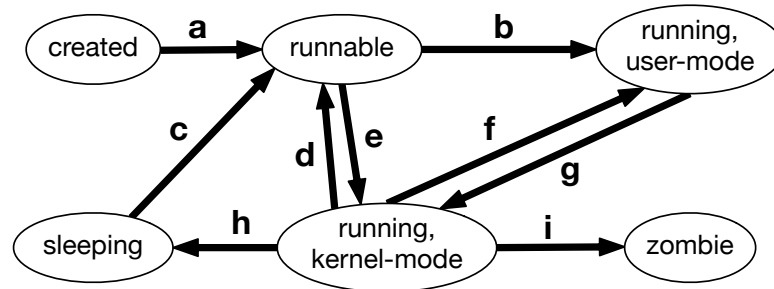


3 Operating Systems (rmm1002)



- (a) The diagram above is a simplified state machine for processes in a UNIX operating system. For each of the following, give the state transition(s) taken by the process, and state whether or not the scheduler runs.
- (i) A running user process is interrupted by a timer, whose interrupt handler determines it has used all of its allocated time slice. [2 marks]
 - (ii) A running user process invokes a non-blocking asynchronous IO operation. [2 marks]
 - (iii) A single-threaded running user process invokes a blocking synchronous IO operation that takes some considerable time to return. [2 marks]
- (b) Assume the process scheduler is *pre-emptive*. Which transitions will cause it to be entered? If it were replaced with a *non-preemptive* scheduler, which transitions would now cause the process scheduler to be entered? [6 marks]
- (c) Consider three CPU-bound processes arriving to a First Come First Served (FCFS) scheduler as follows:

Process	Arrival Time	Duration
P ₁	0	3
P ₂	1	12
P ₃	5	1

Give the schedule computed, and the average waiting time across all three processes. [3 marks]

- (d) A weakness of FCFS is that its performance is sensitive to the arrival process. Assume process arrival times remain $t = 0, 1, 5$ but the arrival order changes. Give an alternative arrival order that improves the average waiting time. Define the *convoy effect* and give a second alternative arrival order displaying it. [5 marks]