TOPIC 1.2: DYNAMICS

S4P-1-4 Solve vector problems for objects in equilibrium.

S4P-1-5 Calculate the forces acting on an object resting on an inclined plane.

Include: normal force, friction, components of the gravitational force (mg)

S4P-1-6 Calculate the components of $\vec{F}_{\text{gravity}}$ exerted on an object resting on an inclined plane.

S4P-1-7 Solve problems with $\vec{F}_{\text{friction}}$ for objects on a horizontal surface and on an inclined plane.

Include: coefficient of friction

S4P-1-8 Solve problems using $\vec{F}_{\text{net}} = m\vec{a}$ where $\vec{F}_{\text{net}} = \vec{F}_{\text{applied}} + \vec{F}_{\text{friction}}$ and using kinematics equations from above.

Include: $\vec{F}_{\text{applied}}$ at an angle to horizontal motion; combined mass systems; $\vec{F}_{\text{applied}}$ on an inclined plane; forces acting at various angles on a body

S4P-1-9 Perform an experiment to investigate forces acting on an object.

GENERAL LEARNING OUTCOME CONNECTION

Students will…

Demonstrate appropriate scientific inquiry skills when seeking answers to questions (GLO C2)

SPECIFIC LEARNING OUTCOME

S4P-1-4: Solve vector problems for objects in equilibrium.

SUGGESTIONS FOR INSTRUCTION

Entry Level Knowledge

In Senior 3 Physics, vector problems were collinear and at right angles. Students also prepared free-body diagrams for forces acting on an object.

Class Discussion

Students solve problems for objects in equilibrium using vector components. See the illustrative example below.

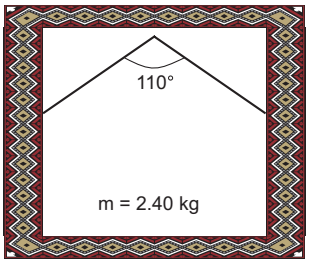


Diagram 1

Problem: Calculate the tension in the wire that is supporting the picture as illustrated.

Solution:

Step 1. Calculate the weight of the object.

$$\vec{F} = m\vec{g} = (2.40 \text{ kg})(9.8 \text{ N/kg})$$
$$= 23.5 \text{ N [downwards]}$$

Step 2. The total upward force equals the total downward force.

$$\vec{F}_{upward} = \vec{F}_g$$

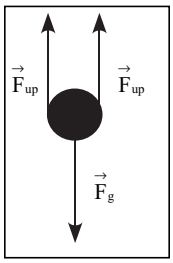


Diagram 2

Step 3. Since there are two support wires,

$$\vec{F}_{upward} = \vec{F}_g/2 = 23.5 \text{ N}/2 = 11.75 \text{ N [up]}$$

in each support wire.

Step 4. Bisect the angle $\theta = 55°$ and draw a vector diagram showing the components of the force and the resultant force.

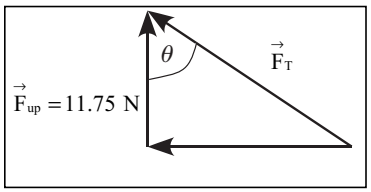


Diagram 3

Step 5. Solve for the hypotenuse that is the tension in the wire.

$$\cos 55^\circ = 11.75 \text{ N}/\vec{F}_T$$
$$\vec{F}_T = 11.75 \text{ N}/\cos 55^\circ =$$
$$11.75 \text{ N}/0.574 = 20.5 \text{ N}$$

SKILLS AND ATTITUDES OUTCOMES

S4P-0-2a: Select and use appropriate visual, numeric, graphical, and symbolic modes of representation to identify and represent relationships.

S4P-0-2h: Analyze problems using vectors.
Include: Adding and subtracting vectors in straight lines, at right angles, and at non-orthogonal angles

GENERAL LEARNING OUTCOME CONNECTION

Students will…

Understand the properties and structures of matter as well as various common manifestations and applications of the actions and interactions of matter (GLO D3)

SUGGESTIONS FOR INSTRUCTION

Teacher Demonstration

Suspend a pair of spring scales to support a weight (1 kg). Show that as the supporting angle increases, the tension also increases.

Laboratory Activity

Use a laboratory activity to measure the forces on an object in equilibrium.

SUGGESTIONS FOR ASSESSMENT

Visual Display

Students design and build a mobile that illustrates the concept of static equilibrium. This could be a decorative mobile that would amuse infants.

Pencil-and-Paper Task

Students work on equilibrium problems.

SUGGESTED LEARNING RESOURCES

BLM 17-1: Balancing Forces, *Physics: Concepts and Connections*, Irwin Publishing Ltd., 2003

Lab 7.1: Equilibrium and Forces, *Physics: Concepts and Connections,* Irwin Publishing Ltd., 2003

Quick Lab: Maintaining Equilibrium, p. 468, *Physics 12,* McGraw-Hill Ryerson, 2003

GENERAL LEARNING OUTCOME CONNECTION

Students will…

Demonstrate appropriate scientific inquiry skills when seeking answers to questions (GLO C2)

SPECIFIC LEARNING OUTCOMES

S4P-1-5: Calculate the forces acting on an object resting on an inclined plane.

Include: normal force, friction, components of the gravitational force (mg)

S4P-1-6: Calculate the components of $\vec{F}_{\text{gravity}}$ exerted on an object resting on an inclined plane.

SUGGESTIONS FOR INSTRUCTION

Notes to the Teacher

The vector nature of force is now being extended to forces on an inclined plane.

Class Discussion

Illustrate how the force of gravity $\left(\vec{F}_g\right)$ is broken down into components. One component is parallel to the surface of the inclined plane $\left(\vec{F}_{\parallel}\right)$ and the other component force is perpendicular to the surface of the inclined plane $\left(\vec{F}_{\perp}\right)$.

The angle of the plane from horizontal equals the angle closest to the object in the triangle with the components.

$$\sin\theta = \frac{\vec{F}_{\parallel}}{\vec{F}_g}$$

$$\cos\theta = \frac{\vec{F}_{\perp}}{\vec{F}_g}$$

Note: $\vec{F}_N = \vec{F}_{\parallel}$, but $\vec{F}_N$ is opposite in direction. Be sure to include the coordinate system in your diagram as this requires the student to draw the component force vectors in the proper orientation to the object's motion.

Provide several examples for the students to solve for component forces on an inclined plane.

SKILLS AND ATTITUDES OUTCOME

S4P-0-2h: Analyze problems using vectors.

Include: Adding and subtracting vectors in straight lines, at right angles, and at non-orthogonal angles

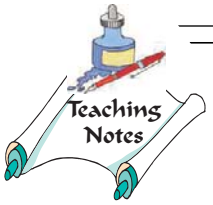
GENERAL LEARNING OUTCOMES CONNECTION

Students will…

Understand how stability, motion, forces, and energy transfers and transformations play a role in a wide range of natural and constructed contexts (GLO D4)

Recognize that characteristics of materials and systems can remain constant or change over time, and describe the conditions and processes involved (GLO E3)

SUGGESTIONS FOR INSTRUCTION



SUGGESTIONS FOR ASSESSMENT

Visual Display

Students use diagrams to show how the components of $\vec{F}_g$ change with different angles of inclination, like 0°, 25°, 50°, 75°, and 90°.

Pencil-and-Paper Task

Solve problems for components:

- determine the components of $\vec{F}_g$
- determine the normal force
- determine the force of friction
- determine the $\vec{F}_{net}$ on an inclined plane

SUGGESTED LEARNING RESOURCES

BLM 21-2: Sliding Friction, *Physics: Concepts and Connections*, Irwin Publishing Ltd., 2003

Lab 5.1: Kinetic Friction, p. 190, *Physics: Concepts and Connections*, Irwin Publishing Ltd., 2003

Lab 5.2: Static Friction, p. 191, *Physics: Concepts and Connections*, Irwin Publishing Ltd., 2003

GENERAL LEARNING OUTCOME CONNECTION

Students will…

Demonstrate appropriate scientific inquiry skills when seeking answers to questions (GLO C2)

SPECIFIC LEARNING OUTCOMES

S4P-1-7: Solve problems with $\vec{F}_{friction}$ for objects on a horizontal surface and on an inclined plane.

Include: coefficient of friction

S4P-1-8: Solve problems using $\vec{F}_{net} = m\vec{a}$ where $\vec{F}_{net} = \vec{F}_{applied} + \vec{F}_{friction}$ and using kinematics equations from S4P-1-1.

Include: $\vec{F}_{applied}$ at an angle to horizontal motion; combined mass systems;

$\vec{F}_{applied}$ on an inclined plane; forces acting at various angles on a body

SUGGESTIONS FOR INSTRUCTION

Entry Level Knowledge

In Senior 3 Physics, students studied the forces acting on an object on an inclined plane in a qualitative manner. Students are familiar with the coefficient of friction and the calculation of frictional force and normal force.

Notes to the Teacher

Students should solve various situations for objects on inclined planes. For example:

A person in a wheelchair is travelling up an inclined sidewalk. The coefficient of friction is 0.11 and the mass of the person and the wheelchair is 65.0 kg. The degree of incline is 7°. Can the person rest comfortably on the inclined sidewalk, or will this person's wheelchair roll down the incline? Calculate the acceleration if the person cannot rest comfortably on the inclined sidewalk. Support your answer mathematically.

Collaborative Teamwork

Students write a memo to a construction firm, describing the above problem. Students also explain the effect a heavier person, type of material, or angle of the ramp would have on the acceleration of the wheelchair.

Notes to the Teacher

Encourage students to identify all the forces acting on an object in the following situations. These forces should be labelled. See Appendix 1.4 for illustrative examples.

- $\vec{F}_{applied}$ at an angle to horizontal motion
- $\vec{F}_{applied}$ on an inclined plane
- combined mass systems
- forces acting at various angles on a body
- two forces acting horizontally, pulling an object along the horizontal plane

SKILLS AND ATTITUDES OUTCOMES

S4P-0-2a: Select and use appropriate visual, numeric, graphical, and symbolic modes of representation to identify and represent relationships.

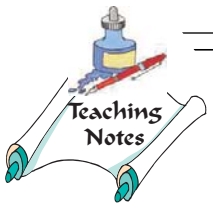
S4P-0-2h: Analyze problems using vectors.
Include: Adding and subtracting vectors in straight lines, at right angles, and at non-orthogonal angles

GENERAL LEARNING OUTCOME CONNECTION

Students will…

Understand how stability, motion, forces, and energy transfers and transformations play a role in a wide range of natural and constructed contexts (GLO D4)

SUGGESTIONS FOR INSTRUCTION



SUGGESTIONS FOR ASSESSMENT

Performance Assessment

Students construct their own problems with answers and they exchange these questions with each other to aid in solving a variety of problems.

Students work in small groups and generate a series of problems with their solutions based on kinematics/dynamics equations. They then exchange their problem set with another group and solve the other group's problem set.

Pencil-and-Paper Task

Students work on a variety of problems such as:

- $\vec{F}_{applied}$ at an angle to horizontal motion
- $\vec{F}_{applied}$ on an inclined plane
- combined mass systems
- applied forces acting at various angles on a body (see Suggestions for Instruction)

Research Report/Presentation

Students prepare a report that discusses how kinematics concepts are applied to real-life situations. For example, how does one move a heavy barrel up an incline? How do piano movers raise a piano into the moving van? How are heavy objects moved from one level to a lower/higher level?

GENERAL LEARNING OUTCOME CONNECTION	SPECIFIC LEARNING OUTCOME	SKILLS AND ATTITUDES OUTCOMES
Students will… Recognize that scientific knowledge is based on evidence, models, and explanations, and evolves as new evidence appears and new conceptualizations develop (GLO A2)	**S4P-1-9: Perform an experiment to investigate forces acting on an object.**	**S4P-0-2b:** Propose problems, state hypotheses, and plan, implement, adapt, or extend procedures to carry out an investigation where required. **S4P-0-2d:** Estimate and measure accurately using SI units.

SUGGESTIONS FOR INSTRUCTION

Notes to the Teacher

See recommended textbooks for suitable labs.

SUGGESTIONS FOR ASSESSMENT

Laboratory Report

Students collect, organize, and graphically illustrate data obtained and submit a lab report using a pre-established format.

Visual Displays

Students design and construct a model of, or a portion of, an amusement park ride.

Students use a free-body diagram and the appropriate algebra to describe the forces and accelerations involved in the ride.

Strategies for Connecting the Dynamics Outcomes Together

Students complete a Three-Point Approach for each of the following terms:

Dynamics

inertia	laws of inertia
inertial frame of reference	force
unbalanced force	normal force
action-reaction forces	force of gravity
weight	dynamics
force of friction	static friction
kinetic friction	applied force
coefficient of friction	net force
inclined plane	

SKILLS AND ATTITUDES OUTCOMES

S4P-0-2e: Evaluate the relevance, reliability, and adequacy of data and data-collection methods.

Include: discrepancies in data and sources of error

S4P-0-2f: Record, organize, and display data using an appropriate format.

Include: labelled diagrams, tables, graphs

S4P-0-4a: Demonstrate work habits that ensure personal safety, the safety of others, and consideration of the environment.

GENERAL LEARNING OUTCOME CONNECTION

Students will…

Demonstrate curiosity, skepticism, creativity, open-mindedness, accuracy, precision, honesty, and persistence, and appreciate their importance as scientific and technological habits of mind (GLO C5)

SUGGESTIONS FOR ASSESSMENT

Journal Entries

1. On the Compare and Contrast frame, compare and contrast the force of kinetic friction and the force of static friction.
2. On the Concept Relationship frame, compare and contrast gravitational mass and inertial mass.
3. Prepare a concept map relating these key concepts:

kinematics	dynamics
the Second Law	force of friction
normal force	applied force
net force	force of gravity
inclined plane	free body diagram
coefficient of friction	

SUGGESTIONS FOR ASSESSMENT

Concept Questions: Newton's Laws of Motion

Using the appropriate law, explain the following.

1. A bullet is fired from a rifle. The rifle recoils.
2. A Judo expert attempts to break 10 boards piled on top of each other by striking them with one blow of his hand. In the process, he breaks a bone in his hand.
3. The stationary car in which a passenger sits is struck from the rear by a second car. The passenger suffers whiplash.
4. A boy throws an egg as hard as he can at a blanket held by two people. The egg is caught in the blanket without being broken.
5. A curling rock slides along the ice and slowly comes to a stop.
6. A rock is dropped from a bridge and accelerates towards the Earth. The rock exerts a force on the Earth. We do not notice the Earth accelerating towards the rock.

SUGGESTED LEARNING RESOURCES

Quick Lab: The Slippery Slope, p. 192, *Physics 12,* McGraw-Hill Ryerson, 2003

Investigation 10-A: Atwood's Machine, p. 480, *Physics 12*, McGraw-Hill Ryerson, 2003

Lab 6.2: Amusement Park Physics, *Physics: Concepts and Connections,* Irwin Publishing Ltd., 2003

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