Question 1. [6 MARKS]

Consider the following database:

Q

D	E
33	44
12	44
25	30
33	30
20	18
96	30
30	20

R

D	G
12	18
25	30
96	11
20	12
33	33
44	8

Give the result (schema and data) returned by the following queries. Use the same tabular format as above; do **not** describe the result in English.

Part (a) [2 MARKS]

$Answer(D, G) := \Pi_{R2.D,R2.G}(\sigma_{R1.G>R2.G}(\rho_{R1}(R) \times \rho_{R2}(R)))$

Solution:

D	G
12	18
25	30
96	11
20	12
44	8

Part (b) [2 MARKS]

$\Pi_E Q - \Pi_E([(\Pi_D \sigma_{G>22} R) \times \Pi_E Q] - Q)$

Solution:

E
30

Part (c) [2 MARKS]

$\Pi_{Q1.D,Q3.D}(\sigma_{Q1.E=Q2.D \wedge Q2.E=Q3.D}(\rho_{Q1}(Q) \times \rho_{Q2}(Q) \times \rho_{Q3}(Q)))$

Solution:

Q1.D	Q3.D
25	20
33	20
96	20

Question 2. [8 MARKS]

This question is about schools and robotics teams. A team can give their robot a task and earn a score for how well it performs. Each score is earned by a team alone, rather than be two teams competing against each other. The following schema attempts to represent this sort of information:

Team(tID, school, city). Each tuple records the team ID, school name and city name of a team.

MemberOf(player, team). Each tuple indicates that a given player is a member of a given team.

Score(tID, score, date). Each tuple indicates that a given team earned a given score on a given date.

MemberOf[team] $\subseteq$ Team[tID]

Score[tID] $\subseteq$ Team[tID]

Part (a) [6 MARKS]

Which of the following statements are true according to the schema? Circle one answer for each. **Do not guess.** There is 1 point for each correct answer, -1 for each incorrect answer, and 0 points if you leave the answer blank. Your minimum mark for part (a) is 0.

Solutions:

1. Score[tID] $\subseteq$ Team[tID] is a foreign key constraint.
   [True] False
2. tID is a key for relation Score.
   True [False]
3. A school name can be associated with more than one team ID.
   [True] False
4. A player cannot be a member of two teams.
   True [False]
5. A team cannot have two scores on the same date.
   True [False]
6. A team can have more than one member.
   [True] False

Part (b) [2 MARKS]

Using one of the two forms defined in the texbook, write an integrity constraint to enforce the following: Every team that has earned a score has at least one member.

Solution:

$\Pi_{tID}Score \subseteq \Pi_{team}MemberOf$

Question 3. [12 MARKS]

Using the same schema as question 2, write the following queries. Use only the basic Relational Algebra operators $\Pi, \sigma, \bowtie, \times, \cap, \cup, -, \rho$. Assume the set semantics (not bag semantics) for Relational Algebra.

1. Find the team ID and city of every team that has at least two team members and has never scored over 500.

   Solution:

   $TwoPlus(tID) := \Pi_{M1.team}(\sigma_{M1.team=M2.team \wedge M1.player \neq M2.player}((\rho_{M1} Mem) \times (\rho_{M2} Mem)))$
   $Over500 := \Pi_{tID}(\sigma_{score>500} Score)$
   $Answer := \sigma_{tID,city}((TwoPlus - Over500) \bowtie Team)$

2. Find the team ID of the team or teams with the second-highest score. If there are multiple teams with that score, report them all. For example, if the scores, in descending order are 590, 590, 588, 588, 588, 567, 540, you should report all the teams who scored 588.

   Solution:

   $NotFirst := \Pi_{S1.score}(\sigma_{S1.score<s2.score}((\rho_{S1} Score) \times (\rho_{S2} Score)))$
   $NotSecond := \Pi_{NF1.score}(\sigma_{NF1.score<NF2.score}((\rho_{NF1} NotFirst) \times (\rho_{NF2} NotFirst)))$
   $Second := NotFirst - NotSecond$
   $Answer := \Pi_{tID}(Second \bowtie Score)$

Question 4. [4 MARKS]

Part (a) [2 MARKS]

Suppose relation R contains the following:

A	B	C
1	5	10
4	4	15
2	8	12
3	4	90
1	1	33
3	3	21

Show the result of the following SQL query:

```
SELECT A*5 as X, B
FROM R
WHERE A = B;
```

Solution:

X	B
20	4
5	1
15	3

Part (b) [2 MARKS]

Suppose that

- X has the value NULL
- Y has the value 13

Fill in the table below to show the value of each of the expressions.

Solution:

`(Y = 13) AND (X < 10)`	Unknown
`(NOT(X > 5)) AND (NOT(Y < 20))`	False