

12.2.1 State-transition Diagrams

Name: _____ Class: _____ Date: _____ **Total: 29 marks**

KEY WORDS state • transition • input • output • self-loop

Objective

Read and construct the state-transition diagrams used in the exam: convert a table into labelled arrows, handle self-loops and missing outputs, and check a diagram row by row. This sheet prepares you for past-paper set **12.2.1 State-transition Diagrams**.

1 Key knowledge and worked examples

■ Key knowledge: the exam notation

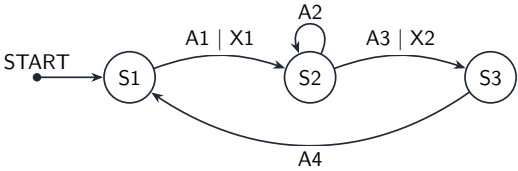
A **state-transition diagram** documents an algorithm by showing its possible states and how an input changes the current state and may produce an output.

- A circle contains a **state** name, such as S1. A filled START dot and an arrow indicate the initial state.
- A directed arrow goes from the **current state** to the **next state**. Its label is **input | output**, for example A1 | X1. The vertical bar separates input from output; it does not mean 'or'.
- If the table's Output cell is blank, label the arrow with the **input alone**. Do not invent an output or write 'None'.
- If current state equals next state, draw a **self-loop** back to the same circle. An input can produce output without changing the state.
- The same input may do different things in different states. Always identify the current state first.
- The diagram represents only the transitions given. A state with no outgoing rows needs no invented return arrow. Do not add a double circle unless the question specifies a final-state symbol.

■ Worked example: transition table to diagram

The initial state is S1. Each row specifies one arrow:

Current state	Input	Output	Next state
S1	A1	X1	S2
S2	A2		S2
S2	A3	X2	S3
S3	A4		S1



1. Draw and label all three state circles. Put START into S1.
2. Row 1 gives an arrow S1 to S2 labelled A1 | X1.
3. Row 2 has S2 as both states, so draw a self-loop labelled A2. Its output is blank.
4. Row 3 gives S2 to S3 labelled A3 | X2.
5. Row 4 gives S3 to S1 labelled A4, with no output.
6. Audit each row against one arrow: source, destination, input and output. Then check that no extra arrows were added.

■ Worked example: trace inputs and outputs

Start at S1 and apply A1, A2, A3, A4 in order.

Current state	Input	Output	Next state
S1	A1	X1	S2
S2	A2		S2
S2	A3	X2	S3
S3	A4		S1

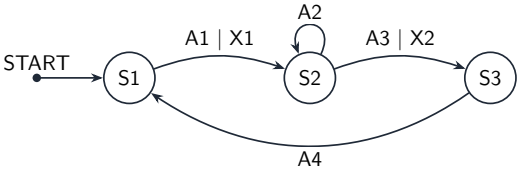
After A1 the state is S2; A2 follows the self-loop so it remains S2. A3 moves to S3 and A4 returns to S1. The output sequence is **X1, X2**; the blank cells produce no output.

■ Key knowledge: larger exam diagrams

For five-state questions, place circles to leave space for arrows and labels. Two inputs can share a source and destination: draw two labelled arrows, or clearly list both input-output pairs on one arrow. Different outputs must stay paired with their own inputs. Keep arrowheads clear and labels away from crossings. A structure chart shows module hierarchy and parameter passing; a state-transition diagram shows input-driven behaviour over time.

2 Practice

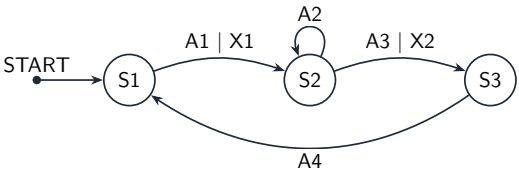
2.1 Use the diagram below. Complete the missing entries. A dash in the Output column means no output.



Current state	Input	Output	Next state
S1	A1		S2
S2	A2	-	
S2		X2	S3

2.2 A table row is S4, A3, blank output, S4. Draw the single transition it represents.

2.3 Start at S1 in the diagram below. The inputs are A1, A2, A2, A3. State the final state and the output sequence.



2.4 (a) Draw a complete state-transition diagram from the table. The initial state is S1.

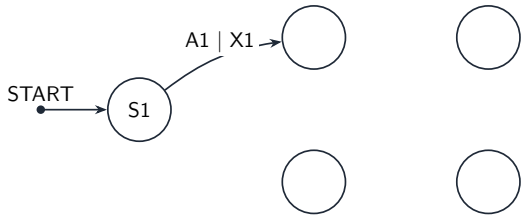
Current state	Input	Output	Next state
S1	A1	X1	S2
S2	A2		S2
S2	A3	X2	S3
S3	A1		S1

(b) Explain why the same input A1 produces different outputs in states S1 and S3.

3 Exam-style questions

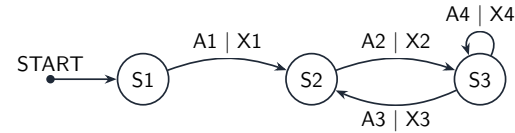
3.1 Complete the five-state diagram from the table. Its first transition and START marker are supplied. Add the missing state labels and arrows directly to the diagram. [5]

Current state	Input	Output	Next state
S1	A1	X1	S2
S1	A2		S3
S2	A3	X2	S2
S2	A4	X3	S4
S3	A1		S2
S3	A4	X3	S5
S4	A2		S3
S4	A4	X4	S5



3.2 The following diagram contains four errors relative to this table. Identify each error and state its correction. [4]

Current state	Input	Output	Next state
S1	A1	X1	S2
S2	A2		S2
S2	A3	X2	S3
S3	A4		S1



3.3 (a) Draw a complete state-transition diagram from the table. The initial state is S1. [5]

Current state	Input	Output	Next state
S1	A1		S2
S2	A2	X2	S3
S3	A1	X1	S3
S3	A2	X1	S3
S3	A3	X3	S4
S3	A4		S2
S4	A1	X4	S5
S4	A3	X4	S5
S4	A4		S2

(b) Start at S1. For inputs A1, A2, A1, A2, A3, A4, give the final state and the output sequence. [2]

Solutions

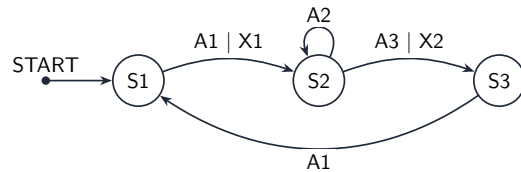
2.1 X1; S2; A3.

2.2 A circle labelled S4 with an arrow looping back to S4, labelled A3 without an output.



2.3 Final state S3. Outputs X1, X2. Each A2 stays in S2 and produces no output.

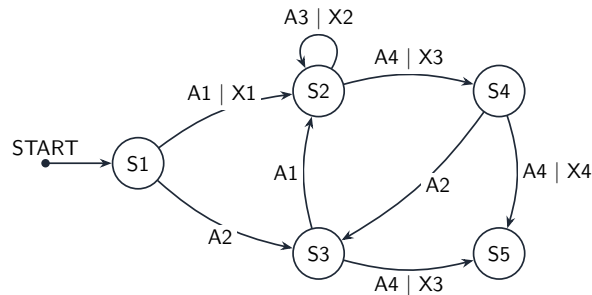
2.4 (a)



START into S1 and all three labelled states; S1 to S2 with A1 | X1; S2 self-loop A2 and S2 to S3 with A3 | X2; S3 to S1 labelled A1 only.

(b) In S1, A1 produces X1. In S3, A1 produces no output. The transition is determined by both the current state and the input, not the input alone.

3.1

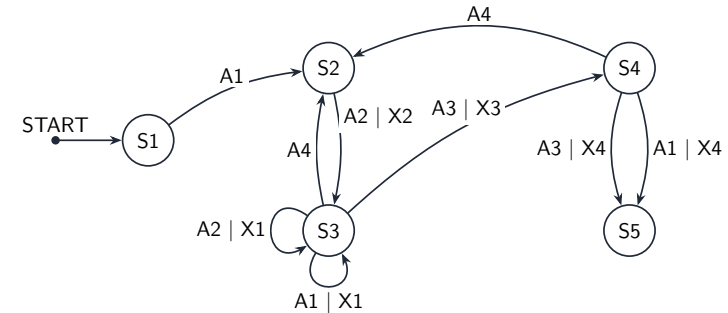


Correct missing state names; S1 to S3 labelled A2; both outgoing S2 transitions including its loop; both outgoing S3 transitions; both outgoing S4 transitions with correct labels. S5 has no outgoing transition in the table.

3.2 Award one mark for each error with its correction:

- The S2 to S3 arrow labelled A2 | X2 is wrong: replace it with a self-loop on S2 labelled A2, with no output.
- The required S2 to S3 arrow labelled A3 | X2 is missing: add it.
- The S3 to S2 arrow labelled A3 | X3 has no matching table row: remove it.
- The A4 | X4 self-loop on S3 is wrong: replace it with an arrow S3 to S1 labelled A4 only.

3.3 (a) START into S1 and all five state names; S1 to S2 and S2 to S3 correctly labelled; both S3 self-loops and S3 to S4; S3 to S2 and S4 to S2, each labelled A4 only; both S4 to S5 input-output pairs. No outgoing arrows from S5.



(b) The states after each input are S2, S3, S3, S3, S4, S2. Final state **S2**; outputs **X2**, **X1**, **X1**, **X3**. The first A1 and last A4 produce no output.