS34800 HOMEWORK 3
Due date: November 11, 2014 @ class time

1. (1.5 pts) For the following SQL query on the relational schema shown in figure 3.7, write the corresponding (unoptimized) relational algebra expression, draw the initial query tree and another query tree that includes some heuristic optimization over the initial tree.

```
SELECT Plocation, Address
FROM PROJECT, EMPLOYEE, DEPARTMENT
WHERE Dnumber=Dno AND Dnumber=Dnum AND Dname='Management'
AND Salary>40000;
```

2. (1.5 pts) For the following relational algebra expressions on the relational schema in figure 3.7, provide an equivalent relational algebra expression that provides a heuristic optimization. Explain why your expression is more optimal than the original.

a. \( \pi_{Address} (\sigma_{Ssn=001}(EMPLOYEE \bowtie PROJECT)) \)

b. \( \pi_{plocation} (\pi_{plocation,pname} (\sigma_{Hours>10} (PROJECT \bowtie_{pnumber=pno} WORKS_ON))) \)

c. \( \pi_{pnumber} (\sigma_{pname='ProjectX' \AND Plocation='Seattle' \AND Dnum=5}(PROJECT) ) \)

3. (1 pt) Given the following relation \( R \) and the set of functional dependencies \( S \) that hold on \( R \), find all candidate keys for \( R \). Show your work.

\( R \) (A, B, C, D, E, F)

\( S: \)
DF \( \rightarrow \) C
BC \( \rightarrow \) F
E \( \rightarrow \) A
ABC \( \rightarrow \) E
4. (1 pt)
   a. How do we judge the goodness of a relational database schema (list three properties)?
   b. What is the purpose of database normalization?

5. (1.5 pts) Given the relation $R$ in the flat relational model and the set of functional dependencies $F$ that hold on $R$, what is the highest normal form of $R$ (1NF, 2NF, 3NF or BCNF)? Show your work.

   $R (C, O, L, D, P, S)$

   $F :$
   \begin{align*}
   &C \rightarrow D \\
   &O \rightarrow L \\
   &CO \rightarrow P \\
   &P \rightarrow S
   \end{align*}

6. (3 pts) Consider the decomposition of $R$ in Question 5 into the relations below. State the highest normal form (1NF, 2NF, 3NF or BCNF) for each of the relations in the decomposition. Show your work.

   $R1(C, O, P, S); R2(C, O, L); R3(C, D)$

7. (2 pts) Given the following decomposition of the relation $A$ with the functional dependencies $F$,
   b. Is the decomposition lossless (non-additive) join? Explain why.

   $A (K, L, M, N, O, P, Q, R, S, T)$

   $F :$
   \begin{align*}
   &KL \rightarrow M \\
   &K \rightarrow NO \\
   &L \rightarrow P \\
   &P \rightarrow QR \\
   &N \rightarrow ST
   \end{align*}

   Decomposition: $R1(K, L, M, N, O); R2(L, P, Q, R); R3(N, S, T)$
8. (2 pts) Given the relation $A$ and the set of functional dependencies $F$ that hold on $A$ as below, find a decomposition of $A$ into dependency-preserving, lossless-join 3NF relations. Show your work.

$A \ (K, L, M, N, O, P, Q, R, S, T)$

$F: \begin{align*}
KL & \rightarrow M \\
LN & \rightarrow OP \\
KN & \rightarrow QR \\
K & \rightarrow S \\
R & \rightarrow T
\end{align*}$

9. (1.5 pts) For the relation $R$ in Question 5, find a decomposition into lossless-join BCNF relations. Show your work.

10. (bonus 2 pts) Given the following set of functional dependencies $F$ that hold on the relation $R$ below, find a minimal cover of $F$. Show your work.

$R \ (A, B, C, D, E, G, H, I)$

$F: \begin{align*}
A & \rightarrow B \\
ABCD & \rightarrow E \\
EG & \rightarrow H \\
EG & \rightarrow I \\
ACDG & \rightarrow EI
\end{align*}$
Figure 3.7
Referential integrity constraints displayed on the COMPANY relational database schema.