IS 503
Assignment #4
Deadline: January 5, 2020 23:59

1. Consider the schedules S1, S2, S3, and S4 below. State whether each schedule is strict, cascadeless, and recoverable. Explain your reasons by referring to the lecture notes. (15*3 points)
    a. S1: R3(D); R3(B); R1(C); R2(C); R2(A); R4(D); R1(C); W1(C); W4(C); R3(D); C2; A4; C3; A1;

T1	T2	T3	T4
		R3(D)	
		R3(B)	
R1(C)			
	R2(C)		
	R2(A)		
			R4(D)
R1(C)			
W1(C)			
			W4(C)
		R3(D)	
	C2		
			A4
		C3	
A1			

It is recoverable since every commit that has a read operation is committed after the item that is read was written and committed before. It is cascadeless since every transaction reads items that are written in committed transactions. It is not strict since T4 writes on C after T1 writes on C, but T4 commits before T1.

    b. S2: R1(A); W3(C); R4(A); R4(C); W1(B); R4(C); W2(B); R2(A); W1(B); W4(B); R4(C); R1(C); C3; C1; C4; C2;

T1	T2	T3	T4

R1(A)			
		W3(C)	
			R4(A)
			R4(C)
W1(B)			
			R4(C)
	W2(B)		
	R2(A)		
W1(B)			
			W4(B)
			R4(C)
R1(C)			
		C3	
C1			
			C4
	C2		

It is recoverable since every commit that has a read operation is committed after the item that is read was written and committed before. It is not cascadeless since T1 reads C which was updated by T3 before T3 commits. Since it is not cascadeless, it is not strict as well.

c. S3: R2(C); R3(B); R3(C); R2(A); W4(A); R3(D); W4(C); R2(D); R4(B); R3(B); R4(C); R4(D); W1(D); C2; R4(B); R3(B); R1(B); W1(D); C1; W3(D); R4(B); C4; R3(C); C3;

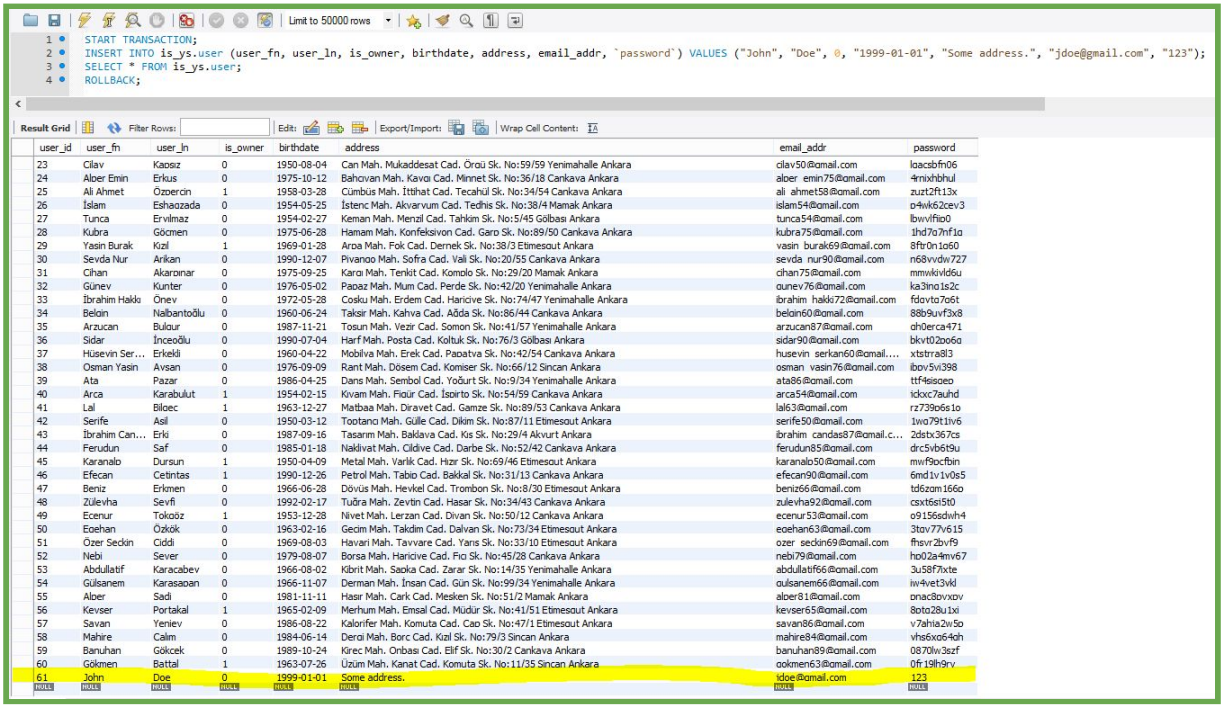
T1	**T2**	**T3**	**T4**
	R2(C)		
		R3(B)	
		R3(C)	
	R2(A)		
			W4(A)
		R3(D)	

			W4(C)
	R2(D)		
			R4(B)
		R3(B)	
			R4(C)
			R4(D)
W1(D)			
	C2		
			R4(B)
		R3(B)	
R1(B)			
W1(D)			
C1			
		W3(D)	
			R4(B)
			C4
		R3(C)	
		C3	

It is recoverable since every commit that has a read operation is committed after the item that is read was written and committed before. It is cascadeless since every transaction reads items that are written in committed transactions. It is strict since no transaction reads or updates something that was updated by another transaction before that transaction commits.

2. While database management systems automatically handle transactions for us, we can manually create transactions and observe these concurrency problems. Follow the instructions below and observe how a phantom read occurs. You are supposed to use the database you created in your second assignment. (15 points)
    - Open MySQL Workbench, if you had not imported the previously provided schema (is_ys), import it.
    - Open a new SQL tab.
    - Start your transaction with “START TRANSACTION;” since we want to do it manually. You do not need to set the autocommit feature off since this statement temporarily turns it off (after a commit or rollback, it turns back to the automatic mode).
    - Write an insert query with the user table to create add a new user.

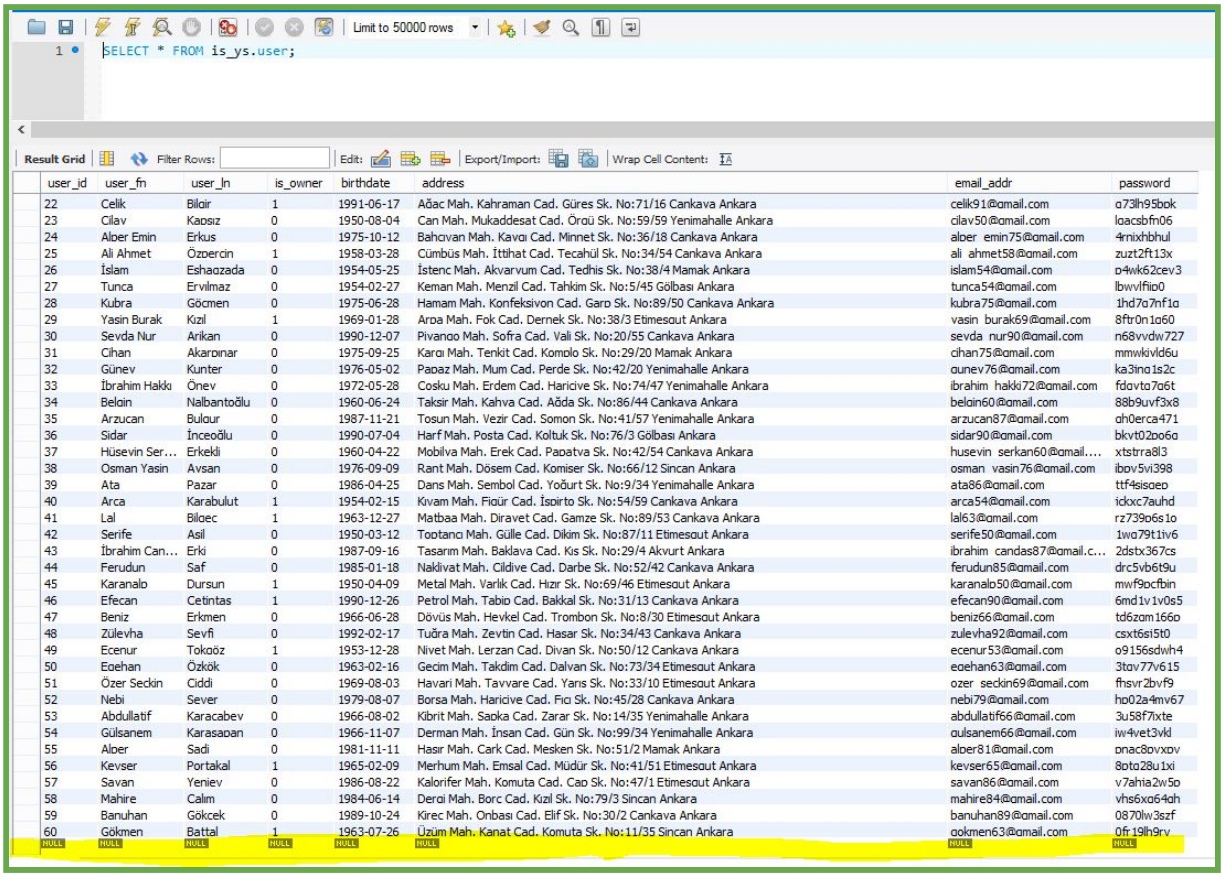
- Write a query to select all users.
- Finally, end your transaction with a rollback (“ROLLBACK;”).
- Notice that since we rollback our transaction, nothing should change in the user table. Run this transaction. It should retrieve the users. Here, check the row you inserted. Although you did not commit, you should still see that your table has a new row. You are looking at a version of your table that never existed. Take a screenshot that features your query tab and the retrieved table. Highlight the row that looks inserted.
- Open another SQL tab, select the user table here as well. Notice that this table does not feature the new row since you did not commit. Take a screenshot of this version as well, and highlight how it differs from your previously retrieved table.
- Briefly explain what do transactions, commit, and rollback do.



```
START TRANSACTION;
INSERT INTO is_ys.user (user_fn, user_ln, is_owner, birthdate, address, email_addr, `password`) VALUES ("John", "Doe", 0, "1999-01-01", "Some address.", "jdoe@gmail.com", "123");
SELECT * FROM is_ys.user;
ROLLBACK;
```

Result Grid

user_id	user_fn	user_ln	is_owner	birthdate	address	email_addr	password
23	Cilav	Kaosız	0	1950-08-04	Can Mah. Mukaddesat Cad. Örgü Sk. No:59/59 Yenimahalle Ankara	cilav50@gmail.com	loacsbfn06
24	Alper Emin	Erkus	0	1975-10-12	Bahcıvan Mah. Kavgı Cad. Minnet Sk. No:36/18 Cankaya Ankara	alper_emin75@gmail.com	4rnixhbhul
25	Ali Ahmet	Özpercin	1	1958-03-28	Cümbüs Mah. İttihat Cad. Tecahül Sk. No:34/54 Cankaya Ankara	ali_ahmet58@gmail.com	zuzt2ft13x
26	İslam	Eshaqzada	0	1954-05-25	İstenc Mah. Akvarvum Cad. Tedhis Sk. No:38/4 Mamak Ankara	islam54@gmail.com	p4wk62cev3
27	Tunca	Ervılmaz	0	1954-02-27	Keman Mah. Menzil Cad. Tahkim Sk. No:5/45 Gölbası Ankara	tunca54@gmail.com	lbwvlfiip0
28	Kubra	Göcmen	0	1975-06-28	Hamam Mah. Konfeksıvon Cad. Garp Sk. No:89/50 Cankaya Ankara	kubra75@gmail.com	1hd7a7nf1q
29	Yasin Burak	Kızıl	1	1969-01-28	Arpa Mah. Fok Cad. Dernek Sk. No:38/3 Etimesgut Ankara	yasin_burak69@gmail.com	8ftr0n1o60
30	Sevda Nur	Arıkan	0	1990-12-07	Pivanoo Mah. Sofra Cad. Vali Sk. No:20/55 Cankaya Ankara	sevda_nur90@gmail.com	n68vvdw727
31	Cihan	Akarpınar	0	1975-09-25	Karqı Mah. Tenkit Cad. Komolo Sk. No:29/20 Mamak Ankara	cihan75@gmail.com	mmwkivld6u
32	Günev	Kunter	0	1976-05-02	Papaz Mah. Mum Cad. Perde Sk. No:42/20 Yenimahalle Ankara	gunev76@gmail.com	ka3inq1s2c
33	İbrahim Hakkı	Önev	0	1972-05-28	Cosku Mah. Erdem Cad. Haricive Sk. No:74/47 Yenimahalle Ankara	ibrahim_hakki72@gmail.com	fdovta7o6t
34	Belgin	Nalbantoğlu	0	1960-06-24	Taksir Mah. Kahva Cad. Ağda Sk. No:86/44 Cankaya Ankara	belgin60@gmail.com	88b9uvf3x8
35	Arzucan	Bulgur	0	1987-11-21	Tosun Mah. Vezir Cad. Somon Sk. No:41/57 Yenimahalle Ankara	arzucan87@gmail.com	oh0erca471
36	Sidar	İnceoğlu	0	1990-07-04	Harf Mah. Posta Cad. Koltuk Sk. No:76/3 Gölbası Ankara	sidar90@gmail.com	bkvt02po6q
37	Hüsevin Ser…	Erkekli	0	1960-04-22	Mobilva Mah. Erek Cad. Papatva Sk. No:42/54 Cankaya Ankara	husevin_serkan60@gmail.…	xtstrra8l3
38	Osman Yasin	Avsan	0	1976-09-09	Rant Mah. Dösem Cad. Komiser Sk. No:66/12 Sincan Ankara	osman_yasin76@gmail.com	ibov5vi398
39	Ata	Pazar	0	1986-04-25	Dans Mah. Sembol Cad. Yoğurt Sk. No:9/34 Yenimahalle Ankara	ata86@gmail.com	ttf4sisoeo
40	Arca	Karabulut	1	1954-02-15	Kıvam Mah. Fıqür Cad. İspirto Sk. No:54/59 Cankaya Ankara	arca54@gmail.com	ickxc7auhd
41	Lal	Biloec	1	1963-12-27	Matbaa Mah. Diravet Cad. Gamze Sk. No:89/53 Cankaya Ankara	lal63@gmail.com	rz739o6s1o
42	Serife	Asil	0	1950-03-12	Toptancı Mah. Gülle Cad. Dikim Sk. No:87/11 Etimesgut Ankara	serife50@gmail.com	1wo79t1iv6
43	İbrahim Can…	Erki	0	1987-09-16	Tasarım Mah. Baklava Cad. Kıs Sk. No:29/4 Akvurt Ankara	ibrahim_candas87@gmail.c…	2dstx367cs
44	Ferudun	Saf	0	1985-01-18	Naklivat Mah. Cildive Cad. Darbe Sk. No:52/42 Cankaya Ankara	ferudun85@gmail.com	drc5vb6t9u
45	Karanalp	Dursun	1	1950-04-09	Metal Mah. Varlık Cad. Hızır Sk. No:69/46 Etimesgut Ankara	karanalp50@gmail.com	mwf9ocfbin
46	Efecan	Cetintas	1	1990-12-26	Petrol Mah. Tabip Cad. Bakkal Sk. No:31/13 Cankaya Ankara	efecan90@gmail.com	6md1v1v0s5
47	Beniz	Erkmen	0	1966-06-28	Dövüs Mah. Hevkel Cad. Trombon Sk. No:8/30 Etimesgut Ankara	beniz66@gmail.com	td6zam166o
48	Zülevha	Sevfi	0	1992-02-17	Tuğra Mah. Zevtin Cad. Hasar Sk. No:34/43 Cankaya Ankara	zulevha92@gmail.com	csxt6si5l0
49	Ecenur	Tokgöz	1	1953-12-28	Nivet Mah. Lerzan Cad. Divan Sk. No:50/12 Cankaya Ankara	ecenur53@gmail.com	o9156sdwh4
50	Eqehan	Özkök	0	1963-02-16	Gecim Mah. Takdim Cad. Dalvan Sk. No:73/34 Etimesgut Ankara	eqehan63@gmail.com	3tqv77v615
51	Özer Seckin	Ciddi	0	1969-08-03	Havari Mah. Tavvare Cad. Yarı Sk. No:33/10 Etimesgut Ankara	ozer_seckin69@gmail.com	fhsvr2bvf9
52	Nebi	Sever	0	1979-08-07	Borsa Mah. Haricive Cad. Fıq Sk. No:45/28 Cankaya Ankara	nebi79@gmail.com	hp02a4mv67
53	Abdullatif	Karacabev	0	1966-08-02	Kibrit Mah. Sapka Cad. Zarar Sk. No:14/35 Yenimahalle Ankara	abdullatif66@gmail.com	3u58f7ixte
54	Gülsanem	Karasapan	0	1966-11-07	Derman Mah. İnsan Cad. Gün Sk. No:99/34 Yenimahalle Ankara	gulsanem66@gmail.com	iw4vet3vkl
55	Alper	Sadi	0	1981-11-11	Hasır Mah. Cark Cad. Mesken Sk. No:51/2 Mamak Ankara	alper81@gmail.com	pnac8pvxpv
56	Kevser	Portakal	1	1965-02-09	Merhum Mah. Emsal Cad. Müdür Sk. No:41/51 Etimesgut Ankara	kevser65@gmail.com	8pta28u1xi
57	Savan	Yeniev	0	1986-08-22	Kalorifer Mah. Komuta Cad. Cap Sk. No:47/1 Etimesgut Ankara	savan86@gmail.com	v7ahia2w5p
58	Mahire	Calm	0	1984-06-14	Deroi Mah. Borc Cad. Kızıl Sk. No:79/3 Sincan Ankara	mahire84@gmail.com	vhs6xo64qh
59	Banuhan	Gökcek	0	1989-10-24	Kirec Mah. Onbası Cad. Elif Sk. No:30/2 Cankaya Ankara	banuhan89@gmail.com	0870lw3szf
60	Gökmen	Battal	1	1963-07-26	Üzüm Mah. Kanat Cad. Komuta Sk. No:11/35 Sincan Ankara	gokmen63@gmail.com	0fr19lh9rv
61	John	Doe	0	1999-01-01	Some address.	jdoe@gmail.com	123
NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL



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SELECT * FROM is_ys.user;
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user_id	user_fn	user_ln	is_owner	birthdate	address	email_addr	password
22	Celik	Bilgir	1	1991-06-17	Ağaç Mah. Kahraman Cad. Güres Sk. No:71/16 Cankaya Ankara	celik91@gmail.com	a73lh95bok
23	Cilav	Kapsız	0	1950-08-04	Can Mah. Mukaddesat Cad. Örgü Sk. No:59/59 Yenimahalle Ankara	cilav50@gmail.com	laacsbfn06
24	Alper Emin	Erkus	0	1975-10-12	Bahcıvan Mah. Kavaı Cad. Minnet Sk. No:36/18 Cankava Ankara	alper_emin75@gmail.com	4rnixhbhul
25	Ali Ahmet	Özpercin	1	1958-03-28	Cümbüs Mah. İttihat Cad. Tecahül Sk. No:34/54 Cankava Ankara	ali_ahmet58@gmail.com	zuzt2ft13x
26	İslam	Eshaqzada	0	1954-05-25	İstenc Mah. Akvarvum Cad. Tedhis Sk. No:38/4 Mamak Ankara	islam54@gmail.com	p4wk62cev3
27	Tunca	Ervilmaz	0	1954-02-27	Keman Mah. Menzil Cad. Tahkim Sk. No:5/45 Gölbası Ankara	tunca54@gmail.com	lbvvlfiip0
28	Kubra	Göcmen	0	1975-06-28	Hamam Mah. Konfeksivon Cad. Garp Sk. No:89/50 Cankava Ankara	kubra75@gmail.com	1hd7a7nf1a
29	Yasin Burak	Kızıl	1	1969-01-28	Arpa Mah. Fok Cad. Dernek Sk. No:38/3 Etimesgut Ankara	yasin_burak69@gmail.com	8ftr0n1a60
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31	Cihan	Akarpınar	0	1975-09-25	Karaı Mah. Tenkit Cad. Komplo Sk. No:29/20 Mamak Ankara	cihan75@gmail.com	mmwkivld6u
32	Günev	Kunter	0	1976-05-02	Papaz Mah. Mum Cad. Perde Sk. No:42/20 Yenimahalle Ankara	gunev76@gmail.com	ka3ina1s2c
33	İbrahim Hakkı	Önev	0	1972-05-28	Cosku Mah. Erdem Cad. Haricive Sk. No:74/47 Yenimahalle Ankara	ibrahim_hakki72@gmail.com	fdavta7a6t
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35	Arzucan	Bulgur	0	1987-11-21	Tosun Mah. Vezir Cad. Somon Sk. No:41/57 Yenimahalle Ankara	arzucan87@gmail.com	ah0erca471
36	Sidar	İnceoğlu	0	1990-07-04	Harf Mah. Posta Cad. Koltuk Sk. No:76/3 Gölbası Ankara	sidar90@gmail.com	bkvt02po6a
37	Hüsevin Ser…	Erkekli	0	1960-04-22	Mobilva Mah. Erek Cad. Papatva Sk. No:42/54 Cankava Ankara	husevin_serkan60@gmail.…	xtstrra8l3
38	Osman Yasin	Avsan	0	1976-09-09	Rant Mah. Dösem Cad. Komiser Sk. No:66/12 Sincan Ankara	osman_vasin76@gmail.com	ibov5vi398
39	Ata	Pazar	0	1986-04-25	Dans Mah. Sembol Cad. Yoğurt Sk. No:9/34 Yenimahalle Ankara	ata86@gmail.com	ttf4sisaep
40	Arca	Karabulut	1	1954-02-15	Kıvam Mah. Figür Cad. İspirto Sk. No:54/59 Cankava Ankara	arca54@gmail.com	ickxc7auhd
41	Lal	Bilgec	1	1963-12-27	Matbaa Mah. Diravet Cad. Gamze Sk. No:89/53 Cankava Ankara	lal63@gmail.com	rz739p6s1o
42	Serife	Asil	0	1950-03-12	Tootancı Mah. Gülle Cad. Dikim Sk. No:87/11 Etimesgut Ankara	serife50@gmail.com	1wo79t1iv6
43	İbrahim Can…	Erki	0	1987-09-16	Tasarım Mah. Baklava Cad. Kıs Sk. No:29/4 Akvurt Ankara	ibrahim_candas87@gmail.c…	2dstx367cs
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45	Karanalp	Dursun	1	1950-04-09	Metal Mah. Varlık Cad. Hızır Sk. No:69/46 Etimesgut Ankara	karanalp50@gmail.com	mwf9ocfbin
46	Efecan	Cetintas	1	1990-12-26	Petrol Mah. Tabip Cad. Bakkal Sk. No:31/13 Cankava Ankara	efecan90@gmail.com	6md1v1v0s5
47	Beniz	Erkmen	0	1966-06-28	Dövüs Mah. Hevkel Cad. Trombon Sk. No:8/30 Etimesgut Ankara	beniz66@gmail.com	td6zam166o
48	Zülevha	Sevfi	0	1992-02-17	Tuğra Mah. Zevtin Cad. Hasar Sk. No:34/43 Cankava Ankara	zulevha92@gmail.com	csxt6si5t0
49	Ecenur	Tokgöz	1	1953-12-28	Nivet Mah. Lerzan Cad. Divan Sk. No:50/12 Cankava Ankara	ecenur53@gmail.com	o9156sdwh4
50	Egehan	Özkök	0	1963-02-16	Gecim Mah. Takdim Cad. Dalvan Sk. No:73/34 Etimesgut Ankara	egehan63@gmail.com	3tav77v615
51	Özer Seckin	Ciddi	0	1969-08-03	Havari Mah. Tavvare Cad. Yarıs Sk. No:33/10 Etimesgut Ankara	ozer_seckin69@gmail.com	fhsvr2bvf9
52	Nebi	Sever	0	1979-08-07	Borsa Mah. Haricive Cad. Fıcı Sk. No:45/28 Cankava Ankara	nebi79@gmail.com	hp02a4mv67
53	Abdullatif	Karacabey	0	1966-08-02	Kibrit Mah. Sapka Cad. Zarar Sk. No:14/35 Yenimahalle Ankara	abdullatif66@gmail.com	3u58f7ixte
54	Gülsanem	Karasapan	0	1966-11-07	Derman Mah. İnsan Cad. Gün Sk. No:99/34 Yenimahalle Ankara	gulsanem66@gmail.com	iw4vet3vkl
55	Alper	Sadi	0	1981-11-11	Hasır Mah. Cark Cad. Mesken Sk. No:51/2 Mamak Ankara	alper81@gmail.com	pnac8pvxpv
56	Kevser	Portakal	1	1965-02-09	Merhum Mah. Emsal Cad. Müdür Sk. No:41/51 Etimesgut Ankara	kevser65@gmail.com	8pta28u1xi
57	Savan	Yeniev	0	1986-08-22	Kalorifer Mah. Komuta Cad. Cap Sk. No:47/1 Etimesgut Ankara	savan86@gmail.com	v7ahia2w5o
58	Mahire	Calım	0	1984-06-14	Dergi Mah. Borc Cad. Kızıl Sk. No:79/3 Sincan Ankara	mahire84@gmail.com	vhs6xa64qh
59	Banuhan	Gökcek	0	1989-10-24	Kirec Mah. Onbası Cad. Elif Sk. No:30/2 Cankava Ankara	banuhan89@gmail.com	0870lw3szf
60	Gökmen	Battal	1	1963-07-26	Üzüm Mah. Kanat Cad. Komuta Sk. No:11/35 Sincan Ankara	gokmen63@gmail.com	0fr19lh9rv
NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL

- A transaction is a group of operations that has to be treated as a whole. If one operation fails, the other operations should fail as well, so that the data integrity is protected.
- Commit confirms your operations and saves the changes while rollback reverts the operations, achieving the last committed state of the database.

3. Consider the schedules S4, S5, and S6 below. State whether each schedule is conflict serializable and view serializable. Draw the precedence graph and show the related data items on arrows. If it is view serializable, show the equivalent serial schedule(s). Explain your reasons by referring to the lecture notes.
    a. S4: W2(A); W3(C); W2(D); R2(C); R1(B); R2(A); R1(D); R3(B); R1(C); R2(B); C3; C2; C1; (10 points)

T1	T2	T3
	W2(A)	
		W3(C)
	W2(D)	
	R2(C)	
R1(B)		
	R2(A)	
R1(D)		

		R3(B)
R1(C)		
	R2(B)	
		C3
	C2	
C1		

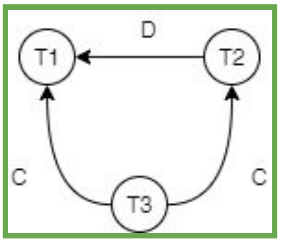
Candidate equivalent serial schedules:
~~T1→T2→T3~~
~~T1→T3→T2~~
~~T2→T3→T1~~
~~T2→T1→T3~~
~~T3→T1→T2~~
T3→T2→T1

Initial read:
-

Final write:
-

Update read:
T1 and T2 must read C after T3 writes on it, so T3 must come first.
T1 must read D after T2 writes on it.

It is view serializable. Its equivalent serial schedule is T3→T2→T1.



Since there is no cycle, it is conflict serializable as well, which confirms its view serializability.

b. S5: W1(C); R3(C); W1(A); R1(C); R3(B); W2(C); W2(B); R1(C); R2(B); R1(B); R3(C); C1; C3; C2; (12 points)

T1	**T2**	**T3**
W1(C)		

		R3(C)
W1(A)		
R1(C)		
		R3(B)
	W2(C)	
	W2(B)	
R1(C)		
	R2(B)	
R1(B)		
		R3(C)
C1		
		C3
	C2	

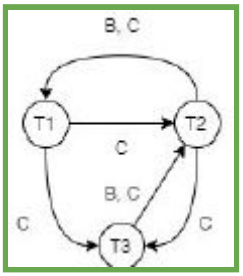
Candidate equivalent serial schedules:
~~T1→T2→T3~~
~~T1→T3→T2~~
~~T2→T3→T1~~
~~T2→T1→T3~~
~~T3→T1→T2~~
~~T3→T2→T1~~

Initial read:
T3 must read B before T2 writes on it, so T2 cannot come before T3.

Final write:
T2 must write on C after T1, so T1 cannot come before T2.

Update read:
T3 must read C after T1 writes on it, so T1 must come before T3.
T3 must read C after T2 writes on it, so T1 must come before T3.

These conditions eliminate all of our candidate equivalent schedules. Therefore, this schedule is not view serializable.



Since it is not view serializable and there are cycles in the graph, it is not conflict serializable either.

c. S6: R1(C); R2(D); R4(A); W1(C); R2(A); R3(B); R3(D); W1(C); W2(D); R1(A); R4(C); R3(A); W2(A); R4(A); R3(C); R2(A); W4(C); R4(A); C4; C2; C1; C3; (18 points)

T1	**T2**	**T3**	**T4**
R1(C)			
	R2(D)		
			R4(A)
W1(C)			
	R2(A)		
		R3(B)	
		R3(D)	
W1(C)			
	W2(D)		
R1(A)			
			R4(C)
		R3(A)	
	W2(A)		
			R4(A)
		R3(C)	
	R2(A)		
			W4(C)
			R4(A)
			C4

	C2		
C1			
		C3	

Candidate equivalent serial schedules:

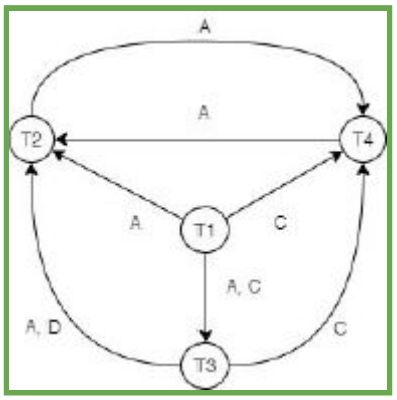
~~T1 → T2 → T3 → T4~~
~~T1 → T2 → T4 → T3~~
~~T1 → T3 → T2 → T4~~
~~T1 → T3 → T4 → T2~~
~~T1 → T4 → T2 → T3~~
~~T1 → T4 → T3 → T2~~
~~T2 → T1 → T3 → T4~~
~~T2 → T1 → T4 → T3~~
~~T2 → T3 → T1 → T4~~
~~T2 → T3 → T4 → T1~~
~~T2 → T4 → T1 → T3~~
~~T2 → T4 → T3 → T1~~
~~T3 → T1 → T2 → T4~~
~~T3 → T1 → T4 → T2~~
~~T3 → T4 → T1 → T2~~
~~T3 → T4 → T2 → T1~~
~~T3 → T2 → T1 → T4~~
~~T3 → T2 → T4 → T1~~
~~T4 → T1 → T2 → T3~~
~~T4 → T1 → T3 → T2~~
~~T4 → T2 → T3 → T1~~
~~T4 → T2 → T1 → T3~~
~~T4 → T3 → T1 → T2~~
~~T4 → T3 → T2 → T1~~

Initial read:
T1 must read C before T4 writes on it, so T4 cannot come before T1.
T4 must read D before T2 writes on it, so T2 cannot come before T4.
T4 must read A before T2 writes on it, so T2 cannot come before T4.

Final write:
T4 must write on C after T1, so T4 cannot come before T1.

Update read:
T4 must read C after T1 writes on it, so T4 cannot come before T1.
T3 must read C after T1 writes on it, so T3 cannot come before T1.
T4 must read A after T2 writes on it, so T4 cannot come before T2.

These conditions eliminate all of our candidate equivalent schedules. Therefore, this schedule is not view serializable.



Since it is not view serializable and there is a cycle, it is not conflict serializable either.