IMPORTANT

- **Deposit hard copy** of your answers in class at 1:30pm on Tuesday, 3/24/2015.
- Separate answers, as usually, i.e., please solve each of the 4 questions on a separate page, and type the usual, full information, on each page: your name, Andrew ID, course #, Homework #, and Question #.

Reminders

- **Plagiarism**: Homework may be discussed with other students, but all homework is to be completed individually.
- **Typeset** all of your answers whenever possible. Illegible handwriting may get no points, at the discretion of the graders.
- **Late homeworks**: please email late homeworks
  - to all TAs
  - with the subject line exactly 15-415 Homework Submission (HW 6)
  - and the count of slip-days you are using.

For your information:

- Graded out of 100 points; 4 questions total
- Rough time estimate: ≈6 hours (1-2 hours for each question)

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<thead>
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<th>Question</th>
<th>Points</th>
<th>Score</th>
</tr>
</thead>
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</table>
Question 1: Query Optimization........................... [20 points]
Submit on separate page
Course: 15-415/615; HW: ; Q: 
Name: __________________; andrew-id: __________________; late days: 
For this problem we consider a movie reviewing database with following three tables:

1. Movies(title, imdb_number, year), where the primary key is imdb_number;
2. Reviewers(userid, username), where the primary key is userid;
3. Reviews(userid, imdb_number, rating, comment), where the primary key is (userid, imdb_number), userid is foreign key referencing Reviewers, and imdb_number is foreign key referencing Movies.

For these tables we know the following statistics:
- Movies consists of $N_1 = 60,000$ tuples, there are:
  - 40,000 distinct movie titles,
  - 90 distinct years, 1925–2014 inclusive.
- Reviewers consists of $N_2 = 50,000$ tuples, there are:
  - 50,000 distinct userids,
  - 50,000 distinct usernames
- Reviews consists of $N_3 = 1,300,000$ tuples, there are:
  - 38,000 distinct userids,
  - 33,000 distinct movie titles,
  - 5 distinct ratings (i.e. 1, 2, 3, 4, and 5) without nulls.

For the queries below, assume that there are no correlations between the columns of a table nor any prior knowledge about the data (i.e., assume uniform distribution). Estimate the number of resulting tuples for the query, and give the answer with fourth significant digit accuracy. We will accept either rounding half up or down, but no partial credit will be given.

(a) [3 points] SELECT * FROM Movies WHERE year = 2001;

(b) [4 points] SELECT * FROM Movies WHERE year = 1999 AND title = "Fight Club"

(c) [4 points] SELECT * FROM Reviews WHERE rating > 3

(d) [4 points] SELECT year, count(*) FROM Movies GROUP BY year
(e) [5 points] SELECT count(*)
    FROM Movies JOIN Reviews ON Movies.imdb_number = Reviews.imdb_number
    GROUP BY Movies.title

(e) ____________

Homework 6 continues...
Question 2: Functional Dependencies .................. [20 points]

Submit on separate page
Course: 15-415/615; HW: ; Q:
Name: ___________________; andrew-id: ___________________; late days:

2.1 Consider the following legal instance of a relational schema $S$ with attributes $ABC$:

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$</td>
<td>9</td>
<td>T</td>
<td></td>
</tr>
<tr>
<td>$\alpha$</td>
<td>16</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td>$\beta$</td>
<td>20</td>
<td>F</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Legal instance of schema $S$ for question 2.1

(a) Which of the following dependencies are violated by the instances of $S$ in Table 1?

i. [1 point] Yes/No: $A \rightarrow B$ is violated.

ii. [1 point] Yes/No: $B \rightarrow A$ is violated.

iii. [1 point] Yes/No: $C \rightarrow A$ is violated.

iv. [1 point] Yes/No: $AC \rightarrow B$ is violated.

v. [1 point] Yes/No: $B \rightarrow AC$ is violated.

(b) [1 point] By only observing the instance of $S$ in Table 1 can you identify the functional dependencies that hold on schema $S$?

□ Yes □ No

2.2 For the next set of questions consider the relational schema $r = \{P, Q, R, S, T, U, V\}$ and the set of functional dependencies FD:

\[
\begin{align*}
P & \rightarrow Q \\
Q & \rightarrow R \\
PS & \rightarrow TRV \\
QT & \rightarrow UR \\
S & \rightarrow V
\end{align*}
\]

(a) [3 points] Which of the following is a minimum cover of the FD?

(a) The given FD is a minimum cover.
(b) $\{P \rightarrow Q, Q \rightarrow R, PS \rightarrow T, QT \rightarrow UR, S \rightarrow V\}$
(c) $\{P \rightarrow Q, Q \rightarrow R, P \rightarrow T, Q \rightarrow U, S \rightarrow V\}$
(d) $\{P \rightarrow Q, Q \rightarrow R, PS \rightarrow T, QT \rightarrow U, S \rightarrow V\}$
(e) none of the above - the cover is ______________________________________

(b) Yes/No: Which of the following functional dependencies can be deduced, from the above set of functional dependencies (Eq. (1)-(5))?

Question 2 continues...
i. [1 point] □ Yes □ No : \( P \rightarrow R \)

ii. [2 points] □ Yes □ No : \( PS \rightarrow U \)

iii. [2 points] □ Yes □ No : \( QS \rightarrow U \)

iv. [2 points] □ Yes □ No : \( QST \rightarrow P \)

(c) [2 points] True or False: The attribute closure \( \{Q\}^+ \) is \( \{Q, R, T\} \).
□ True □ False

(d) [2 points] True or False: The attribute closure \( \{PS\}^+ \) is \( \{P, Q, R, S, T, U, V\} \).
□ True □ False

Homework 6 continues...
Question 3: Decompositions ....................... [30 points]
Submit on separate page
Course: 15-415/615; HW: ; Q:
Name: __________________; andrew-id: __________________; late days:

3.1 For this set of questions, consider the relation with attributes, \( S = \{A, B, C, D, E, F\} \),
let the following functional dependencies \( FD \) be defined over the relation \( S \):

\[
\begin{align*}
A & \rightarrow D \\
A & \rightarrow E \\
D & \rightarrow C \\
D & \rightarrow F 
\end{align*}
\]

(a) [6 points] Provide the attribute closure of \( \{AB\} \).

(b) Identify whether the decomposition \( ABC, CDE, EFA \) is lossless and dependency-preserving?
   i. [3 points] □ Yes □ No : Lossless?
   ii. [3 points] □ Yes □ No : Dependency Preserving?

(c) Identify whether the decomposition \( ABCE, ADC, ADEF \) is lossless and dependency-preserving?
   i. [3 points] □ Yes □ No : Lossless?
   ii. [3 points] □ Yes □ No : Dependency Preserving?

3.2 Consider the relation with attributes, \( A = \{P, Q, R, S, T, U, V\} \). The following functional dependencies hold over \( A \).

\[
\begin{align*}
RT & \rightarrow P \\
QS & \rightarrow T \\
R & \rightarrow Q 
\end{align*}
\]

(a) Identify whether the decomposition \( QST, QR, PRSUV \) is lossless and dependency-preserving?
   i. [3 points] □ Yes □ No : Lossless?
   ii. [3 points] □ Yes □ No : Dependency Preserving?

(b) Identify whether the decomposition \( QST, QR, PRSUV, PRT \) is lossless and dependency-preserving?
   i. [3 points] □ Yes □ No : Lossless?
   ii. [3 points] □ Yes □ No : Dependency Preserving?
Question 4: Normal Forms .......................... [30 points]

Consider the relation with attributes, \( S = \{A, B, C, D, E\} \). Let the following functional dependencies be defined over the relation \( S \),

\[
\begin{align*}
A & \rightarrow BC \\
CD & \rightarrow E \\
B & \rightarrow D \\
E & \rightarrow A
\end{align*}
\]

(a) Identify whether this relationship is in 3NF and/or BCNF?

i. [2 points]  □ Yes  □ No : 3NF

ii. [2 points] □ Yes  □ No : BCNF

(b) [5 points] Provide the projection of FDs for the subset of attributes \( \{ABD\} \)

(c) [8 points] Give a BCNF decomposition of \( S \) that is lossless.

(d) [3 points] Is your BCNF decomposition dependency preserving?

□ True  □ False

(e) [10 points] Give a 3NF decomposition of \( S \) that is lossless and dependency preserving.