1. If only 10% of students have URL addresses, then Student(SSN, Name, …, URL) is a poor design, because 90% of the last column values will be nulls. But the following is a better design. Assume that each student has up to one webpage address.
   a. Student(SSN, Name, …), WebPage(SSN, URL)
   b. Student(SSN, Name, …), WebPage(SSN, URL)
   c. Student(SSN, Name, …), WebPage(SSN, URL)
   d. Student(SSN, Name, …), WebPage(SSN, URL)
   e. Student(SSN, URL, Name, …)

2. Fill in the blank:
   “Design relation schemas so that they can be ______ with ______ conditions on attributes that are either primary keys or foreign keys in a way which guarantees that no ____ tuples are generated.”
   a. created, normal, unique
   b. created, normal, spurious
   c. joined, normal, spurious
   d. joined, equality, unique
   e. joined, equality, spurious

3. A functional dependency (Y → X), between X and Y specifies a constraint on the possible tuples that can form a relation instance r of R. The constraint states that for any two tuples t1 and t2 in r such that
   a. t1[X] = t2[Y], then t1[Y] = t2[X]
   b. t1[Y] = t2[Y], then t1[X] = t2[X]
   c. t1[X] = t2[Y], then t1[X] = t2[Y]
   d. t1[X] = t2[X], then t1[Y] = t2[Y]
   e. t1[Y] = t2[X], then t1[Y] = t2[X]

4. Given the following relation schema ED(S, E, B, A, D, M, G) with the following dependencies
   F = { S → EBAD, D → MG }
   What functional dependency can be inferred from F using decomposition rule?
   a. S → S
   b. S → E
   c. S → G
   d. D → DMG
   e. D → S

5. If all Y-values are different and all X-values are the same in all possible r(R), does Y → X in R?
   a. Yes
   b. No
6. Given the relational schema: \( R = (\text{PILOT, FLIGHT, DATE, DEPARTS, TERMINAL}) \) that satisfies the following functional dependencies:

\[
\text{FLIGHT} \rightarrow \text{DEPARTS}, \quad \text{TERMINAL} \rightarrow \text{FLIGHT}, \quad \text{FLIGHT, DATE} \rightarrow \text{PILOT}
\]

and the following instance:

<table>
<thead>
<tr>
<th>PILOT</th>
<th>FLIGHT</th>
<th>DATE</th>
<th>DEPARTS</th>
<th>TERMINAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cushing</td>
<td>83</td>
<td>9 Aug</td>
<td>10:15am</td>
<td>A</td>
</tr>
<tr>
<td>Cushing</td>
<td>116</td>
<td>10 Aug</td>
<td>1:25pm</td>
<td>B</td>
</tr>
<tr>
<td>Clark</td>
<td>281</td>
<td>8 Aug</td>
<td>5:50pm</td>
<td>A</td>
</tr>
<tr>
<td>Clark</td>
<td>301</td>
<td>12 Aug</td>
<td>6:35pm</td>
<td>C</td>
</tr>
<tr>
<td>Clark</td>
<td>83</td>
<td>11 Aug</td>
<td>10:15am</td>
<td>A</td>
</tr>
<tr>
<td>Chin</td>
<td>83</td>
<td>13 Aug</td>
<td>10:15am</td>
<td>A</td>
</tr>
<tr>
<td>Chin</td>
<td>116</td>
<td>12 Aug</td>
<td>1:25pm</td>
<td>B</td>
</tr>
</tbody>
</table>

Is \( R \) consistent with the dependencies specified above? Is it a valid instance?

a. YES
b. NO, since \( \text{FLIGHT} \rightarrow \text{DEPARTS} \) is violated by \( r(R) \).
c. NO, since \( \text{TERMINAL} \rightarrow \text{FLIGHT} \) is violated by \( r(R) \).
d. NO, since \( \text{FLIGHT}, \text{DATE} \rightarrow \text{PILOT} \) is violated by \( r(R) \).
e. NO, since \( \text{FLIGHT}, \text{DATE} \rightarrow \text{PILOT} \) and \( \text{TERMINAL} \rightarrow \text{FLIGHT} \) are violated by \( r(R) \).

7. Given the following relation state. Which of the following FDs may be a valid one?

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>a1</td>
<td>b1</td>
<td>c1</td>
<td>d1</td>
</tr>
<tr>
<td>a2</td>
<td>b2</td>
<td>c2</td>
<td>d2</td>
</tr>
<tr>
<td>a2</td>
<td>b3</td>
<td>c2</td>
<td>d3</td>
</tr>
<tr>
<td>a3</td>
<td>b3</td>
<td>c2</td>
<td>d4</td>
</tr>
</tbody>
</table>

a. \( A \rightarrow B \)    b. \( A \rightarrow C \)    c. \( C \rightarrow A \)    d. \( A \rightarrow D \)    e. \( B \rightarrow D \)

8. The key for the universal relation \( R = \{ \text{A, B, X, D, E, Y, G, H, Z} \} \) is

Given the following set of functional dependencies:

\[
\text{F} = \{ \text{BD} \rightarrow \text{EY}, \quad \text{AD} \rightarrow \text{GH}, \quad \text{A} \rightarrow \text{Z}, \quad \text{AB} \rightarrow \text{X} \}
\]

a. \( AB \)    b. \( ABD \)    c. \( ABX \)    d. \( BD \)    e. \( BDZ \)
Consider the following relation \( \text{CAR-SALE}(\text{car, salesman, date-sold, commission, discount}) \) and FDs = \{date-sold \rightarrow \text{discount}, \text{salesman} \rightarrow \text{commission}\}

9. Is CAR-SALE relation in 1NF?  
   a. Yes  
   b. No 

10. Is CAR-SALE relation in 2NF?  
    a. Yes  
    b. No 

11. The 3NF of CAR-SALE relation is  
    a. \( \text{CAR(car, salesman, date-sold, discount)}, \ \text{COMM(salesman, commission)} \)  
    b. \( \text{CAR(car, salesman, date-sold, commission)}, \ \text{DATE(date-sold, discount)} \)  
    c. \( \text{CAR(car, salesman, date-sold)}, \ \text{COMM(salesman, commission)}, \ \text{DATE(date-sold, discount)} \)  
    d. \( \text{CAR-SALE(car, salesman, date-sold, commission, discount)} \)  
    e. None of the above 

12. Which of the following statement about normal forms is false?  
   a. If a relation \( R \) is in BCNF, it is also in 3NF.  
   b. If a relation \( R \) is not in BCNF, we can always obtain its BCNF by applying lossless-join decomposition on \( R \).  
   c. If a relation \( R \) is not in BCNF, we can always obtain its BCNF by applying decomposition which is dependency preserving on \( R \).  
   d. If a relation \( R \) is not in 3NF, we can always obtain its 3NF by applying lossless-join decomposition on \( R \).  
   e. If a relation \( R \) is not in 3NF, we can always obtain its 3NF by applying decomposition which is dependency preserving on \( R \). 

13. Consider the relation for an appliance dealer \( R(M, Y, R, P, C) \)  
    Assume that \( M \rightarrow P, \ MY \rightarrow R, \ P \rightarrow C \)  
    Consider the decomposition \( R1 (M, Y, P), \ R2 (M, R, C) \).  
    Does this decomposition have the lossless join property?  
    Circle: YES  
    NO  

    Justify: \( R1 \cap R2 = M \)  
    \( R1 \ - \ R2 = (Y, P) \)  
    \( R2 \ - \ R1 = (R, C) \)  
    Because \( M \) doesn’t functionally define either \( (R1 \ - \ R2) \) or \( (R2 \ - \ R1) \), this Decomposition is not lossless join.
14. Consider the following relation with its functional dependencies:

\[ R (C, T, O, S, D) \]

\[ F = \{ C \rightarrow S, T \rightarrow O, CT \rightarrow D \} \]

Also, consider a decomposed version of the above relation:

\[ R1 (C, T, S) \]
\[ R2 (C, S) \]
\[ R3 (T, O, D) \]

Using the algorithm for lossless join decomposition testing (Algorithm 15.3), determine if this decomposition is indeed lossless. Describe how you came to your conclusion.

(2pts – tableau setup and change & 2pts- explanation & correct conclusion)

\[
\begin{array}{c|c|c|c|c|c}
C & T & O & S & D \\
\hline
R1 & a1 & a2 & b13 & a4 & b15 \\
R2 & a1 & b22 & b23 & a4 & b25 \\
R3 & b31 & a2 & a3 & b34 & a5 \\
\end{array}
\]

Considers FDs \{ C \rightarrow S, T \rightarrow O, C, T \rightarrow D \}

\[
\begin{array}{c|c|c|c|c|c}
C & T & O & S & D \\
\hline
R1 & a1 & a2 & a3 & a4 & b15 \\
R2 & a1 & b22 & b23 & a4 & b25 \\
R3 & b31 & a2 & a3 & b34 & a5 \\
\end{array}
\]

Since there is no row of entirely “a” symbols, this decomposition is not lossless.

EXPLANATION: In the first row, we can set b13 to a3 because a2 \(\rightarrow\) a3 and a2 and a3 are present in row3. In row1 b15 cannot be set to a5 because a1, a2 \(\rightarrow\) a5 needs to have another row that has all of a1, a2 and a5 present in the same row. Since no such row is presented, we cannot change b15 to a5 and conclude that no row can be set to all a’s.
15. Consider the relation \( R(T, S, D) \) with MVD \( T \rightarrow\rightarrow S \) and \( T \rightarrow\rightarrow D \). \( R \) currently has the following tuples:

\[
\begin{array}{ccc}
T & S & D \\
P & G & U \\
P & G & R \\
P & S & U \\
P & S & R \\
N & M & U \\
N & M & T \\
N & V & U \\
N & V & T \\
\end{array}
\]

a. The above relation is not in 4NF. Normalize it into 4NF.

\( R_1(T, S) \) and \( R_2(T, D) \)

b. What is the table look like after decomposition?

\[
\begin{array}{ccc}
T & S & D \\
T & P & N \\
T & P & N \\
T & S & M \\
T & P & N \\
T & N & U \\
T & N & U \\
T & N & T \\
\end{array}
\]
16. If speed of disk rotation \((p)\) is 3000 rpm, what is the average rotational delay \((rd)\)?

- 50 rps
- 1 rev. = 20 msec. (1 second = 1000 msec)
- \(rd = 10 \text{ ms}\)

|   a. 8.33  b. 20  c. 16.66  d. 10  e. 50 |

17. If track size = 25000 bytes, disk rotation \((p)\) = 3600 rpm, and block size \(B\) = 3000 bytes. What is transfer rate \((tr)\) in bytes/msec?

\[ tr = \frac{25000}{60 \times 1000/3600} = 1500 \text{ bytes/msec} \]

|   a. 3000  b. 1800  c. 2400  d. 1500  e. 3600 |

18. If transfer rate \((tr)\) = 1000 bytes/msec and block size \((B)\) = 3000 bytes. What is block transfer time \((btt)\) in bytes/msec?

\[ btt = \frac{B}{tr} = \frac{3000}{1000} = 3 \text{ msec} \]

|   a. 3  b. 0.333  c. 2  d. 1  e. 1.5 |

19. Consider a table \texttt{emp} with \(r = 160,000\) records of \(R = 98\) bytes each, created with the statement:

\[ \text{create table emp (eid integer primary key, ... \texttt{pctfree 20;}} \]

where \texttt{pctfree n} clause refers to the amount of free space \((\%n)\) that must be left on each data page in placing records on the page.

How many data pages \((b)\) needed to store the records of the table \texttt{emp}. Assuming only \texttt{2-byte} inter-record gap, page size is \(B = 4000\) bytes, and an \texttt{unspanned organization}. Ignore the file header size. Hint: first, compute the file blocking factor \(bfr\).

\[ bfr = \frac{4000 \times 0.80/100}{32} = \text{floor}(B \times 0.80/(R+G)) \]

\[ b = \text{Celing}(160,000/32) = 5000 \text{ blocks} = \frac{r}{bfr} \]
20. Consider a disk with the following characteristics: average rotational latency = 6ms, average seek time = 6ms, block transfer time = 0.5ms.

How much time (in ms) would it take to read 200 blocks that are randomly stored on disk?

\[ 200 \times (6 + 6 + 0.5) = 2500 \text{ ms} \]

21. Consider a disk with block size \( B = 1024 \) bytes. Suppose we want to construct a secondary index on field \( xyz \) of size 25 bytes. What is the index blocking factor if an index pointer is 7 bytes long?

Hint: compute first the size of each index entry \( R_i \).

\[ R_i = V + P = 25 + 7 = 32 \]

\[ \text{bf}_{ri} = \frac{B}{R_i} = \frac{1024}{32} = 32 \]

22. Consider the following B+-tree. Which nodes would be accessed to find all items in the range 4 to 14, inclusive?

![B+-tree diagram]

- a. 1, 2, 5, 6, and 7
- b. 1, 2, 4, 5, 6, and 7
- c. 1, 2, 5, 3, 6, and 7
- d. 1, 2, 3, 4, 5, and 6
- e. 1, 2, 4, 5, 3, 6, and 7
23. Give the B'-tree below, draw the final tree that results after inserting 10.