Page 516, problem #1 a), b), d), e):

a) For the $R$ chart, use the limits given in equation (7-86). In Table B-2, for $m = 3$, $D_1$ is not given, so there is no lower control limit. $D_2 = 4.358$ and $d_2 = 1.693$, so

\[
\text{Center Line}_{R} = d_2 s = 1.693(1.0) = 1.693 \text{ oz}
\]

and

\[
UCL_R = 4.358(1.0) = 4.358 \text{ oz}.
\]

There is little evidence that the $s$ associated with the process was above 1.0 oz.

*System in Control.*

For the $\bar{x}$ chart,

use $\mu$ as a center line, and use the limits given in equation (7-70).

Center Line $\bar{x} = 21.0$ oz,

\[
\text{LCL} \bar{x} = 21.0 - \frac{3 \times 1.0}{\sqrt{3}} = 19.26795 \text{ oz},
\]

and

\[
\text{UCL} \bar{x} = 21.0 + \frac{3 \times 1.0}{\sqrt{3}} = 22.73205 \text{ oz}.
\]
There is no evidence that the process mean $\mu$ was not equal to 21.0 oz. *System in Control*

b) Use $c_4s$ as a center line, and use the limits given in equation (7-90). From Table B-2 with $m = 3$, $c_4 = 0.8862$, $B_5$ is not given (so there will be no lower control limit), and $B_6 = 2.276$.

Center Line$_S = 0.8862(1.0) = 0.8862$ oz,

and

$$UCL_S = 2.276(1.0) = 2.276$ oz.

This chart is very similar in appearance to the R chart. *System in Control*

d) For the R chart, use the limits given in equation (7-88). In Table B-2, for $m = 3$, $D_3$ is not given, so there is no lower control limit. $D_4 = 2.574$, so

Center Line$_R = \bar{R} = 2.3$ oz

and

$$UCL_R = 2.574(2.3) = 5.9202$ oz.

There is little evidence that the $s$ associated with the process was unstable. The short-term variability seems to have been in control.
For the $\bar{x}$ chart, use $\bar{x}$ as a center line, and use the limits given in equation (7-70), substituting $\bar{x}$ for $\mu$ and $\frac{\bar{R}}{d_2}$ for $s$.

Center Line $\bar{x} = 21.25833$ oz,

$LCL_{\bar{x}} = 21.25833 - 3 \frac{1.358535}{\sqrt{3}} = 18.90528$ oz,

and

$UCL_{\bar{x}} = 21.25833 + 3 \frac{1.358535}{\sqrt{3}} = 23.61138$ oz.

There is no evidence that the process mean $\mu$ was unstable. The process mean seems to have been in control.

e) For the $s$ chart, use the limits given in equation (7-92). In Table B-2, for $m = 3$, $B_3$ is not given, so there is no lower control limit. $B_4 = 2.568$, so

Center Line $s = \bar{s} = 1.209262$ oz

and

$UCL_s = 2.568(1.209262) = 3.105385$ oz.
For the $\bar{x}$ chart, use $\bar{x}$ as a center line, and use the limits given in equation (7-70), substituting $\bar{x}$ for $\mu$ and $\frac{\bar{x}}{c_4}$ for $s$.

Center Line $\bar{x} = 21.25833$ oz,

$$\text{LCL } \bar{x} = 21.25833 - 3 \frac{1.364548}{\sqrt{3}} = 18.89487 \text{ oz},$$

And

$$\text{UCL } \bar{x} = 21.25833 + 3 \frac{1.364548}{\sqrt{3}} = 23.6218 \text{ oz}.$$

These charts are very similar to the ones made in part d).