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Generic Story Problem Solution Template

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Abstract—**Students routinely face homework and exam exercises presented as situational narratives requiring development of solutions that demonstrate grasp of concepts, relationships and analytical skills. This paper presents a "cookbook" style template that guides students through the solution process.**

Keywords-homework; exams; learning; teaching; instruction; STEM; education; classroom; template

I. Introduction

The Generic Story Problem Solution Template guides students through a solution process using five segments: A) Restate problem, B) List variables, C) List formulas D) Describe solution and E) Solve problem. Each segment requires students to follow specific instructions. This paper provides an example of correct template application.

Several years of use instructing students enrolled in an introductory Physics course helped refine the template and associated instructions. Typically students initially object to following the template when answers can be readily discerned directly seeing its use as unnecessary. As course material becomes more challenging and students master use of the template, advanced topics readily lead to solution with the template enabling students who otherwise might struggle to succeed.

Solutions to problems evolve through iteration rather than by completing the template segments serially. Because subsequent segments build on previous work, omissions and confusion not immediately apparent during an early segment resolve toward corrections and consistency.

The following sections of this paper present each template segment in detail with associated rationale and explanation for use.

In addition to the solution, the template includes page headings listing the course title, type of submission, student's name and course session. Students typically submit work electronically following a specific file naming convention that readily supports administration and grading.

Each submission presents concise results of student study that reflects genuine understanding and mastery of material. Since template application emphasizes quality rather than quantity of student study, homework assignments should consider effort required so as to not present excessive burden on students' time.

II. Template Segments

A. Restate Problem

The first segment of the template requires the student to copy the problem exactly as stated in the text. This requirement insures that the student has at a minimum read the problem. Mistakes can result from failure to adequately acknowledge and understand the terms and concepts stated.

B. List Variables

The template provides the following table for students to complete using information from the problem statement combined with additional information required to solve the problem:

Symbol	Name	U/M	Const	Ind	Dep

The following paragraph details the content and purpose for each of the table columns:

1) Content

- Symbol: The letter or abbreviation to be used in equations for the named parameter
- Name: A descriptive name for the symbol specific to the problem statement or use of the listed symbol.
- U/M (Unit of Measure): The units associated with the parameter listed.

Students indicate one of the following by placing an "X" in each row of the table based on the purpose for the entry:

- Const (Constant): Represents a value characteristic of a fundamental or derived natural property or dimensional ratio. Optionally, the Constant column can contain a value rather than "X."
- Ind (Independent): Indicates a value explicitly given in the problem statement.
- Dep (Dependent): Indicates a value to be obtained through solution of the problem.

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2) *Purpose*

- Symbol: The use of a symbol to represent a quantity introduces students to abstracts of analysis. Scientific material routinely introduces equations with little or missing descriptions for symbols used. Although the parameters implied by many symbols can be readily discerned from an equation's context by an experienced scientist, students should not be expected to do so during the early stages of education. What later becomes "obvious" can be confusing for new learners. Symbols in the table serve one of two distinct purposes: 1) Identify parameters specific to the problem statement or 2) Identify parameters necessary for solving the problem.

- Name: The name of the symbol should unambiguously provide context for the listed symbol. If the symbol relates directly to the problem, the name should so indicate. If the symbol refers to a generic quantity, typically a constant or ratio, the name should reflect accepted scientific terminology.

- U/M (Unit of Measure): Indicates the dimensional units for the listed parameter.

By placing an "X" in the row of the table adjacent to the symbol, students:

- Const (Constant): Indicate that the listed symbol represents either a basic natural quantity, a quantity derived from basic quantities or a dimensional ratio. The value for the symbol may be entered if appropriately referenced.

- Ind (Independent): Indicate that the problem statement explicitly provides values for the parameter to be used for subsequent solution.

- Dep (Dependent): Set the focus for solution of the stated problem. Problem statements typically require students to answer questions leading to numerical solutions, i.e., parameters that *depend* on solution of the problem.

Of the final three columns, one and only one should contain an entry.

C. *List Formulas*

Using the symbols from the table previously completed and an associated narrative students list formulas symbolically and in text forms, with units, which express relationships leading toward solution of the problem.

The process of listing formulas leads students to discover possible omissions and inconsistencies missed in completion of the table of symbols. Requiring both symbolic and narrative representations of relationships reinforces learning and insures proper application toward solution of the problem. Sources for formulas should be noted and appropriately cited.

D. *Describe Solution*

A narrative description of the solution requires students to reflect on the context of the problem statement and how to proceed toward a solution. This segment requires students to express thoughts in complete sentences and encourages development of communication skills.

The narrative should present the process of discovery and development of material supportive of a solution, concepts explored, sources researched, etc.

E. *Solve Problem*

Students often attempt to solve problems before completely understanding solution requirements, particularly when problem statements seem trivial or superficial. Deferring use of any parameter values by use of symbols prior to actually solving the problem encourages students to form complete, accurate solutions.

Solving the problem requires students to draw on material previously developed and to perform algebraic manipulation leading to equations having dependent parameters on the left side of equal signs and other parameters on the right side of equal signs.

After the student has equations in the proper form, substitution of numerical values for symbols and performing necessary arithmetic generates the solution.

Students should include units throughout the solution process to insure consistency.

III. EXAMPLE APPLICATION

Section III presents a typical application for solving a problem using the template. The highlighted entries indicate those made by the student. The example distinguishes between the sections of the template, A-E, and the activities of the student which are listed as steps in the solution process.

A. *Restate Problem*

Step One: Students may complete the template in any sequence preferred. For this example, the author begins by copying the problem statement exactly as given from an unnamed source, perhaps a text, and highlighting possible terms that may be represented symbolically indicating solution parameters.

Chapter nn, Problem nn: A glass marble weighing two oz. rolls through a tube from a height of two meters onto a carpeted floor and comes to rest one yard from the end of the tube. Estimate the marble's increase in temperature.

B. List Variables

Step Two: Students enter one row in the variable table for each term highlighted in the problem statement. Order of entry does not matter. Students may select any symbol for entry in the first column. The Name column must unambiguously indicate the parameter highlighted rather than a generic reference, i.e. "temperature" would not be acceptable for ΔT.

Sym	Name	U/M	Const	Ind	Dep
delT	Increase in marble temperature	°DEG C			X
W	Weight of marble	oz		X	
H	Initial Height of marble	m		X	
D	Distance between end of tube and stop	yd		X	

Step Four: Continued from (D. Describe Solution)

Sym	Name	U/M	Const	Ind	Dep
θ	Specific Heat for glass[1]	KJ/Kg K	0.84		
M	Mass of marble	Kg			X
R1	Kilograms per Ounce	Kg/Oz	X		
gn	Standard acceleration due to gravity[2]	cm/s^2	980. 665		
R5	Meter/centimeter [6]	m/cm	1/100		
PE	Initial Potential Energy of marble	J			X
Et	Energy transferred to marble	J			X
R2	Kilo-Joule per Joule [6]	Kg/J	1/ 1000		
R3	Kilogram per Pound-mass(av) [3]	Kg/#m	0.453 94		
R4	Ounces per pound [4]	oz/#m	16		
J	Joule definition [5]	Kg-m^2 /s^2	1		
R5	Degrees Celsius per degrees Kelvin [7]	(deg C)/K	1		

C. List Formulas symbolically and as text

DELT (deg C)=? The change in temperature in degrees Celsius equals an unknown.

Step Three: The student realizes the parameters given do not support derivation of a solution directly using a simple formula. Proceed to segment (D. Describe

Step Five: With the new entries now available, the student can locate equations relevant to the solution.

DELT (deg C) = θ (KJ/Kg K) * Et (J)/R2, the change in temperature in degrees Celsius equals the specific heat of glass multiplied by the energy transferred to the marble maintaining consistent units. [8] (

Et (J) = PE (J), the energy transferred to the marble equals the potential energy available at the marble's initial height. [9]

PE (J) = M (Kg) *gn (m/s^2) * H (m), the potential energy in Joules equals the mass of the marble in kilograms multiplied by the standard acceleration due to gravity multiplied by the height of travel to the floor in meters. [10]

M (Kg) = R1 (Kg/oz) * W (oz), the mass of the marble in kilograms equals the ratio of kilograms to ounces times the weight of the marble in ounces.

R1 (Kg/oz) = R3 (Kg/#m) / R4 (oz/#m), the ratio of one kilogram to one ounce equals the ratio of one kilogram to one pound-mass divided by the number of ounces per pound.

D. Describe Solution

Determining an increase in temperature for an object requires three parameter values: 1) the object's mass, 2) the amount of energy transferred and 3) the specific heat for the object's material [8]. The problem statement does not provide any of the listed values directly. The values must be determined from values given.

Note also that the problem statement employs units of measure from both SI and English systems. Care must be exercised to insure consistency.

Solution of the problem requires application of the following assumptions: 1) all potential energy available when the marble drops transfers to the marble and 2) the distance the marble rolls need not be considered.

All parameter values and equations used will cite authoritative sources.

Step Four: Referencing the discussion above, the student returns to add parameters to Segment B. List Variables.

E. Solve Problem

Step Six: The student assembles the formulas developed in the order which leads to solution of the problem.

R1 (Kg/oz) = R3 (Kg/#m) / R4 (oz/#m)
R1 (Kg/oz) = 0.45394 (Kg/#m) / 16 (oz/#m)
R1 (Kg/oz) = 0.02837125 (Kg/oz)

M (Kg) = R1 (Kg/oz) * W (oz)
M (Kg) = 0.02837125 (Kg/oz) * 2 (oz)
M (Kg) = 0.0567425 (Kg)

PE (J) = M (Kg) *gn (m/s^2) * H (m)
PE (J) = 0.0567425 (Kg) *9.80665 (m/s^2) * 2 (m)
PE (J) = 1.11290767525 Kg-m/s^2 (J)

Et (J) = PE (J)
Et (J) = 1.11290767525 (J)

DELT (deg C) = θ (KJ/Kg K) * Et (J)/R2
DELT (deg C) = 0.84 (KJ/Kg K) * 1.11290767525 (J)/1000
DELT (deg C) = 9.3e-4 (deg C)

The temperature of the marble increases 9.3e-4 (℃).

IV. CONCLUSION

A. *Document Header*

The document template includes a header on each page for identifying the course, the type of assignment, the student's name and date or session the work was assigned.

PHYS 102 Homework Name: Marty Grogan Session: One

The document footer automatically time stamps the creation of the document, indicates the page number and the assignment template used.

8/22/2014 2:45:00 PM 10:58:39 AM Page 4 of 4 Homework Template

B. *File Automation and Naming Convention*

Templates can be automated to force students to complete the heading information and save the document prior to beginning the assignment. Requiring file names that include the student's last name, first name and assignment information assist with administration for grading.

GroganMartinSessionOneHomew

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[2] NIST Special Publication 330, Appendix 1, citing 3rd CGPM, 1901, "Declaration on the unit of mass and on the definition of weight; conventional value of gn, section 3, p 57"

[3] http://www.bipm.org/en/si/si_brochure/chapter4/conversion_factors#MASSinertia

[4] NIST, Handbook 44 – 2014 Appendix C – General Tables of Units of Measurement

[5] http://www.bipm.org/utils/common/pdf/si_brochure_8_en.pdf

[6] Bureau International des Poids et Mesures (International Bureau of Weights and Measures) The International System of Units (SI), 8th edition 2006, Section 3: Decimal multiples and submultiples of SI units, 3.1: SI prefixes, Table 5. SI prefixes

[7] 13th CGPM, 1967/68, Resolution 3, "The unit of Celsius temperature is the degree Celsius, symbol (deg C), which is by definition equal in magnitude to the kelvin. A difference or interval of temperature may be expressed in kelvins or in degrees Celsius."

[8] http://www.engineeringtoolbox.com/specific-heat-capacity-d_339.html

[9] http://en.wikipedia.org/wiki/Conservation_of_energy

[10] http://en.wikipedia.org/wiki/Potential_energy

AUTHOR'S PROFILE

Mr. Grogan currently teaches introductory courses in Physics, Computer Science and Engineering for ERAU's Worldwide Organization as an adjunct instructor holding the rank of Asst. Professor.

His credentials include two engineering degrees from the University of Kansas, a BSAE, a MSEE and a four decade career of consulting, contributing and management roles in electronics design, software engineering, systems automation and communications.

He holds three patents and has been recognized with PMP and CISSP certifications.

When not otherwise occupied, he develops support for his proprietary Enterprise Transition Technology and Wisdom Activation Framework, visualization and analytical methodologies that enable characterization and negotiation through conceptually complex contexts.