Mathematics Curriculum

Topic E: First-Person Video Games—Projection Matrices

N-VM.C.8, N-VM.C.9, N-VM.C.10, N-VM.C.11

Focus Standards:	N-VM.C.8	(+) Add, subtract, and multiply matrices of appropriate dimensions.
	N-VM.C.9	(+) Understand that, unlike multiplication of numbers, matrix multiplication for square matrices is not a commutative operation, but still satisfies the associative and distributive properties.
	N-VM.C.10	(+) Understand that the zero and identity matrices play a role in matrix addition and multiplication similar to the role of 0 and 1 in the real numbers. The determinant of a square matrix is nonzero if and only if the matrix has a multiplicative inverse.
	N-VM.C.11	(+) Multiply a vector (regarded as a matrix with one column) by a matrix of suitable- dimensions to produce another vector. Work with matrices as transformations of vectors.
Instructional Days:	3	
Lesson 25:	First-Person Computer Games (E) ¹	
Lesson 26:	Projecting a 3-D Object onto a 2-D Plane (E)	
Lesson 27:	Designing Your Own Game (P)	

The module ends with Topic E, in which students apply their knowledge developed in this module to understand how first-person video games use matrix operations to project three-dimensional objects onto two-dimensional screens and animate those images to give the illusion of motion (**N-VM.C.8**, **N-VM.C.9**, **N-VM.C.10**, **N-VM.C.11**).

Throughout this topic, students explore the projection of three-dimensional objects onto two-dimensional space. In Lesson 25, students create and manipulate objects in three dimensions and attempt a projection of a cube onto a flat screen. Through a discussion of the historical development of perspective drawing, students will learn how vanishing points can be used to create realistic two-dimensional representations of three-dimensional objects. In Lesson 26, students engage the mathematics that underlies animations like the kind seen in video games. In particular, students learn to take points in three-dimensional space and map

¹ Lesson Structure Key: P-Problem Set Lesson, M-Modeling Cycle Lesson, E-Exploration Lesson, S-Socratic Lesson



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them onto a two-dimensional plane in the same way that a programmer would seek to model the 3-D world on a 2-D screen. Students analyze the 2-D projection of a path followed by an object being rotated through three-dimensional space.

Topic E and Module 2 end with Lesson 27, where students create a brief scene in a video game including onestep turn and roll procedures. Students describe the motions of the characters with respect to the scene and as rotations about specific axes. Students apply the mathematics from the previous lessons to use matrices to represent the motions of the characters in their scenes. Students make characters move in a straight line, turn, and flip in all directions by exploring rotations about each axis, consistently relating these motions back to their matrix representations.

The materials support the use of geometry and game-creating software, such as GeoGebra and the freely available ALICE 3.1.

In Topic E, students are making sense of vectors, understanding them as abstract representations of real world situations such as programming video games (MP.2), and modeling video games with vectors and matrices (MP.4). Through the use of computer games (ALICE 3.1) and software (GeoGebra), students are also using appropriate tools strategically to apply and understand mathematical concepts; further, they come to see matrices as tools to create transformations (MP.5).





