Fall and Winter Standards

CVPM — Constant Velocity Particle Model		
Core Skills	Identify situations with constant velocity motion from motion maps, graphs, equations, and observation	
	Draw a diagram modeling the motion	
	Use the definition of velocity to solve simple problems	
	Understand the characteristics of x and v graphs that relate one graph to the other	
Proficiency Indicators	Draw position graph given velocity graph and vice versa	
	Represent chosen direction of positive correctly and consistently with graphs	
	Recognize and apply information about special cases of motion (no initial or final v, zero displacement, etc.)	
	Differentiate graphically between instantaneous and average velocity and between distance and displacement	
	Use motion graphs for quantitative problem-solving and motion modeling	

CAPM — Constant Acceleration Particle Model		
Core Skills	Identify situations with constant acceleration motion from motion maps, graphs, equations, and observation	
	Understand the characteristics of x, v, and a graphs that relate one graph to another	
	Draw a diagram modeling the motion	
	Use the definition of acceleration to determine the direction of the acceleration and to solve simple problems	
Proficiency Indicators	Convert between position and velocity graphs and velocity and acceleration graphs	
	Represent chosen direction of positive correctly and consistently with all graphs	
	Recognize and apply information about special cases of motion (no initial or final v, zero displacement, etc.) using graphical models	
	Differentiate graphically between instantaneous and average velocity and acceleration	
	Determine the direction of acceleration from information about the motion	
	Use motion graphs for quantitative problem-solving and motion modeling	
Advanced Indicators	Analyze non-constant acceleration motion using graphs	

OPM: T/f — Period and Frequency		
Core Skills	Calculate the period and frequency of an oscillator from data, including data that you take yourself	
	Know and use the units for period and frequency correctly and consistently	
Proficiency Indicators	Use period and frequency to solve problems	
	Understand the variables that affect the period and frequency of pendula	
	Understand the variables that affect the period and frequency of spring systems	
Adv. Ind.	Use the algebraic models relating the period/frequency of pendula or spring systems to physical variables (mass, spring stiffness, string length)	

OPM: G — Oscillation Graphs		
Core Skills	Calculate the amplitude of an oscillator's motion from a position graph	
	Calculate the period and frequency of an oscillator's motion from a graph	
Proficiency Indicators	Determine the equilibrium point of an oscillator from a position graph	
	Determine the displacement during a time interval from a position or velocity graph	
	Determine the velocity of an oscillator at a moment from a position or velocity graph	
	Identify driving and damping forces and their effects on oscillation graphs	
	Understand and identify maxima, minima, and zeroes of position and velocity from position or velocity graphs	
Adv. Ind.	Determine the acceleration from the velocity graph and identify acceleration maxima on position and velocity graphs	

OPM: A — Amplitude		
Core Skills	Calculate the amplitude of any oscillator's motion, including from data that you take yourself	
	Determine the equilibrium point of an oscillator	
	Know and use the units for amplitude correctly and consistently	
Proficiency Indicators	Understand and apply the concept of amplitude independence	
	Use the symmetry of simple harmonic motion to solve problems involving amplitude and distance traveled	

Wave Descriptions	Core Skills	Understand that wave motion requires a medium of oscillators, and that waves are coordinated behaviors of oscillators
		Distinguish between transverse and longitudinal waves and between peaks/troughs and compressions/rarefactions
		Determine the period, frequency, length, and speed of a wave, either from given information or by taking data, in simple contexts
	Proficiency Indicators	Understand which wave quantities are related and which are not
		Determine the period, frequency, length and speed of a wave in any context, including problem solving
	Adv. Ind.	Use a *position vs. time* graph to determine the wavespeed and other advanced applications

Interference and Reflection	Core Skills	Draw simple reflection and interference results of transverse waves
	Proficiency Indicators	Use the principle of superposition to relate the amplitudes of interfering waves to the amplitude of the interference product
		Differentiate between constructive and destructive interference; recognize its effects
		Draw more involved interference and reflection products
		Differentiate between the effects of constrained and unconstrained ends on reflection
	Adv. Ind.	Apply interference and reflection to standing waves, explaining the physical causes and effects of standing waves

Two Source Interference	Core Skills	Identify situations in which two sources radiate waves outward, causing a pattern of positions with different types of interference
		Recognize that the difference between a points distance to one source and its distance to the other source causes differing types of interference in different places
	Proficiency Indicators	For sources that are in phase, identify the locations at which amplitudes are high or low
		Understand and apply the numbering system for maxima and minima; relate the number system to the physical cause of the different types of interference
		Draw more involved interference and reflection products
		Understand the effects on the interference pattern of changing the source frequency and source-to-source distance
	Adv. Ind.	Analyze situations with out-of-phase sources or other extensions of the model

Standing Waves	Core Skills	Determine whether a node or an antinode exists on each end of a standing wave
		Draw a standing wave diagram for a given harmonic or overtone
		Differentiate between longitudinal and transverse standing waves
	Proficiency Indicators	Differentiate between the number of wavelengths long a wave is and its wavelength
		Correctly identify harmonic and overtone numbers from a SW diagram
		Relate the frequency, wavelength, and wavespeed of standing waves
		Understand and apply the inverse relationship between SW frequency and wavelength
	Adv. Ind.	Differentiate conceptually between displacement nodes/antinodes and pressure nodes/antinodes

Resonance	Core Skills	Identify systems where driving at one of an oscillator's natural frequencies causes a large amplitude
		Connect the medium's natural frequencies to the optimum frequencies for driving
	Proficiency Indicators	Determine the natural frequencies of a driven system
		Graph the oscillator's amplitude (qualitatively) as a function of driving frequency, and interpret these graphs
		Determine the frequencies at which driving gives high or low amplitude, as desired
		Understand the result of driving a system at many frequencies simultaneously, as in a musical instrument
		Identify the driving force of a system
	Adv. Ind.	Use the half width at half maximum to quantitatively determine an oscillator's sensitivity to driving frequency

FFT *Frequency Spectra*	Core Skills	Interpret the meanings of peaks in a frequency spectrum	
		Determine whether a complex sound was produced by a medium with mixed or similar ends using the frequency spectrum	
	Proficiency Indicators	Analyze a frequency spectrum to determine the fundamental frequency of an system with mixed or similar ends	
		Use a frequency spectrum to gain information to calculate wavelengths or the speed of sound	
		Correctly identify harmonics and overtones on an FFT for a system with mixed or similar ends	

Timbre	Core Skills	Identify timbre as the quality or color of a sound, separate from the pitch or volume
		Use a frequency spectrum to distinguish between simple and complex sounds and noise
		Use a *pressure vs. time* graph to distinguish between simple and complex sounds and noise
	Proficiency Indicators	Distinguish between dark and bright sounds using frequency spectra or *pressure vs. time* graphs
		Identify corresponding frequency spectra and *pressure vs. time* graphs on the basis of timbre
		Determine the frequencies at which driving gives high or low amplitude, as desired

Beats	Core Skills	Recognize the phenomenon of beats from a description, observation, or a *pressure vs. time* or *amplitude vs. time* graph
		Understand and apply the fact that similar but unequal frequencies cause beats
	Proficiency Indicators	Explain beats using the principle of superposition and wave interference
		Calculate the beat frequency or use the beat frequency to determine possible interfering frequencies
		Determine the point at which a beat frequency begins to be heard as a combination tone and find the frequency of combination tones
		Determine the consonance or dissonance of a pair or tones heard simultaneously; determine the amplitudes of the interfering sounds based on the *pressure vs. time* graph

Doppler Effect	Core Skills	Identify situations in which relative motion of the source and observer causes a perceived frequency shift
		Identify for which observers a sound will be heard higher than, lower than, or the same as the source frequency
	Proficiency Indicators	Identify the compression or stretching of wave fronts as the cause of the Doppler Effect, and apply this concept to conceptual analysis
		Calculate the amount of shift in frequency due to relative motion between the source and the observer
		Correctly determine the frequency heard by any observer
		Draw diagrams that communicate the frequencies heard by different observers, and label them well enough to be helpful in determining those frequencies and/or speeds
		Use the Doppler Effect to explain, analyze, and recognize sonic booms

Algebra	Core Skills	Determine the reasonableness of results before submitting them
		Begin algebraic problem-solving with a known principle or definition
	Proficiency Indicators	Fluently solve equations for unknown quantities
		Use percentages and ratios accurately
	Adv. Ind.	Solve all equations symbolically, using numbers only after the desired quantity has been solved for

Units	Core Skills	Always state units; know the correct (SI) units for every quantity
	Proficiency Indicators	Check expressions for proper unit cancellation
		Fluently use metric prefixes
		Easily convert units, given conversion factors
		Recognize unreasonable answers
	Adv. Ind.	Use appropriate prefixes for your answers

Writing	Core Skills	Write with proper grammar and linear structure
		Use a formal tone
	Proficiency Indicators	Reference data to support conclusions
		Be precise and specific; use appropriate physics vocabulary and use it accurately
		Structure assignments as directed
		Be as concise as possible, within the limits above
	Adv. Ind.	Have fluent and exceptional technical writing skills