Algorithms:

1. Definitions:
   - Connected Graph
   - Connected component
   - Spanning tree
   - MST

2. b) Give an algorithm to find the components in a graph.
   Use algorithm to trace following adj matrix and show that components in this example is 2.

   \[ \text{Adj Matrix:} \quad \begin{pmatrix} \text{AC} & J \end{pmatrix} = \begin{pmatrix} \text{Given} \end{pmatrix} \]

   c) Sample Graph Given (15 nodes)
   Find MST using Kruskal's Alg.

   d) What special data structures are used in Kruskal?
   Explain how they are used in Kruskal's Alg.

2.

a) Define NP
   Class Co-NP
   Class NP-complete

b) State Cook's theorem

c) Show CNFSAT \& CLIQUE

Operating Systems:

1. k = # frames = 4
   Stream is: 1, 2, 3, 4, 1, 2, 5, 1, 2, 3, 4, 5

a) Show page replacements, # faults, # hits in FIFO, LRU. Show data structures used

b) Give an algorithm OPT which will give minimum # faults provided the entire stream is known in advance.
c) What is Belady's anomaly?
Show it for an algorithm for above reference stream.

d) Let $s_0, s_1, \ldots, s_n$ be a page reference stream.
   $K$ - # frames in memory.
   $C_k$ - minimum constant

Show that:

$$\left\lceil \frac{\# faults for s_0, \ldots, s_n}{\text{using FIFO}} \right\rceil \geq C_k \times \left\lceil \frac{\# faults for s_0, \ldots, s_n}{\text{using OPT}} \right\rceil + 1$$

Show that $C_k = K$.

3. 3 Strategies:
1) No Preemption
2) Preemption without Timeslice
3) Preemption, $ts = 2$ ms

<table>
<thead>
<tr>
<th>Job</th>
<th>Arrival</th>
<th>CPU(%)</th>
<th>Priority</th>
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<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>4</td>
<td>1</td>
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<td>2</td>
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<td>3</td>
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<td>3</td>
<td>2</td>
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<tr>
<td>5</td>
<td>3</td>
<td>4</td>
<td>1</td>
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</tbody>
</table>

Each process gets an I/O request every 1 ms.
Each I/O request takes 2 ms to complete.

Enough I/O devices so that processes need not compete for I/O device.

Find for each strategy, throughput, waiting time, turnaround time and compare.
CP Connections

![Diagram of CP Connections](image)

- Link 1 & 4: 100 Mbps
- Link 2 & 3: 10 Mbps

- A sends a very large file to B. Data travels via A to R to B in Link 1 & Link 2. Ack from B comes in Link 3 & Link 4.

- Congestion Window size initially 16 KB (??)
- Data Segment size (including headers) = 1280 bytes
  - Ack size is 0

- Prop delay on each link = 10 ms
- R has buffer of 10 packets and does tail drop queueing
- B has 1 packet buffer

a) What is the min time between 2 Ack received at A?
b) What is the RTT?
c) If CW is quadrupled, what will happen to throughput?
d) If A is transmitting packet 15, where will other packets be? What is the state of R?
2.
(a) Large # users use ALOHA with 50 requests/second. Time is slotted at 40 ms.
   Prop = probability of transmitting.

(b) What is the prob. that a pkt is txn successfully?
(c) What is the prob. that k collisions occur and then packet is transmitted successfully?
(d) What is the avg # txn for successful txn?

(b) P - Primary
   S - Secondary
   System uses rollcall polling.
   There are N secondaries.
   \[ \alpha = \frac{\text{delay}_{\text{prop}}}{\text{delay}_{\text{txn}}} \]
   delay_{prop} is the prop. delay from P to last S.

(ii) If only one S wants to transmit data (last S)
    Show that
    \[ \text{throughput} \approx \frac{1}{1 + N\alpha} \]

(iii) If all S are ready to transmit data
     Show that
     \[ \text{throughput} \approx \frac{1}{1 + \alpha} \]