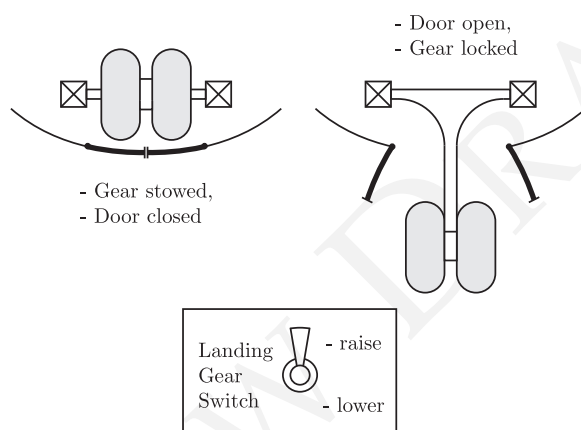


## 04.05 Exercises for Chapter 04

### Exercise 04.1 *Landing gear finite state machine*

Consider the series of actions controlling the operation of an airplane landing gear. For example, beginning in the “stowed” position, when the cockpit switch is set to “lower”, first the landing gear door opens; and then the gear moves down to the “locked” position. Subsequently, when the switch is set to “raise”, the gears moves up, and the door closes. See Figure 04.8.



**Figure 04.8:** landing gear schematic.

Our task is to design a Finite State Machine (FSM) to produce outputs that actuate the motors that move the door and gear. Inputs to the FSM are from the cockpit switch, and from door and gear position limit sensors.

**Operation rules** The following are the required operation rules.

1. When the switch is set to “raise”, the gear moves up to the stowed position, and then the door closes.
2. When the switch is set to “lower”, the door opens, and then the gear moves down to the locked position.
3. If, while the gear is moving up, the switch is changed to “lower”, the gear should reverse direction and move down to the locked position.
4. If, while the gear is moving down, the switch is changed to “raise”, the gear should reverse direction and move up to the stowed position, with the door closed.

5. ...
6. If, while the door is closing, the switch is changed to “lower”, the sequence should reverse: door opens and gear moves down.
7. If, while the door is opening, the switch is changed to “raise”, the sequence should reverse: door closes.

**FSM Inputs** There are three inputs to the FSM. The possible values of each variable are shown in brackets.

1. switch (sw), [raise, lower] A two-position Landing Gear Switch used to command the raising or lowering of the gear.
2. gear limit sensor (gs), [top, bottom, other] The limit sensor variable gs indicates whether the gear is at the top, the bottom, or in between.
3. door limit sensor (ds), [opened, closed, other] The limit sensor variable ds indicates whether the door is completely open, completely closed, or in between.

**FSM Outputs** There are two outputs from the FSM. Again, the possible values of each variable are in brackets.

1. gear motor (gm), [raising, lowering, off] The motor variable gm controls whether the gear motor is raising or lowering the gear, or is off.
2. door motor (dm), [opening, closing, off] The motor variable dm controls whether the door motor is opening or closing the door, or is off.

**FSM States** At any time, the landing gear control system can be in one of six states. The system remains in a state until conditions are met that cause a transition to another state.

Name the states as follows:

1. gear stowed (up) GS
2. gear locked (down) GL
3. gear moving up GMU
4. gear moving down GMD
5. door moving open DMO
6. door moving closed DMC

Perform the following steps to complete the exercise.

1. Draw the state transition diagram. Use the input, output, and state variable names and values defined above. For each transition show

**Table 04.3:** the state transition table.

current state	Inputs			Outputs		next state
	sw	gs	ds	gm	dm	
GL						
GMU						DMC
GMU						
DMC						GS
GS						
DMO						GMD
GMD						
GMD						GL
DMO						
DMC						

the event that caused the transition, and the output resulting from the transition.

- From your diagram fill in the corresponding state transition table [Table 04.3](#). Again, use the input, output, and state variable names and values defined previously. Use a “–” to indicate no change in a variable.