Reminders - IMPORTANT:

- Like all homeworks, it has to be done individually.
- Please typeset your answers.
- Please submit your answers in hard copy, in class, 1:30pm, on Tuesday, 03/26/2013.
- As before, for ease of grading, please solve each of the three questions on a separate page, and type your name and andrew ID on each of the three pages.

Reminders - FYI:

- Weight: 5% of homework grade.
- The points of this homework add up to 100.
- Rough time estimates: 2-4 hours.
Q1. Query Optimization - Selectivities, 30 pts - SUBMIT ON SEPARATE PAGE

Consider the tables WORKS_AT(SSN, gymID) and GYM(gymID, name). Notice that gymID is not a candidate key for the table GYM.

WORKS_AT(SSN, gymID) consists of \(N_1 = 100,000\) tuples and has

- \(V(SSN,\text{WORKS_AT}) = 50,000\) distinct values of SSN
- \(V(\text{gymID},\text{WORKS_AT}) = 20,000\) distinct values of gymID.

GYM(gymID, name) consists of \(N_1 = 40,000\) tuples and has

- \(V(\text{gymID},\text{GYM}) = 20,000\) distinct values of gymID
- \(V(\text{name},\text{GYM}) = 30,000\) distinct values of name.

For all the computations below:

- Please give numerical answers, accurate up to the fourth significant digit.
- No need for explanations, unless explicitly requested.

Q1.1 [5 pts] Estimate the number of qualifying tuples of the query:

\[
\text{SELECT } * \text{ FROM WORKS_AT WHERE SSN = 123456789;}
\]

Q1.2 [5 pts] Can SSN be a candidate key for the table WORKS_AT? Give a short explanation for your answer.

Q1.3 [5 pts] Estimate the number of qualifying tuples of the query:

\[
\text{SELECT } * \text{ FROM GYM WHERE name = "Gym_planet";}
\]

Q1.4 [5 points] Estimate the number of qualifying tuples of the query:

\[
\text{SELECT } * \text{ FROM WORKS_AT WHERE SSN = 123456789 AND gymID=101;}
\]

Q1.5 [5 points] Notice that gymID is not a candidate key for the table GYM. Estimate the number of qualifying tuples of the query:

\[
\text{SELECT SSN, GYM.gymID, name FROM WORKS_AT JOIN GYM WHERE GYM.gymID = WORKS_AT.gymID;}
\]

Q1.6 [5 points] Estimate the number of qualifying tuples of the query:

\[
\text{SELECT WA1.SSN, WA2.SSN FROM WORKS_AT AS WA1 JOIN WORKS_AT AS WA2 WHERE WA1.gymID = WA2.gymID;}
\]
Q2. Functional Dependencies, 30pts - SUBMIT ON SEPARATE PAGE

Q2.1 Consider the relation schema \( R = \{P, Q, S, T, U, V\} \) and the set of functional dependencies \( FD = \)

\[
\begin{align*}
PQ &\rightarrow S \\
PS &\rightarrow Q \\
PT &\rightarrow U \\
Q &\rightarrow T \\
QS &\rightarrow P \\
U &\rightarrow V
\end{align*}
\]

(1) \hspace{2cm} (2) \hspace{2cm} (3) \hspace{2cm} (4) \hspace{2cm} (5) \hspace{2cm} (6)

Answer the following questions. Notice that:

- For Yes/No or True/False questions, you may just give binary answers. Explanations are optional and will be used for partial credit. Wrong answers, with no, or wrong explanations, will get negative points.
- For the rest of the questions, please give short justifications.

2.1.1 [2 pts] Yes/No. Is FD a minimum cover?

2.1.1 [4 pts] Yes/No. Is the decomposition \( \{PQ, QS, PQTU, UV\} \) lossless?

2.1.2 [4 pts] Somebody claims that the decomposition \( \{PQ, QS, PQTU, UV\} \) is not dependency-preserving. If you agree with the statement, give all the missing dependencies. If you disagree, just state so.

2.1.3 [5 pts] Yes/No. Is the decomposition \( \{PQS, PSTU, PTV\} \) lossless?

2.1.4 [1 pts] True/False. The decomposition \( \{PQS, PSTU, PTV\} \) is not dependency-preserving, because it does not preserve \( U \rightarrow V \).

2.1.5 [2 pts] True/False. The decomposition \( \{PQS, PSTU, PTV\} \) is not dependency-preserving, because it does not preserve \( U \rightarrow V \) nor \( Q \rightarrow T \).

2.1.6 [2 pts] True/False. The decomposition \( \{PQS, PSTU, PTV\} \) is dependency-preserving.

Q2.2 Consider now the same relation schema \( R = \{P, Q, S, T, U, V\} \) with different, simpler, set of functional dependencies \( FD' = \)

\[
\begin{align*}
Q &\rightarrow ST \\
P &\rightarrow T \\
PS &\rightarrow T \\
QU &\rightarrow V
\end{align*}
\]

(7) \hspace{2cm} (8) \hspace{2cm} (9) \hspace{2cm} (10)

Answer the following questions. Again, negative points for wrong, binary answers.

2.2.1 [1 pts] True/False. The attribute closure \( \{P\}^+ \) is \( \{P, S, T\} \).

2.2.2 [1 pts] True/False. The attribute closure \( \{P\}^+ \) is \( \{P, T\} \).
2.2.3 [1 pts] True/False. The attribute closure \( \{P,Q\}^+ \) is \( \{P,T,Q,S\} \).
2.2.4 [1 pts] True/False. The attribute closure \( \{P,Q\}^+ \) is \( \{P,S,T\} \).
2.2.4 [1 pts] True/False. The attribute closure \( \{P,Q\}^+ \) is \( \{P,T,Q,S,U,V\} \).
2.2.5 [1 pts] True/False. The dependency \( Q \rightarrow S \) can be deduced from FD’.
2.2.6 [2 pts] True/False. The dependency \( QU \rightarrow TUV \) can be deduced from FD’.
2.2.7 [2 pts] True/False. All the candidate keys of R are \( \{P,Q\} \).
Q3. **BCNF and 3NF, 40pts** - **SUBMIT ON SEPARATE PAGE**

Consider the relation schema R = \{P,Q,S,T,U,V\} and the functional dependencies FD =

\[
\begin{align*}
PQ & \rightarrow S \\
PS & \rightarrow Q \\
PT & \rightarrow U \\
Q & \rightarrow T \\
QS & \rightarrow P \\
U & \rightarrow V
\end{align*}
\]

Consider also the relation schemas

- R1=\{P,Q,S\}
- R2=\{P,Q,S,U,V\} and
- R3=\{P,Q,S,T\}

As before, **negative points** for wrong, binary answers; explanations are optional, unless explicitly requested.

Q3.1 [2 pts] Write the projection of the FDs on R1.
Q3.2 [2 pts] True/False. The set of dependencies FD given above (11-16) is a minimal cover.
Q3.3 [4 pts] True/False. R1 is in 3NF.
Q3.4 [4 pts] True/False. R1 is in BCNF.
Q3.5 [2 pts]. Write the projection of the FDs on R2.
Q3.6 [4 pts] True/False. All the candidate keys of R2 are \{PQU, QSU\}.
Q3.7 [4 pts]. True/False. R2 is in BCNF.
Q3.8 [4 pts] True/False. Consider the decomposition of R2 \{PQU, PQS, UV\}. The new relations are in BCNF.
Q3.9 [2 pts]. Write the projection of the FDs on R3.
Q3.10 [2 pts] True/False. The candidate keys of R3 are \{PQ,QS,PS\}.
Q3.11 [4 pts] R3 is *not* in BCNF. Give all the dependencies of FD that violate the BCNF.
Q3.12 [2 pts] True/False. R3 is in 1NF.
Q3.13 [4 pts] True/False. Consider the decomposition of R3 to \{PQS, QT\}. The new relations are in BCNF.

_________________________  End of homework questions  _________________________