**Question#1**

**Normalize up to 3rd Normal Form**

**Solution:**

**Conversion to First Normal Form:**

**Step 1: Eliminate the Repeating Groups**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| OID | ODATE | CID | CNAME | CSTATE | PID | PDESC | PPRICE | QTY |
| 1006 | 40110 | 2 | APEX | NC | 7 | TABLE | 800 | 1 |
| 1006 | 40110 | 2 | APEX | NC | 5 | DESK | 325 | 1 |
| 1006 | 40110 | 2 | APEX | NC | 4 | CHAIR | 200 | 5 |
| 1007 | 40111 | 6 | ACME | GA | 11 | DRESSER | 500 | 4 |
| 1007 | 40111 | 6 | ACME | GA | 4 | CHAIR | 200 | 6 |

**Step 2: Identify the Primary Key**

Primary key is composed of a combination of **OID** and **PID.**

**Step 3: Identify All Dependencies**

**(OID**, **PID** 🡪 ODATE, CID, CNAME, CSTATE, PDESC, PPRICE, QTY)

**Partial Dependencies:**

(**OID** 🡪 ODATE, CID, CNAME, CSTATE)

(**PID** 🡪 PDESC, PPRICE)

**Transitive Dependency:**

(**CID** 🡪 CNAME, CSTATE)

**Conversion to Second Normal Form:**

**Step 1:  Make New Tables to Eliminate Partial Dependencies**

|  |  |  |
| --- | --- | --- |
| PID | PDESC | PPRICE |
| 4 | CHAIR | 200 |
| 5 | DESK | 325 |
| 7 | TABLE | 800 |
| 11 | DRESSER | 500 |

Table Name: PRODUCT

|  |  |  |
| --- | --- | --- |
| OID | PID | QTY |
| 1006 | 7 | 1 |
| 1006 | 5 | 1 |
| 1006 | 4 | 5 |
| 1007 | 11 | 4 |
| 1007 | 4 | 6 |

Table Name: ASSIGNMENT

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| OID | ODATE | CID | CNAME | CSTATE |
| 1006 | 40110 | 2 | APEX | NC |
| 1007 | 40111 | 6 | ACME | GA |

Table Name: ORDER

**Step 2: Reassign Corresponding Dependent Attributes**

PRODUCT (**PID**, PDESC, PPRICE)

ASSIGNMENT (**OID**, **PID**, QTY)

ORDER (**OID**, ODATE, CID, CNAME, CSTATE)

**Conversion to Third Normal Form:**

**Step 1: Make New Tables to Eliminate Transitive Dependencies**

|  |  |  |
| --- | --- | --- |
| CID | CNAME | CSTATE |
| 2 | APEX | NC |
| 6 | ACME | GA |

Table Name: CUSTOMER

|  |  |  |
| --- | --- | --- |
| PID | PDESC | PPRICE |
| 4 | CHAIR | 200 |
| 5 | DESK | 325 |
| 7 | TABLE | 800 |
| 11 | DRESSER | 500 |

Table Name: PRODUCT

|  |  |  |
| --- | --- | --- |
| OID | ODATE | CID |
| 1006 | 40110 | 2 |
| 1007 | 40111 | 6 |

Table Name: ORDER

|  |  |  |
| --- | --- | --- |
| OID | PID | QTY |
| 1006 | 7 | 1 |
| 1006 | 5 | 1 |
| 1006 | 4 | 5 |
| 1007 | 11 | 4 |
| 1007 | 4 | 6 |

Table Name: ASSIGNMENT

**Step 2: Reassign Corresponding Dependent Attributes**

CUSTOMER (CID, CNAME, CSTATE)

PRODUCT (**PID**, PDESC, PPRICE)

ORDER (**OID**, ODATE, CID)

ASSIGNMENT (**OID**, **PID**, QTY)

**Question#2**

**Normalize up to Boyce-Codd Normal Form**

**Solution:**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| VisitNo | VisitDate | PatNo | PatAge | PatCity | ProvNo | ProvSpeciality | Diagnosis |
| V10020 | 1/13/2007 | P1 | 35 | DENVER | D1 | INTERNIST | EAR INFECTION |
| V10020 | 1/13/2007 | P1 | 35 | DENVER | D2 | NURSE PRACTIONER | INFLUENZZ |
| V93030 | 1/20/2007 | P3 | 17 | ENGLEWOOD | D2 | NURSE PRACTIONER | PREGNANCY |
| V82110 | 1/18/2007 | P2 | 60 | BOULDER | D3 | CARDIOLOGIST | MURMUR |

**Primary Key:**

Primary key is composed of a combination of **VisitNo** and **ProvNo**.

**All Dependencies**

**(VisitNo**, **ProvNo** 🡪 VisitDate, PatNo, PatAge, PatCity, ProvSpeciality, Diagnosis)

**Partial Dependencies:**

(**VisitNo** 🡪 VisitDate, PatNo, PatAge, PatCity)

(**ProvNo** 🡪 ProvSpeciality)

**Transitive Dependency:**

(**PatNo** 🡪 PatAge, PatCity)

**Conversion to Second Normal Form:**

**Step 1:  Make New Tables to Eliminate Partial Dependencies**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| VisitNo | VisitDate | PatNo | PatAge | PatCity |
| V10020 | 1/13/2007 | P1 | 35 | DENVER |
| V82110 | 1/18/2007 | P2 | 60 | BOULDER |
| V93093 | 1/20/2007 | P3 | 17 | ENGLEWOOD |

Table Name: VISIT

|  |  |
| --- | --- |
| ProvNo | ProvSpeciality |
| D1 | INTERNIST |
| D2 | NURSE PRACTIONER |
| D3 | CARDIOLOGIST |

Table Name: PROVIDER

|  |  |  |
| --- | --- | --- |
| VisitNo | ProvNo | Diagnosis |
| V10020 | D1 | EAR INFECTION |
| V10020 | D2 | INFLUENZZ |
| V93093 | D2 | PREGNANCY |
| V82110 | D3 | MURMUR |

Table Name: ASSIGNMENT

**Step 2: Reassign Corresponding Dependent Attributes**

VISIT (**VisitNo**, VisitDate, PatNo, PatAge, PatCity)

PROVIDER (**ProvNo**, ProvSpeciality)

ASSIGNMENT (**VisitNo**, **ProvNo**, Diagnosis)

**Conversion to Third Normal Form:**

**Step 1:  Make New Tables to Eliminate Transitive Dependencies**

|  |  |  |
| --- | --- | --- |
| PatNo | PatAge | PatCity |
| P1 | 35 | DENVER |
| P2 | 60 | BOULDER |
| P3 | 17 | ENGLEWOOD |

Table Name: PATIENT

|  |  |
| --- | --- |
| ProvNo | ProvSpeciality |
| D1 | INTERNIST |
| D2 | NURSE PRACTIONER |
| D3 | CARDIOLOGIST |

Table Name: PROVIDER

|  |  |  |
| --- | --- | --- |
| VisitNo | VisitDate | PatNo |
| V10020 | 1/13/2007 | P1 |
| V82110 | 1/18/2007 | P2 |
| V93093 | 1/20/2007 | P3 |

Table Name: VISIT

|  |  |  |
| --- | --- | --- |
| VisitNo | ProvNo | Diagnosis |
| V10020 | D1 | EAR INFECTION |
| V10020 | D2 | INFLUENZZ |
| V93093 | D2 | PREGNANCY |
| V82110 | D3 | MURMUR |

Table Name: ASSIGNMENT

**Step 2: Reassign Corresponding Dependent Attributes**

PATIENT (PatNo, PatAge, PatCity)

PROVIDER (**ProvNo**, ProvSpeciality)

VISIT (**VisitNo**, VisitDate, PatNo)

ASSIGNMENT (**VisitNo**, **ProvNo**, Diagnosis)

**Question#4**

**Solution:**

(TransactionID=TID, CustomerID=CID, CustomerName=CName, CustomerEmail=CEmail, TransactionDate=TDate, TransactionTime=TTime, TransactionTotalAmount= TTotalAmount, TransactionTax=TTax, ProductID=PID, ProductDescription= PDescription, ProductCategory=PCategory, ProductManufacturerID=MID, ManufacturerName=MName, ProductListPrice= PListPrice, ProductPurchasePrice= PPurchasePrice, ProductQuantity=PQuantity, TransactionProductTotal=TPTotal)

1. **Identify the functional dependencies between the attributes.**

Primary key is composed of a combination of **TID** and **PID**

**Dependencies:**

(**TID,** **PID** 🡪 CID, CName, CEmail, TDate, TTime, TTotalAmount, TTax, PDescription, PCategory, MID, MName, PListPrice, PPurchasePrice, PQuantity, TPTotal)

**Partial Dependency:**

(**TID** 🡪 CID, CName, CEmail, TDate, TTime, TTotalAmount, TTax)

(**PID** 🡪 PDescription, PCategory, MID, MName, PListPrice, PPurchasePrice, PQuantity)

**Transitive Dependency:**

(**CID** 🡪 CName, CEmail)

(**MID** 🡪 MName)

1. **Identify the reasons why this set of data is not in 3NF and indicate the normal form (if any) it is in.**

* If there occurs any transitive dependency, then table is not in 3rd Normal Form. In given table, there are two transitive dependencies so table is not in 3rd Normal Form.
* If there occurs any partial dependency, then table is not in 2nd Normal Form. In given table, there are two transitive dependencies so table is not in 2nd Normal Form.
* If there occurs any multivalued attributed then table is not in 1st Normal Form. In given

table, there is no multivalued attribute so **table is in 1st Normal Form**.

1. **Including all intermediate stages, organize the attributes into a set of 3NF relations.**

**Conversion to Second Normal Form:**

**Step 1:  Make New Tables to Eliminate Partial Dependencies**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| TID | TDate | TTime | TTotalAmount | TTax | CID | CName | CEmail |
| 823434434582 | 9/2/2015 | 10.28.34 | 167.23 | 10.37 | 2434254 | Silver Patrick | psilver@mail. net |

Table Name: TRANSACTION

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| PID | PDescription | PCategory | PListPrice | PPurchasePrice | PQuantity | MID | MName |
| 78234 | “Achieving One’s Fullest Potential” | self-help | 29.95 | 24.75 | 1 | 145432 | Brown and Gray |
| 4782349 | “Programming Server-side Solutions with Python” | Programming | 47.95 | 39.99 | 2 | 63453632 | Green & Yellow |
| 2342343 | “Murder at Eleven” | fiction | 14.95 | 12.50 | 5 | 145432 | Brown and Gray |

Table Name: PRODUCT

|  |  |  |
| --- | --- | --- |
| TID | PID | TPTotal |
| 823434434582 | **78234** | **24.75** |
| 823434434582 | **4782349** | **79.98** |
| 823434434582 | **2342343** | **62.50** |

Table Name: ASSIGNMENT

**Step 2: Reassign Corresponding Dependent Attributes**

TRANSACTION (**TID**, TDate, TTime, TTotalAmount, TTax, CID, CName, CEmail)

PRODUCT (**PID**, PDescription, PCategory, PListPrice, PPurchasePrice, PQuantity, MID, MName)

ASSIGNMENT (**TID**, **PID**, TPTotal)

**Conversion to Third Normal Form:**

**Step 1:  Make New Tables to Eliminate Transitive Dependencies**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| TID | TDate | TTime | TTotalAmount | TTax | CID |
| 823434434582 | 9/2/2015 | 10.28.34 | 167.23 | 10.37 | 2434254 |

Table Name: TRANSACTION

|  |  |  |
| --- | --- | --- |
| CID | CName | CEmail |
| 2434254 | Silver Patrick | psilver@mail. net |

Table Name: CUSTOMER

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| PID | PDescription | PCategory | PListPrice | PPurchasePrice | PQuantity | MID |
| 78234 | “Achieving One’s Fullest Potential” | self-help | 29.95 | 24.75 | 1 | 145432 |
| 4782349 | “Programming Server-side Solutions with Python” | Programming | 47.95 | 39.99 | 2 | 63453632 |
| 2342343 | “Murder at Eleven” | fiction | 14.95 | 12.50 | 5 | 145432 |

Table Name: PRODUCT

|  |  |
| --- | --- |
| MID | MName |
| 145432 | Brown and Gray |
| 63453632 | Green & Yellow |

Table Name: MANUFACTURE

|  |  |  |
| --- | --- | --- |
| TID | PID | TPTotal |
| 823434434582 | **78234** | **24.75** |
| 823434434582 | **4782349** | **79.98** |
| 823434434582 | **2342343** | **62.50** |

Table Name: ASSIGNMENT

**Step 2: Reassign Corresponding Dependent Attributes**

TRANSACTION (**TID**, TDate, TTime, TTotalAmount, TTax, CID)

CUSTOMER (CID, CName, CEmail)

PRODUCT (**PID**, PDescription, PCategory, PListPrice, PPurchasePrice, PQuantity, MID)

MANUFACTURE (MID, MName)

ASSIGNMENT (**TID**, **PID**, TPTotal)

**Question#5**

**Solution:**

(RouteID=RID, RouteStartPoint= RStartPoint, RouteEndPoint= REndPoint, RouteStandardDrivingTime= RStandardDrivingTime, ScheduleDate= ScheduleDate, ScheduledDepTime= ScheduledDepTime, ScheduledArrTime= ScheduledArrTime, DriverID=DID, DriverFName= DFName, DriverLName= DLName, DateDriverJoinedCompany= DateDJoinedCompany, DriverDOB=DDOB, VehicleID=VID, VehicleMake=VMake, VehicleMode=VModel, VehiclePassangerCapacity= VPassangerCapacity, DriverCertStartDate= DCertStartDate, DriverCertEndDate= DCertEndDate)

1. **Identify the functional dependencies between the attributes.**

Primary key is composed of a combination of **RID** and **DID**

**Dependencies:**

(**RID,** **DID** 🡪 RStartPoint, REndPoint, RStandardDrivingTime, ScheduleDate, ScheduledDepTime, ScheduledArrTime, DID, DFName, DLName, DateDJoinedCompany, DDOB, VID, VMake, VModel, VPassangerCapacity, DCertStartDate, DCertEndDate.)

**Partial Dependency:**

(**RID** 🡪 RStartPoint, REndPoint, RStandardDrivingTime)

(**DID** 🡪 DFName, DLName, DateDJoinedCompany, DDOB, VID, VMake, VModel, VPassangerCapacity, DCertStartDate, DCertEndDate)

**Transitive Dependency:**

(**VID** 🡪 VMake, VModel, VPassangerCapacity)

1. **Identify the reasons why this set of data is not in 3NF and indicate the normal form (if any) it is in.**

* If there occurs any transitive dependency, then table is not in 3rd Normal Form. In given table, there are one transitive dependencies so table is not in 3rd Normal Form.
* If there occurs any partial dependency, then table is not in 2nd Normal Form. In given table, there are two transitive dependencies so table is not in 2nd Normal Form.
* If there occurs any multivalued attributed then table is not in 1st Normal Form. In given

table, there is no multivalued attribute so **table is in 1st Normal Form**.

1. **Including all intermediate stages, organize the attributes into a set of 3NF relations.**

**Conversion to Second Normal Form:**

**Step 1:  Make New Tables to Eliminate Partial Dependencies**

|  |  |  |  |
| --- | --- | --- | --- |
| RID | RStartPoint | REndPoint | RStandardDrivingTime |
| 28 | Grand Avenue | Madison Street | 38 |

Table Name: ROUTE

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| DID | DFName | DLName | DateD  Joined  Company | DDOB | VID | VMake | VModel | VPassanger  Capacity | DCert  StartDate | DCert  EndDate |
| 8273 | Mary | Smith | 5/2/2007 | 3/23/1974 | 1123 | Great  Trucks | CityCoach | 58 | 6/10/2015 | 6/9/2016 |
| 7234 | John | Jones | 10/12/2011 | 12/15/1991 | 5673 | Great  Trucks | CityCoach2 | 62 | 4/12/2015 | 4/11/2016 |
| 2343 | Pat | Moore | 2/24/1982 | 1/19/1958 | 4323 | Power  Transport | MidiBus | 32 | 8/20/2015 | 8/19/2016 |

Table Name: DRIVER

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| RID | DID | ScheduleDate | ScheduledDepTime | ScheduledArrTime |
| 28 | **8273** | 9/12/2015 | 8.30 | 9.18 |
| 28 | **7234** | 9/12/2015 | 9.30 | 10.12 |
| 28 | **2343** | 9/12/2015 | 10.30 | 11.08 |

Table Name: Assignment

**Step 2: Reassign Corresponding Dependent Attributes**

ROUTE (**RID**, RStartPoint, REndPoint, RStandardDrivingTime)

DRIVER (**DID**, DFName, DLName, DateDJoinedCompany, DDOB, VID, VMake, VModel, VPassangerCapacity, DCertStartDate, DCertEndDate)

ASSIGNMENT (**RID**, **DID**, ScheduleDate, ScheduledDepTime, ScheduledArrTime)

**Conversion to Third Normal Form:**

**Step 1:  Make New Tables to Eliminate Transitive Dependencies**

|  |  |  |  |
| --- | --- | --- | --- |
| RID | RStartPoint | REndPoint | RStandardDrivingTime |
| 28 | Grand Avenue | Madison Street | 38 |

Table Name: ROUTE

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| DID | DFName | DLName | DateD  Joined  Company | DDOB | VID | DCert  StartDate | DCert  EndDate |
| 8273 | Mary | Smith | 5/2/2007 | 3/23/1974 | 1123 | 6/10/2015 | 6/9/2016 |
| 7234 | John | Jones | 10/12/2011 | 12/15/1991 | 5673 | 4/12/2015 | 4/11/2016 |
| 2343 | Pat | Moore | 2/24/1982 | 1/19/1958 | 4323 | 8/20/2015 | 8/19/2016 |

Table Name: DRIVER

|  |  |  |  |
| --- | --- | --- | --- |
| VID | VMake | VModel | VPassanger  Capacity |
| 1123 | Great  Trucks | CityCoach | 58 |
| 5673 | Great  Trucks | CityCoach2 | 62 |
| 4323 | Power  Transport | MidiBus | 32 |

Table Name: VEHICLE

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| RID | DID | ScheduleDate | ScheduledDepTime | ScheduledArrTime |
| 28 | **8273** | 9/12/2015 | 8.30 | 9.18 |
| 28 | **7234** | 9/12/2015 | 9.30 | 10.12 |
| 28 | **2343** | 9/12/2015 | 10.30 | 11.08 |

Table Name: ASSIGNMENT

**Step 2: Reassign Corresponding Dependent Attributes**

ROUTE (**RID**, RStartPoint, REndPoint, RStandardDrivingTime)

DRIVER (**DID**, DFName, DLName, DateDJoinedCompany, DDOB, VID, DCertStartDate, DCertEndDate)

VEHICLE (VID, VMake, VModel, VPassangerCapacity)

ASSIGNMENT (**RID**, **DID**, ScheduleDate, ScheduledDepTime, ScheduledArrTime)

**Question#6**

**Solution:**

1. **Identify the functional dependencies that exist between the columns of the table and identify the primary key and any alternate key(s) (if present) for the table.**

**Functional Dependencies:**

**(leaseNo** 🡪 bannerID, placeNo, fNAME, lName, startDate, finishDate, flatNo, flatAddress)

**Transitive Dependencies:**

(**bannerID** 🡪 fNAME, lName)

(**placeNo** 🡪 flatNo)

(**flatNo** 🡪 flatAddress)

**Primary Key:**

**leaseNo** is the primary Key.

**Alternate Key:**

There is no alternate Key.

1. **Describe why the table in Figure 14.23 is not in 3NF.**

If there occurs any transitive dependency, then table is not in 3rd Normal Form.

In given table, there are three transitive dependencies:

(**bannerID** 🡪 fNAME, lName)

(**placeNo** 🡪 flatNo)

(**flatNo** 🡪 flatAddress)

So, table is not in 3rd Normal Form.

1. **The table shown in Figure 14.23 is susceptible to update anomalies. Provide examples of how insertion, deletion, and modification anomalies could occur on this table.**

**Anomalies**

* **Update Anomalies:**

1. If we change fName, lName then it will make changes in all Table with their respective bannerID.
2. If we change flatAddress then it will make changes in all Table with their respective flatNo.

* **Insertion Anomalies:**

1. If we insert flatNo, then there will be no placeNo to associate with flatNo.
2. If we insert placeNo, then there will be no bannerID to associate with placeNo.

* **Deletion Anomalies:**

1. If we delete bannerID, then we can’t retrieve fName, lName.
2. If we delete placeNo, then we can’t retrieve flatNo.
3. If we delete flatNo, then we can’t retrieve flatAddress.

**Question#7**

**Consider the relation R (V, W, X, Y, Z) with functional dependencies**

**F = {Z 🡪 Y, Y 🡪 Z, X 🡪 Y, X 🡪 V, VW 🡪 X}.**

1. **Find the X-closure of all the attributes V, W, X, Y and Z**

W+ = W

V+ = V

X+ = VXYZ

Y+ = YZ

Z+ = YZ

1. **Find all candidate keys.**

VW+ = VWXYZ

XW+ = VWXYZ

Candidate Key = {VW, XW}

**Question#8**

**You are given the below functional dependencies for relation R (A, B, C, D, E)**

**F = {AB🡪 C, AB 🡪 D, D 🡪 A, BC 🡪 D, BC 🡪 E}.**

1. **Find all candidate keys.**

B+ = B

AB+ = ABCDE

CB+ = ABCDE

DB+ = ABCDE

EB+ = BE

Candidate Key = {AB, CB, DB}

1. **Identify the best normal form that R satisfies (1NF, 2NF, 3NF, or BCNF).**

3NF

1. **Is this relation in BCNF? If not, show all dependencies that violate it.**

No, it’s not in BCNF.

F = {D 🡪 A}

1. **Is this relation in 3NF? If not, show all dependencies that violate it.**

Yes, it’s in 3NF.

**Question#9**

**You are given the below set of functional dependencies for a relation R (A, B, C, D, E, F, G)**

**F = {AD** 🡪 **BF, CD** 🡪 **EGC, BD** 🡪 **F, E** 🡪 **D, F** 🡪 **C, D** 🡪 **F}.**

1. **Find all candidate keys.**

A+ = A Using Reflexive Property

B+ = B Using Reflexive Property

C+ = C Using Reflexive Property

D+ = CDEFG Using Reflexive Property, F = {D 🡪 F, F 🡪 C, CD🡪EGC}

E+ = CDEFG Using Reflexive Property, F = {E🡪D, D 🡪 F, F 🡪 C, CD🡪EGC}

F+ = CF Using Reflexive Property, F = {F 🡪 C}

G+ = G Using Reflexive Property

AD+ = ABCDEFG (Candidate Key)

CD+ = CDEFG Using Reflexive Property, F = {CD🡪EGC}

BD+ = BCDEFG Using Reflexive Property, F = {BD🡪F, F 🡪 C, CD🡪EGC}

AE+ = ABCDEFG (Candidate Key)

Candidate Key = {AD, AE}

1. **Find F-closure.**

Reflexivity: A → A, B → B, C → C, D → D, E → E, F → F, G → G**, AD → AD**

Decomposition: AD → BF implies **AD → B** and **AD → F**

Transitivity: AD → F and F → C implies **AD → C**

Union: AD → AD, AD → B, AD → F and AD → C implies **AD → ABCDF**

Transitivity: AD → CD and CD → EGC implies **AD → EGC**

It concludes that AD → ABCDEFG and hence **AD** is a key.

E → D implies that AE → ABCDE and hence **AE** is also a key.

1. **Find the minimal cover for the above set of functional dependencies**

F = {AD🡪B, D🡪E, D🡪F, D🡪G, E🡪D, F🡪C}