phone (Sc_phone), permanent address (Sp_addr) and phone (Sp_phone), birth date (Bdate), sex (Sex), class (Class) ('freshman', 'sophomore', ... , 'graduate'), major department (Major_code), minor department (Minor_code) (if any), and degree program (Prog) ('b.a.', 'b.s.', ... , 'ph.d.'). Both Ssn and student number have unique values for each student.

b. Each department is described by a name (Dname), department code (Dcode), office number (Doffice), office phone (Dphone), and college (Dcollege). Both name and code have unique values for each department.

c. Each course has a course name (Cname), description (Cdesc), course number (Cnum), number of semester hours (Credit), level (Level), and offering department (Cdept). The course number is unique for each course.

d. Each section has an instructor (Iname), semester (Semester), year (Year), course (Sec_course), and section number (Sec_num). The section number distinguishes different sections of the same course that are taught during the same semester/year; its values are 1, 2, 3, ..., up to the total number of sections taught during each semester.

e. A grade record refers to a student (Ssn), a particular section, and a grade (Grade).

Design a relational database schema for this database application. First show all the functional dependencies that should hold among the attributes. Then design relation schemas for the database that are each in 3NF or BCNF. Specify the key attributes of each relation. Note any unspecified requirements, and make appropriate assumptions to render the specification complete.

15.20. What update anomalies occur in the EMP_PROJ and EMP_DEPT relations of Figures 15.3 and 15.4?

15.21. In what normal form is the LOTS relation schema in Figure 15.12(a) with respect to the restrictive interpretations of normal form that take *only the primary key* into account? Would it be in the same normal form if the general definitions of normal form were used?

15.22. Prove that any relation schema with two attributes is in BCNF.

15.23. Why do spurious tuples occur in the result of joining the EMP_PROJ1 and EMP_ LOCS relations in Figure 15.5 (result shown in Figure 15.6)?

15.24. Consider the universal relation $R = \{A, B, C, D, E, F, G, H, I, J\}$ and the set of functional dependencies $F = \{ \{A, B\} \rightarrow \{C\}, \{A\} \rightarrow \{D, E\}, \{B\} \rightarrow \{F\}, \{F\} \rightarrow \{G, H\}, \{D\} \rightarrow \{I, J\} \}$. What is the key for R? Decompose R into 2NF and then 3NF relations.

15.25. Repeat Exercise 15.24 for the following different set of functional dependencies $G = \{\{A, B\} \rightarrow \{C\}, \{B, D\} \rightarrow \{E, F\}, \{A, D\} \rightarrow \{G, H\}, \{A\} \rightarrow \{I\}, \{H\} \rightarrow \{J\} \}$.

15.26. Consider the following relation:

A	B	C	TUPLE#
10	b1	c1	1
10	b2	c2	2
11	b4	c1	3
12	b3	c4	4
13	b1	c1	5
14	b3	c4	6

a. Given the previous extension (state), which of the following dependencies *may hold* in the above relation? If the dependency cannot hold, explain why *by specifying the tuples that cause the violation.*

i. $A \rightarrow B$, ii. $B \rightarrow C$, iii. $C \rightarrow B$, iv. $B \rightarrow A$, v. $C \rightarrow A$

b. Does the above relation have a potential candidate key? If it does, what is it? If it does not, why not?

15.27. Consider a relation $R(A, B, C, D, E)$ with the following dependencies:

$AB \rightarrow C$, $CD \rightarrow E$, $DE \rightarrow B$

Is AB a candidate key of this relation? If not, is ABD? Explain your answer.

15.28. Consider the relation R, which has attributes that hold schedules of courses and sections at a university; R = {Course_no, Sec_no, Offering_dept, Credit_hours, Course_level, Instructor_ssn, Semester, Year, Days_hours, Room_no, No_of_students}. Suppose that the following functional dependencies hold on R:

{Course_no} → {Offering_dept, Credit_hours, Course_level}
{Course_no, Sec_no, Semester, Year} → {Days_hours, Room_no, No_of_students, Instructor_ssn}
{Room_no, Days_hours, Semester, Year} → {Instructor_ssn, Course_no, Sec_no}

Try to determine which sets of attributes form keys of R. How would you normalize this relation?

15.29. Consider the following relations for an order-processing application database at ABC, Inc.

ORDER (O#, Odate, Cust#, Total_amount)
ORDER_ITEM(O#, I#, Qty_ordered, Total_price, Discount%)

Assume that each item has a different discount. The Total_price refers to one item, Odate is the date on which the order was placed, and the Total_amount is the amount of the order. If we apply a natural join on the relations ORDER_ITEM and ORDER in this database, what does the resulting relation schema look like? What will be its key? Show the FDs in this resulting relation. Is it in 2NF? Is it in 3NF? Why or why not? (State assumptions, if you make any.)