Consider the following database scheme:

- OCCUPANTS (SSN, Room#)
- PHONEJACKS (Jack#, Room#)
- WIREDPHONES (Jack#, Phone#)
- CELLPHONES (SSN, Phone#)

Write relational expressions that retrieve the following:

a) People who have a cell phone and occupy a room having a wired phone.
b) Useless phone jacks; i.e., those that have no assigned phone number or are in a room with no occupants.
c) People who occupy the room having wired phone number 819-2375.

Recall the ZOO universal relation scheme (p. 16 notes):

- ZOO (Kind, InventoryNo, Area, House, Cage, Keeper, Head).

Give sets of designated FDs that enforce the following constraints, which are independent from each other and those in the notes:

a) No keeper works in two areas, but some keepers work in more than one house.
b) There can be more than one kind of animal in a house, but not in a cage.
c) A keeper can work in more than one area, but not more than one house within an area.
d) Each animal is assigned to at least one keeper, but not more than one head keeper.

Give sets \( F \) containing one FD that satisfy the following properties:

a) \( F \) is redundant.
b) \( F \) is L-minimum, but not LR-minimum.
c) \( F \) is L-minimum, but not optimum.

Give an algorithm that efficiently implements the following specification:

Input: sets of FDs \( F_1 \) and \( F_2 \)

Output: \( \begin{cases} 
\text{true,} & \text{if } F_1 \text{ is equivalent to } F_2 \\
\text{false,} & \text{otherwise}
\end{cases} \)
Let $r$ be a relation over relation scheme $R(U)$, $F$ be a set of FDs over $U$ satisfied by $r$, and $K$ be a key (w.r.t. $r$). Prove the following:

**Theorem.** $A \in U - \bigcup_{X \rightarrow Y \in F} (Y - X) \implies A \in K$.

Let $R(A, B, C, D, E, G, H)$ be a universal relation scheme with designated FDs

$$F = \{ \begin{align*}
    BH & \rightarrow AC, \\
    AE & \rightarrow A, \\
    C & \rightarrow BH, \\
    D & \rightarrow AD, \\
    C & \rightarrow D, \\
    G & \rightarrow ADE
\end{align*} \}.$$

a) Give a derivation of $CE \rightarrow A$ from $F$ using inference rules FD1, FD2, FD3.

b) Give a minimum set of FDs equivalent to $F$ obtained by Algorithm 3.4.

c) Give a circular LR-minimum set of FDs equivalent to $F$ obtained by Algorithm 3.5.

d) Give a lossless BCNF decomposition (w.r.t. $F$) of the universal relation scheme $R(U)$ obtained by Algorithm 5.1.

Consider the following database scheme:

- FOODGROUPS (Ingredient, Group)
- INGREDIENTS (Ingredient, Recipe)
- MENUS (Date, Meal, Recipe)

Give SQL `SELECT` statements that implement the following relational expressions:

a) $\pi_{\text{Date}}(\sigma_{\text{Ingredient}=\text{"rice"}}(\text{INGREDIENTS}) \bowtie \text{MENUS})$.

b) $\pi_{\text{Group}}(\text{FOODGROUPS} \bowtie \text{INGREDIENTS} \bowtie \sigma_{\text{Date}=6/6/2004}(\text{MENUS}))$. 