

1.

A .

Students(sid, firstname, lastname, status, gpa, email)

{sid -> firstname lastname status gpa email}

Candidate key: email

Courses(dept_code, course#, title, credits, deptname)

{dept_code course# -> title credits deptname}

{dept_code -> deptname}

{course# -> title}

Prerequisites(dept_code, course#, pre_dept_code, pre_dept_course#)

Non-trivial functional dependency is absent here as all the attributes(dept_code, course#, pre_dept_code, pre_dept_course#) together form a key/super key.

There are no other attributes which are dependent on dept_code, course#, pre_dept_code or pre_dept_course#.

Following are the trivial functional dependencies:

{dept_code course# pre_dept_code pre_dept_course# -> dept_code}....By reflexivity rule

{dept_code course# pre_dept_code pre_dept_course# -> course#}....By reflexivity rule

{dept_code course# pre_dept_code pre_dept_course# -> pre_dept_code}....By reflexivity rule

{dept_code course# pre_dept_code pre_dept_course# -> pre_dept_course#}....By reflexivity rule

Classes(classid, dept_code, course#, sect#, year, semester, start_time, end_time, limit, size, classroom, capacity, fid)

{classid -> dept_code course# sect# year semester start_time end_time limit size classroom capacity fid}

{capacity -> limit}

{limit -> size}

{start_time -> end_time}

Classes_days(classid, day)

Non-trivial functional dependency is absent here as all the attributes(classid and day) together form a key/super key. There are no other attributes which are dependent on classid and day.

Following are the trivial functional dependencies:

{classid day -> classid}.....By reflexivity rule

{classid day -> day}.....By reflexivity rule

Faculty(fid, name, rank, office, email, deptname)

{fid -> name rank office email deptname}

Candidate key: office email

Departments(deptname, chair, office)

{deptname -> chair office}

Candidate key: office

Registration(sid, classid, lgrade, ngrade)

{sid classid -> lgrade ngrade}

{lgrade->ngrade}

Student_majors(sid, deptname)

Non-trivial functional dependency is absent here as all the attributes(sid and deptname) together form a key/super key. There are no other attributes which are dependent on sid and deptname.

Following are the trivial functional dependencies:

{sid deptname -> sid}.....By reflexivity rule

{sid deptname -> deptname}....By reflexivity rule

B.

Students(sid, firstname, lastname, status, gpa, email)

Students schema is in **3NF** because sid(superkey) functionally determines all other attributes and email(Candidate key) also functionally determines all the attributes which makes it prime(part of a candidate key).

Courses(dept_code, course#, title, credits, deptname)

Courses is **not in 3NF or BCNF** because dept_code and course# together forms a superkey which violates the rule of 2NF(2NF defines key must be a single column)

Prerequisites(dept_code, course#, pre_dept_code, pre_dept_course#)

Neither **3NF not BCNF**: Because all attributes together form a superkey and Prerequisites have a trivial FD as it follows the Reflexivity rule. 3NF or BCNF ignores trivial FD.

Classes(classid, dept_code, course#, sect#, year, semester, start_time, end_time, limit, size, classroom, capacity, fid)

Classes is in **BCNF** because classid is a superkey on which all other attributes are dependent and are a part of superkey. Other FD are {capacity -> limit}, {limit ->size}, {start_time->end_time}. Here LHS of -> are not a part of candidate keys.

Classes_days(classid, day)

Neither 3NF not BCNF: Because all attributes together form a superkey making classes_days FD trivial. 3NF or BCNF ignores trivial FD.

Faculty(fid, name, rank, office, email, deptname)

candidate key: office email

Faculty is in **3NF** because fid is a superkey on which all other attributes are dependent and are a part of it. office and email are prime attributes.

Departments(deptname, chair, office)

Departments is in **3NF** because deptname functionally determines all other attributes and is a superkey. Office is a prime attribute which is a part of superkey.

Registration(sid, classid, lgrade, ngrade)

Neither 3NF nor BCNF: because ngrade is functionally dependent on lgrade (for eg: A-→4). lgrade depends on both: sid and classid. This violates the 2NF rule.

Student_majors(sid, deptname)

Neither 3NF nor BCNF: Because Student_majors have a trivial FD as it follows the Reflexivity rule. 3NF or BCNF ignores trivial FD.

C:

Departments(deptname, chair, office)

Step 1: Candidate keys: office

Step 2: F_{min}

{deptname → chair office}

Decomposing,

(Departments: deptname → chair, deptname → office)

Considering, deptname → chair

Finding deptname+

deptname → office

Finding deptname+

deptname → chair

$F_{min} = \{\text{deptname} \rightarrow \text{chair}, \text{deptname} \rightarrow \text{office}\}$

$D = \{\text{deptname chair office}\}$

2.

a) $\{X \rightarrow Y, Z \rightarrow W\} \models \{XZ \rightarrow YW\}$

Proof:

$X \rightarrow Y$(given)

By using augmentation rule: $\{X \rightarrow Y\} \models XZ \rightarrow YZ$ -----1

As $Z \rightarrow W$(given)

Substituting $Z \rightarrow W$ in RHS of 1

$XZ \rightarrow YW$

Hence, $\{X \rightarrow Y, Z \rightarrow W\} \models \{XZ \rightarrow YW\}$

b) $\{X \rightarrow Y, YZ \rightarrow W\} \models \{XY \rightarrow W\}$

Proof:

Augmenting $X \rightarrow Y$ with Z ,

$XZ \rightarrow YZ$ ----- 1

$YZ \rightarrow W$ ----- (given)

Substituting given in 1,

$XZ \rightarrow W$

Functional dependency is not getting satisfied.

3.

$R(A,B,C,D,E,F)$

FD: $\{A \rightarrow B, BC \rightarrow D, BD \rightarrow CE, E \rightarrow F, F \rightarrow A\}$

$K\{B,C\}$

$R-K(A,D,E,F)$

Computing $(BC)^+$

$kplus = BC$

B is a subset of $kplus$

$kplus = BCD$

BD is a subset of $kplus$

$kplus = BCDE$

E is a subset of $kplus$

$kplus = BCDEF$

F is a subset of $kplus$

$kplus = BCDEFA$

Reorganizing

$kplus = ABCDEF$

$kplus$ determines all the attributes of $R-K$, hence $K(B,C)$ is a superkey of R .