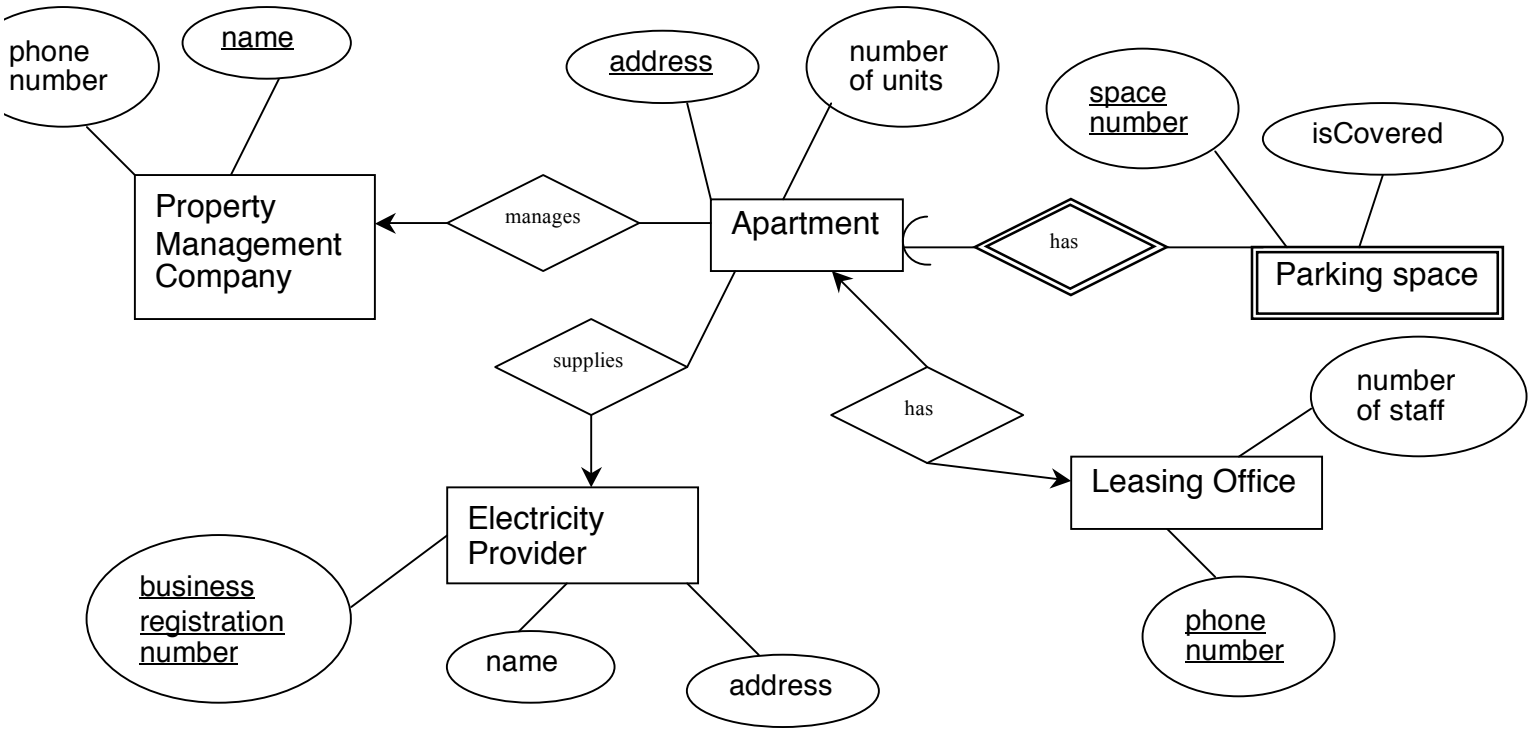
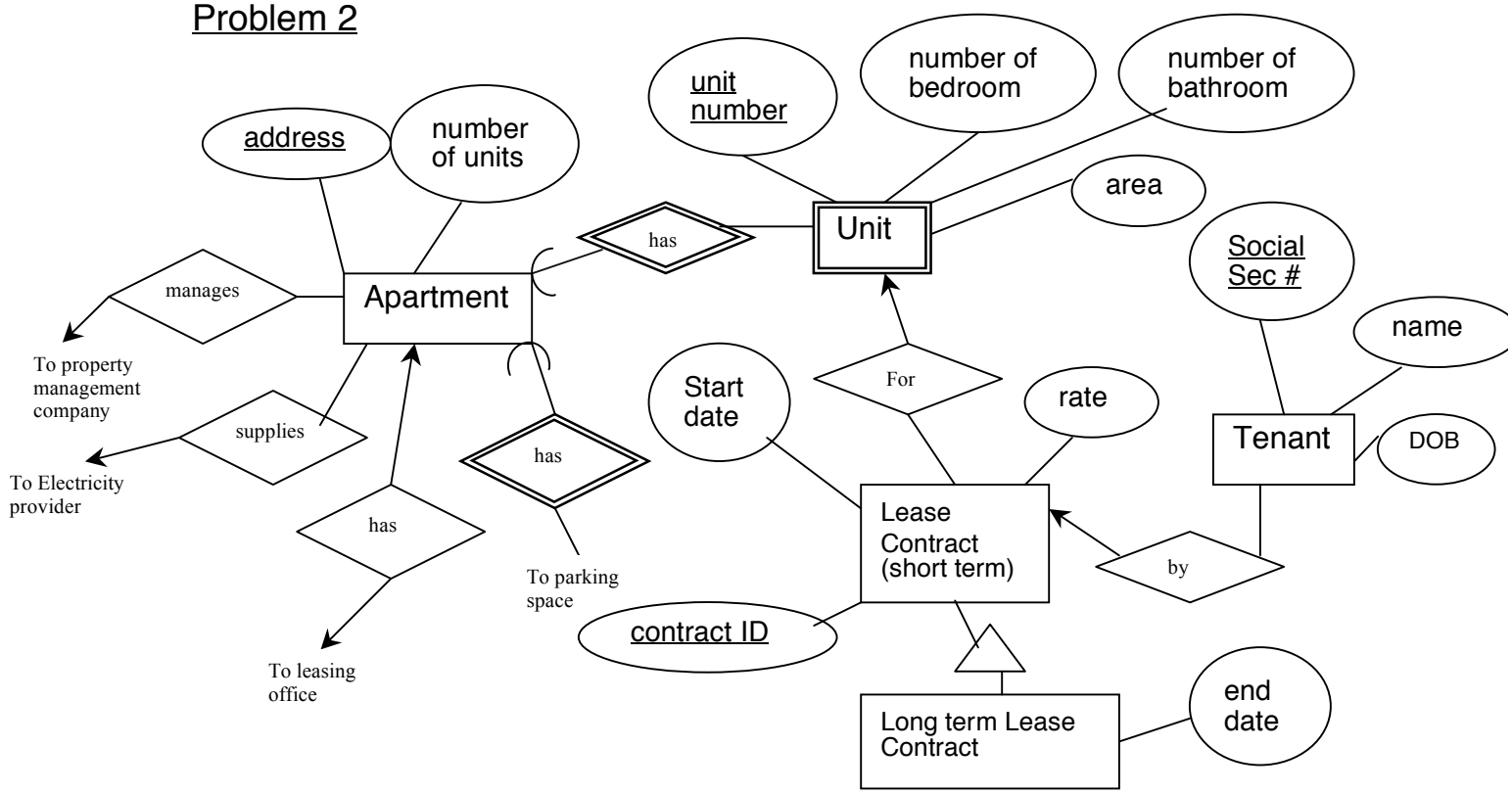
Problem 1



Problem 2



Problem 3

a) Convert the E/R diagram of Problem 1 to a relational database schema. Don't forget to indicate the keys (by underlining them) for each relation. Note that you don't need to combine the relations for removing duplications in this problem. (4 points)

ANSWER:

Property Management Company(name, phone number)
Apartment(address, company name, electricity provider reg num, number of units, leasing office phone number, leasing office number of staff)
Parking space(apartment address, space number, isCovered)
Electricity Provider(Business reg num, name, address)

b) Convert the Leasing contract, long term contract, and monthly contract (Note you may use different names other than ones given here, as long as you make it clear for graders to understand) relationships in Problem 2 into relational schema, using the following three approaches: 1. ER approach, 2. Object oriented approach, 3. and Null approach. (6 points, 2 points for each approach)

ANSWER:

ER approach:
Short term lease contract(contract ID, rate, start date)
Long term lease contract(contract ID, end date)

OO approach:
Short term lease contract(contract ID, rate, start date)
Long term lease contract(contract ID, rate, start date, end date)

Null approach:
Lease contract(contract ID, rate, start date, end date)

Problem 4 Basic Concepts of Keys (25 points, part b 10 and other parts 5 points)

a) Given a relation R, explain how you can use the closure to test if a subset of attributes A_1, A_2, ..., A_n is a candidate key for R.

ANSWER: By first checking that the closure of A_1, A_2, ..., A_n (i.e. { A_1, A_2, ..., A_n}+ is all attributes of the relation R, and then checking that no subset of A_1, A_2, ..., A_n is all attributes of R.

b) Suppose R is a relation with attributes A_1, A_2, ..., A_n. As a function of n, tell how many superkeys R has, if
(1) the only keys are A_1 and A_2, and

ANSWER: Number of combinations of attributes that contains {A1}, {A2} or {A1,A2}: 3 * 2^{n-2}

c) Show that each of the following are not valid rules about FD's by giving example relations that satisfy the given FD's (following the "if") but not the FD that allegedly follows (after the "then"). Explain your answer and state any assumption you make.
1. If A → B then B → A
2. If AB → C then A → C or B → C

ANSWER:

1.

StudentID	Surname	First name
12335	Jones	James
56932	Jones	Bridget

Surname is functionally dependent on StudentID, but more than one student may share a same surname.

2.

SupplierID	ProdID	Quantity
1	4902	300
1	9088	10
2	4902	500

Multiple suppliers (of some product) may supply the same product with varying quantity. SupplierID and ProdID are both required to uniquely identify the quantity supplied.

d) Consider a relation with schema R(A,B,C,D) with functional dependencies (FD's): BC → A, AD → B, CD → B, AC → D.
Find all the candidate keys of R.

ANSWER: BC, CD, AC

Problem 5 Functional Dependency (20 points, 5 points each)

Consider a relation with schema R(A,B,C,D) and FDs AC → B, B → A, BD → C and D → A.
a) Describe the concept of Functional Dependency and Dependency-preserving decomposition.

ANSWER:

Functional dependency can be thought of as a generalization of the idea of a key for a relation. It states that if 2 tuples of a relation agrees on the attributes $A_1A_2…A_n$, then they must also agree on attributes $B_1B_2…B_n$, written $A_1A_2…A_n$ -> $B_1B_2…B_n$. Simply put, it means attributes $A_1A_2…A_n$ functionally determines attributes $B_1B_2…B_n$.

Dependency-preserving decomposition is a decomposition of a relation R into R1, R2…,Rn according to some FD where all FDs that hold on R also hold on all "sub-relations" R1, R2…,Rn.

b) Find the closures for subsets A, BD and BC respectively.
ANSWER:
{A}+ = {A}
{BD}+ = {ABCD}
{BC}+ = {ABC}

c) List all nontrivial FD's that follow from the given FD's.
ANS: BD -> A, CD -> A, CD -> B, CD -> AB, ABD -> C, BCD -> A, ACD -> B, BC -> A, BD -> AC

d) Find all the candidate keys for this relation (you don't need to list superkeys that are not keys). Explain your answer.
ANSWER: BD, CD since {B,D} and {C,D} are both minimal set of attributes whose closure contains all attributes {A,B,C,D,E}

Problem 6 Normalization and Schema Design (20 points, 5 points each)
Consider a relation R(A, B, C, D), with FDs AB → C , BC → D, CD → A.
a) Is R in BCNF? Explain why or why not.
ANSWER: No, R is not in BCNF since the functional dependency CD->A violates the condition; CD is not a superkey of R.

b) We are considering to decompose R into R1 (A, B, C) and R2 (A, C, D). Is this a lossless decomposition?
ANSWER: No.
Assume R has the following tuples to start with:

A	B	C	D
1	2	3	4
1	4	3	2

After decomposition, R1 and R2 will have the following tuples:

R1:

A	B	C
1	2	3
1	4	3

R2:

A	C	D
1	3	4
1	3	2

Joining R1+R2 results in R' as follows:

R':

A	B	C	D
1	2	3	4
1	2	3	2
1	4	3	4
1	4	3	2

Since R is not the same as R' (2nd and 3rd tuples are introduced after join), this decomposition is not lossless.

c) Provide the BCNF normal form for this relation
ANSWER:
Decomposing using CD->A
R1(ACD), R2(BCD)

d) Provide the 3rd normal form for this relation.
ANSWER: R(ABCD) is in 3NF