**The Spreadsheet Lab Manual Table of Contents:** *2020 Microsoft Excel & Google Sheets* **All modules (100+ level have credentialed PD hours) has files coded with alpha-numeric suffixes (0-6, S and P) as follows:
 -0 Lesson Plan (.xls) -** Fully NGSS aligned with DCIs, SEPs and CCCs, objectives, content area, strategies, skills, assessment.
 **-1 Teacher Preparation (.doc)** – Planning, Prep work to delivery, Professional Development Training Time
 **-2 Student Handout (.doc) -** Objective, Discussion, Programming Procedure, Guided Inquiry, and Assessment.
 **-3 Introductory Slide Show (.ppt) -** Quickly sets the objective and summarizes the modeling process before starting.
 **-4 Un-coded Template (.xls) -** Saves class time by filling in data labels and column headings, students get to build the model.
 **-5 Coded Complete Model (.xls) -** Teachers need not build the model (could also provide partially coded model to students)
 **-6 Answer Key (.doc) -** Descriptions of process to solve every problem included with answers, sample solutions, sample writings
 **-S** **Supplemental Activities/Questions (.doc)** – Sourced by teachers doing PD training through original content creation.
 **-P Teacher PD training or Teacher Pilot Study Coding File** (Template -4 **(.xls)** or Teacher Procedures -2 **(.doc)**)
 ***Example Coding:*** *(Genetics Simulation) Answer Key Code #:* ***405-6;*** *Supplement Template File Code #:* ***405-S4***

**001 - Letter from Principal Investigator, Editor/Author, and STEM Educator
002 - Justification:** "Spreadsheet Modeling with Numeric Methods Using Spreadsheet Lab Manual Pedagogy"

 **003 - Getting Started Guide for High School Teachers**

 **004 – Interactive:** Skills, Content Areas, DCIs, SEPs and CCCs + Module Descriptions

**004 – List:** Activity Descriptions, Planning, and Standards Alignment

 **005 - Teacher Tips**

 **006 - SGO Smart Form:** Teacher Procedure (2) Score SGOs for NJSMART + SGO Slide Show (3) & Spreadsheet (5)

 **007 - PLC Plan.**  SLM Professional Learning Community Strategy

 **008 - Copyright Notice**

**010 TRAINING RESOURCES**

 **011 - 9 Quick Activities.** Highly generic tasks, concise numbered procedures

**012 - Keyboard Commands and Corner Cuts.** Time saving operations with worker efficiency added  **013 - Spreadsheet Modeling; A Comprehensive How-To.** From coding a blank worksheet to presentation-ready data

 **014 – Generic Graphing Instructions (Excel or Sheets).** Adaptable to any X-Y cartesian graphing

**100 MATH SPREADSHEET LAB MANUAL MODULES\***

**101 - Designing the Optimum Can.** Using surface area and volume of cylinders to optimize packaging
**102 - Modeling Investments and Amortizations.**  Calculate simple interest and observe compounding
**103 - Quadratic Formula.** Solve quadratics and observe roots on graph immediately upon entering coefficients
**104 - Graphing and Analyzing Functions.** 100 & 1,000 point graphs, set starting value and interval
 **104.2 – Quadratics:** Vertical and Horizontal Shift, Intercepts, Growth, Scaling, Applications
 **104.3 – Cubics:** Vertical and Horizontal Shift, Intercepts, Growth, Scaling, Applications
 **104.4 – Exponentials** Vertical and Horizontal Shift, Intercepts, Growth, Scaling, Applications

 **104.5 – Hyperbolas** Vertical and Horizontal Shift, Dynamic Asymptote Zooming, Growth, Scaling, Applications **105 - The Spreadsheet Casino** Probability simulation with binary outcome and specifiable betting behaviors
**106 - The Monty Hall Problem** Probability simulation with nested IF functions to simulate a classic gameshow scenario

[**200 PHYSICS SPREADSHEET LAB MANUAL MODULES**](https://www.dropbox.com/sh/v5q2czn28n7isd9/AABn4rpoIEqwwzzJX4YXjK37a?dl=0)**\***

 **201 - Vector Solver**, Vector component calculation, addition by decomposition, resultants & equilibrants, Newton’s 1st

 **202 - Terminal Velocity,** 1D Motion with drag force, motion graphs, direction change, dynamic simulation

 **203 - Comparing Trajectories,** 2D Motion with and without drag force, dynamic simulation

 **204 - Buoyancy and Balloons,** Archimedes’ Principle, density in gases, apparent weight, net force, dynamic simulation

 **205 - Rocket Science,** impulse, momentum, motion graphs, Newton’s 1st, 2nd, 3rd, drag, design, dynamic simulation

 **206 – Gravitational Fields,** Forces, energy, escape velocity, Schwarzchild Radius, computed field model

 **207 - Angular Motion in Cars,** Linear to angular, vehicle acceleration timing and drag race simulation

 **208 - The Superposition Principle,** Amplitude, frequency, constructive & destructive interference, beats

 **209 - Electrostatic Forces and Energy:** Coulomb's Law 2D, polar coordinates, fusion, field mapping

 **210 - Electrostatic Forces and Energy:** Coulomb's Law 3D, ijk unit vector notation, AP Physics C *E & M*

 **211 - Basic Circuit Analysis:** Ohm’s Law and electric power in resistors, direct vs. inverse relationships **300 CHEMISTRY SPREADSHEET LAB MANUAL MODULES\***
 **301 - Determining the Limiting Reagent:** Automating percent excess, mass-mass stoichiometry computations  **302 - Titration Simulation:** Set volume increment, graph *pH of strong acid/base* vs. *volume of base/acid added* **303 - Four Gas Laws:** Using the ideal gas law to simulate Boyle’s, Charles’, Avogadro's and Gay Lussac’s Laws **304 - Graham's Law:** Using kinetic energy, molar mass & velocity to experiment & simulate diffusion scenarios **305 - Newton's Law of Cooling (Object Only)** Heating/Cooling curves in an infinitely large ambient fluid system

 **306 - Newton's Law of Cooling (Object and Finite Ambient Environment)** Energy conservation, adiabatic system **400 BIOLOGY & ENVIRONMENTAL SPREADSHEET LAB MANUAL MODULES\*
 401 - Modeling Population Growth and Carrying Capacity:** Comparing Natural (Ideal) vs. Logistic Models **402 – Population Dynamics: Infectious Diseases**

 **403 – Modeling the COVID-19 Pandemic; Sandbox and Parameter Study**

**404.a – Modeling Interacting Populations: (1) Predator & Prey; (2) Self-Limiting (Toxin Creation);
 (3) Competing Native vs Invasive Species Dynamic Population Modeling
404.b – Dynamic Population Parameter Study** Investigating (a1,2,3) parameters and modeling similarities.

**405 – Genetics Simulation:** Dominant and Recessive Phenotype & Genotype, Allele Frequency, Hardy-Weinberg **500 AUTOMOTIVE SPREADSHEET LAB MANUAL MODULES\* 501 Spreadsheet Modeling: A Comprehensive How –To.** Simulate and graph car speeding up against drag force.

 **502 Angular Motion in Cars:** Redesigned and drive style simulated with a Toyota Corolla

 **503 Passenger Car Driving Fuel Economy Simulation:** Side by side routes fuel economy experiments with infinite variations.

**010 TRAINING RESOURCES**

**011 9 Quick Activities: (Multidisciplinary – Physics, Chemistry, Biology, Math)** These are activities that can be used individually in class as a brief (15-30 minutes) individual student activity or as a training activity for inexperienced teachers in order to get them acquainted with Excel.   They start from a blank spreadsheet or run in a series that builds skills and uses data from a previous activity.  The procedures are somewhat generic but can be applied to a generic application such as graphing an equation or solving an equation.  There are some subject specific areas for Biology, Chemistry and Physics.  Completing the activates will address how to write formulas, replicate formulas, use fixed vs. floating cell references, graphing functions, fitting curves and lines to graphs, goal seek to solve equations, random number generations for simulations and more.
They could also be used for demonstrations.  This is ideal for a teacher or student who is getting started with Excel for the first time and could use some guidance in getting acquainted with the program.

**012 Keyboard Commands and Corner Cutting:** This activity will make it faster to work on Excel for anybody working on simulations from The Spreadsheet Lab Manual or any other spreadsheets. Keyboard commands save time compared to using the mouse to find the specific command that you are looking to execute in a drop down menu.  Some of the keyboard commands described with this activity are highlighting ranges of cells, copying, pasting, reformatting, changing the appearance of cells, toggling between worksheets, jumping to the end of large columns or rows and many other things that will save time and allow you to work more smoothly.
Navigating a large spreadsheet can be difficult using a mouse.   If you work on spreadsheets regularly or even occasionally it is worth it to learn these shortcuts.  Spreadsheets eliminate repetition and save time with calculations, shortcuts eliminate repetition and save time with user operations.

**013 Spreadsheet Modeling: A Comprehensive “How To”:** The goal of the activity is to give a crash course on modeling with Excel.  14 page word document will describe every aspect of spreadsheet modeling including formula writing, cell references (both fixed and floating), pivot tables, and goal seek.  In addition to creating models this module describes in detail formatting cells, numbers, borders, filling in colors, changing font sizes, resizing columns and rows, centering horizontally and vertically within cells, setting print area and a variety of other finishing touches.
The activity is essentially a tutorial on spreadsheet modeling that will enable students to conduct data analysis and leave tables and graphs “Presentation Ready” to put in reports.  Rather than take an entire course, run through this module and see how simple math combined with the calculating power of the spreadsheet can model just about anything you could imagine.
The spreadsheet objectives will be achieved as users create a model of a car speeding up from rest. The model will calculate over 100 data points for each of which the position, velocity, acceleration, net force, work, and power output are calculated. Graphs of the velocity and position vs. time are created. Included is a 14 page word document, the completed spreadsheet, and an answer key that includes descriptions of how each answer should be interpreted.  This activity walks the user through the entire modeling process covering every important detail along the way to make a finished product.

**100 MATHEMATICS ACTIVITIES**

**101 Designing the Optimum Can:** In this activity students will program a spreadsheet that performs the calculations relevant to designing cylindrical cans on cylinders of all sizes.  They will display a spectrum of aspect ratios ranging from tall and skinny to short and wide.  Students will consider the volume which relates to how much food each can will hold and the surface area which determines the quantity of material needed.  They will be given cost specifications for the ends and side walls of the cans and be guided to calculate the cost of canning a given quantity of food.  They use a graph and the shape function on Excel to actually see the shape that the can that will minimize cost after optimizing the surface area to volume ratio and the volume to cost ratio for the table in question.
Analysis questions guide students to look at how many cans of a given type will fit into certain boxes and calculate the costs of canning and boxing a certain quantity of food.  Students will also problem solve on the cost of replacing cans with pop tops.  In another design problem students consider the savings as a return on investment to pay for an upfront cost to redesign and change a process to one that will decrease the cost per unit volume of food canned.  This geometry and engineering themed activity will be something that certainly can be adapted in a variety of ways including hands on activities in which students bring in cans from home and can even be used to encourage students to get more involved during canned food drives.
Included is the NGSS Aligned Lesson Plan, Teacher Preparation Guide, Introductory PowerPoint (14 Slides), Activity Handout, Blank Spreadsheet Template, Answer Key, and a copy of the Completed Spreadsheet. Microsoft Office files are sent to the email address provided when completing the purchase.

**102 Modeling Investments and Amortizations:** In this activity students will create a spreadsheet that calculates the principle of a debt and an investment.  The spreadsheet counts time in months and displays time, debt principle, investment principle, the total invested and the monthly change to the investment over 600 intervals (50 years).  It will simulate putting money away every month as an investment at a given interest rate of return and a separate column will simulate paying off the balance of a loan.  Students will specify the annual interest rate that will compound monthly and be added to the principle and the monthly payment (or investment) will be subtracted (or added).  They will predict the mortgage payment amount necessary to pay off the debt in a given time period (amortization) using “Goal Seek” on Excel (or “Solver” on Google Sheets).  They will then answer analysis questions that guide them to better understand debts and investments and conclude sound investment principles.
There is an additional supplement that instructs students to develop a long term investment plan that varies with changing salary conditions that they can specify and consider what type of investment plan is necessary to retire with a given amount of money.  This can be used in real life for high school students planning on taking out loans to go to college or to buy cars.  Whether for practical skills classes, accounting, business math or even as a math refresher, students will benefit from learning and problem solving on a spreadsheet and to be empowered to answer financial questions on their own.
Included is the NGSS Aligned Lesson Plan, Teacher Preparation Guide, Introductory PowerPoint (13 Slides), Activity Handout, Blank Spreadsheet Template, Answer Key, and a copy of the Completed Spreadsheet. Microsoft Office files are sent to the email address provided when completing the purchase.

**103 Quadratic Formula:** In this 2 part activity students will create a spreadsheet that solves for the roots of a quadratic equation given the coefficients in standard form (A, B and C).  It will also graph the quadratic equation so students can observe the roots as the points that intersect the X axis on the graph.
The second part of the activity shows how the problem solving function “Goal Seek” can be used to solve for the roots of any complex equations.  Google Sheets has a similar function called “Solver” that can do the same.  Both essentially use computerized trial and error to solve.  Once the roots are obtained they are confirmed by checking the graph.
Included is the NGSS Aligned Lesson Plan, Teacher Preparation Guide, Introductory PowerPoint (11 Slides), Activity Handout, Blank Spreadsheet Template, Answer Key, and a copy of the Completed Spreadsheet. Microsoft Office files are sent to the email address provided when completing the purchase.

**104 Graphing and Analyzing Functions:** In this activity (4 separate activities, 0.1 Quadratics, 0.2 Cubics, 0.3 Exponentials, 0.4 Hyperbolas), students create a spreadsheet that will evaluate a function and then display 2 graphs, one plotted over 100 and the other over 1000 points.  Students can specify and adjust the starting point of the graphs and the size of the increment over which the X axis varies.  They can view both graphs together and are guided through 4 modules to study parabolic functions, cubic, exponential and hyperbolas.  This study allows students to zoom in on asymptotes as far as they want, observe exponential growth, and compare it to parabolic and cubic equations to help student gain perspective on the behavior of a variety of functions.
Students can move graphs with vertical and horizontal shifts, changes in coefficients, and look at large and small domains of the graph.  Each function has real world application problems that give meaning to the mathematical relationships in a way that makes them easy to visualize and gives students practical examples of how engineers use math to solve problems.
Included is the NGSS Aligned Lesson Plan, Teacher Preparation Guide, Introductory PowerPoint (7 Slides), Activity Handout, Blank Spreadsheet Template, Answer Key, and a copy of the Completed Spreadsheet. Microsoft Office files are sent to the email address provided when completing the purchase.

**105 The Spreadsheet Casino:** In this activity students will create a probability simulation spreadsheet that models a player betting at a casino in which the “house edge” of the game is known.  The house edge is the percentage of each dollar bet in a casino game that will be lost in the long run based on probability.  Sometimes the player wins, but in the long run the house will always win based on this house edge that exists for every game.  It will simulate 8 trips to the casino each of which will be 200 plays.  To simulate the bet students follow the procedures to write the simulation with a random number generator and logical functions to simulate the outcome of an even money (1 to 1) bet given the house edge.   The activity will teach students how to program a spreadsheet, how a random number generator and an “IF Function” works.
The bigger the house edge the more often the player will lose and the more money they will lose on average.  After answering questions and simulating bets on casino games such as roulette, students will test another betting strategy known as “double up – catch up” using If functions.  With this strategy the bet is doubled each time a player loses and in theory they will win and gain back all of their losses eventually. Another lesson students will learn is that sometimes you win at the casino but much more often you lose which is why they say “the house always wins”.
Included is the NGSS Aligned Lesson Plan, Teacher Preparation Guide, Introductory PowerPoint (11 Slides), Activity Handout, Blank Spreadsheet Template, Answer Key, and a copy of the Completed Spreadsheet. Microsoft Office files are sent to the email address provided when completing the purchase.

**106 The Monty Hall Problem:** In this activity students open a blank spreadsheet and are guided to program it to simulate a scenario similar to the classic game show “Let’s Make a Deal”.  “Monty Hall” is the original host for whom the problem is named. In the game contestants are asked to choose one of three possible doors hoping to choose the one that hides a prize. Of the two remaining doors, one of them will be revealed as a losing door. Then the question they must then answer: Keep the door you chose first or switch to the unopened door?
Students will construct the simulation to assign the winning door using a logical “IF Function” and the random number generation function to randomly specify the winner. They will use logical functions to simulate keeping their first pick and switching to the other remaining door.  The spreadsheet is programmed to count the number of wins for each decision and students will use this information to determine whether keeping or switching will be the best course of action for 100 plays or if both actions have equal odds of winning.
The activity will show students how probability can predict outcomes when repeated over a large number of points.  Also how actually running a test can produce results consistent with theoretical percentages although not always exactly the same. The activity can be completed in roughly an hour and the results may be surprising and entertaining for everyone.
Included is the NGSS Aligned Lesson Plan, Teacher Preparation Guide, Introductory PowerPoint (6 Slides), Activity Handout, Blank Spreadsheet Template, Answer Key, and a copy of the Completed Spreadsheet. Microsoft Office files are sent to the email address provided when completing the purchase.

**200 Physics Activities**

**201 Vector Solver:** Solve 2 dimensional, non perpendicular vector addition problems on a spreadsheet students create from scratch.  Students construct the spreadsheet in a computer lab or at home by following the procedures on the activity handout.  Students then answer assessment questions about how they programmed the spreadsheet and then solve problems using the spreadsheet. Outstanding concept review for adding vectors of all types.
-Included is the NGSS Aligned Lesson Plan, Teacher Preparation Guide, Introductory PowerPoint (14 Slides), Activity Handout, Blank Spreadsheet Template, Answer Key, and Completed Spreadsheet. Files are sent to the email address provided as Microsoft Office files.
The answer key provides full descriptions of any/all necessary spreadsheet manipulations so it is perfect for teachers learning the basics of Excel as well as experts wanting to provide skills with spreadsheets to their students.

**202 Terminal Velocity:** In this activity students will create a spreadsheet that calculates the speed at which an object will fall through air over a specified time increment. It incorporates drag force based on the cross sectional area, drag coefficient and velocity of the object and balances that with weight to produce a net force. Newton’s 2nd Law is used to calculate the acceleration which is then used to calculate the new velocity until the drag force is equal to the weight when the object has reached terminal velocity. Using a spreadsheet allows students to do this over 90 increments and to observe any object reach its terminal velocity both on a graph and in the table.
This is an outstanding link between kinematics and forces and Newton’s Laws. It is the free sample on [www.spreadsheetlabmanual.com/freesample.htm](file:///C%3A%5CUsers%5CMike%5CDesktop%5C2015%20Stuff%5Cwww.spreadsheetlabmanual.com%5Cfreesample.htm) and is the inspiration for all other “Spreadsheet Labs” that have been written since 2006.
Included is the NGSS Aligned Lesson Plan, Teacher Preparation Guide, Introductory PowerPoint (8 Slides), Activity Handout, Blank Spreadsheet Template, Answer Key, and Completed Spreadsheet. Files are sent to the email address provided as Microsoft Office files.

**203 Comparing Trajectories:** Comparing Trajectories enables students to solve projectile motion problems with air resistance starting from a blank spreadsheet.  Students create the model that calculates the real and ideal trajectories and then plot the X and Y position coordinates on a single set of axes for a projectile both without air resistance (ideal trajectory) and with air resistance (real trajectory).  The model uses 1000 separate intervals over which drag force, acceleration, velocity and position are recalculated in both the X and Y directions.  The entire activity takes about 1.5 – 2 hours depending on student ability level.  Students see the trajectory of a projectile experiencing drag force next to an ideal parabolic trajectory for the same object but will also have a calculated range for a variety of different practical problems including baseballs, golf balls, and even **accurately predict the range of the 16 inch cannons of the USS Battleship New Jersey.**
Included is the NGSS Aligned Lesson Plan, Teacher Preparation Guide, Introductory PowerPoint (10 Slides), Activity Handout, Blank Spreadsheet Template, Answer Key, and a copy of the Completed Spreadsheet. Microsoft Office files are sent to the email address provided when completing the purchase.
\*A favorite of many physics teachers using The Spreadsheet Lab Manual.\*

**204 Buoyancy and Balloons:** Like every Spreadsheet Lab Manual activity this one starts from a blank spreadsheet.  In this simulation activity students will follow steps to program a spreadsheet to predict whether or not a balloon will float based on its known weight, the weight of the gas that it contains and the density of the fluid in which it is immersed (i.e. the surrounding air).  The independent variable is the diameter of the balloon which starts small and is incrementally increased.  The buoyant force is graphed vs. diameter along with the weight vs. diameter on the same axes and the point at which those two graphs intersect is the minimum diameter necessary to float.
Students can experiment with the weight of the balloon, string, or whatever it is lifting, the fluid (helium, hydrogen, nitrogen, hot air) that is inside the balloon, and the air density.  **An activity supplement is included**which allows students to observe the speed at which a balloon will rise if it is released in air which is a completely new dynamic problem.
Included is the NGSS Aligned Lesson Plan, Teacher Preparation Guide, Introductory PowerPoint (10 Slides), Activity Handout, Blank Spreadsheet Template, Answer Key, and a copy of the Completed Spreadsheet. Microsoft Office files are sent to the email address provided when completing the purchase.

**205 Rocket Science:** In this activity students will build a spreadsheet that simulates the motion of a small rocket experiencing drag force.  The simulation is built by students starting from a blank spreadsheet and they follow the instructions to build the model.  The rocket uses a constant thrust force which vanishes when the fuel runs out.  Since mass changes continually as spent fuel is ejected, weight changes continually.  As the speed of the rocket changes, the magnitude of the drag force changes and its direction changes when the spent rocket falls back down toward the ground.  With variable forces in order to use Newton’s 2nd Law and kinematics equations (needing uniform acceleration) the motion must be modeled over 3000 separate time intervals which are uniform and very small.  This enables the assumption of uniform acceleration to be valid.  IF functions are used to control aspects of the rocket that vary over time such as mass and the direction of the drag force.Analysis questions will guide students to test the effects of varying the mass of the rocket, cross sectional area and drag coefficient, thrust force, specific impulse, amount of fuel compared to the payload and rocket mass.  Students will also observe and interpret velocity vs. time and position vs. time graphs of the motion of the rocket.  Included is the NGSS Aligned Lesson Plan, Teacher Preparation Guide, Introductory PowerPoint (9 Slides), Activity Handout, Blank Spreadsheet Template, Answer Key, and a copy of the Completed Spreadsheet. Microsoft Office files are sent to the email address provided when completing the purchase.

**206 Gravitational Forces and Energy:** Students create a spreadsheet that calculates gravitational force, acceleration and potential energy as a function of position for a specified central object.  The spreadsheet calculates at increments of every 1/5 of the central object radius starting at the surface of the central object moving out 1000 increments.  Force and potential energy are graphed up to 10 radii away from the surface.  The Earth, Moon and several planets along with the sun, specific stars and two types of black holes (stellar and super massive) are investigated.  The escape velocity at the surface (and at every position increment) of each object is calculated and goal seek can be used to solve for the radius of the event horizon on any given object if it was to be compressed sufficiently to form a black hole.
The “energy to get there” in kilograms of rocket fuel is calculated for all altitudes and gives students perspective on overcoming gravity for launching a specified mass from the surface of the object for the sake of space travel.  Analysis questions also prompt students to use the spreadsheet to solve problems relating to the lunar landing module and the mother ship of the Apollo mission and to consider the logistics of mining the moon.
Included is the NGSS Aligned Lesson Plan, Teacher Preparation Guide, Introductory PowerPoint (11 Slides), Activity Handout, Blank Spreadsheet Template, Answer Key, and a copy of the Completed Spreadsheet.  Microsoft Office files are sent to the email address provided when completing the purchase.

**207 Angular Motion in Cars:** In this activity students construct and then investigate a spreadsheet that simulates the motion of a manual transmission car.  The spreadsheet is programmed from a blank worksheet (or from the blank template) in roughly 30 minutes (or 20 minutes starting from the template with column headings and constants filled in, formulas must still be programmed).  The car can be “driven” by shifting the gears and observing the time it takes to speed up through each gear until it must be shifted which is displayed on the worksheet.  Analysis questions guide students through the basic physics concepts including kinetic energy and power calculations as well as acceleration up an inclined plane in addition to studying the mathematical relationships in the model.
The independent variable is the engine RPM’s and the gear is selected by the student. The spreadsheet displays engine angular velocity in RPM’s and rad/sec, the tire angular velocity in rad/sec, car speed in m/sec and MPH are calculated for increments of 10 RPM from 600 up to 7500 RPM engine speed.  Explanation of how each term in the model is connected whether through gear ratios, differential drive ratio, transmission output torque at each gear, car mass, tire diameter, and gear ratios can be varied and the car speed can be observed as the car is driven.
Included is the NGSS Aligned Lesson Plan, Teacher Preparation Guide, Introductory PowerPoint (9 Slides), Activity Handout, Blank Spreadsheet Template, Answer Key, and a copy of the Completed Spreadsheet. Microsoft Office files are sent to the email address provided when completing the purchase.

**208 The Superposition Principle:**  Appropriate for all levels of high school Physics. Applying spreadsheets to study science provides students with skills essential to success in higher education. This activity gives students an interactive experience manipulating variables and observing the resulting wave functions.
The activity handout provides step by step instructions on how to program a spreadsheet that will model superposition of waves starting from a blank Excel or Google Sheets worksheet. Two separate waves are specified by their amplitude and wavelength and then they are graphed on the same set of axes over 2000 separate points. The waves are then added together point by point and the resulting superimposed wave is graphed. Development questions assess the building of the model and the analysis questions guide the students to investigate the superposition of mathematical waves to observe behaviors such as constructive interference, destructive interference and beats. This activity guides students to use the capability of the spreadsheet to use math to produce a scientific behavior that can be readily observed.
Included is the NGSS Aligned Lesson Plan, Teacher Preparation Guide, Introductory PowerPoint (10 Slides), Activity Handout, Blank Spreadsheet Template, Answer Key, and Completed Spreadsheet.  Microsoft Office files are sent to the email address provided when completing the purchase.

**209 Electrostatic Forces and Energy: Coulomb’s Law 2D:** This Physics computer lab activity\* guides students to program *from scratch* an Excel spreadsheet that will solve for the field I, force (F), potential energy (U) and potential (V) for any number of electrostatic point charges distributed in an X-Y coordinate plane.  It is able to solve for each of these values at any field point for any number of source points they specify as a graph of the actual point charges in the 2D coordinate plane that they create is displayed before their eyes.
This activity will provide an involved and detailed study of charge distributions. The instructions guide students with easy to follow directions to study electrostatics using the user friendly and visual graph on a spreadsheet. In addition skills in Microsoft Excel (or Google Sheets) will benefit students in a number of different ways in their future. This activity is perfect for all levels of high school physics including Honors/AP Physics C or any first semester college Physics course studying electrostatics.
Included is the NGSS Aligned Lesson Plan, Teacher Preparation Guide, Introductory PowerPoint (14 Slides), Activity Handout , Blank Spreadsheet Template , Answer Key, and Completed Spreadsheet . Files are sent to the email address provided as Microsoft Office.  A problem bank of 14+ modeling questions with varying levels of difficulty serve as assessment questions allow students to study diverse aspects of the mathematical nature of electrostatic interactions and review the construction of the model. Answer key provides detailed explanations of correct method to solve each problem so teachers with limited experience working on Excel can develop applications. Enhance your curriculum with spreadsheet modeling.
\*(\*1hr 30 min or less\*) Approximate lesson time will vary depending on students level of speed and background working on the computer.

**210 Electrostatic Forces and Energy: Coulomb’s Law 3D:** In this activity students will start with a blank spreadsheet and follow the instructions to program it to solve for the electric field and electric potential at any given field point based on the presence of any number of source points arranged in 3D space with XYZ Cartesian coordinates. If the field point contains a charge then the electrostatic force on and the potential energy of the field point are also calculated. Vector directions are specified in *I-J-K* notation as a magnitude multiplied by a unit vector. With the calculating power of the spreadsheet and some simple formula writing students are guided to create lines of charge, rings, ellipses and any number of point charges and solve for field, potential, force and potential energy for electrostatics.This serves as an excellent link between using Coulomb’s Law with the superposition principle and Gauss’s Law. Students will see how a system of a large number of point charges behaves the same as a continuous charge distribution.
Included is the NGSS Aligned Lesson Plan, Teacher Preparation Guide, Introductory PowerPoint (17 Slides), Activity Handout, Blank Spreadsheet Template, Answer Key, and a copy of the Completed Spreadsheet. Microsoft Office files are sent to the email address provided when completing the purchase.

**211 Basic Circuit Analysis:** This activity takes students through the basic mathematical relationships in circuits.  Students open a blank spreadsheet and create and graph a data set that first calculates the current produced by a range of different resistors when a set voltage is applied.  Then they create and graph a data set for a given resistor that shows the current and power output that will be produced by a range of different voltages.  Ohm’s Law (V=IR) and the Power Equation (P=VI) are investigated by graphing several different resistors on one set of axes and then assign and observe several different voltages on another set of axes.
Students will identify the mathematical relationships as direct or inverse when graphing voltage vs. current for a given resistance or resistance vs. current for a given voltage.   The activity is one of the more basic activities of The Spreadsheet Lab Manual and is appropriate for high school students of virtually all academic levels who are studying circuits.
Included is the NGSS Aligned Lesson Plan, Teacher Preparation Guide, Introductory PowerPoint (10 Slides), Activity Handout, Blank Spreadsheet Template, Answer Key, and a copy of the Completed Spreadsheet. Microsoft Office files are sent to the email address provided when completing the purchase.

**300 CHEMISTRY ACTIVITIES**

**301 Determining the Limiting Reagent:** In this activity students will open a blank spreadsheet and create a form that will perform mass-mass stoichiometry calculations finding the amount of product produced based on the starting amount of each compound that is to react.  They will program the spreadsheet to automatically identify the species that is the limiting reactant and then calculate the percent excess of the other substance.
With trial and error or “Goal Seek” the spreadsheet can calculate the amount of reactant it will take to produce a given amount of product or a specific percent excess.  Students will gain experience solving problems on a spreadsheet and will also get to focus on the conceptual aspects of solving limiting reactant problems rather than the mechanical steps of solving the problems by hand to reinforce concepts.
Included is the NGSS Aligned Lesson Plan, Teacher Preparation Guide, Introductory PowerPoint (6 Slides), Activity Handout, Blank Spreadsheet Template, Answer Key, and a copy of the Completed Spreadsheet. Microsoft Office files are sent to the email address provided when completing the purchase.

**302 Titration Simulation:** In this activity students create a spreadsheet (starting from a blank worksheet) that simulates a titration by incrementally adding a base (or acid) to neutralize a specified solution of acid (or base).  The spreadsheet uses 3000 increments  over which the volume of the base added, total volume, solution H+ & OH- molarity, and pH are tracked. The spreadsheet can be used to solve the titration problems provided in the analysis questions and to create and manipulate a titration curve for a variety of situations.
With this spreadsheet the volume increment by which the standard solution can be added can be adjusted to add standard solution by fractions of a ml or even fractions of a drop to directly observe and better understand how pH changes very quickly when at intermediate values (close to 7). This allows students can get a close look at how logarithmic scale works in practice making sense of how indicators that transition at 9 or 10 pH can still be used to indicate neutralization when completing a titration.
Included is the NGSS Aligned Lesson Plan, Teacher Preparation Guide, Introductory PowerPoint (14 Slides), Activity Handout, Blank Spreadsheet Template, Answer Key, and a copy of the Completed Spreadsheet. Microsoft Office files are sent to the email address provided when completing the purchase.

**303 Four Gas Laws:** In this activity students follow instructions to build a spreadsheet that displays graphs of the related variables in Boyle’s Law (P vs. V), Charles’ Law (V vs. T), Gay Lussac’s Law (P vs. T) and Avogadro’s Law (V vs. n) starting from a blank worksheet. Students will be able to alter any variable and observe how it impacts a graph of the variables for each law. By varying the starting value and the increment by which the independent variable changes, each gas law can be observed in action showing the graph of 100 intervals calculated and displayed instantly. Students will draw conclusions about each law and then apply each one to a specific real world problem **from a spreadsheet they programmed themselves**. Examples include leaving an aerosol can in a hot car, inflating an air mattress, hot air balloons with helium bladders and more.
There is a design module at the end of the activity that incorporates buoyancy and students design a floating hot air balloon and supply it with provisions for a long journey.  They will use the spreadsheet model and research to predict the size of the balloon necessary.  This is an NGSS themed product supplement at the end of the activity in which students can engineer a solution but they are guided so that they will not struggle with the chemistry concepts.
Included is the NGSS Aligned Lesson Plan, Teacher Preparation Guide, Introductory PowerPoint (16 Slides), Activity Handout, Blank Spreadsheet Template, Answer Key, and a copy of the Completed Spreadsheet. Microsoft Office files are sent to the email address provided when completing the purchase.

**304 Graham’s Law:** In this activity students will produce a spreadsheet that calculates molar mass given the chemical formula and the average atomic masses of the elements composing the compound.  It will then use Graham’s Law to predict the relative times it will take two substances to diffuse over a given distance or the distance that each substance will travel in a given amount of time.
The spreadsheet will also predict the location of the chemical reaction inside a tube in a simulation of the classic Graham’s Law experiment in which gaseous substances that will react and form a precipitate in air (such as HCl and NH3)are simultaneously placed on opposite sides of an open ended tube.  The velocity of one of the substances and the length of the tube along with the molar masses of each substance must be specified.  The spreadsheet is then used to solve problems related to effusion such as uranium enrichment for nuclear fuel by determining relative rates of effusion of uranium hexafluoride (UF6) through a diffusion barrier for the two primary isotopes of interest U-238 and U-235.
Included is the NGSS Aligned Lesson Plan, Teacher Preparation Guide, Introductory PowerPoint (17 Slides), Activity Handout, Blank Spreadsheet Template, Answer Key, and a copy of the Completed Spreadsheet. Microsoft Office files are sent to the email address provided when completing the purchase.

**305 Newton’s Law of Cooling:** In this activity students create a spreadsheet that will calculate the temperature of an object being heated or cooled by its surroundings.  It uses 300 time intervals of an object given its mass, initial temperature, temperature of the environment (ambient) temperature, specific heat and a heat transfer coefficient.  It calculates the temperature change, heat loss or gain, rate of heat loss or gain, and new temperature of the object every time a specified time interval passes,  Varying the length of that time interval enables students to model objects over long or short time periods.  Objects can be either cooling off or heating up depending on whether they are hotter or colder than the ambient temperature.  Students will answer development questions to assess the model building part of the activity and analysis questions to assess the investigation part of the activity.  The activity works for students of all levels from basic conceptual levels all the way up to AP.  Real experimental data can also be plotted as an extra series on the graph produced in the model and the model can be used to make predictions about the temperature of the object over time.  Included is the NGSS Aligned Lesson Plan, Teacher Preparation Guide, Introductory PowerPoint (12 Slides), Activity Handout, Blank Spreadsheet Template, Answer Key, and a copy of the Completed Spreadsheet. Microsoft Office files are sent to the email address provided when completing the purchase.

**400 BIOLOGY ACTIVITIES**

**401 Modeling Population Growth 1: Ideal vs. Logistic Model** This activity provides students with instructions to program a mathematical model starting with a blank spreadsheet that simulates population growth using an ideal model and a logistic model. The activity provides background discussion and then after programming students are guided to produce a graph to display the ideal and logistic population models together on the same axes. Their results are studied for various cases including human population, rabbits, polar bears, bacterial and yeast colonies in which the ideal can be compared to the logistic model with a competitive factor.
This quantitative population model is a good independent honors or AP activity that can be completed by students of all levels in small groups in a computer lab.  It takes approximately 90 minutes to complete. Incorporates spreadsheets and quantitative modeling into the Biology or Environmental Science curriculum.
Included is the NGSS Aligned Lesson Plan, Teacher Preparation Guide, Introductory PowerPoint (14 Slides), Activity Handout, Blank Spreadsheet Template, Answer Key, and Completed Spreadsheet. Microsoft Office files are sent to the email address provided when completing the purchase.

**402– Population Dynamics: Infectious Disease-** In this activity students will program a spreadsheet model of an epidemic to explore how projections of the spread and progress of transmission of a disease in a hypothetical population. Included is the NGSS Aligned Lesson Plan, Teacher Preparation Guide, Introductory PowerPoint (12 Slides), Activity Handout, Blank Spreadsheet Template, Answer Key, and Completed Spreadsheet. Microsoft Office files are sent to the email address provided when completing the purchase.

**403** **– Modeling the COVID-19 Pandemic** In this activity students will use a “sandbox” spreadsheet to access a preprogrammed model of the Covid-19 pandemic to explore how projections of the epidemic’s progress depend on the values of key disease parameters and parameters that represent the combination of public policy decisions and societal behavior. Included is the NGSS Aligned Lesson Plan, Teacher Preparation Guide, Introductory PowerPoint (12 Slides), Activity Handout, Blank Spreadsheet Template, Answer Key, and Completed Spreadsheet. Microsoft Office files are sent to the email address provided when completing the purchase.

**404 – Modeling Interacting Populations**

**404a Modeling Population Growth 2: Predator-Prey Dynamic Model:** This activity allows students to construct a quantitative predator prey population simulation on a spreadsheet. They will then study the behavior or the model based on various scenarios involving dingoes and rabbits outlined in the analysis section. The model is programmed by the students and assessment questions guide the students through altering the model variables and observing the effects on the output of the model.
Terms incorporated into the model that students can adjust and observe the outcome of the alteration include: growth factors of both predator and prey species, logistic competitive factor for predators, predator benefit term due to a kill (based on the size of the prey), prey fatality frequency (based on number of interactions), extinction due to minimum viable population size, accelerated dying off of predator species when prey species drops below a critical value.
Included is the NGSS Aligned Lesson Plan, Teacher Preparation Guide, Introductory PowerPoint (10 Slides), Activity Handout, Blank Spreadsheet Template, Answer Key, and Completed Spreadsheet. Microsoft Office files are sent to the email address provided when completing the purchase.

**405 Genetics Simulation:** In this activity students will program a spreadsheet that predicts the genotype and phenotype of an offspring by combination of two alleles.  Students will use a random number generator to assign the alleles and then use IF functions to decipher the resulting genotypes and sum functions count them up to compare the frequency of each genotype and phenotype in the offspring.  Students will vary the population size and the percentage of recessive alleles in the population and observe the impact of varying the percentages of recessive alleles.  Students will also look at how the size of the population affects the actual percentages that result and how they differ from the theoretical or ideal percentages.  They will also calculate the probability of producing offspring exhibiting a recessive trait given its allele frequency in a population.
Included is the NGSS Aligned Lesson Plan, Teacher Preparation Guide, Introductory PowerPoint (10 Slides), Activity Handout, Blank Spreadsheet Template, Answer Key, and Completed Spreadsheet. Files are sent to the email address provided as Microsoft Office files.

**500 AUTOMOTIVE ACTIVITIES**

**501 Spreadsheet Modeling: A Comprehensive How -To:** The spreadsheet objectives will be achieved as users create a model of a car speeding up from rest. The model will calculate over 100 data points for each of which the position, velocity, acceleration, net force, work, and power output are calculated. Graphs of the velocity and position vs. time are created. Included is a 14 page word document, the completed spreadsheet, and an answer key that includes descriptions of how each answer should be interpreted.  This activity walks the user through the entire modeling process covering every important detail along the way to make a finished product. The goal of the activity is to give a crash course on modeling with Excel.  14 page word document will describe every aspect of spreadsheet modeling including formula writing, cell references (both fixed and floating), pivot tables, and goal seek.  In addition to creating models this module describes in detail formatting cells, numbers, borders, filling in colors, changing font sizes, resizing columns and rows, centering horizontally and vertically within cells, setting print area and a variety of other finishing touches.
The activity is essentially a tutorial on spreadsheet modeling that will enable students to conduct data analysis and leave tables and graphs "Presentation Ready" to put in reports.  Rather than take an entire course, run through this module and see how simple math combined with the calculating power of the spreadsheet can model just about anything you could imagine.

**502 Angular Motion in Cars:** (Replaces 207 hypothetical car with specifications for a Toyota Corolla). In this activity students construct and then investigate a spreadsheet that simulates the motion of a manual transmission car, but is modified to have gears accurate for more recent model year Corolla and adapted to simulate a driving economy factor and other differences in layout from 207.  The spreadsheet is programmed from a blank worksheet (or from the blank template) in roughly 30 minutes (or 20 minutes starting from the template with column headings and constants filled in, formulas must still be programmed).  The car can be "driven" by shifting the gears and observing the time it takes to speed up through each gear until it must be shifted which is displayed on the worksheet.  Analysis questions guide students through the basic physics concepts including kinetic energy and power calculations as well as acceleration up an inclined plane in addition to studying the mathematical relationships in the model.
The independent variable is the engine RPM's and the gear is selected by the student. The spreadsheet displays engine angular velocity in RPM's and rad/sec, the tire angular velocity in rad/sec, car speed in m/sec and MPH are calculated for increments of 10 RPM from 600 up to 7500 RPM engine speed.  Explanation of how each term in the model is connected whether through gear ratios, differential drive ratio, transmission output torque at each gear, car mass, tire diameter, and gear ratios can be varied and the car speed can be observed as the car is driven.
Included is the NGSS Aligned Lesson Plan, Teacher Preparation Guide, Introductory PowerPoint (9 Slides), Activity Handout, Blank Spreadsheet Template, Answer Key, and a copy of the Completed Spreadsheet. Microsoft Office files are sent to the email address provided when completing the purchase.

**503 Passenger Car Fuel Economy Simulation:**

Objectives: 1). To calculate the total work done by an engine in a moving car for a specific number of accelerations through each gear and a number of minutes specified at various speeds. Then use it to simulate the fuel economy for a car based on its fuel consumption by the operation of the engine to produce that work. 2). Design and run experiments to test the effects of a number of different variables on fuel economy. 3). Incorporate a way to save energy into a specific task for something that involves driving in your day to day life. This simulation is provided to students already programmed because of the many long and complicated formulas that needed to be developed to link each variable that is referenced in a way that is able to be tested. This 6 speed transmission model was developed for Professional Fleet Management Analysts to specifically quantify the cost of speeding and city vs. highway driving for a variety of vehicle types. Included is the NGSS Aligned Lesson Plan, Teacher Preparation Guide, Introductory PowerPoint (13 Slides), Activity Handout, Answer Key, and a copy of the Completed Spreadsheet. (Microsoft Office).