

Problem-Based Learning for College Physics
A Website of Life-like Activities

Problem Submission Guide





Problem Submission Guide

When submitting a problem using the Problem Submission Form, please follow the guidelines listed in this Problem Submission Guide in order to maintain a certain level of consistency. You may also refer to any problem presented in this site if you are not sure how to present the information in one or more of the sections.

Title:

The title of your problem must be captivating and refer to the lifelike situation presented in your problem.

Central theme:

Identify the main theme with which the problem can be associated.
For example, for the course 203-NYA, the central themes are:

1. Kinematics: (specify 1-D, 2-D or circular)
 2. Dynamics: (specify 1-D or 2-D)
 3. Circular Dynamics
 4. Work-Energy
 5. Momentum Conservation (specify 1-D or 2-D)
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All related concepts:

Choose all the concepts related to the theme(s) of the problem.
For example, for the course 203-NYA, the related concepts are:

1. Kinematics

- a) 1-D
- b) 2-D
- c) Circular Motion

2. Dynamics: (specify 1-D or 2-D)

- a) Newton's First Law
- b) Newton's Second Law
- c) Newton's Third Law
- d) Universal Law of Gravitation
- e) Hooke's Law
- f) Friction forces
 - I) Static
 - II) Kinetic

3. Circular Dynamics

- I) Angular momentum
- II) Torque

4. Work-Energy

- a) Work-Energy Theorem
- b) Conservation of Energy
 - I) Without friction
 - II) With friction

5. Momentum Conservation: (specify 1-D or 2-D)

- a) Elastic Collisions
 - b) Inelastic Collisions
 - c) Impulsion
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Author

The author is the college professor(s) who has come up with the problem.

College

The name of the college where the professor works.

Discipline

The first phase of this project concerns Physics. Depending on how the project progresses, we will eventually open problems to all disciplines.

Course

The name and code of the course.

Example: Introduction to Newton's Mechanics (Physics 203-NYA)

Keywords

Keywords are the main concepts and notions that will be used in the development of the problem.

Example: Speed, acceleration, distance, collision, crumple zone, insurance

Lab/class time required

The lab/class time required is the amount of time that it will take to complete the problem. This should be stated in hours and also as the suggested number of class or lab periods. This only refers to the lab/class time devoted to the task. Students may very well be required to complete a formal report or extra calculations outside of school time.

Type/environment

Specify if the problem takes place in a class or in a lab.

Materials needed

If the problem is given in a lab, list the materials to be used.

Abstract

The abstract should be a quick synopsis of the problem. It should include the context, the main theme and a brief description of the problem.

Skills needed

Specify the skills needed (and the level of the skills) for students to accomplish the task and the concepts required to solve the problem. Example: Algebra

Learning objectives

A description of the skills that students should acquire through solving the problem. The learning objectives should correspond to the ministerial terminology found in the Objectives and Standards document for the course concerned (see the example in Appendix 1 at the end of this document). The objectives should be listed following the stated sentence "After completing this problem, students will be able to":

Example:

After completing this problem, students will be able to:

- Describe the relationships between position, displacement, average velocity, instantaneous velocity, average acceleration and instantaneous acceleration. (Learning objective 1.1.2.)
 - Solve problems for an object in motion with constant acceleration, including objects in free fall. (Learning objective 1.4.1.)
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The Problem

First, the PBL scenario should propose a lifelike problem in which the student is the central actor. Second, the problem structure must also include meaningful questions that have to be answered to solve the problem. However, these questions must not structure the problem in such a way that an algorithmic solution is possible. That is, the problem should not be immediately solvable by placing the variables given in the problem into an equation. Solutions should require more than one-step calculations. In fact, one of the major goals of PBL is to allow students to come up with a structured definition of the problem to be solved.

The recommended PBL scenario is the one developed by the University of Minnesota's physics education group (<http://groups.physics.umn.edu/phised/index.html>) and described in their book on the subject (<http://groups.physics.umn.edu/phised/Research/CGPS/GreenBook.html>).

The criteria for context-rich problems are as follows:

- Each problem is a short story where the main character is the student. The personal pronoun “you” is therefore used frequently.
- The proposed scenario contains a plausible motivation to calculate something.
- The objects described in the problem are real (or imaginable) and consist – as much as possible – of familiar objects.
- The problems cannot be solved in one mathematical step. That is, the problem does not consist of an algorithmic solution where students need only to plug values into an appropriate equation.

In-class teacher's guide

The in-class teacher's guide is a very important part of the problem. It is aimed at helping teachers use your problems without too much difficulty. It presents a general presentation of the problem, an in-class implementation synopsis and the evaluation modalities of the problem. Here is the suggested structure for the in-class teacher's guide for your problem.

1. General Presentation of the Problem
2. Implementation Synopsis
 - a) Brief description of context (in-class vs. lab problem)
 - b) Steps needed to solve the problem
 - c) Time allocation
3. Suggested Evaluation Modalities
 - a) Evaluations: formative vs. summative
 - b) Student submissions:
 - I) Report/portfolio
 - II) Documents showing cognitive paths
 - III) In-class participation (evaluation modalities)

Appendix 1 Objectives and Standards for Physics 203-NYA at John Abbott College

STANDARDS

Specific Performance Criteria

OBJECTIVES

Intermediate Learning Objectives

1. Translational kinematics

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| 1.1 Correct use of terminology and concepts used to describe linear motion | 1.1.1 Define position, displacement, velocity and acceleration.
1.1.2 Describe the relationships between position, displacement, average velocity, instantaneous velocity, average acceleration and instantaneous acceleration. |
| 1.2 Construction and interpretation of graphs relating position, velocity and acceleration with time | 1.2.1 Correctly interpret the meaning of the slope of a graph as being the rate of change of one variable with another: <ul style="list-style-type: none">• to find the slope of a position-time graph and plot a velocity-time graph• to find the slope of a velocity-time graph and plot an acceleration-time graph 1.2.2 Interpret the meaning of the area between the curve and the horizontal axis: <ul style="list-style-type: none">• to find the displacement from a velocity-time graph and plot a position-time graph• to find the change in velocity from an acceleration-time graph and plot a velocity-time graph |
| 1.3 <i>Application of differential calculus to linear motion*</i> | 1.3.1 <i>Use the first and second derivatives of position as a function of time to solve polynomial functions.</i>
1.3.2 <i>Relate the derivative with respect to time to the slope of the appropriate graph.</i> |
| 1.4 Use of algebraic equations for linear motion with constant acceleration | 1.4.1 Solve problems for an object in motion with constant acceleration, including objects in free fall.
1.4.2 Solve problems involving two bodies in relative motion, in the same straight line. |
| 1.5 Application of vector techniques to two-dimensional motion | 1.5.1 Distinguish between scalar and vector quantities.
1.5.2 Express displacement, velocity and acceleration vectors in graphical form, polar form and rectangular components.
1.5.3 Solve problems by drawing vector diagrams to scale.
1.5.4 Resolve vectors into components and solve two-dimensional vector problems analytically.
1.5.5 Analyze projectile motion using rectangular components.
1.5.6 Solve circular motion problems using radial and tangential components of the acceleration vector. |

2. Rotational kinematics

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| 2.1 Use of terminology and concepts used to describe rotational motion | 2.1.1 Define angular position, angular displacement, angular velocity and angular acceleration.
2.1.2 Describe the relationships between angular position, angular displacement, average angular velocity, instantaneous angular velocity, average angular acceleration and instantaneous angular acceleration. |
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| 2.2 | Construction and interpretation of graphs relating angular position, angular velocity and angular acceleration with time | 2.2.1 | Be able to interpret slopes, areas and intercepts from the graphs relating angular position, angular velocity and angular acceleration with time. |
| 2.3 | <i>Application of differential calculus to rotational motion*</i> | 2.3.1 | <i>Use the first and second derivatives of angular position as a function of time, and relate them to the slopes of the appropriate graphs.</i> |
| 2.4 | Use of algebraic equations for rotational motion with constant angular acceleration | 2.4.1 | Apply algebraic equations and solve problems for an object rotating with constant angular acceleration. |
| | | 2.4.2 | Describe the motion of a point moving in a circular path as tangential motion and also in angular terms. |
| | | 2.4.3 | Use radian measure and relate rotational motion to linear measurements for motion in a circular path. |

3. Application of the concepts and laws of dynamics

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| 3.1 | Correct use of terminology and concepts basic to mechanics | 3.1.1 | Describe different types of forces in nature, such as the force of gravity (weight), tension, static and kinetic friction, and the normal reaction. |
| | | 3.1.2 | Be able to explain the relationship between mass and weight. |
| 3.2 | Definition of Newton's Three Laws of Motion | 3.2.1 | Correctly state Newton's First Law, the law of inertia. |
| | | 3.2.2 | Correctly state Newton's Second Law, and how net force and the mass of a system affect the acceleration of the system. |
| | | 3.2.3 | Correctly state Newton's Third Law and explain action-reaction pairs. |
| | | 3.2.4 | Identify a system to which Newton's Laws apply. |
| 3.3 | Application of Newton's Laws to solve problems | 3.3.1 | Draw free-body diagrams: <ul style="list-style-type: none"> • to show all the relevant forces acting • to indicate the coordinate system • to resolve the forces into rectangular components |
| | | 3.3.2 | Apply Newton's Laws of Motion to solve problems with an object moving in a straight line with constant acceleration. |
| | | 3.3.3 | Analyze and solve problems for a system of objects moving along rough surfaces with different slopes, and connected together by means of "ideal" cords and pulleys. |
| | | 3.3.4 | Solve problems with an object moving in a horizontal circular path: <ul style="list-style-type: none"> • on a level surface • by means of cords • on a banked curve |
| 3.4 | Use of Newton's Laws to explain everyday phenomena | 3.4.1 | Solve a variety of problems, with the appropriate equations, using realistic values in example situations from everyday life (e.g., how fast a car will be moving on a rough banked curve when it starts to skid). |

4. Work and energy involved in simple situations

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| 4.1 | Correct use of terminology and concepts basic to work and energy | 4.1.1 | Be able to define work and describe the relationship between work, force and displacement. |
| | | 4.1.2 | Describe the relationship between kinetic energy, mass and speed. |

- 4.2 Application of mathematical expressions to calculate work done and kinetic energy
- 4.2.1 Apply the dot product to problems involving work done in two dimensions.
- 4.2.2 Construct graphs relating force and position, in order to calculate the work done by a varying force.
- 4.2.3 Be able to calculate the work done on an object by specific forces, including:
- gravity
 - friction
 - normal force
 - force exerted by an ideal spring
- 4.2.4 Explain the sign convention associated with positive and negative work and give examples of forces that do positive work, negative work.
- 4.2.5 Calculate kinetic energy.
- 4.2.6 Describe the relationship between work and kinetic energy; use the Work-Energy Theorem to solve problems.

5. Principles of conservation of energy and momentum

- 5.1 Correct use of terminology and concepts basic to the conservation of mechanical energy
- 5.1.1 Be able to define and identify conservative forces and non-conservative forces.
- 5.1.2 Define potential energy and describe the relationship between potential energy and the work done by a conservative force.
- 5.1.3 Be able to explain the concept of conservation of mechanical energy.
- 5.2 Application of the Work-Energy Theorem to solve problems
- 5.2.1 Calculate gravitational potential energy using a variety of different “zero” levels.
- 5.2.2 Calculate the potential energy stored in a spring.
- 5.2.3 Solve problems using the Work-Energy Theorem.
- 5.3 Use of terminology and concepts basic to the conservation of momentum
- 5.3.1 Define impulse and momentum.
- 5.3.2 Describe the relationship between impulse and momentum.
- 5.3.3 Be able to explain the concept of conservation of momentum.
- 5.3.4 Explain the difference between elastic, inelastic and completely inelastic collisions.
- 5.4 Application of the Law of Conservation of Momentum
- 5.4.1 Use vector algebra to solve problems involving impulse and momentum in two dimensions.
- 5.4.2 Calculate the change in kinetic energy to determine whether a collision is elastic or inelastic.
- 5.5 Application of the appropriate mathematical expressions to solve word problems
- 5.5.1 Solve a variety of problems in example situations from everyday life using specific situations that involve conservation of momentum and conservation of energy (e.g., energy and momentum involved in a car crash).

6. Experimental verification of a number of laws and principles in mechanics

- 6.1 Meticulous experimentation
- 6.1.1 Use equipment appropriately to gather data from an experiment and display it in appropriate tabular form.
- 6.1.2 Use a computer interface to collect data from an experiment.

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| 6.2 | Critical analysis of results and justification of the steps in the analysis of data | 6.2.1 | Plot a graph from a table of data with appropriate title, labels and curve fit: <ul style="list-style-type: none"> • on millimetric paper • using a spreadsheet/graphical analysis program on the computer |
| | | 6.2.2 | Draw intelligent conclusions from an analysis of graphical or tabular data. |
| 6.3 | Laboratory report in line with established standards | 6.3.1 | Write a report that includes: <ul style="list-style-type: none"> • Objective • Theory • Data tables and/or graphs • Data analysis • Conclusion and/or discussion of results |
| 6.4 | Experimental verification of specific laws and principles in mechanics. | 6.4.1 | Demonstrate the vector nature of force, acceleration, velocity and displacement by performing appropriate experiments. |
| | | 6.4.2 | Demonstrate the validity of Newton's Second Law. |
| | | 6.4.3 | Demonstrate the dependence of angular speed on centripetal force, mass and radius. |
| | | 6.4.4 | Demonstrate the work-energy theorem. |
| | | 6.4.5 | Demonstrate the law of conservation of momentum in two-dimensional collisions. |

7. Undertaking of a project

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| 7.1 | Application of the scientific method when performing an experiment | 7.1.1 | Prepare adequately before the experiment, forming a hypothesis. |
| 7.2 | Ability to write a detailed technical report | 7.1.2 | Use, appropriately, measuring instruments and computers to collect data. |
| 7.3 | Correct use of a computer for data collection and/or analysis | 7.1.3 | Judge which data are appropriate. |
| | | 7.2.1 | Use an accepted format for the report, and a word-processing program. |
| | | 7.2.2 | Write a clear, concise conclusion based on the results. |
| | | 7.3.1 | Present data in table format using a spreadsheet program. |
| | | 7.3.2 | Analyze data using a graphical analysis program. |

** Depending on institutions, these topics may be optional.*