Skateboard Assembly Line Balancing – High School
Student Worksheet

Name:_________________________ Date:______________

Name:_________________________ Date:______________

Part I: Vocabulary Words

Match the following words with their definitions.

G 1. Assembly Line
   A. Where the time taken to perform work at each workstation is not the same (some shorter, some longer), usually resulting in a build-up at one of more workstations

H 2. Bottleneck
   B. A model that is used for the design and analysis of a manufacturing process and shows the flow of parts or products

F 3. Manufacturing
   C. A particular “stop” on the assembly line where a specific task (work) is performed

B 4. Process Simulation
   D. A measure of busy time - How busy a person is on the line relative to how much time they could be busy or working

E 5. Throughput
   E. The rate at which products come off the line (parts per second or per minute)

A 6. Unbalanced Assembly Line
   F. The production of goods for use or sale using people, machines, and tools - Typically, materials are transformed into finished goods

D 7. Utilization
   G. A manufacturing process in which parts are added to a product in a specific order or sequence to create a finished product

C 8. Workstation
   H. A circumstance where the performance of an entire system is limited by one workstation, typically the slowest workstation
Part II: “Base Case” Simulation - Calculation of Utilization

1. Why do engineers use simulations to study processes? It can be cheaper, faster, and safer.

2. Record the busy times for the “Base Case” scenario and calculate the utilizations of each operator in the table below.

$$\text{Utilization} = \frac{\text{Busy Time}}{\text{Total Time}}$$

<table>
<thead>
<tr>
<th>Operator #</th>
<th>Busy Time (seconds)</th>
<th>Utilization ($\frac{\text{Busy Time}}{\text{Total Time}}$)</th>
<th>Utilization (as a reduced fraction)</th>
<th>Utilization (as a percent, round to nearest tenth)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>324</td>
<td>324/360</td>
<td>9/10</td>
<td>90.0%</td>
</tr>
<tr>
<td>2</td>
<td>228</td>
<td>228/360</td>
<td>19/30</td>
<td>63.3%</td>
</tr>
<tr>
<td>3</td>
<td>234</td>
<td>234/360</td>
<td>13/20</td>
<td>65.0%</td>
</tr>
<tr>
<td>4</td>
<td>132</td>
<td>132/360</td>
<td>11/30</td>
<td>36.7%</td>
</tr>
<tr>
<td>5</td>
<td>360</td>
<td>360/360</td>
<td>1</td>
<td>100.0%</td>
</tr>
<tr>
<td>6</td>
<td>270</td>
<td>270/360</td>
<td>¾</td>
<td>75.0%</td>
</tr>
<tr>
<td>7</td>
<td>318</td>
<td>318/360</td>
<td>53/60</td>
<td>88.3%</td>
</tr>
</tbody>
</table>

3. What does it mean for an operator’s utilization to be 75%? They are busy (working) for 75% of their shift. (So they are idle, not working, for 25%.)

4. What would the utilizations of the operators look like in a balanced assembly line? They would be as high as possible and about equal to each other.

5. What are some changes that could be made in order to balance the assembly line for better utilization of all operators? Add another station operator (to help with station #5) Divide up work more equally (reallocate tasks)

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III: Improved Method Simulation- Calculation of Utilization

1. What changes were made in the simulation to try to balance the assembly line?
   Tasks were reallocated

2. Record the new busy times for this simulation scenario and calculate the new utilizations of each operator in the table below.

   \[ Utilization = \frac{Busy\ Time}{Total\ Time} \]

Table 2

<table>
<thead>
<tr>
<th>Operator #</th>
<th>Busy Time (seconds)</th>
<th>Utilization (as a reduced fraction)</th>
<th>Utilization (as percent, round to nearest tenth)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>345</td>
<td>345/360</td>
<td>95.8%</td>
</tr>
<tr>
<td>2</td>
<td>277</td>
<td>277/360</td>
<td>76.9%</td>
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<tr>
<td>3</td>
<td>275</td>
<td>275/360</td>
<td>76.4%</td>
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<tr>
<td>4</td>
<td>281</td>
<td>281/360</td>
<td>78.1%</td>
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<tr>
<td>5</td>
<td>231</td>
<td>231/360</td>
<td>64.2%</td>
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<tr>
<td>6</td>
<td>325</td>
<td>325/360</td>
<td>90.3%</td>
</tr>
<tr>
<td>7</td>
<td>360</td>
<td>360/360</td>
<td>100.0%</td>
</tr>
</tbody>
</table>
Part IV: Comparing Utilizations, Effects on a Manufacturing Company

1. How did the utilization change after the adjustment was made to the assembly line?  
Most of them increased
2. Were there any unexpected results? If so, what were they?  
Yes the utilization for operator #5 decreased
3. Calculate the Percent Change of the utilizations in the table below.

\[
\text{Percent Change} = \left( \frac{\text{Original Utilization} - \text{New Utilization}}{\text{Original Utilization}} \right) \times 100
\]

<table>
<thead>
<tr>
<th>Operator #</th>
<th>Base Case Utilization (as a percent, round to nearest tenth)</th>
<th>Improved Method Utilization (as a percent, round to nearest tenth)</th>
<th>Percent Change (Round to the nearest 100\textsuperscript{th})</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>90.0%</td>
<td>95.8%</td>
<td>6.44%</td>
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<tr>
<td>2</td>
<td>63.3%</td>
<td>76.9%</td>
<td>21.48%</td>
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<tr>
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<td>65.0%</td>
<td>76.4%</td>
<td>17.54%</td>
</tr>
<tr>
<td>4</td>
<td>36.7%</td>
<td>78.1%</td>
<td>112.81%</td>
</tr>
<tr>
<td>5</td>
<td>100.0%</td>
<td>64.2%</td>
<td>-35.8%</td>
</tr>
<tr>
<td>6</td>
<td>75.0%</td>
<td>90.3%</td>
<td>20.4%</td>
</tr>
<tr>
<td>7</td>
<td>88.3%</td>
<td>100.0%</td>
<td>13.25%</td>
</tr>
</tbody>
</table>

4. How can the Overall Percent Change in utilization of the assembly line be calculated?  
Add the total time for each method and calculate the percent change between those times.

5. What is the Overall Percent Change in utilization of the assemble line?  \text{12.22\%}

6. With better utilization, throughput on the assembly line increases (increases or decreases).

7. How does a better utilization affect a manufacturing company?  \text{Less costs for production which means higher profits for the company.}
Part V: Modeling & Cost Analysis

1a. The Toyota Factory wants to have all its employees utilized 95% of the time. If each employee works an 8.5 hour shift, for how many hours will they be “busy”? 8.075 hours
Do not round your answer.

1b. If each employee is paid $9.75/hour, how much is it costing the company (per employee, per shift) to pay for idle time of the employees when they are not “busy”? Round your answer to the nearest cent. $4.14

2a. An employee on an assembly line spends a total of 47 minutes of his 9-hour shift waiting for the previous part on the line to arrive. What is his utilization for the day? Express your answer as a percent rounded to the nearest whole number. 91%

2b. The following day the same employee’s utilization rate is 89%. What is the percent increase or decrease in his utilization from the previous day? Do not subtract the utilization percents! Round your answer to the nearest thousandth of a percent. 2.198% decrease
3. What are some costs of running a skateboard manufacturing company? 
Materials, Labor, Utilities, Rent/Lease, Equipment, etc.

4. The cost of manufacturing skateboards during one month at a production company can be demonstrated using the following equation: \( C = 8h + 4500 \), where \( C \) represents the total cost and \( h \) is the number of hours paid for labor.

   a. What is the slope of this equation? 8 
   What does it represent? hourly rate of pay

   b. If there are 10 employees working 40 hours a week, how much is the total cost, \( C \), for the month? (Use 1 month = 4 weeks) $17,300

   c. If 346 skateboards are produced in a month, what is the cost of producing 1 skateboard? $50

   d. Assume the workers perform at 85% utilization when the 346 skateboards are produced. Industrial engineers design a better production process and operator utilization increases to 92% the following month. How many skateboards can they expect to produce that month? 374 skateboards

   e. What is the percent increase in the monthly production of skateboards? Round to the nearest hundredth of a percent. 8.09%

   f. What is the cost of producing 1 skateboard with the newly designed production process? Round your answer to the nearest cent. $46.26