Unpacked South Dakota State Mathematics Standards

Purpose: *In order for students to have the best chance of success, standards, assessment, curriculum resources, and instruction must be aligned in focus, coherence, and rigor. Unpacked standards documents are intended to help align instruction to the focus, coherence, and rigor of the South Dakota State Mathematics Standards. The standards have been organized in clusters as they are not so much built from topics, but rather woven out of progressions. Not all content in a given grade is emphasized equally in the mathematics standards. Some clusters require greater emphasis than others based on the depth of the ideas, the time that they take to master, and/or their importance to future mathematics or the demands of college and career readiness. To say that some things have greater emphasis is not to say that anything in the standards can safely be neglected in instruction. Neglecting standards will leave gaps in student skill and understanding and may leave students unprepared for the challenges of a later grade.*

<table>
<tr><td colspan="2">Domain: Precalculus</td><td>Grade Level: 4th Year</td></tr>
<tr><td colspan="3">HS4.PC.PE.A Cluster: Define parametric equations.
Students work with different types of coordinate systems such as polar and parametric, and compare them to what they already know about rectangular coordinates.
Students extend their understanding of inverse functions using parametric equations.</td></tr>
<tr><td colspan="3">This is a SUPPORTING cluster. Students should spend the large majority of their time (65-85%) on the major work of the grade. Supporting work and, where appropriate, additional work should be connected to and engage students in the major work of the grade.

PC.PE.1 Given equations for a parametric function, plot the graph and make conclusions about the geometric figure that result.
PC.PE.2 Convert between a pair of parametric equations and an equation in x and y. Model and solve problems using parametric equations.</td></tr>
<tr><td colspan="3">Aspects of Rigor of Student Learning: (Conceptual, Procedural, and/or Application)</td></tr>
<tr><td colspan="3">PC.PE.1 Given equations for a parametric function, plot the graph and make conclusions about the geometric figure that results.</td></tr>
<tr><td>Conceptual Understanding</td><td>Procedural Fluency</td><td>Application</td></tr>
<tr><td>Students should be able to recognize the parent parametric equations for standard functions and be able to apply transformations to graph variations.</td><td>Students can plot points to find the graph of a parametric function. Students know that a parametric function has direction.</td><td>Students explore real world situations where two variables each depend on a third variable.</td></tr>
<tr><td colspan="3">PC.PE.2 Convert between a pair of parametric equations and an equation in x and y. Model and solve problems using parametric equations.</td></tr>
<tr><td>Conceptual Understanding</td><td>Procedural Fluency</td><td>Application</td></tr>
<tr><td></td><td>Students should be able to eliminate the parameter to move from parametric form to Cartesian form.</td><td>Students can model a three dimensional concept using parametric equations.</td></tr>
<tr><td colspan="3">Enacting the Mathematical Practices - Evidence of Students Engaging in the Practices</td></tr>
<tr><td colspan="3">1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
• Students will need to reason abstractly to be able to connect the parameter to its real world meaning.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics. Students can model three dimensional concepts using parametric equations.</td></tr>
</table>

5. **Use appropriate tools strategically.**
6. **Attend to precision.**
7. **Look for and make use of structure.**
    - Students revisit the idea of transformations from a parent function when graphing conics from parametric equations.
8. **Look for and express regularity in repeated reasoning.**

Vertical and Horizontal Coherence and Learning Progressions		
Previous Learning Connections	***Current Learning Connections***	***Future Learning Connections***
In prior courses students have graphed Cartesian equations. Students have noticed that graphing Cartesian equations that are not functions can be difficult. For example, graphing functions with a calculator requires a y = equation, so graphing circle would require two separate y = equations.	Students are working with different types of coordinate systems such as polar and parametric, and are comparing them to what they already know about rectangular coordinates. Students can extend their understanding of inverse functions using parametric equations.	Students will use parametric equations in Calculus and in a Discrete Mathematics course.

Vocabulary (key terms and definitions)

- Parametric equations
- Parameter

Relevance, Explanations, and Examples:

A unit circle has the parametric equations of x(t) = cos t and y(t) = sin t. This can be considered the parent function for all circles and ellipses. Any circle or ellipse can be written as a transformation of this parent equation. For example, a circle with radius 5, centered at the point (2,3) could be written as x(t) = 5 cos t + 2 and y(t) = 5 sin t + 3.

A circle in rectangular coordinates can be three-dimensionalized by adding a third variable such as time using parametric equations. For example x(t) = cos t ; y(t) = sin t and x(t) = sin t; y(t) = cos t are both equations of circles, but are different because of t. Introducing this variable allows us to move along the circles in different directions. As t increases, the first circle would develop counter clockwise, where the second circle would develop clockwise.

Example of using Parametric Equations to find inverses. The equation $y = x^2$ is a function but does not have an inverse unless the domain is restricted. The original function can be written using parametric equations $x = t$; $y = t^2$. Because an inverse function just switches the input and output of the original function, the inverse of the parametric function can be written as $x = t^2$; $y = t$.