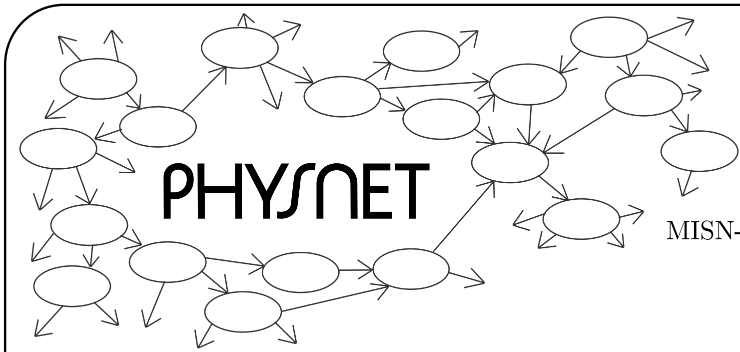
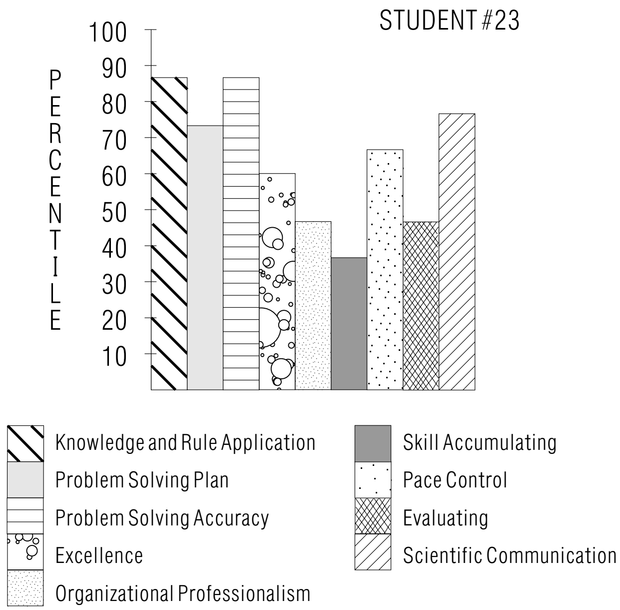


MISN-0-155

STUDENT STRATEGIES FOR SUCCESS IN CBI PHYSICS



Project PHYSNET Physics Bldg. Michigan State University East Lansing, MI

STUDENT STRATEGIES FOR SUCCESS IN CBI PHYSICS

by

Peter Signell and William C. Lane, Michigan State University

Title: **Student Strategies for Success In CBI Physics**

Author: Peter Signell, Michigan State University

Version: 2/1/2000 Evaluation: Stage 2

Length: 1 hr; 27 pages

Input Skills:

(none)

Output Skills (Knowledge):

K1. Describe each of the three main reasons why students of science and technology are required to take general physics by their colleges and accrediting associations.

K2. Describe the three main professional answers to the naive question, "I know I can always look up all this stuff in books when I need it professionally, so why do they make me learn it in college?"

K3. Describe each of the four main strategies used by professionals for efficient learning from scientific/technical material.

K4. Describe each of the six main problem-solving strategies used by scientific/technical professionals.

K5. Describe the assumed reason why almost all people require concentrated effort over an extended period of time in order to learn mathematics-based scientific/technical material.

K6. Explain (in detail) why, if you are stuck on a problem, you should not ask someone to show you a complete solution to the problem.

K7. List the four most important items to watch on the daily-posted CBI student-progress charts.

K8. Describe how CBI's Pace credit is awarded and give a specific example, *in detail*, using your course's Pace Day.

K9. List the two problem-solving subskills that are not generally acquired through merely learning the solutions to problems.

THIS IS A DEVELOPMENTAL-STAGE PUBLICATION
OF PROJECT PHYSNET

The goal of our project is to assist a network of educators and scientists in transferring physics from one person to another. We support manuscript processing and distribution, along with communication and information systems. We also work with employers to identify basic scientific skills as well as physics topics that are needed in science and technology. A number of our publications are aimed at assisting users in acquiring such skills.

Our publications are designed: (i) to be updated quickly in response to field tests and new scientific developments; (ii) to be used in both classroom and professional settings; (iii) to show the prerequisite dependencies existing among the various chunks of physics knowledge and skill, as a guide both to mental organization and to use of the materials; and (iv) to be adapted quickly to specific user needs ranging from single-skill instruction to complete custom textbooks.

New authors, reviewers and field testers are welcome.

STUDENT STRATEGIES FOR SUCCESS IN CBI PHYSICS

by

Peter Signell and William C. Lane, Michigan State University

1. Start Out Properly

1a. New Goals, New Strategies. The MSU CBI physics courses have been designed to help you start acquiring those skills and habits that are the mark of successful professionals in pure and applied science.[1] In order to meet our expectations for you, you will probably have to employ some new study and exam strategies. The ones we outline here should give you enough of a feel for the CBI system to get you started. Then, after taking a few exams, you will be in a good position to start emphasizing those strategies that work best for you.

1b. Use the "Getting Started" Sheet. We cannot emphasize strongly enough that you should carefully follow the current term's "Required Steps for Getting Started in CBI Physics" sheet before you do anything else in your CBI course. That sheet is in your updated *CBI Student Handbook*. Before you can take an exam or receive consulting assistance, we require you to sign a statement that you yourself have carried out all of the steps on the "Getting Started" sheet. Some students have had severe problems because they deliberately bypassed steps listed on that sheet.

1c. Study Together. We urge you to study the material for this course with someone else who is taking the same course at the same time or who has taken it in the past. If you don't know how to find a learning partner, ask one of our Consultants for a list of persons in your course. When studying together, we suggest you discuss the material together in detail.

If you become really stuck at some point, ask your partner to just help you get past the sticking place so that you can then go ahead and finish it by yourself. You may think it much easier to have your partner show you how to work a problem, and that you will then be all set to

[1] See "Skills for Professional Success," MISN-0-180, in your updated *CBI Student Handbook*.

work it or problems like it on the exam or in professional practice. We can assure you from long experience that if you follow that procedure you will do poorly on most exams and in professional practice. Problem solving ability is acquired by wrestling with problems yourself, not by observing others. It is much like learning to solve crossword puzzles: watching another person do one does not much help you to do a different one yourself. Most of us must practice, practice, practice.

1d. Estimate Your Readiness. Before starting into a lesson, decide whether you are ready for the lesson and whether you want to try for additional "review" credit while you are studying the lesson.

To decide whether you are ready for the lesson, turn to the "ID Sheet" located on or inside the front cover of the lesson. Skim down to the "Input Skills." These are the skills the lesson's author assumes you already have. If you feel that you are not comfortable with a particular Input Skill, get help from the lesson referenced in parentheses immediately following the statement of the skill.

1e. Decide Whether to Learn Reviewing. If you think you might want to learn how to evaluate technical writing while studying the physics in a lesson, be sure to make that decision before you start into a lesson ("later" will be too late).[2] Credit for this may or may not be available in your course: see your Syllabus.

1f. Learn How to Solve New Problems. Given that a major goal of this course is to get you to the point where you can solve problems that are new to you, it may seem to you that learning problem solutions is the royal road to success. Although this "learning problem solutions" approach seems logical, it has been found to not work for students taking courses similar to yours.

To be more precise, two of the six subskills necessary for solving new problems are not learned sufficiently well by learning problem solutions, even when the number of solutions learned is double that available in the usual homework sets.

The two missing subskills are: (1) determining which law(s) to apply to a new problem without getting outside help and without spending huge amounts of labor and time; and (2) associating the proper concepts with the quantities occurring in the relevant law(s). It appears that the

[2] For details see the lesson "Evaluating While Learning," MISN-0-69, on the "CBI Home Page" at `http://www.physnet.org/cbi.html`.

only practical way for most students to acquire these two subskills is by carefully working through the lesson's narrative, then working problems, then cycling back and forth between different parts of the narrative and between the narrative and problems until all parts of the narrative are really understood. While going over a narrative on a new subject, many professionals make up their own examples and problems to solve. They often find it helpful to discuss the narrative with colleagues.

A narrative can be made available through text and graphics in professional publications, through lectures and talks, and in hypermedia presentations that include all of those. In any case one must keep going back over the narrative until it is understood in detail.

Sometimes students have expressed the idea that they will understand a subject if they can only learn the solutions to the problems they missed on that subject's exam. They reason that if they had been able to solve those problems at the time of the exam, then they would have been certified as understanding the subject. They say that it is better to gain the necessary understanding after the exam than not at all. What they do not realize is that the point of the exam is to certify that examinees can solve problems which are *new* to them. Learning the exam-problem solutions is exactly the same as extending the homework problem sets slightly, and such extensions have been found to be fairly useless in creating the ability to solve *new* problems.

2. Know Why You are Doing This

2a. Know Why You Are Learning Physics. There are three main reasons why departments, colleges, and professional accrediting associations want their students to learn physics:

(i) They view the people they let into their fields as representing themselves, their institution, and their profession. Thus, if they require the study of physics in the training of their practitioners, they want those people to have enough of a talking and writing knowledge of physics so they are thought of as educated scientists and technicians, not as scientific/technical lightweights.

When a scientific/technical person makes elementary physics mistakes while talking or writing in his or her own field, that person is mentally discounted by listeners or readers and may even be "made fun of" behind the person's back. A sufficient amount of this can tarnish the reputation of the institution from which the person came, and possibly the reputation of the field itself.

(ii) The professionals know that the attainment of certain skills in physics is a necessary prerequisite for the development of skills in their own fields. Physics departments are put in charge of developing these pre-professional physics skills because it is physics teachers who are specifically trained in this field.

(iii) The professionals want students in their fields to develop general problem-solving skills, and physics is uniquely suited as the arena in which to develop them. This is because physics has multi-stage word problems with well-defined symbolic and numerical solutions, making it easier to judge whether one has indeed acquired problem-solving skills. In fact, much research into how to promote the development of problem-solving skills has used physics as the content area.

2b. Know Why You Must Learn Concepts. (why you cannot just "look them up" when you need them). A professional must have a working knowledge of words and concepts because:

(i) While receiving professional presentations, one cannot keep stopping to "look up" and try to understand physics terms. It is simply impossible to do this during oral presentations and it ruins the continuity of printed presentations. Carrying the naive argument to the absurd, it is like claiming that one needs no vocabulary whatsoever in order to read a newspaper because one can always go to a dictionary and look up all the words.

(ii) When conversing with another professional, you would look foolish if you had to keep looking up concepts in order to understand the discussion and construct replies.

(iii) You need words and concepts on "instant recall" in order to even think about a pure or applied topic when you are a professional, even more so to think about it creatively.

In determining which concepts must be available for instant recall, the instructor is guided by tradition and by strong feedback from experience and colleagues.

2c. Know Why Learning Math-Based Science is Hard. For most people, acquiring math-based scientific/technical material is not easy. It generally requires strong mental discipline and an attitude of being "up for the challenge." Another way of saying it is that very few people have a high I.Q. for math-based material. This is presumably because this particular I.Q. was not much needed for survival while the human race was evolving. Nevertheless, in today's competitive international market the very survival of many organizations depends on having members with strong math-based problem-solving skills. The few people who do put in the effort, and succeed in acquiring such skills, become valuable to the institutions that eventually employ them and to society at large.

3. Use Prof'l Learning Strategies

3a. Four Main Strategies.

(1) Understand the organization of the document. A scientific/technical document is normally organized as sentences, paragraphs, subsections and sections. Each section and subsection has a line in the Table of Contents and each paragraph, section and subsection has an overview.

(2) Obtain preliminary overviews at all levels. Before plunging into a lesson, or any organized part of it, try to get an idea of what it covers. Your initial guess as to the content provides a mental structure on which you can store new information as you go along. You will find that you automatically correct the overview as you go along through the material.

To gain an idea of what the entire lesson covers, examine the Table of Contents on the lesson's cover. Examine the cover drawing for clues. Check the Output Skills on the ID Sheet (just after the cover) and check the Abstract if there is one.

To get an overview of a section, check the section's title and read its first subsection.

To get an overview of a paragraph, check its first sentence, its "topic sentence."

(3) Obtain an understanding at all levels of the document. After reading a sentence, make a good effort to understand it before you go on to the next sentence. This will not always work, but make a strong effort.

Stop at the end of the paragraph and, in your head, formulate what you have learned from the paragraph, what its theme is. Go over the individual sentences again and again until you are satisfied that you understand the paragraph's message.

(4) Understand each equation in the document. When you meet an equation, determine how the result varies as each constant or variable is separately increased or decreased and ask yourself whether the results make sense. Take constants to extremes; for example, you might eliminate friction or gravity from an example or problem and see what happens, or you might let frictional force or gravity become infinitely strong. See if the result agrees with what you would expect.

3b. Last Resort: Get Help. If you become stuck at some point, and you have tried *hard* to figure it out yourself, look to see if there is a "[S-]" symbol nearby in the text. If so, there is assistance available in the lesson's Special Assistance Supplement (usually located immediately after the Problem Supplement). If there is no such assistance symbol, get a minimum of help from a friend. If no credible friend is available, wait until your class time arrives and come to our Consulting Room for help. Allow enough time for our Consultant to become familiar with the problem (this may take awhile).

4. Use Prof'l Problem-Solving Skills

Work all of the problems in a lesson's Problem Supplement, practicing these professional problem-solving skills:

(1) Write down the quantities given in the problem, equating their names and/or values in the problem to the symbols that generally represent those quantities in physics equations. Then do the same for the desired quantities.

(2) Sketch the situation, labeling the various objects. Draw any given or desired vectors such as velocities and forces. Label the characteristics of the objects in a manner consistent with the names used in (1).

(3) Try to decide whether you will have to break the problem into parts each of which must be solved independently. An example might be a light ray which travels through air, then travels through the glass

in a lens, then emerges and again travels through air (a two-part problem because the light ray changes direction at each of the two interfaces between glass and air). Then write down the equations that connect the given quantities to the desired quantities.

(4) Use your knowledge of mathematics to solve the problem. If there are two or more equations containing some unknowns, use your math skills to eliminate the unknowns and put the answer solely in terms of just given quantities. Do this in terms of symbols rather than numbers, right through to the final answer if possible. *Check the answer* by letting symbols become values like zero of infinity or ninety degrees, where the answer is obvious.

(5) Substitute numbers for symbols and solve for the numerical answer, keeping units all along the way.

(6) Perform these three checks:

Check that the answer's units obtained from solving the equation agree with what the units of the answer should be.

Check your numerical answer(s) with 1- or 2-digit arithmetic, preferably done in your head.

Check that you have kept an appropriate number of digits in your final answer(s).

Persist: pursue the solution diligently. If you become stuck, wrestle with it. Go back over the text for clues. Work hard at it: in science and technology one must frequently wrestle with tough material, trying all manner of things until it finally comes together in one's head and the problem is licked. It is often said that "science is not a spectator sport."

Much practice is needed in order to acquire the proper mental discipline for problem-solving. This is very much like solving crossword puzzles in that it is difficult to describe the skills involved. Also, seeing someone else do it does not help you very much when you try to do it yourself. It is a mental discipline, somewhat like a sport that only comes with long hard practice.

Of course if you still can't get a problem after struggling with it, seek help as outlined in Sect. 3b.

5. Review the Lesson

5a. Review the Output Skills. When finished studying a lesson, look at its "ID Sheet" and find the Output Skills. Look at the skill types and think about how we will likely give credit in these categories:

- Knowledge: Answering a question whose essence can be completely specified in an Output Skill statement (e.g. "State Ohm's law, defining all symbols").
- Rule Application: Applying an appropriate rule properly in an application that is new to you, but one so simple as to not require much of a "plan" for its solution (e.g., "calculate the frequency of 586 nm light").
- Problem-Solving Plan: Outlining appropriate strategies for solving a complex problem that is new to you, starting with appropriate physical laws or principles.
- Accuracy: Solving a problem or applying a rule with appropriate mathematical accuracy.
- Project: Combining skills in the areas of knowledge, rule application, problem-solving, accuracy and/or communication to carry a specified project through to completion.
- Demonstration: Using physical apparatus to successfully demonstrate and explain a concept to an examiner.

For each of the lesson's Rule Application and Problem Solving Skills, make sure you have actually solved representative problems that are new to you *with no help from any person or materials.* Consider this a final "dress rehearsal" for the relevant parts of the real certifying exam.

5b. Look over the Model Exam. After studying a lesson, examine its "Model Exam" (not present if all the Output Skills are "Knowledge"). The Model Exam is a module supplement that was a viable candidate for a certifying (real) exam, so it will show you the equations and constants, if any, that will be given to you on the real exam. Like a real exam, the Model Exam usually covers only a selection of the Output Skills. We do not provide consulting assistance on Model Exams.

6. Show Skills on Exams

6a. Communicate Effectively on Exams. Your exams will be evaluated for your skill in communicating, according to our "Scientific Communication Guide" shown in Appendix B and on the back of every Exam Application. In addition, if your communication is sufficiently poor on an exam item, the grader may simply give you zero points for that entire item. No one should have to painfully piece together what you are trying to say.

6b. Show Your Reasoning. Scores are assigned to your exam responses only on what you have put down at the time: you cannot later add any further material. Furthermore, if your reasoning is missing, wrong, or irrelevant, we simply ignore the rest of your work on that item: we are not interested in answers arrived at by erroneous or mysterious methods.

6c. Get Credit for General Skills. Here are some general skills and the ways you can earn course-grade points by demonstrating them:

- Skill Accumulation: To get these points, take a "topic block" exam that gives you credit for the skills covered by two or more units. With "unit" exams you get no skill accumulation credit. Another advantage of a topic block exam is that it is usually shorter than the sum of the unit exams it covers. However, some skills are credited only through block exams and some only through unit exams.

- Communication: Get these points by exhibiting good scientific communication skills on the exam. (See Appendix B).

- Answer Excellence: To get this credit on an exam item, obtain the maximum possible score for the item.

- Exam Excellence: You get this credit if you achieve the maximum possible score for the entire exam. Be sure to examine the sample exam sheets and the graphic summary of our grading technique in Appendix C.

- Evaluation: To get evaluation credit you can: (i) point out policy or exam or module inadequacies on a "Consultation" form; (ii) produce a good review of a module; and/or (iii) circle appropriate responses on Learner Questionnaires. See your updated *CBI Student Handbook* for sample Evaluation credit forms.

- Pace Control: You can receive Pace Points for each Pace week in which your Raw Projected Grade is 2.5 or higher at the end of that

Pace Week. The Pace Week consists of the seven calendar days ending on your course's Pace Day (to determine your course's Pace Day, see your *Classroom and Exam Schedule*.

The Pace Week's points are included in the calculation of whether the exam boosts an examinee past the 2.5 threshold. If so, the examinee gets those Pace Points.

Pace Points can add up to a substantial amount of credit toward a grade.

Pace Points are assigned to the exam that fulfills the requirements set forth above.

Here is an example: Suppose your course's Pace Day is Wednesday. Suppose you take an exam on the previous Thursday but it *does not* result in Pace Points because you would not thereby have a high enough Raw Projected Grade at the end of the Pace Week (in this example, at the end of Wednesday). Seeing this bad result on Friday morning, you can study over the weekend and take another exam to try to get your projected grade up high enough before the end of Wednesday. If you do, you will get the Pace Points for that Pace Week.

An exam cannot give you Pace Points for any Pace Week that occurred before the Pace Week in which the exam is taken. Thus if you do not get the Pace Points for, say, your first Pace Week, those points will be lost to you forever.

An exam can give you Pace Points for Pace Weeks in the future. Suppose that during the first week of the semester you took a lot of exams. Suppose you did well on them and acquired enough points to ensure you would have a Raw Projected Grade of 2.5 or better at the end of the semester *even if you did no further work in the course*. Then you would receive, during that first week, all of the Pace Points available for the entire semester!

Suppose you have a serious illness. If you bring a doctor's note, specifying the time period during which you were incapacitated, you may qualify for a "make-up exam" arrangement (see the *CBI Policies Handbook*). However, you must apply for it promptly upon the end of the doctor-specified period of incapacitation.

- Independent Study: To get points in this skill, actively pursue and acquire scientific skills through the use of professional-type materials. For example, don't require us to repeat material orally that you can easily read for yourself in print form. Points for this skill are also affected by how efficiently you make use of our consultants. For further details see your updated *CBI Student Handbook*.

7. Monitor Your Progress

► **Watch Your "Projected Grade."** Every CBI class day we post a fresh chart showing what we call your "Raw Projected Grade": it is our best estimate of the points (in "raw grade" format) you will eventually get in the course. Watch your Raw Projected Grade closely and, throughout the term, keep it up to, or above, the course grade you want. If your projected grade falls below the grade you want, work harder and get better scores on your exams, just as you would in any other course. If your projected grade is lower than you want because you have not been taking exams at a high enough rate, then speed up your pace until your projected grade is where you want it to be.

► **Watch Your "Earned Grade."** On the chart that we post every CBI class day, you will see your current "earned grade": if at some point it gets up to the grade you want in the course, then simply do not interact with us again and that is the grade you will get at the end of the term (barring an error in your record, which is extremely unlikely and for which it would be up to us to help you rectify).

► **Watch Two "Pace" items.** On the daily-posted chart you can see all of the Pace Weeks for which you have received Pace Credit. You can also see the additional course points you must still acquire to get "up to pace" by the end of your current Pace Week. Remember that the available Pace Points are substantial!

Acknowledgments

This module has been revised extensively over the years. Thanks go to the many staff persons and students who have suggested improvements. Preparation of this module was supported in part by the National Science Foundation, Division of Science Education Development and Research, through Grant #SED 74-20088 to Michigan State University.

Appendices: A, B, C

A. Scientific Communication Guide

It is exceedingly important that scientific communication should be: (i) clear to the recipient; (ii) laid out for easy checking; and (iii) concise. Every scientist, no matter how important or famous, is required to conform to these three rules which go to the very heart of science and are a major reason for its successes. As an enrollee in this course you are assumed to have a serious interest in developing and demonstrating those competencies which are the hallmark of good scientists and technologists. To this end we will reward you if your formal communications in this course, your exams, follow those three traditional rules of scientific communication.

There are common attributes which are generally characteristic of clear, easily-checkable, concise scientific communication:

1. The logic of your solution must flow only downward on your page. Show only those intermediate answers necessary for checking major sections of the solution.

2. All vector quantities are marked as vectors:

$$\boxed{\vec{r} = 3.0\, m\, \hat{y}} \quad \text{not} \quad \boxed{r = 3.0\, m\, \hat{y}}$$

3. Equality signs are centered vertically on fractions:

$$\boxed{y = \frac{ab}{c}} \quad \text{not} \quad \boxed{\begin{array}{l} y = \;\; ab \\ \;\;\;\;\;\;\;\;\; \overline{\;c\;} \end{array}}$$

4. A combination of algebraic symbols is always set equal to another symbol:

$$\boxed{V = k_e \frac{q}{r}} \quad \text{not} \quad \boxed{k_e \frac{q}{r}}$$

5. Problems are first solved for symbolic answers involving the input parameters or explicitly defined combinations of them:

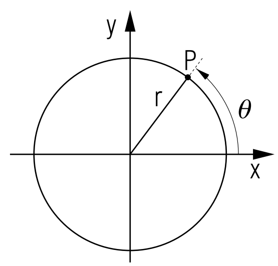
$$\boxed{C = C_1 + C^* \; : \; C^* \equiv \frac{C_2\,C_3}{C_2 + C_3}}$$

6. Numbers are substituted, with their units, for the input symbols and the units are then reduced to obtain the units of the answer:

$$\boxed{d = \frac{1}{2}(32\,\mathrm{ft/s^2})(2.1\,\mathrm{s})^2 = 70.56\,\mathrm{ft} \;\Rightarrow 71\,\mathrm{ft}}$$

7. Numerical answers are given to an appropriate number of digits, neither more nor less. A number like 130 must finally be written so as to show its number of significant digits (1.3×10^2 or 1.30×10^2 or ...). If only multiplications and divisions are used to compute the answer, then the final answer should have exactly the number of digits of the least precise of the input parameters (see the examples in #6 above and #10 below). If subtraction is involved, the subtraction must be checked to see if some precision is thereby lost due to cancellation of the leading digits.

8. The situation is sketched, showing the meaning of the symbols used:



9. Assumptions used at the beginning of a problem are clearly stated in both words and equations:

1.	I combine Coulomb's Law: $\vec{F} = k_e \dfrac{q\,q'}{r^2}\,\hat{r}$
	and Newton's Second Law: $\vec{F} = m\vec{a}$
	to get ...

10. Equality signs that are part of a derivation sequence, but which begin different lines on the page, lie directly underneath each other:

$$\begin{aligned}
\vec{a} &= k_e \frac{q\,q'}{m(a+b)^2}\,\hat{r} \\
&= \frac{(2.0\times10^{-5}\,\mathrm{C})(-3.0\times10^{-6}\,\mathrm{C})(9.0\times10^{9}\,\mathrm{N\,C^{-2}\,m^2}}{(8.0\,\mathrm{kg})(0.20\,\mathrm{m} + 0.05\,\mathrm{m})^2}\,\hat{r} \\
&= -1.08\,\mathrm{N\,kg^{-1}}\,\hat{r} = -1.08\,\mathrm{m\,s^{-2}}\,\hat{r} \\
&\Rightarrow -\,(1.1\,\mathrm{m/s^2})\,\hat{r}
\end{aligned}$$

B-I. Exam Application (Front)

MISN-8-38 **APPLICATION FOR CBI EXAM** 1/2(vi)

ID	COURSE	EXAM

Print Name: ______________________ (Last) (First) Date: __________

I agree that any violation of these terms will result in a course grade penalty:

1. The materials I have can be checked by course staff at any time while I am entering, in, or leaving the exam room. I will put all non-test materials (coat, alphanumeric calculator, notes, etc.) in the front of the exam room. I agree that any material which violates this agreement can be seized and held by CBI staff for at least one complete CBI class day.
2. The exam I requested (above) will be graded and entered into my record even if the specific request is a **mistake**.
3. Before leaving the exam room, I will staple together and turn in all pieces of paper of all kinds that I had while in the exam area, **including the printed Exam-question sheet**.
4. I will write nothing on either side of this sheet except what is requested on it.
5. I will ask no question of exam-area staff (a claim of "unfair exam" can be submitted in the Consulting Room later).

Signature (required): ______________________________

STAPLE THIS SHEET, THIS SIDE OUTWARD, BEHIND YOUR ANSWERS + EXAM + SCRATCH SHEETS

LEARNER QUESTIONNAIRE: Please circle one number in each of the six topics for every unit covered by this exam, in ascending order of unit number, left to right. To obtain credit, each unit must have a response in each category.

	lowest unit no.	next higher unit no.	next higher unit no.	next higher unit no.
	☐	☐	☐	☐
Level of Difficulty				
1. Not enough challenge	1	1	1	1
2. Sufficient challenge	2	2	2	2
3. Too difficult	3	3	3	3
Clarity of Material				
1. OK	1	1	1	1
2. Rewrite some parts	2	2	2	2
3. Rewrite completely	3	3	3	3
My interest in Topic				
1. No interest	1	1	1	1
2. Moderate interest	2	2	2	2
3. High interest	3	3	3	3
Adequacy of Text				
1. Add more text	1	1	1	1
2. Amount just right	2	2	2	2
3. Too wordy: trim it	3	3	3	3
Assistance Needed				
1. I needed no help	1	1	1	1
2. Small amount of help	2	2	2	2
3. A lot of help	3	3	3	3
Study Time Required				
[Circle the closest to	1	1	1	1
the number of hours you	2	2	2	2
spent on this unit.]	3	3	3	3

B-Ii. Exam Application (Back)

MISN-8-38 **TWO EXAM-ROOM SKILLS** 2/2(v)

1. Communication Credit

1. You have shown only those intermediate answers necessary for checking major sections of the solution.
2. Your logic flows only rightward and/or downward on the page.
3. All intermediate vector quantities are marked as vectors.

$$\boxed{\vec{r} = 3.0\,m\,\hat{y}} \quad \text{not} \quad \boxed{r = 3.0\,m\,\hat{y}}$$

4. Equality signs are centered vertically:

$$\boxed{x = 3\,\text{m}\,; \quad y = \tfrac{ab}{c}} \quad \text{not} \quad \boxed{x = 3\,\text{m}\,; \quad y = \tfrac{ab}{c}}$$

5. Any conglomerate of algebraic symbols is set equal to another symbol.
6. Numbers are substituted, with their units, for the input symbols and explicit units conversion factors are used where needed:

$$\boxed{d = \tfrac{1}{2}(32\,\text{ft/s}^2)(2.1\,\text{s})^2 = 70.56\,\text{ft} \Rightarrow 71\,\text{ft}}$$

7. Assumptions used at the beginning of a problem are clearly stated in both words and equations:

> 1. I combine Coulomb's Law: $\vec{F} = \frac{q\,q'}{4\pi\epsilon_0 r^2}\,\hat{r}$
> and Newton's Second Law: $\vec{F} = m\vec{a}$
> to get ...

8. Line-starting equality signs are aligned vertically.
9. The situation is sketched, showing the meaning of the symbols used.
10. The Exam Answer Sheets contain nothing extraneous, nothing crossed out, nothing partially erased.
11. At the end of the response to each numbered exam item a horizontal line is drawn across the entire Exam Answer area.

2. "Organizational Professionalism" Credit

For these combined acts that allow us to better serve students:

1. Entering all three requested items on the manual sign-in sheet for exams.
2. Conduct in the Exam Room as specified on the reverse side of this sheet.
3. Stapling exam materials in the correct order and orientation.
4. Efficiently/professionally using the Consultants in the Consulting Room.

Knowledge ("K") Credit: The exam question explicitly requests the demonstration of a skill listed in the unit's *Output Skills (Knowledge)* and the response meets the request.

Rule Application ("R") Credit: An appropriate physics rule is applied to the problem correctly. This includes the replacement of symbols, in equations, by numbers that are appropriate to the problem.

Math Accuracy ("A") Credit: Any math used is applied correctly. This includes: (1) numerical answers are given to an appropriate number of digits, neither more nor less; (2) units are given explicitly wherever they are appropriate; and (3) vector specifiers are given wherever appropriate.

C-I. Exam Scoring: General Examples

MISN-8-49 **EXAM ANSWER SHEET** (iii)

- Only material on official Exam Answer Sheets will be graded.
- Reasoning (unless question is Knowledge), must be shown, explained, and correct, or rest of answer will be ignored in grading.

ID #	Course #	Exam #	Vers. #
99	237B	T403	0

Comm	K & R	Plan	Accur	Ans Exc
5 / 5	4 / 5	1 / 1	2 / 2	5 / 6

(Student Signature) (Date) 12/11/90 — (Grader Initials) EK — (Date) 12/12 — Grader # 98

C	K	R	P	A	X	Your responses, separated by entire-width horizontal lines:
1	1				1	Example 1. A Derivation. Good communication, correct and complete derivation, excellence (x) credit for having full credit for both.
1	1				1	Example 2. A Definition. Good communication, correct and complete derivation, excellence (x) credit for having full credit for both.
1	1				1	Example 3. Description of an experiment. Good communication, correct and complete description, excellence (x) credit for having full credit for both.
1		1		1	1	Example 4. Application of a Rule to a New Situation. Good communication, correct rule, reasoning shown and correct, numbers correctly identified with symbols, math work and answer are correct (including units, etc.); excellence (x) credit for having full credit for C, R, A.
–		0		–	0	Example 5. Another "Rule Application". Good communication, correct rule, reasoning wrong or missing, answer correct ("C" and "A" are ignored).
1			1	1	1	Example 6. Combining several rules in a new situation. Good communication, correct rules, reasoning shown and correct, numbers correctly identified with symbols, math work and answer are correct (including units, etc); excellence credit (x) for having full credit for C, P, A.

C — communication
K — knowledge
R — Rule application
P — plan
A — accuracy
X — answer excellence

(Continue on other side if necessary)

C-Ii. Exam Scoring: an Example

MISN-8-49 **EXAM ANSWER SHEET** (iii)

- Only material on official Exam Answer Sheets will be graded.
- Reasoning (unless question is Knowledge), must be shown, explained, and correct, or rest of answer will be ignored in grading.

ID #	Course #	Exam #	Vers. #
99	237B	T403	0

Comm	K & R	Plan	Accur	Ans Exc
2 / 4	6 / 8	– / –	0 / 2	0 / 4

(Student Signature) (Date) 12/11 — (Grader Initials) EK — (Date) 12/12 — Grader # 98

C	K	R	P	A	X	Your responses, separated by entire-width horizontal lines:
	1					1a The difference between the "value" and the "magnitude" of a number is that the magnitude is the same as the value except that any minus sign is disregarded. ✓
1	0				0	1b The condition of unit consistency is that the quantities on both sides of an equation must be in the same units. **wrong: see module**
		1		0		2a $x = s_0 t - \frac{1}{2} a t^2 = (16\ m/s)(8s) - \frac{1}{2}(1.6\ m/s^2)(8s)^2 = 78.6\ m$ **erroneous arithmetic: A=0**
0		0		–	0	2b $s = s_0 - at = 16 - (1.6)(8) = 3.2$ **no units here: C=0** **no units here: R=0**
0		3			0	3 answer s is "speed," for which unit is "m/s." $\frac{D^2T}{LA} = \frac{m^2s}{m\,m^2} = \frac{s}{m}$: wrong ✓; $\frac{LD^2}{TA} = \frac{m\,m^2}{s\,m^2} = \frac{m}{s}$: right ✓; $\frac{TL}{D^2A} = \frac{s\,m}{m^2m^2} = \frac{s}{m^3}$: wrong **violates condition #4 for communication credit: C=0**
1		1		0	0	4 $D = L_1 + L_2 = (1.2\times10^9 m) + (0.22\times10^9 m) = 1.42\times10^9 m$ ✓ **violates mathematical condition for significant digits: A=0**

(Continue on other side if necessary)