**Q1**

Given R1(L,M,N,O,P,Q,R,S,T)

FDs = { LRP->Q,LR->ST,M->LO,MR->N}

**a):**

Closure of LPR = LPRQST which are not all, then LRP->Q violates BCNF.

Closure of LR = LRST which are not all, then LR->ST violates BCNF.

Closure of M = MLO which are not all, then M->LO violates BCNF.

Closure of MR = MRN which are not all, then MR->N violates BCNF.

**b):**

Closure of LPR = LPRQST.

LPR->Q violates BCNF for R1

Split R1 into

R2(L,P,R,Q,S,T) {LPR->Q,LR->ST}

R3(L,M,N,O,P,R) {M->LO,MR->N}

Closure of LR = LRST

LR->ST violates BCNF for R2

Split R2 into

R4(L,R,S,T) {LR->ST}

R5(L,P,R,Q) {LPR->Q}

Closure of M = MLO

M->LO violates BCNF for R3

Split R3 into

R6(M,L,O) {M->LO}

R7(M,N,P,R) {MR->N}

Closure of MR = MRNLO

MR->N violates BCNF for R7

Split R7 into

R8(M,R,N) {MR->N}

R9(M,P,R) {empty}

Final decomposition

R8(M,N,R) {MR->N}

R9(M,P,R) {empty}

R6(L,M,O) {M->LO}

R5(L,P,Q,R) {LPR->Q}

R4(L,R,S,T) {LR->ST}

**Q2**

**a):** Find minimal basis

Step 1: rewrite FD such that there is only one attribute on RHS.

AB->C

AB->D

ACDE->B

ACDE->F

B->A

B->C

B->D

CD->A

CD->F

CDE->F

CDE->G

EB->D

Step 2: minimize LHS

B->C

B->D

CDE->B

CD->F

B->A

B->C

B->D

CD->A

CD->F

CD->F

CDE->G

B->D

Step 3: remove redundant FDs and get minimal basis

CDE->B

B->C

CD->A

CD->F

CDE->G

B->D

**b):** Find all keys

Step 1: find attributes that are not on RHS of minimal basis

EH (All key should contain EH)

Step 2: find attributes that are on RHS but not on LHS

AFG (No key contain AFG)

Step 3: find keys

Closure of EHB = ABCDEFGH which is key

Closure of EHC = EHC which is not key

Closure of EHD = EHD which is not key

Closure of EHCD = ABCDEFGH which is key

Keys: EHB, EHCD

**c):** Employ decomposition to find 3NF relations

Recall revised minimal basis:

CDE->B

B->CD

CD->AF

CDE->G

For each FD:X->Y in minimal basis, define new relation with schema (XY)

R1(CDEB)

R2(BCD)

R3(CDAF)

R4(CDEG)

Since BCD in BCDE, get new relations

R1(CDEB)

R2(CDAF)

R3(CDEG)

Since no relation is a superkey for R, add a relation whose schema is some key

R1(CDEB)

R2(CDAF)

R3(CDEG)

R4(HB)

**d):**

Since closure of B = BCD, then B->CD violates BCNF for R1(CDEB).

Then allow redundancy.