1.a. 2 years: cost when outsourced = 750 \times 1,000 \times 24 = 18,000,000

cost when produced in house = 5,000,000 + 1,000 \times 24 \times 0.6 \times 750 = 15,800,000

\Rightarrow \text{It is worth producing in house.}

1.b. 5,000,000 + 1000 \times 24 \times 0.7 \times P^* = 750 \times 1,000 \times 24 \times 0.7

\Rightarrow P^* = \$452.38

1.c. 5,000,000 + \sum_{x=1}^{n} \left( 500 - \frac{x}{1000} \right) = 750 \times n

\Rightarrow n \geq 19,921

Also OK, if understood cost of producing X units (not Xth unit) is \( 500 - x/1000 \);

750 \times x = 5,000,000 + (500 - x/1000) \times \frac{x^2}{1000} + 250x - 5,000,000 = 0

x = 18,615

2.a. \( 2^{-b} = 0.92 \) \Rightarrow b = 0.12

\[ Y(1) = 120 \text{ min.} \]

\[ 120 = a \times 1^{-b} \Rightarrow a = 120 \]

\[ Y(500) = 120 \times 100^{-b} = 56.82 \text{ minutes} = 0.947 \text{ hours} \]

2.b. 45 = 120 \times 100^{-b} \Rightarrow b = 0.213 \Rightarrow \text{it does not fly}

\[ \ln(Y(u)) = \ln(a) - b \times \ln(u) \]

\[ y(1) = 120 \Rightarrow \ln(Y(1)) = 4.7875 \quad \ln(1) = 0 \]

\[ Y(1000) = 45 \Rightarrow \ln(Y(1000)) = 3.807 \quad \ln(1000) = 6.908 \]
\[
\frac{Y - Y_1}{X - X_1} = \frac{Y_2 - Y_1}{X_2 - X_1} \Rightarrow \text{finding equation of line}
\]

\[
\frac{\ln(Y(u)) - 4.4875}{\ln(u) - 0} = \frac{3.807 - 47875}{6.908 - 0}
\]

\[
6.908\ln(Y(u)) - 33,702 = -0.9805 \times \ln(u)
\]

\[
\ln(Y(u)) = 4.7875 - 0.142 \times \ln(u)
\]

\[
2^{-b} = 2^{-0.142} = 0.906 = 90.6\%
\]

Also OK if found new \( b \) by:

\[
Y(1000) = 2 \times (1000) - b = 0.75 \text{ hour}
\]

\[
(1000)^{-b} = 0.75/2
\]

\[
b = 0.142
\]

\[
L_{\text{new}} = 2^{-b} = 2^{-0.142} = 90.6\%
\]

3.a. annual demand \( = 75 \times 52 = 3,900 \) units

\[
Q^* = \sqrt{\frac{2 \times 20 \times 3900}{0.2 \times 1.5}} \approx 721
\]

\[
T = \frac{Q}{D} = \frac{721}{3900} = 0.185 \text{ years} = 9.61 \text{ weeks}
\]

3.b. If 4 orders per year,

\[
T = \frac{1}{4} \text{ years}
\]

\[
\frac{1}{4} = \frac{Q}{3900} \Rightarrow Q = 975
\]

\[
975 = \sqrt{\frac{2 \times K \times 3900}{0.2 \times 1.5}} \Rightarrow K = 36.56
\]

4.a. \( K = $100 \)

\[
h = $2/\text{year}
\]

\[
P = 8,000 \text{ unit/ year}
\]

\[
d = 2,000 \text{ unit/ year}
\]
\[ Q^* = \sqrt{\frac{2 \times 100 \times 2000}{2 \times (1 - \frac{2000}{6000})}} \approx 517 \]

4.b. \( H = \frac{517 \times (1 - \frac{2000}{6000})}{8000} \approx 388 \)

4.c. \( T_1 = \frac{Q}{P} = \frac{517}{8000} = 0.064625 \text{ years} = 3.3005 \text{ weeks} \)

4.d. \( T = \frac{Q}{d} = \frac{517}{2000} = 0.2585 \text{ years} = 13.442 \text{ weeks} \)

\[ T_2 = T - T_1 = 10,0815 \text{ weeks} \]

5.a. A worker can produce \( \frac{7}{2.5} \times 20 = 50 \text{ units/month} \)

<table>
<thead>
<tr>
<th>Cumulative production per worker</th>
<th>cumulative demand</th>
<th># of workers required</th>
<th>cumulative prodn.</th>
<th>ending inventory</th>
</tr>
</thead>
<tbody>
<tr>
<td>56</td>
<td>6750</td>
<td>121</td>
<td>6,776</td>
<td>26</td>
</tr>
<tr>
<td>112</td>
<td>10,750</td>
<td>96</td>
<td>13,552</td>
<td>2,802</td>
</tr>
<tr>
<td>168</td>
<td>17,750</td>
<td>106</td>
<td>20,328</td>
<td>2,578</td>
</tr>
<tr>
<td>224</td>
<td>21,750</td>
<td>97</td>
<td>27,104</td>
<td>5,354 + 500</td>
</tr>
</tbody>
</table>

Fire 200 - 121 = 79 workers at the beginning

Total cost = \( 79 \times 2,500 + 30 \times 7 \times 20 \times 121 \times 4 + (26 \times 2,802 + 2,578 + 5,354 + 500) \times 15 \)

Firing cost \( + \) worker cost \( + \) inventory holding cost

\( = 197,500 + 2,032,800 + 16,890 \)

\( = 2,399,200 \)

5.b.
<table>
<thead>
<tr>
<th></th>
<th>56</th>
<th>6,750</th>
<th>121</th>
<th>26</th>
<th>79</th>
</tr>
</thead>
<tbody>
<tr>
<td>56</td>
<td>4,000</td>
<td>72</td>
<td>58</td>
<td>49</td>
<td></td>
</tr>
<tr>
<td>56</td>
<td>7,000</td>
<td>125</td>
<td>58</td>
<td>53</td>
<td></td>
</tr>
<tr>
<td>56</td>
<td>4,000</td>
<td>72</td>
<td>90 + 500</td>
<td>53</td>
<td></td>
</tr>
</tbody>
</table>

Total cost = (79 + 49 + 53) \times 2,500 + 53 \times 1,250 + 7 \times 30 \times 20 \times 121 + 7 \times 30 \times 20 \times 72 + 7 \times 30 \times 20 \times 125 \\
+ 7 \times 30 \times 20 \times 72 + (26 + 58 + 58 + 90 + 500) \times 15 = 2,167,730

5.c. From part a, apply a constant workforce plan with 106 workers (2\textsuperscript{nd} highest). Fire 94 workers at the beginning

<table>
<thead>
<tr>
<th>Cumulative production</th>
<th>Ending inventory</th>
<th>Backorder</th>
</tr>
</thead>
<tbody>
<tr>
<td>5,936</td>
<td>-</td>
<td>814</td>
</tr>
<tr>
<td>11,872</td>
<td>308</td>
<td>-</td>
</tr>
<tr>
<td>17,808</td>
<td>58</td>
<td>-</td>
</tr>
<tr>
<td>23,744</td>
<td>1,994 + 500</td>
<td>-</td>
</tr>
</tbody>
</table>

Total cost = 94 \times 2,500 + 30 \times 7 \times 20 \times 106 \times 4 + (308 + 58 + 1,994 + 500) \times 15 + 814 \times 50 \\
= 2,099,400

6.a. No, because the EOQ model is for systems which have constant demand. However, in this case demand is seasonal.

6.b. Uncertainties, speculators, economies of scale

6.c. (b)

6.d. (c)

6.e. (c)