1. (20 pts) Given F = { a → b, b → c, c → {d, e} }. What is {b}+ (i.e. the closure of b)? Show your steps to achieve the answer.

   {b}+ = {b}

   = {b,c} = {b,c,d,e}

2. (20 pts) Given F = { a → b, c → d, b → {d, e}, {a, b} → c }. What is {a}+ (i.e. the closure of a)? Show your steps to achieve the answer.

   {a}+ = {a}

   = {a,b}

   = {a,b,d,e}

   = {a,b,d,e,c}

3. (30 pts) Given R(a, b, c, d, e) with two keys, (a,b) and c, and given the following set of functional dependencies F = { {a, b} → {c, d, e}, c → {a, b, d} }.
   1. Is R in 1NF? Justify your answer.
      1. There is not enough information to determine it. There is no semantics given for the the relation. I have no idea if an attribute is a multi-value attribute or not. I assume it is in 1NF.
   2. Is R in 2NF? Justify your answer.
      1. Non-primary key attribute ‘d’ is fully functional dependent on {a,b} or {c}. Non-primary key attribute ‘e’ is fully functional dependent on {a,b} so R is in 2NF. Assuming R is already in 1NF.
   3. Is R in 3NF? Justify your answer.
      1. Every FD’s left side is a superkey so this passes the test for 3NF, so R is in 3NF. Also, no non-prime attribute functionally assuming R is already in 1NF determines a non-prime attribute.

4. (30 pts) Given R(a, b, c, d, e) with a key (a,b) and given the following set of functional dependencies F = { a → b, {a, b} → c, b → {d, e} }.
    1. Is R in 1NF? Justify your answer.
        1. Given no information about the semantics of the columns. I will not be able to determine R is in 1NF or not. I will assume R is in 1NF.
    2. Is R in 2NF? Justify your answer.
        1. Non prime attribute d is have a partial functional depedency. It is being determined by part of a prime attribute. This violates the rule for 2NF. Attribute d also have this same problem. So R is not in 2NF.
    3. Is R in 3NF? Justify your answer.
        1. For the FD a->b a is not a superkey so violates the rule to be 3NF. Also in order to be in 3NF, R must be in 2NF first and R is not in 2NF so is not in 3NF as well.