Part II: Attempt all questions [70 pts].

Database Context:

1. Consider the following database schema (**R_S_U**) to answer the following questions.

Relation, R

A	B	C	D
cat	1	10	Red
cat	1	20	Blue
dog	1	30	Green
dog	1	40	Green
bat	1	50	Blue
bat	1	60	Blue
bird	1	70	red

Relation, S

C	E	F
20	male	1
20	male	2
60	female	3
10	male	4
20	male	5

Relation, U

F	G
1	P001
1	P002
5	P003

Metadata table

attributes	Sizes (in bytes)
A	10 bytes
B	4 bytes
C	4 bytes
D	20 bytes
E	20 bytes
F	4 bytes
G	8 bytes

Estimate the result sizes of the queries (Q1 to Q5) below: (**Assume** A = 10 bytes of String; B = 4 bytes of integer; C = 4 bytes of integer; D = 20 bytes of String; E = 20 bytes of String; F= 4 bytes of integer; G = 8 bytes of String - as shown in the metadata table).

   a. Q1 = $\pi_{A, B}$ (R) **[5 pts]**

b. Q2 = $\sigma_{A \neq 10}$(R) **[5 pts]**

correction

$C \mathrel{!=} 10$

c. Q3 = $\sigma_{A \neq 10 \vee B > 5}$ (R) **[5 pts]**

correction

$C \mathrel{!=} 10 \vee B > 5$
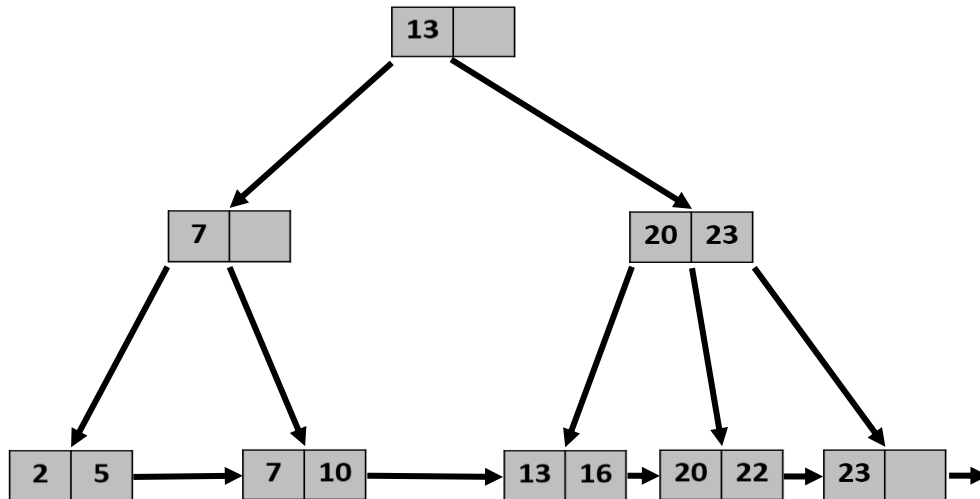
d. Q4 = R ⋈ S **[5 pts]**

e. Q5 = R ⋈ S ⋈ U **[5 pts]**

2. Suppose each B+-tree node can hold up to two (2) keys. Draw the B+-trees that would result after insertion (a) and deletion (b) operations as shown below.

(a)   Insertion [5 pts]
First, insert **6**. Then, insert **21** [Show individual trees at each insertion].

(b)   Deletion: Use the tree after inserting 21 in part (a) [15 pts]
First, delete **13**; then delete **16**; next, delete **20**; after that, delete **23**; and finally, delete **7**
[Show individual trees at each deletion].

[cont'd: Show individual trees at each deletion].

3. Consider the following schedules **(S1, S2 and S3)** with two transactions **T1** and **T2** as shown below.

Schedule 1 (S1)

Instructions	T1	T2
1	Read (A);	
2	A:= A + 10;	
3	Write (A);	
4	Read (B);	
5	B:= B + 10;	
6	Write(B);	
7		Read (A);
8		A:= A*2;
9		Write (A);
10		Read(B);
11		B:= B*2;
12	Commit1	Write (B);
13		Commit2

Schedule 2 (S2)

Instructions	T1	T2
1	Read (A);	
2	A:= A + 10;	
3	Write (A);	
4		Read (A);
5		A:= A*2;
6		Write (A);
7	Read (B);	
8	B:= B + 10;	
9	Write(B);	
10		Read(B);
11		B:= B*2;
12	Commit1	Write (B);
13		Commit2

Schedule 3 (S3)

Instructions	T1	T2
1	Read (A);	
2	A:= A + 10;	
3	Write (A);	
4		Read (A);
5		A:= A*2;
6		Write (A);
7		Read (B);
8		B:= B*2;
9		Write (B);
10	Read (B);	
11	B:= B + 10;	
12	Write(B);	Commit2
13	Commit1	

a. Are S2 and S3 serializable schedules? Please explain along with any form of evidence or proof. ***Assume an initial value: A = 100 + x, B = 100 + x*** [8 pts]

b.   Is schedule S3 recoverable? Explain **[5 pts].**

4. Check whether schedule S is conflict serializable or not. If S is conflict serializable, give all possible schedules equivalent to Schedule S **[12 pts]**

Schedule S: R1(A), W1(A), R3(B), W3(B), R2(A), W2(A), R5(A), R4(B), W4(B), R5(B), W5(A), W5(B).