Standard Area	Level	Skills/ Content	Chapters
Vectors	I	Find length from components or vice versa Graphical addition/ subtraction of vectors Adding and subtracting vectors by components	1
	II	Find a unit vector in two or three dimensions Calculating a vector representing the change in some quantity Calculating the scalar product (“dot product”) of two vectors Finding the direction of the vector product with the right-hand rule	1,5,11
	III	Calculating the vector product (“cross product”) of two vectors	1,11
Kinematics	I	Qualitative understanding of displacement, speed, velocity, acceleration Describe and classify motion of objects from motion diagrams or graphs Sketch kinematic graphs given motion diagrams or descriptions of motion	1
	II	Calculate displacement, velocity, speed, acceleration of objects given position data Predict the future position of an object in uniform motion Predict the position and velocity of an object undergoing constant acceleration	1,2
	III	Calculate position and velocity for non-constant acceleration Calculate perpendicular and parallel acceleration for an object in circular motion	1,2,5
Momentum Principle	I	Qualitative understanding of force as an interaction Calculation of vector momentum given mass and velocity Qualitative understanding of reciprocity Qualitative understanding of momentum conservation Qualitative understanding of forces in equilibrium Drawing force diagrams Identifying internal and external forces for a system of objects	17
	II	Calculations using momentum update for constant forces Calculations using the spring force law	17

		Calculations of forces in equilibrium in 2-d or 3-d Calculations using conservation of momentum (negligible external forces) in 1-d Calculation of oscillation period for spring	
	III	Calculations using momentum update for non-constant forces Calculations using conservation of momentum in 2-d or 3-d Calculations involving forces and circular motion	17
Interactions	I	Qualitative understanding of gravitational force Qualitative understanding of electric force Calculation of magnitude of gravitational or electric force Qualitative understanding of "ball-and-spring" model for contact forces (tension, normal force) Qualitative understanding of friction and air resistance	19
	II	Calculating gravitational or electric force vectors Calculating interatomic spacing using ball-and-spring model Calculating using friction and air resistance	19
	III	Calculating interatomic spring stiffness using ball-and-spring model Calculating speed of sound in a solid Iterative calculations using air resistance	19
Energy Principle	I	Qualitative understanding of work and energy Calculating energy of a single-particle system Qualitative understanding of potential energy in a multi-particle system Sketch graphs of potential and kinetic energy Classification of bound and unbound systems, qualitative understanding of escape	20
	II	Calculation of potential and kinetic energy for constant forces and springs Calculation of work done by constant forces Calculation of energy transfer due to temperature difference	20
	III	Calculation of work by non-constant forces Using the Energy Principle with dissipative forces	20

Complex Systems	I	Qualitative understanding of center of mass in 3-d Calculation of center of mass in 1-d Calculation of moment of inertia for point masses, single shapes Identifying “point particle” and “real” systems Qualitative understanding of elastic and inelastic collisions	18, 21
	II	Calculating rotational kinetic energy Calculating moment of inertia for composite objects	18,21
	III	Calculating using “point particle” and “real” systems	18, 21
Angular Momentum	I	Qualitative understanding of translational and rotational angular momentum Qualitative understanding of torque Calculation of the magnitude of the angular momentum for single particles and simple solid objects Calculation of the magnitude of torque	22, 23
	II	Calculation of the vector angular momentum of single particles and simple solid objects Calculation of torque vectors Using the Angular Momentum Principle in cases of zero net torque	22, 23
	III	Using the Angular Momentum Principle in cases of non-zero net torque	22, 23
VPython	I	Reading commented code and determining what it does Using code written by others to calculate simple results	
	II	Modifying code written by others to achieve a new result	
	III	Writing a VPython program with all necessary elements, including comments	
Math/ Units	I	Correctly reporting calculated quantities with appropriate units	
	II	Correctly performing calculations to get numerical answers	
	III		
General	I	Identifying assumptions in a calculation or derivation Identifying approximations in a calculation	

		Estimating uncertainties in a measurement Properly formatting graphs with axis labels, units, scaling, and equation(s)	
	II	Understanding when to make an approximation Propagating uncertainties in a calculation Judging whether the results of a calculation are reasonable	
	III	Designing an experimental procedure	
Writing	I	Writing in scientific style: clear, direct, concise Using graphs and/or tables to illustrate and support arguments Using language that effectively communicates meaning and is virtually free of errors	
	II	Organizing the presentation of ideas to provide a clear and logical flow for the reader Writing individual sections of a formal lab report as described in the Guide to Lab Writing	
	III	Writing an entire formal lab report as described in the Guide to Lab Writing	
Class Participation	I	Completing the diagnostic pre-test	
	II	Actively participating in class discussions and in-class activities Completing the diagnostic post-test and making an honest effort to improve the score	
	III	Attending talks at Steinmetz or other events as announced in class	