1. (4 points) There are 2 machines in a factory that operate under random failures. The parameters of the processes of these two machines are summarized below.

**Process A**
- \( t_0 = 25 \text{ min} \) (base process time)
- \( \sigma_0 = 3 \text{ min} \) (standard deviation of base process time)
- \( m_f = 500 \text{ min} \) (mean time to failure)
- \( m_r = 200 \text{ min} \) (mean time to repair)
- \( c_r = 1.2 \) (coefficient of variability of repair times (\( \sigma_r / m_r \)))

Similarly,

**Process B**
- \( t_0 = 12 \text{ min} \)
- \( \sigma_0 = 2.2 \text{ min} \)
- \( m_f = 120 \text{ min} \)
- \( m_r = 35 \text{ min} \)
- \( c_r = 0.9 \)

a. Find the effective processing times and rates of the two processes
b. Find the availability of the two machines
c. Find the effective variance of the two processes
d. Compare two processes in terms of variability (Check the \( c_e^2 \) values). Classify the variability of the two processes according to the following table:

<table>
<thead>
<tr>
<th>Variability Class</th>
<th>Coefficient of Variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low (LV)</td>
<td>( c &lt; 0.75 )</td>
</tr>
<tr>
<td>Medium (MV)</td>
<td>( 0.75 \leq c &lt; 1.33 )</td>
</tr>
<tr>
<td>High (HV)</td>
<td>( 1.33 \leq c )</td>
</tr>
</tbody>
</table>

2. (6 points) According to the “Buffering Law”:
   a. List three types of buffer we can have in a system. Explain each one.
   b. Give at least one example to these buffer types.
3. (12 points) A student accumulated 5 assignments in the final day of their due dates. She estimates the processing times for these assignments and notes down the exact due times in order of assignment in the following table:

<table>
<thead>
<tr>
<th>Assignment</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process Time</td>
<td>40</td>
<td>150</td>
<td>20</td>
<td>240</td>
<td>90</td>
</tr>
<tr>
<td>Due Time</td>
<td>1pm</td>
<td>4pm</td>
<td>4pm</td>
<td>3pm</td>
<td>6pm</td>
</tr>
</tbody>
</table>

Assuming that this student is going to start working on the assignments at noon (12pm), find the mean flow time, average tardiness and number of tardy assignments for the following scheduling rules:

a. First Come First Serve (FCFS) (from assignment 1 to 5)
b. Shortest Processing Time (SPT)
c. Earliest Due Date (EDD)
d. Critical Ratio (CR)

Compare the results. If the length of tardiness doesn’t matter once the assignment is late, what is (are) the most desired scheduling rule(s) for the student?

4. (3 points)

a. Briefly explain the difference between job shop and flow shop scheduling
b. List 3 objectives of job shop scheduling
c. Is it possible to have a positive average tardiness but a zero average lateness for the same scheduling problem? Explain.