12.5
• Know how to find the integral using iteration (Example 1) and understand the statement of Fubini's theorem.
• Know how to find triple integrals over general solids. Be able to change the order of integration by looking at the projections of the solid on the different coordinate planes. (Examples 2, 3)
• Let \( E \) be a solid, then \( \iiint_E 1 \, dV = \text{Volume of } E \) (Example 4)

12.6
• Know the definition of cylindrical coordinates \((r, \theta, z)\) and their geometrical interpretation.
• Know how to convert from cartesian to cylindrical and vice versa:

\[
\begin{align*}
  x &= r \cos \theta \\
  y &= r \sin \theta \\
  z &= z
\end{align*}
\]

\[r^2 = x^2 + y^2 \quad r \geq 0\]
\[\tan \theta = \frac{y}{x} \quad 0 \leq \theta \leq 2\pi\]

Be careful when determining \(\theta\): if the projection of the point is in quadrants II or III, then \(\theta = \arctan \left( \frac{y}{x} \right) + \pi\).

If the projection is in quadrant IV, then \(\theta = \arctan \left( \frac{y}{x} \right) + 2\pi\). (Example 1)

• Know how to recognize the graphs of basic equations in cylindrical coordinates and how to convert them to cartesian coordinates and vice versa. (Example 2)
• Know how to change the variables in a triple integral from cartesian to cylindrical. Remember to multiply by \(r\). (Example 3, 4)

12.7
• Know the definition of spherical coordinates \((\rho, \theta, \phi)\) and their geometrical interpretation (note that the angle \(\theta\) has the same geometrical meaning as in cylindrical coordinates).
• Know how to convert from cartesian to spherical, from cylindrical to spherical and vice versa. (Example 1, 2)

\[
\begin{align*}
  x &= \rho \cos \theta \sin \phi \\
  y &= \rho \sin \theta \sin \phi \\
  z &= \rho \cos \phi
\end{align*}
\]

\[
\begin{align*}
  \rho^2 &= x^2 + y^2 + z^2 \\
  r &= \rho \sin \phi \\
  r \geq 0
\end{align*}
\]

\[0 \leq \phi \leq \pi\]

• Know how to recognize the graphs of basic equations in spherical coordinates:

\[
\begin{align*}
  \rho = c & \quad \text{is a sphere of radius } c \\
  \phi = c & \quad \text{is a cone at an angle } c \text{ with the positive } z \text{-axis} \\
  \theta = c & \quad \text{is a vertical plane}
\end{align*}
\]

Know how to convert equations from cartesian to spherical and vice versa (Examples 6,7).

• Know how to change the variables in a triple integral from cartesian to spherical. Remember to multiply by \(\rho^2 \sin \phi\). (Example 3, 4)

Recommended review problems from Ch. 12 pages 722-724
Concept check: 7, 8.
Exercises: 23, 25, 26, 27, 28, 31, 32, 34, 39, 41, 42, 43, 47