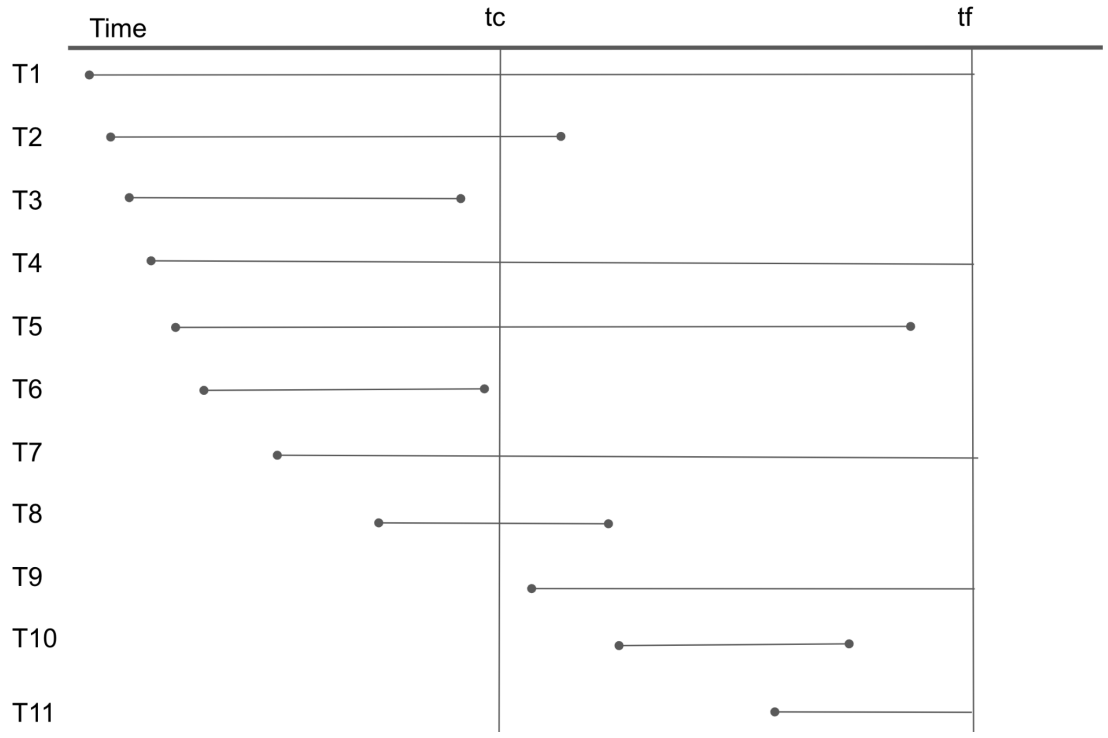
TASK 5: Transaction Theory (10 marks):

(a) A database has eleven transactions running as listed below (the time is shown horizontally from left to right):



At time *tc* a checkpoint is taken, at time *tf* the database fails due to a power outage. If the database is a **write through** database, three stages are involved in the recovery process when the database is restarted.

Use the diagram above to discuss what happens at each of the three stages and what transactions are involved.

Stage 1: Using the log compile REDO and UNDO lists

REDO List				UNDO List				
T2	T5	T8	T10	T1	T4	T7	T9	T11

Stage 2: UNDO incomplete or rolled back transactions starting from newest

T11	T9	T7	T4	T1

Stage 3: REDO committed transactions starting from oldest

T2	T5	T8	T10

(b) Given the following transaction sequence, copy and paste this sequence into your answer document and clearly indicate what locks are present at each of the indicated times (Time 0 to Time 34).

Cell entries must have the form:

- **S(Tn)** - for a shared lock by Tn,
- **X(Tn)** - for an exclusive lock by Tn or
- **Tn wait Tm** - for a wait of Tn due to Tm (where n and m are transaction numbers).

TIME	TRANS	ACTION	A	B	C	D	E	F	G	H
0	T1	Read A	S(T1)							
1	T2	Read B		S(T2)						
2	T1	Read C			S(T1)					
3	T4	Read D				S(T4)				
4	T5	Read A	S(T5)							
5	T2	Read E					S(T2)			
6	T2	Update E					X(T2)			
7	T3	Read F						S(T3)		
8	T2	Read F						S(T2)		
9	T5	Update A	T5 wait T1							
10	T1	Commit	X(T5)							
11	T6	Read A	T6 wait T5							
12	T5	Rollback	S(T6)							
13	T6	Read C			S(T6)					
14	T6	Update C			X(T6)					
15	T7	Read G							S(T7)	
16	T8	Read H								S(T8)
17	T9	Read G							S(T9)	
18	T9	Update G							T9 wait T7	
19	T8	Read E					T8 wait T2			
20	T7	Commit							X(T9)	
21	T9	Read H								S(T9)

22	**T3**	**Read G**							T3 wait T9	
23	**T10**	**Read A**	S(T10)							
24	**T9**	**Update H**								T9 wait T8
25	**T6**	**Commit**								
26	**T11**	**Read C**			S(T11)					
27	**T12**	**Read D**				S(T12)				
28	**T12**	**Read C**			S(T12)					
29	**T2**	**Update F**						T2 wait T3		
30	**T11**	**Update C**			T11 wait T12					
31	**T12**	**Read A**	S(T12)							
32	**T10**	**Update A**	T10 wait T12							
33	**T12**	**Update D**				T12 wait T4				
34	**T4**	**Read G**							T4 wait T9	

Complete the following:

(i) For **each** of the listed items A .. H, what wait states are present at time 34 (the last time listed). Shown the waits in the form:

Item A: T10 waiting on T12

Item B: No transaction waiting. Only have S(T2).

Item C: T11 waiting on T12

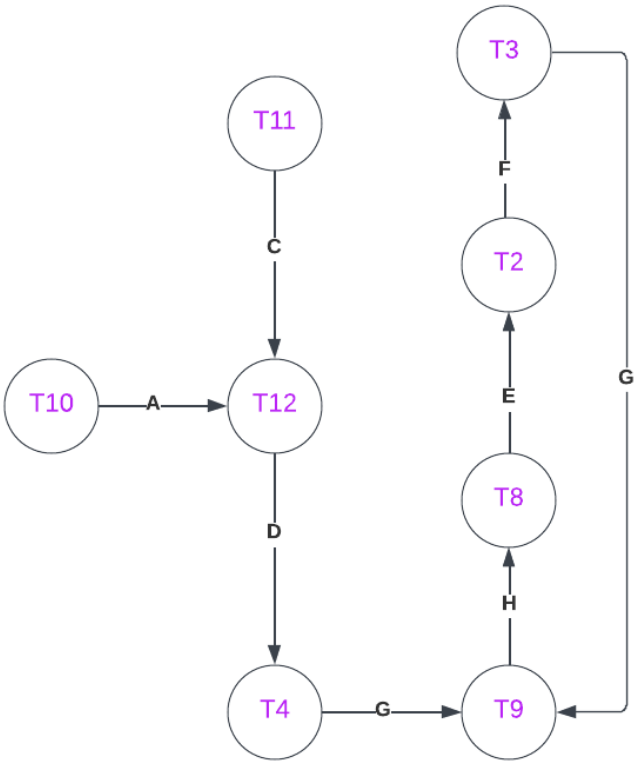
Item D: T12 waiting on T4

Item E: T8 waiting on T2

Item F: T2 waiting on T3

Item G: T3 and T4 waiting on T9

Item H: T9 waiting on T8



Deadlock exists.
T9 wait T8 (**Transaction 24**), T8 wait T2 (**Transaction 19**), T2 wait T3 (**Transaction 29**), T3 wait T9 (**Transaction 22**)

(ii) Prepare a ***wait for graph*** indicating the state of waiting locks at time 34. Your *wait for graph* can be prepared using any drawing package such as LucidChart or free hand drawn. Paste/insert an image of your wait for graph into your answer document below your answer to (i) above

(iii) Report if deadlock exists or not, and if it does exist, list the transactions involved.