

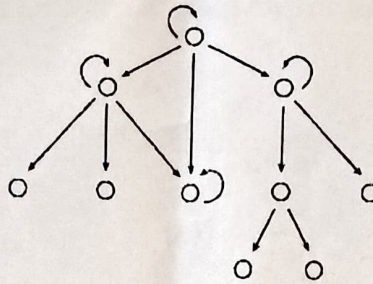
**Systems Biology – Monsoon 2023**  
**End Semester Examination**

Max. Time: 2.0 hrs

Max. Marks: 35

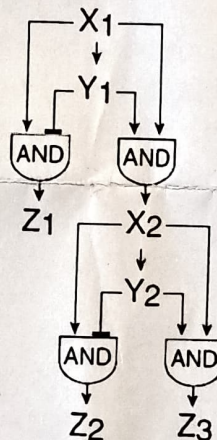
1. How will you identify a motif (s) in a network and establish that it is significant?  
 [CO-1]

[2 marks]



2. Draw the profile of Z1, Z2 and Z3. [CO-1]

[2 marks]



3. How negative autoregulation promotes robustness to fluctuations compared to simple regulation? [CO-2]

[3 marks]

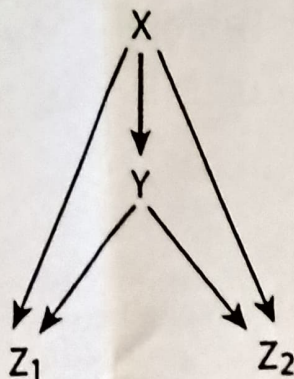
4. Calculate the response time for incoherent feed forward loop and compare it with simple regulation. What is the condition for adaptation? [CO-2,3]

[3 marks]

5. What is the temporal order of turn ON and turn OFF in a multi-output coherent feedforward (figure given below) where all genes are regulated by AND gates? Which thresholds determine the ON and OFF orders of Z1 and Z2? Can one obtain FIFO (first in and first out) orders? (For example, Z1 appears and disappears first with increase and decrease in X, respectively). [CO-2]

[3 marks]





6. Show (by derivation) that multi-site phosphorylation makes a good threshold but can be a poor switch. [CO-3] [4 marks]

7. Show that the model given below exhibit periodic behaviour. [4 marks]

$$\frac{dU}{dt} = U(1 - V)$$

$$\frac{dV}{dt} = \alpha V(U - 1)$$

$\alpha$  is a kinetic parameter (analyze the eigen values). [CO-3]

8. Define nullclines. Use nullclines to show that a positive feedback loop between X and Y proteins can give rise to bistable characteristics. Write the relevant equations. Show how trajectories cross nullclines? If signal S activates X independently, sketch how the steady state of X changes with S. What kind of bifurcation it undergoes? Explain it. [CO-2,3] [8 marks]

9.

$$\frac{dX}{dt} = k_1 \cdot S \frac{K_d^p}{K_d^p + Y^p} - k_{dx} \cdot X$$

$$\frac{dY}{dt} = k_{sy} \cdot X - \left( k_{dy} + \frac{k_2}{K_m + Y^2} \right) \cdot Y$$

(a) Sketch the molecular mechanism (interaction between variables) based on equations given above. (b) Draw the phase plane portrait and depict the trajectories. Comment about the dynamics (plot Y vs t). What happens if parameter  $K_d$  in the first equation is increased or decreased? Draw and comment about the phase plane and dynamics. [CO-2,3] [6 marks]