Problem 1.

Here is a specification of a brand new OfficePhone2000:

The OfficePhone2000 will be available when the phone is on the hook, and busy otherwise.

When the phone receives an incoming call, it will determine whether the phone is busy or available. If the phone is busy, the incoming call will be forwarded to the voice mail unit; if the phone is not busy, then the phone will ring. The phone will stop ringing if the caller hangs up; if the phone is still ringing after 10 seconds, the call will be sent to the voice mail unit and the phone will stop ringing.

The voicemail part of the OfficePhone2000 will wait for calls to be forwarded to it. When a call is forwarded to it, it will play the recording. When the end of the recording is reached, the voicemail unit will begin recording, indicating this with a "beep". If the caller hangs up at any time after being forwarded to the voicemail unit, the voicemail unit will stop whatever it is doing and resume waiting for another call to be forwarded to it. If the recording had begun, the voicemail indicator on the phone will start flashing; when messages are cleared, the indicator will stop flashing.

If the user of the phone presses the "supervisor" button on the phone, the voicemail unit will be deactivated; if there are any callers in the voicemail system and the phone is available, the phone will ring until the phone is either busy or the caller hangs up. If the phone is busy when this happens, the caller will be disconnected. No calls will be forwarded to the voicemail unit and the indicator will not flash until the voicemail unit is reactivated; reactivating the voicemail unit will resume flashing the indicator as appropriate. While the voicemail is inactive, incoming calls will be held until the phone is available. Voicemail can be reactivated by pressing the "supervisor" button again.

a) Draw the StateChart representation of this design.
b) If you were to draw this as an FSM, how many maximum states would you need?

To estimate the total number of FSM states multiply the number of concurrent states together and add the number of sequential states:

Sup button :2
Phone: 4
Vmail: 1 (vmail on or off) + 2 (Vmess clr) x 4 (Vmail op)

Total: 2x4x(1+2x4) = 8x9=72
Problem 2.

What does the following diagram in SDL do? (<true> signals can be ignored)

Left and right SDL models are concurrent to each other, signal A needed by R is generated by L, while signals C and D needed by L are generated by R. The final output signal Success is generated by R. L and R implementations can be drawn as the following FSMs:
This SDL implementation will not work since it has two nondeterministic transitions. One is in L model from l1 state to l2/l3 states. The other is in R model from r1 to r2/r3 states. It is unclear what will be the next state in both situations.

**Problem 3.**
Various correct answers are possible.

**Problem 4.**
Consider the Petri net defined by:

\[ P = \{ p1, p2, p3 \} \]
\[ T = \{ t1, t2, t3 \} \]
\[ A = \{ (p1 \ t1) (p1 \ t3) (p2 \ t1) (p2 \ t2) (p3 \ t3) (t1 \ p2) (t1 \ p3) (t2 \ p3) (t3 \ p1) (t3 \ p2) \} \]

With all weights being one except \( w(p1 \ t1) = 2 \)

a) draw the Petri net graph
b) let \( M0 = \begin{bmatrix} 1 & 0 & 1 \end{bmatrix} \). Show why transition \( t1 \) can’t be enabled in any subsequent operations of the Petri net
c) let \( M0 = \begin{bmatrix} 2 & 1 & 1 \end{bmatrix} \). What happens in the subsequent operations of the Petri net?
Problem 5  An SDF is shown below (edge labels are in dark grey):

\[ H_0 = \begin{bmatrix} 2 & 1 & 1 \\ 0 & 1 & 2 \end{bmatrix} \]

\[ H_1 = \begin{bmatrix} 2 & 0 & 2 \\ 0 & 0 & 3 \\ 0 & 1 & 2 \end{bmatrix} \]

\[ H_0 = \begin{bmatrix} 2 & 1 & 1 \\ 0 & 1 & 2 \end{bmatrix} \]

\[ M_0 = \begin{bmatrix} 0 & 2 & 1 \\ 0 & 1 & 2 \end{bmatrix} \]

a) Write its incidence matrix
\[ G = \begin{bmatrix} -2 & 0 & 1 \\ 2 & 0 & -1 \\ 3 & -1 & 0 \\ 0 & 2 & -3 \end{bmatrix} \]

b) What is its rank? 2

c) System constraints specify that task A has to execute before task B which has to execute before task C. Is there a PASS schedule? If not, change the SDF so that there is a PASS. Derive the PASS schedule.
6 A – 2 B = 0 & 2 B – 3 C = 0 => 3A=B, 2B=3C

Smallest q = [ 1 3 2 ]
PASS = { A BBB CC }

d) Derive the initial condition for the schedule defined in part c) \( \text{Buf}(0) = [2 0 0 0] \)
e) Derive the buffer sizes for the schedule from part c)
\[ [2,0,0,0] \rightarrow [0,2,0,3] \rightarrow [0,2,2,2] \rightarrow [0,2,4,1] \rightarrow [0,2,6,0] \rightarrow [1,1,3,0] \rightarrow [2,0,0,0] \]
Buffer sizes: [2,2,6,3]

**Problem 6.**
Draw a Petri net for the following communication protocol:

- The transmitter sends a frame and stops waiting for an acknowledgement from the receiver (ACK)
- Once the receiver correctly receives the expected packet, it sends an acknowledgement to let the transmitter send the next frame.
- When the transmitter does not receive an ACK within a specified period of time (here you can assume a separate counting process) then it retransmits the packet.

Is there a deadlock? If so, can you fix it?

This protocol has a deadlock if ack or packet is lost: the deadlock is fixed by adding timeouts on loss.

**Problem 7** Draw an FSM equivalent to the following StateChart description
Problem 8  Your job is to implement the following function:

\[ \text{fun}(x,y,n,T) = f(w)|_x \cos \left( \frac{2n}{T} \right) - f(w)|_y \sin \left( \frac{2n}{T} \right) \]

Assume that \( f(w)|_z \) is a mapping function that takes variable \( z \) and provides result \( f(z) \).

a) Implement this system using SDL
b) Implement it using a data flow graph
Problem 9 Briefly discuss which model(s) of computation is best suited for:
   a. a modulo-10 counter
   b. a telephone answering machine
   c. a microprocessor
   d. a communication protocol for accessing a memory
   e. algorithm to determine the median of a set of numbers

various answers are possible