Part I: Redundancy A system requires a certain unreliable component in order to function, so that redundancy has been included in the design. Assume that failure rates are constant and equal to $\lambda$, and that any switches are 100% reliable.

± a. The block diagram on the left above represents “hot” standby of the redundant unit.

± b. In the block diagram on the right, unit #2 does not begin its lifetime until unit #1 has failed.

± c. In the block diagram on the right, the expected system lifetime is the same as the expected time of second arrival in a Poisson process with rate $\lambda$.

o d. In the case of “cold” standby, there is always some probability that the standby unit cannot be started.

o e. The reliability of the system on the left is at least as large as that of the system on the right.

o f. A system with “hot” standby is at least as reliable as one with “cold” standby.

o g. In the block diagram on the left, the system failure time has Erlang-2 distribution.
Part II: Project Scheduling. The activity descriptions and estimated durations for a project are:

<table>
<thead>
<tr>
<th>Activity</th>
<th>Description</th>
<th>Predecessor(s)</th>
<th>Duration (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Clear &amp; level site</td>
<td>none</td>
<td>2</td>
</tr>
<tr>
<td>B</td>
<td>Erect building</td>
<td>A</td>
<td>6</td>
</tr>
<tr>
<td>C</td>
<td>Install generator</td>
<td>A</td>
<td>4</td>
</tr>
<tr>
<td>D</td>
<td>Install water tank</td>
<td>A</td>
<td>2</td>
</tr>
<tr>
<td>E</td>
<td>Install maintenance equipment</td>
<td>B</td>
<td>4</td>
</tr>
<tr>
<td>F</td>
<td>Connect generator &amp; tank to building</td>
<td>B,C,D</td>
<td>5</td>
</tr>
<tr>
<td>G</td>
<td>Paint &amp; finish work on building</td>
<td>B</td>
<td>3</td>
</tr>
<tr>
<td>H</td>
<td>Facility test &amp; checkout</td>
<td>E,F</td>
<td>2</td>
</tr>
</tbody>
</table>

Draw the arrows to complete the AON (activity-on-node) network representing this project:

![Arrow diagram of AON network]

Draw the arrows to represent any required "dummy activities" to complete the AON (activity-on-node) network representing this project:

![Arrow diagram with dummy activities]

- a. A "dummy" activity always has zero duration.
- b. The quantity LT(i) [i.e. latest time] for each node i is determined by a forward pass through the network.
- c. If an activity is represented by an arrow from node i to node j, then ES (earliest start time) for that activity is ET(i).
- d. If an activity is represented by an arrow from node i to node j, then LS (late start time) for that activity is LT(j).
- e. If an activity is represented by an arrow from node i to node j, then that activity has zero "float" or "slack" if and only if ET(i)=LT(j).
- f. An activity is critical if and only if its total float ("slack") is zero.
- g. A "dummy" activity cannot be critical.
- h. The forward and backward pass methods for scheduling a project are applied to the AOA network representation of the project.
- i. Except perhaps for "begin" and "end" activities, "dummy" activities are unnecessary in the AON ("Activity-on-Node") representation of a project.