E & M TIPER Sets Overview

TIPERs tasks are instructional materials based on formats that are inspired by the insights provided by education research into students' reasoning. Good research tasks and questions often make good instructional materials. These TIPERs are designed to target important concepts and reasoning skills in order to promote and establish a strong functional understanding of physics. This understanding provides a base upon which physics students can solve problems with better understanding. These tasks can be used as tools for learning and informative assessment. They are designed to provide small incremental changes to teaching styles that teachers should find less stressful and more acceptable to utilize.

Students enter courses with beliefs about the way the world behaves. Some of these beliefs may be only partially consistent with the physically correct perception. The goal of these tasks is to help students change their ideas when necessary. In many cases, it is very difficult to modify the students' thinking. There is some evidence that instructional approaches which emphasize putting the students into confrontations with phenomena and their peers while debating predictions, testing ideas, and explanations leads to more productive learning. One aspect of this approach is the importance of asking questions in different ways and asking very similar questions that are interrelated. TIPERs provide tasks that encourage using and support active learning and they require little learning on the part of students to handle the task formats effectively.

TIPER formats in this book include: Ranking Tasks (RT); Working Backwards Tasks (WBT); What, if anything, is Wrong Tasks (WWT); Troubleshooting Tasks (TT); Bar Chart Tasks (BCT); Conflicting Contentions Tasks (CCT); Linked Multiple Choice Tasks (LMCT); Changing Representations Tasks (CRT); Predict and Explain Tasks (PET); Qualitative Reasoning Tasks (QRT); and Comparison Tasks (CT). In a particular TIPER set, not all formats are used but there usually are three or four different formats depending on the focus of the set. The sets are much broader in electricity and much more focused in magnetism.

There are two major categories of tasks in this book: electricity (but not circuits) and magnetism. Within each category, tasks are listed by task format. This was done in order to prevent students from readily recognizing tasks dealing with the same question or issue. Each title task has a part that describes briefly the setup and a second part that indicates the target aspect of the task such as force or field. Tasks with identical task setups often are part of the same set. Each task has a short ID such as eT7-TT1 or mT2-QRT1 to allow for quick searches for a task. In the other part of this instructor's guide, a solution including answer and a short explanation to each task is provided with a special **color** indicating a solution. The solution pages match the student edition.

Several common conventions are employed in these tasks. All electric currents are conventional currents unless otherwise specified. A circle with a dot in the center is used to represent a vector pointing out of the page and a circle with an x in the center is used to represent a vector pointing into the page. Uniform fields, electric or magnetic, will be constant both in space and in time. There are no other forces or fields such as gravitation in these situations unless explicitly identified.

In this manual, there is an alternative table of contents in which the tasks are listed by the topics typically found in most textbooks to help educators select tasks for their students. This alternative table also includes a task level where ***F*** represents a Foundational Task level suitable for all students, ***I*** represents an Intermediate Task, and ***A*** represents an Advanced Task level that may use calculus or other aspects such as flux.

One way of using the TIPERs is to have students work on TIPERs individually, then have them compare their work with other students and finally have a class discussion on the issues. Students are encouraged to discuss what they did and the rationale for their responses. It is the expectation that they will eventually come to a correct consensus viewpoint in their group or class. Another way of using them is to place students in small groups where each person can work on a different task from the same set and eventually the issues with each task can be discussed and resolved in the group. There are several other ways to use them such as homework; each instructor needs to find a technique which is comfortable.

TIPERs are intended to be very flexible. Instructors can use individual tasks or any combination of tasks that they think would be useful. While the tasks within a set are correlated, they do not need to be used together. The basic unit is the

individual task. TIPERs can be used to introduce new material, to review previous material or ideas, to introduce lab work, as test items, as homework, as group work in class, or as class discussion items. The various formats provide alternative ways of focusing students on important or confusing ideas and concepts. We know that students' understanding will be more robust if they deal with multiple representations or tasks on important issues.

TIPER Formats

Ranking Tasks (RT)

A Ranking Task is an exercise that presents students with a set of variations, ranging from four to eight, on a basic physical situation. The variations differ in the values (numeric or symbolic) for the variables involved but also frequently include variables that are not important to the task. The students' task is to rank the variations on the basis of a specified physical quantity. Students must also explain the reasoning for their ranking scheme and rate their confidence in their ranking. These tasks require students to engage in a comparison-reasoning process that they seldom do.

For the Ranking Task format, there may be two, three or more of the variations that have equivalent values for the target quantity. In these cases, answers need to explicitly show that they are tied either by putting tied answers in the same answer blank or placing a circle surrounding the ones that are tied. Examples of these are found at the end of this document. In addition, one of the options often available is the ranking for (whatever quantity is designated) cannot be determined. With ranking tasks, it may not be possible to figure out specific values for a quantity, but you may still be able to compare the situations to decide which is largest and so on and thus rank the situations.

Working Backwards Tasks (WBT)

Working Backwards Tasks, also referred to as "Physics Jeopardy" tasks (Van Heuvelen and Maloney, 1999), essentially reverse the order of the problem steps. For example, the given information could be an equation with specific values for all, or all but one, of the variables. The students then have to construct a physical situation for which the given equation would apply. Such working backwards tasks require students to take numerical values, including units, and translate them into physical variables. Working backwards problems also require students to reason about these situations in an unusual way and often allow for more than one solution.

What, if anything, is Wrong Tasks (WWT)

What, if anything, is Wrong Tasks (Peters, 1982) require students to analyze a statement, or diagrammed situation, to determine if it is correct or not. If everything is correct the student is asked to explain what is going on and why it works as described. If something is incorrect the student has to identify the error and explain how to correct it. These are open-ended exercises so they provide insights into students' ideas since they will often have interesting reasons for accepting incorrect situations and for rejecting legitimate situations; and often students' responses provide ideas for generating new items.

Troubleshooting Tasks (TT)

Troubleshooting Tasks are variations on the What, if anything, is Wrong Tasks. In these items, the students are explicitly told that there is an error in the given situation. Their job is to determine what the error is and explain how to correct it. These tasks can often produce interesting insights into students' thinking because they will at times identify some correct aspect of the situation as erroneous. Once again, this outcome helps develop new items.

Bar Chart Tasks (BCT)

Bar Chart Tasks have histograms for one or more quantities. Frequently histograms are given for before and after some physical process with one bar left off. Students are asked to complete the bar chart by supplying the value for the missing quantity. Requiring the students to translate between representations they are using and this one is usually quite productive in developing a better understanding. These items can be especially useful since most students seem to adapt to and understand bar chart representations relatively easily.

Conflicting Contentions Tasks (CCT)

Conflicting Contentions Tasks present students with two or three statements that disagree or conflict in some way. The students have to decide which contention they agree with and explain why. These tasks are very useful for contrasting alternate conceptions with physically accepted statements. This process is facilitated in these tasks because they can be phrased as "which statement do you agree with and why" rather than asking which statement is correct or true. These tasks compliment the WWTs.

Linked Multiple Choice Tasks (LMCT)

Linked Multiple Choice Tasks have one set of answer possibilities that apply to a collection of questions about a related set of cases. In these tasks, different variations of the situation are described and the students choose from a limited set of possible outcomes. These items allow for the comparison of how students think about various aspects and/or variations of a situation. These tasks have the nice feature that one gets both the student's answer to a particular question and their pattern of responses for the variations presented.

Predict and Explain Tasks (PET)

Predict and Explain Tasks describe a physical situation that is set up at a point where some event is about to occur. Students have to predict what will happen in the situation and explain why they think that will occur. These tasks must have situations with which the students are familiar, or have sufficient background information, to enable the students to understand the situation. By doing this, it will make students feel comfortable enough to attempt to complete the task.

Changing Representations Tasks (CRT)

These tasks require students to translate from one representation (e.g., an electric field diagram) to another (e.g., an equipotential curves or surfaces diagram). Students often learn how to cope with one representation without really learning the role and value of representations and their relationship to problem solving. Getting students to go back and forth between/among different representations forces them to develop a more robust understanding of each representation. Among the representations that will be employed at times are mathematical relationships, so this task can serve at times as a bridge between conceptual understanding and traditional problem solving.

Qualitative Reasoning Tasks (QRT)

These tasks can take a variety of forms, but what they have in common is that the analysis is qualitative. Frequently students are presented with an initial and final situation and asked how some quantity, or aspect, will change. Qualitative comparisons (e.g., the quantity increases, decreases, or stays the same) are often the appropriate answer. Qualitative reasoning tasks can frequently contain elements found in some of the other task formats (e.g., different qualitative representations and a prediction or explanation).

Comparison Tasks (CT)

These tasks require making a decision on whether a quantity in one situation is greater than, less than, or equal to that quantity in a second situation along with the reasoning for the decision. These situations may be complicated or difficult but they can be answered without detailed equations and computations. They are useful in eliciting student ideas about underlying concepts. A sequence of related comparison tasks can help in connecting or bridging related concepts and provide for information for assessing and/or guiding future instruction.

List of the E & M TIPER Sets

Category eT1: Charge and Charge Density.
Tasks in this category ask about the values and/or signs of electric charges or about the values and signs of charge densities for continuous distributions.

Category eT2: Working Backwards Tasks
This category contains all of the working backwards tasks since they normally have the identification/construction of a physical situation as their target, rather than some physical quantity.

Category eT3: Force
This category contains the tasks where the Coulomb force between charges, charge distributions, and/or objects is the quantity that is asked about.

Category eT4: Kinematic Quantities
This category contains the tasks that have acceleration, speed, velocity or some other aspect of the motion of charged objects as their target quantities.

Category eT5: Electric Field
This category is for tasks that ask about various aspects, such as magnitudes and directions, of individual or net electric fields.

Category eT6: Work & Electric Potential Energy
This category contains items that ask about the work done to move charges or charged objects to locations near other charges or charge configurations.

Category eT7: Multiple Electrostatic Quantities
Tasks in this category ask about more than one electrostatic quantity. An example would be a task that asks about both the electric field and the electric potential at a point.

Category eT8: Electric Potential
Tasks in this category ask about the electric potential at points near charges, charge distributions or charged objects.

Category eT9: Electric Flux
These tasks have electric flux as the target quantity so they normally relate to situations where Gauss' Law is involved.

Category eT10: Miscellaneous
This is the catch-all category where quantities such as capacitance, torque, or any other non-electrostatic quantity is the target that the task asks about.

Category mT1: Electric Charge near a Bar Magnet or a Current Loop
This set has electric charges sitting at rest near the poles of permanent magnets or moving along the axial line of a circular coil that is carrying a current. The issue being explored is that of treating magnetic poles as if they have electric charges.

Students often incorrectly think that magnetic poles are charged**.** They usually take north poles as positively charged, and that they can attract or repel static electric charges. Note that in experiments to test this or demonstrate this effect, electrostatic charges will attract magnetic and non-magnetic materials. Because the electrostatic force cannot be turned off, some of the situations in this set are problematic since they are experimentally unrealizable.

Category mT2: Charges Moving in a Uniform Magnetic Field
This set deals with charges moving in magnetic fields. There is some variation among the items in the actual physical arrangements, but all of the items in the set ask about the force on and/or motion of electric charges moving in magnetic fields.

Category mT3: Charges near a Straight Current-Carrying Wire
This set deals with electric charges moving near straight current-carrying wires. The questions in the items in the set ask about the force on or acceleration of the particle.