Teacher Toolkit - Forces in Two Dimensions

Objectives:

1. To use vector concepts to add force vectors and determine the resultant or net force.
2. To use vector concepts to determine the components of a force that is directed at an angle.
3. To use Newton's laws and vector concepts to analyze objects that are at equilibrium (e.g., an object hung by two cables stretched diagonally to support points).
4. To use vector resolution and Newton's second law to determine the acceleration of an object along a level surface when a force is applied to it at an angle to the surface.
5. To use free-body diagrams and Newton's second law to analyze the motion of an object moving along an inclined plane.
6. To conduct a Newton's second law analysis of a two-body system that includes two objects connected by a rope that is stretched over a pulley (e.g., an Atwood's or modified Atwood's machine).

Readings: The Physics Classroom Tutorial, Motion and Forces in Two-Dimensions Chapter, Lesson 3

Interactive Simulations:

1. Vector Addition http://www.physicsclassroom.com/Physics-Interactives/Vectors-and-Projectiles/Vector-Addition/Vector-Addition-Interactive
   The Vector Addition Interactive provides learners with a tool for visualizing the addition of vectors using either the head-to-tail method or the component method. Up to three vectors can be added and the resultant is drawn.
2. Name That Vector http://www.physicsclassroom.com/Physics-Interactives/Vectors-and-Projectiles/Name-That-Vector
   This HTML5 skill-building activity presents 12 randomly-selected challenges to students in order to reinforce the concept that the components of the resultant vector is the sum of the components of the individual vectors.
3. Sliding Down an Incline Plane http://www.thephysicsfront.org/items/detail.cfm?ID=9973
   This Java simulation shows a stone block lying at rest on an inclined plane. The slope of the ramp can be increased or decreased, allowing students to see the exact point when the component of gravity equals the force of static friction.
4. PhET: The Ramp http://phet.colorado.edu/en/simulation/the-ramp
   This simulation allows you to push a variety of objects up a virtual ramp: a file cabinet, refrigerator, piano, crate, or a sleepy dog! Set the coefficient of friction, set the ramp angle from 1-90 degrees, and change the applied force from 0-3000 Newtons.

Video and Animation:

1. Physlet Physics: Two-Dimensional Kinematics http://www.compadre.org/Physlets/mechanics/intro3.cfm
   This Physlets chapter provides a comprehensive collection of 17 animation-based problems consisting of: 1) Illustrations, 2) Explorations (accompanied by printable worksheets), and 3) Multi-step problems. The resources vary from multiple choice format to longer exercises that require students to solve problems.
2. Segway Technology http://www.pbslearningmedia.org/resource/phy03.sci.phys.mfw.segway/segway-technology-whats-newton-got-to-do-with-it/
   In this 8-minute video from PBS Learning Media, Kamen talks about how Newton's Laws governed the Segway design, which uses gyroscopic sensors to detect changes in the driver's center of mass.

Interactive Homework Problems **(See the complete toolkit at TPC's Teacher Toolkit website for details.)**

The Interactive Homework Problems from the University of Illinois have 3 components: conceptual analysis, strategic analysis, and calculation. Students answer multiple choice questions designed to encourage critical thinking. Feedback is immediate. Free-body diagrams, drawings, and graphs help the learner visualize the concepts.

1. Stream Crossing http://per.physics.illinois.edu/per/IE/ie.pl?phys111/ie/02/IE_swim_across_stream
2. Mass on Two Strings http://per.physics.illinois.edu/per/IE/ie.pl?phys101/ie/04/two_strings
3. Plane in Flight http://per.physics.illinois.edu/per/IE/ie.pl?phys111/ie/02/IE_plane
4. Block on Incline http://per.physics.illinois.edu/per/IE/ie.pl?phys111/ie/03/IE_block_on_incline

Labs and Investigations: http://www.physicsclassroom.com/lab/index.html#vf

1. The Physics Classroom, The Laboratory, Getting Hung Up by Tension
   Students conduct force analysis on three different objects held at static equilibrium. Vector resolution is used for each individual force to determine their components. Components are added to determine the resultant force.
2. The Physics Classroom, The Laboratory, Sign Hanging Lab
   Students measure the tension force exerted upon a hanging sign in order to predict the mass of the sign.

3. The Physics Classroom, The Laboratory, Science Friction Adventure
   Students measure the friction coefficient for an inclined plane and compare it to the value for the maximum angle at which the plane can be inclined before an object overcomes static friction and slides down it.
4. The Physics Classroom, The Laboratory, Inclined Plane Lab
   This inquiry activity has student lab groups work cooperatively as a class to collect and analyze data that relate the incline angle to the ratio of the gravity force to the parallel component of gravity.
5. The Physics Classroom, The Laboratory, On a Roll Challenge
   Students combine Newton's laws and kinematics to predict the speed of a cart at the end of an inclined plane and compare the predicted value to the actual value.
6. The Physics Classroom, The Laboratory, Modified Atwood's Machine
   Students explore the relationship between final velocity and the amount of hanging mass on a modified Atwood's machine.

Demonstration Ideas: **(See the complete toolkit at TPC's Teacher Toolkit website for details.)**

1. Ladder Demonstration Model http://www.thephysicsfront.org/items/detail.cfm?ID=7849
2. Static and Kinetic Friction http://canu.ucalgary.ca/map/content/force/friction/simulate/horizontal/applet.html

Minds On Physics Internet Modules: http://www.physicsclassroom.com/mop

The Minds On Physics Internet Modules are a collection of interactive questioning modules that target a student's conceptual understanding. Each question is accompanied by detailed help that thoroughly addresses the question. Forces in Two Dimensions module:

Ass't 2D1 - Vector Analysis
Ass't 2D2 - F_{net} = m•a and Forces at Angles
Ass't 2D3 - Equilibrium Concepts
Ass't 2D5 - Static Equilibrium and Analysis
Asst 2D5 - Inclined Plane Concepts
Ass't 2D6 - Incline Plane Analysis

Concept Building Exercises: http://www.physicsclassroom.com/curriculum/force2D

1. The Curriculum Corner, Forces in Two Dimensions, Another Angle on F-m-a
2. The Curriculum Corner, Forces in Two Dimensions, Adding and Resolving Forces
3. The Curriculum Corner, Forces in Two Dimensions, Analyzing Equilibrium Situations
4. The Curriculum Corner, Forces in Two Dimensions, Analyzing Accelerations on Level Surfaces
5. The Curriculum Corner, Forces in Two Dimensions, Inclined Plane Analysis

Problem-Solving Exercises: http://www.physicsclassroom.com/calcpad/vecforce/problems

1. The Calculator Pad, Vectors and Forces in Two Dimensions, Problems #1 - #27

Real Life Connections: **(See the complete toolkit at TPC's Teacher Toolkit website for details.)**

1. CIESE – Navigational Vectors http://ciese.org/curriculum/vectorproj/

Elsewhere on the Web: **(See the complete toolkit at TPC's Teacher Toolkit website for details.)**

1. Tilt Maze Game Model http://www.compadre.org/OSP/items/detail.cfm?ID=11968

Standards:

(Coming very soon. Check back later.)