Academic Skills for the Sciences

- Biology
- Chemistry
- Physics
ACADEMIC SKILLS FOR SCIENCES

There are no tricks or magic formulas for succeeding in science, but this handout does offer practical suggestions for improving your academic skills in science courses. The following strategies are meant to be used in addition to general academic skills which are outlined in our other skills handouts located in the CAA lobby.

These science skills strategies have been separated into three sections: Biology, Chemistry, and Physics, with each offering specific suggestions for that discipline. However, most of the strategies can be applied to any science.

I. Biology

A. Reading Skills

1. **Read slowly and deliberately.** Most college biology texts are written at a 12.6 grade level or higher. For most people, such reading is not easy. Unless you concentrate, you will get very little out of it, and it will seem even more difficult than it really is.

2. **Tackle it three times.** Yes, this sounds like a lot, but if you put quality time and effort into it at the beginning, it should make it easier as you go along.
   a. First: Skim the chapter, noting topic sentences, words in bold, all tables, diagrams, and summary charts. This should be done before the lecture.
   b. Second: Read in more detail, studying each area, and not proceeding until each section is understood. Reread as many times as necessary until you understand. If you are having difficulty, write a specific question about it to ask the instructor.
   c. Third: Go back over the reading to write down terms, definitions, and important concepts. It is helpful for later in-class note-taking to make a list of key words and names at this time.

3. **Talk to yourself as you read.** Explain what you have read aloud, making up your own examples to better understand what you have read. Pretend you are explaining the material to a twelve-year-old. This will help you clarify the information. Hearing yourself really makes a difference!

4. **Words and symbols have specific meanings.** Each time you come across a new term or concept, write it down. Whenever possible, write it in your own words. Strive to understand the definitions, so that you can easily restate them. Remember to talk to yourself out loud.
5. **Study all diagrams and charts.** Graphics condense a lot of important information. After studying, cover the diagram/chart and rewrite it.

6. **Use your text.** You paid for it! Think of it as a learning tool.
   
a. Highlight important facts and key concepts.

   b. Summarize concepts in your own words in the margins.

   c. Note questions that you need clarified.

7. **Mastery.** Make sure you can answer the study questions at the end of the chapters.

8. Remember to use the reading skills strategies given in the “Study Skills” handout. Those strategies are the base on which to add any discipline-specific skills. But of course, you’re already using them!

B. **Study Skills:**

1. Biology utilizes a significant amount of information that must be mastered and memorized.

2. **Re-Organize.** Below are some strategies for reorganizing lecture, lab, and text material more effectively by reducing the amount of information that must be learned and remembered. Another benefit of reorganization is that it forces students to use and think about information in different ways, helping them to detect patterns and predict possible test questions, as well as acting as memory triggers. This strategy is extremely important for visual learners.

   a. **Flash Cards** are used to organize information such as terms and definitions, people and their contributions, lists, identifying characteristics, and structures. To get started using flash cards, use the bold words or main concepts listed in your text. Place the term on the front of the card and the definition, explanation, etc. on the back.
b. **Matrices** are used to show comparisons between two or more concepts (similarities and differences). Matrices require a student to make a connection between different components; the more connections you make, the more likely you are to remember the material. Information is organized into rows and columns, with the objects to be compared written across the top as column headings and the repeating categories written down the left-hand side row headings.
IMMATURE AND MATURE ECOSYSTEMS

<table>
<thead>
<tr>
<th>Plant Size</th>
<th>Immature</th>
<th>Mature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Species Diversity</td>
<td>Small</td>
<td>Large</td>
</tr>
<tr>
<td>Trophic Structure Types</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Niches</td>
<td>Few, Generalized</td>
<td>Many, Specialized</td>
</tr>
<tr>
<td>Organization</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Energy Efficiency</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Nutrient Recycling</td>
<td>Low</td>
<td>High</td>
</tr>
</tbody>
</table>

Matrix from: http://muskingum.edu/~cal/database/content/biology.html

C. **Concept Maps** are used to organize supporting information related to one topic. They help to organize large chunks of related information. Research supports the effectiveness of this strategy in helping students learn complex material. For detailed information on making concept maps, check out these web sites:

http://www.coun.uvic.ca/learn/program/hndouts/map_ho.html
http://classes.aces.uiuc.edu/ACES100/Mind/CMap.html

Map from: http://inspiration.com/vlearning/index.cfm?fuseaction=concept_maps
d. **Hierarchical Organizers** show superordinate and subordinate relationships. When reviewing notes, look for clue words that indicate the information might be hierarchical: characteristics of, for..., styles of..., types of....

### The Linnean Taxonomic Hierarchy

- **Imperium** ("Empire") - the phenomenal world
- **Regnum** ("Kingdom") - the three great divisions of nature at the time - animal, vegetable, and mineral
- **Classis** ("Class") - subdivisions of the above; in the animal kingdom, six were recognized (mammals, birds, amphibians, fish, insects, and worms)
- **Ordo** ("Order") - further subdivision of the above; the class Mammalia has eight
- **Genus** - further subdivisions of the order; in the mammalian order Primates, there are four. e.g. Homo
- **Species** - subdivisions of genus, e.g. *Homo sapiens.*
- **Varietas** ("Variety") - species variant, e.g. *Homo sapiens europaeus.*
Example taken from: http://www.palaeos.com/Systematics/Linnean/Linnean.htm

e. For further information and organizer templates, check out this website:
http://www.myschoolonline.com/content_gallery/0,3138,55356-121175-5-5622,00.html

3. **Memory Strategies** are designed to improve encoding and retrieval of information to and from memory. For biology classes, it is extremely important to begin the memorization process early, so that large amounts of information can be moved to long-term memory.

a. **Mnemonics** are verbal devices which help one remember a large quantity of facts. The first letter of each item is used to form a catchy cue word or phrase. Mnemonics are especially helpful for audio learners.

1) **Create an acronym**: Use the first letter of each item to create an easy-to-remember word.

   To remember types of bacterial flagella:

   **LAMP**

   • Lophotrichous
   • Amphitrichous
   • Monotrichous
   • Peritrichous

2) **Create an acrostic**: Make a sentence using words that have the same first letter as the items you need to remember.

   Mnemonic for remembering planets:

<table>
<thead>
<tr>
<th>Mercury</th>
<th>My</th>
</tr>
</thead>
<tbody>
<tr>
<td>Venus</td>
<td>Very</td>
</tr>
<tr>
<td>Earth</td>
<td>Easy</td>
</tr>
<tr>
<td>Mars</td>
<td>Method</td>
</tr>
<tr>
<td>Jupiter</td>
<td>Just</td>
</tr>
<tr>
<td>Saturn</td>
<td>Speeds</td>
</tr>
<tr>
<td>Uranus</td>
<td>Up</td>
</tr>
<tr>
<td>Neptune</td>
<td>Naming</td>
</tr>
<tr>
<td>Pluto</td>
<td>Planets</td>
</tr>
</tbody>
</table>
3) **Alphabetize:** Simply alphabetizing a long list will often make recall easier. For example, arranging the names of the major systems of the body in alphabetical order forms a list with two consecutive letter combinations, “c-d-e-e” and “l-m-n,” plus double “r.”

- Circulatory
- Digestive
- Endocrine
- Excretory
- Lymphatic
- Musculoskeletal
- Nervous
- Reproductive
- Respiratory

4. **What to Study?**

   a. Anything mentioned in lecture or lab

   b. The more time that is spent on a topic, the more time you should spend studying it.

   c. The more places something is mentioned (lecture, lab, text), the more important it is.

   d. Be able to define terms and symbols used by instructor.

   e. Learn the content of figures used to illustrate concepts, principles, processes, and facts.

   f. Items missed by many students on a quiz or previous test may reappear on the next test.

   g. If it’s important enough for your instructor to repeat it, you should know it!

   h. Problems solved in lab, lecture, or recitation are a sample of what to expect. Practice them so you can solve similar problems.

   i. Hints from instructor.

C. **Test Taking**

   1. **Information Dumping:** As soon as you are handed the test, “dump” all of the information you think you might forget or get confused about. On the back of the test or on scrap paper provided by the instructor, write down numerical data, names, figures, drawings, mnemonics, or organizational schemes. It is
 worth the time it takes to dump the information to ensure that you don’t forget it.

2. See “Test-taking Strategies” handout for important test-taking tips.

D. **Lab Strategies**

1. **Preparation:** Read the procedure before class and prepare a “summarized lab procedure” by writing a shortened, step-by-step version of what you will be doing. Eliminate all extraneous words and explanations. If something isn’t clear during lab, you can refer to your lab manual for clarification.

2. **Slide Identification:** Some lab tests require identification of slides (cell, cell structures, species, or parts of the anatomy). Flash cards are an effective tool for preparing for this type of test. First, photocopy the diagram or picture from your lab book (you may need to reduce the size). Use white-out to cover over any identifying terms on the diagram. Cut out and attach the picture to one side of an index card. Identify the picture on the back of the card.

3. Keep a separate **binder** or binder section for lab materials. A three-ring binder is best because handouts can be added easily.

II. **Chemistry**

A. The above biology strategies also apply to chemistry, but in addition, be aware that chemistry is cumulative. It progresses from simple to complex concepts, building upon existing knowledge at each stage. New material may only be understood after earlier material has been grasped. Therefore, be very careful to keep up with work and not fall behind. Also, chemistry does not always follow a nice logical sequence like most other subjects. You may have to accept some things as fact without being able to understand all the processes at first.

B. **Basic Skills** needed to succeed in chemistry:

1. Simple algebra

2. Metric system (length, mass, volume)

3. Significant numbers
4. Temperature (Fahrenheit, Celsius, Kelvin)
5. Exponential numbers
6. Factor-label method (dimensional analysis)
7. Chemical symbols and names of about 40 commonly used elements
8. Symbols (formulas) and names of commonly used ions
9. Writing and naming chemical formulas

C. Five traditional branches of chemistry: Your chemistry course may include any combination of the five branches. Understanding the focus of each branch of chemistry will help you better understand the concepts you are learning in a particular branch.

1. Inorganic chemistry studies the structure and chemical reactions of substances composed of any of the known elements, except carbon-containing substances.
2. Organic chemistry studies the compounds of carbon.
3. Physical chemistry or theoretical chemistry involves the application of theories and mathematical methods to the solution of chemical problems.
4. Analytical chemistry deals with two areas: qualitative analysis (qual), “What is there?” and quantitative analysis (quant), “How much is there?”
5. Biochemistry (physiological chemistry) studies the chemical structure of living material and the chemical reactions occurring in living cells.
6. General chemistry gives an overview of each of the branches.

D. Reading: See “Reading” section under Biology in this handout.

E. Study Skills

1. Basics

   a. As previously mentioned, it is extremely important to know and understand the basics in chemistry. For example, most of the more complex concepts in chemistry revolve around the topics of chemical bonding, nomenclature, and atomic structure. It is difficult to determine what is happening with nitric acid if you don’t know it is H₂NO₃. It is
difficult to picture how ions are formed, if you don’t know the basic atomic structure. Spend a lot of time studying and understanding the basics to make the rest of your chemistry experience go smoother.

b. It is important to know the difference between an abbreviation and a symbol. An abbreviation is just the shortened form of a word, but a symbol can have many meanings and you may need to know all of those meanings.

2. **Terminology and symbols:** Learning terminology and symbols is key to success in chemistry.

   a. Write the definitions in your own words and gives examples where helpful. Recite the definitions. Do the same with the symbols. The “flashcard” method works well for this activity. (See “flashcards” in the biology section.)

   b. Use every opportunity as a mini-quiz. When reading your text, reviewing notes, or whenever you come across chemical substances, recite their symbol or chemical formula.

   **TIP**—Check out some of the ingredient labels on products at home or in the grocery store. See if you can recognize the common and formal names. For example, “Tums” is calcium carbonate, and rubbing alcohol is isopropyl alcohol. What are their formulas?

   c. Keep a running list of chemical substances and their symbols or formulas. It is also helpful to note any descriptive factors. You can use a matrix to organize the information. (See “matrices” in the biology section.)

   d. Make problem-solving a part of every study session. Decide on a number of problems to work out at every study session and do them! Your proficiency in solving problems will increase with practice. If you find the problems to be difficult at first, practice by using the problems worked out in the text. Cover up the solutions in your text and then work out the problems. If you get stuck, look at the solution to help you figure it out. It is extremely helpful to work problems with a study partner; you can help each other when needed. One major reason why students fail chemistry is that they do not work enough problems!

3. **Become one with the Periodic Table!** Learn how to use it and keep a copy of it easily accessible.
Check out these web-sites for interaction periodic tables and table information.
   http://www.webelements.com
   http://www.taftan.com
   http://www.funbrain.com/periodic/index.html (learning tool)

III. Physics

A. Physics is a problem-solving discipline. Your instructor will stress major themes and principles, but the one major goal is that you, the student, will be able to apply these principles to understand and solve problems.

B. Reading

1. In physics, reading the text and solving homework problems is a cycle: Questions lead to answers which lead back to more questions. An entire chapter will often be devoted to the consequences of a single basic principle. You should look for the basic principles. Understanding these Laws of Nature will help you see the order to the physicists' view of the universe. Nearly all of the problems that you will be faced with in a physics course can be analyzed by means of one or more of these laws.

2. Be sure to review the reading tips in the biology section of this handout and the general study skills handout.

C. Problem Solving

1. Effective problem solving involves answering seven questions:
   a. What's the problem about?
   b. What am I asked to find?
   c. What information am I to use?
   d. What principles apply?
   e. What do I know about similar situations?
   f. How can I go about applying the information to solve the problem?
   g. Does my solution make sense?
2. **Most Effective Approach:**

   a. An effective problem solver will decide "This is an energy problem," or "This is a Newton 2 problem." An inexperienced problem solver is more likely to decide "This is a pulley problem," or "This is a baseball problem." The inexperienced solver concentrates on the surface features of the problem while it is more effective to concentrate on the underlying principle. The expert problem solver will answer these questions, play around (briefly) with the problem, and make drawings and sketches (either in the mind, or, even better, on paper) before writing down formulas and plugging in numbers. An inexperienced solver, on the other hand, will try to write down equations and plug in numbers as soon as possible, making more mistakes and taking more time.

3. **Physics Insight:**

   a. A physicist uses models, pictures, or diagrams to analyze problems. Almost any problem encountered in a physics course can be described with a drawing. Such a drawing often contains or suggests the solution to the problem.

   b. A physicist seeks to find unifying principles that can be expressed mathematically and that can be applied to broad classes of physical situations. Your physics textbook contains many specific formulas, but you must understand the broader Laws of Nature in order to grasp the general overview of physics. This broad understanding is vital if you are to solve problems that may include several different principles and that may use several different formulas. Virtually all specific formulas in physics are combinations of basic laws.

4. **General outline of problem-solving approach:**

   a. **Read** the problem. Look up meanings of any terms you’re not sure about. Ask yourself, “What is this about?” Express the problem in your own words.

   b. **Make a drawing** of the problem. Generally, a rough sketch is all that is needed, but if a more detailed drawing is needed, do the following:

      1) Include a **title** that identifies the quantity you are seeking in the problem.

      2) **Label** the drawing, including the parameters or variables on which the solution depends and that are given in the problem and the given values.
3) Label any **unknown parameters** that must be calculated or obtained in order to find the solution.

4) Use the **units of measure** for all quantities in the problem.

5) Include information that is generally assumed (such as $g$, the value of the acceleration due to gravity), and whether air resistance and friction are neglected.

c. **Establish which general principle** relates the given parameters of the quantity you are seeking. Usually your drawing will suggest the techniques and formulas to be used. Sometimes it may be necessary to obtain further information from your text or notes before the right formulas can be determined. Often further information is needed when the problem has a solution that must be calculated indirectly from the given information. If further information is needed or if intermediate quantities must be computed, it is here that they are often identified.

d. **Draw a second picture** that identifies the coordinate system and origin that will be used in relating the data to the equations. In some situations this second picture may be a graph, free-body diagram, or vector diagram rather than a picture of a physical situation.

1) **Vector diagrams** are diagrams which depict the direction and relative magnitude of a vector quantity by a vector arrow. Vector diagrams can be used to describe the velocity of a moving object during its motion. For example, the velocity of a car moving down the road could be represented by a vector diagram.

2) **Free-body diagrams** are diagrams used to show the relative magnitude and direction of all forces acting upon an object in a given situation. A free-body diagram is a special example of the vector diagram.

3) **Graphs** depict the position and time for a moving car.
e. **Problem-working methods:**

1) In the **concrete method**, calculation is done using the given values from the start, so that the algebra gives numerical values at each intermediate step on the way to the final solution. The disadvantage of this method is that several numerical calculations are involved, making mistakes more likely. However, this method has the advantage that you can see, at every step of the way, how the problem is progressing. It also is more direct and often makes it easier to locate a mistake if you do make one.

2) In the **formal method** you calculate the solution by doing as much as possible without using specific numbers. In other words, you do as much of the algebra as you can before substituting the specific given values of the data. In long and complicated problems, terms may cancel or expressions simplify.

**TIP**→ Gain experience in problem solving by substituting the numbers in the beginning, but gradually adopt the formal approach as you become more confident. Many people adopt a compromise approach in which they substitute some values but retain others as symbols (e.g. "g" for the acceleration due to gravity).

f. **Analyze your solution.** Ask yourself, “Does this make sense?” Compare your solution to any available examples or to previous problems you have done. Often you can check yourself by doing an approximate calculation. Many times a calculation error will result in an answer that is obviously wrong. Be sure to check the units of your solution to see that they are appropriate. This examination will develop your physical intuition about the correctness of solutions, and this intuition will be very valuable for later problems and on exams.

**TIP**→ An important thing to remember in working physics problems is that by showing all of your work you can more easily locate and correct mistakes. You will also find it easier to study the problems when preparing for exams if you show all your work. Also, practice doing the problem faster when studying. This will help you build up your speed and confidence for exam time.

5. **Examples applying problems-solving principles:** In the following examples, problems are stated and the solution is written down as you would work it out for homework.
a. **Example #1:** In 1947, Bob Feller, former Cleveland pitcher, threw a baseball across the plate at 98.6 mph or 44.1 m/s. For many years this was the fastest pitch ever measured. If Feller had thrown the pitch straight up, how high would it have gone?

1) What does the problem ask for, and what is given? Answer: The speed of the baseball is given, and what is wanted is the height that the ball would reach if it were thrown straight up with the given initial speed. You should double check that whoever wrote the problem correctly calculated that 98.6 miles/hr is equal to 44.1 m/s. You should state explicitly, that you will use the 44.1 m/s figure and that you will assume the baseball is thrown from an initial height of zero (ground level). You should also state explicitly what value of $g$ you will use, for example, $g = 9.81$ m/s$^2$. You should also state that you assume that air resistance can be neglected. Since you don't know the mass of the baseball, say that you don't know (You won't need it anyway).

2) Make a drawing:

Vertically thrown ball

To be found:
Maximum height $y_m$

3) The general principles to be applied here are those of uniformly accelerated motion. In this case, the initial velocity $v_0$ decreases linearly in time because of the gravitational acceleration. The maximum height $y_m$ occurs at the time $t_m$ when the velocity reaches zero. The average velocity from $t = 0$ to $t = t_m$ is the average of the initial velocity $v = v_0$ and the final velocity $v = 0$, or half the initial velocity.

4) Make a second drawing. In this case, try a graph of velocity as a function of time:
Notice that the graph is fairly accurate: You can approximate the value of \( g \) as 10 m/s\(^2\), so that the velocity decreases to zero in about 4.5s. Therefore, even before you use your calculator, you have a good idea of the value of \( t_m \).

5) The concrete method can now be applied: An initial velocity of 44.1 m/s will decrease at the rate of 9.81 m/s\(^2\) to zero in a time \( t_m \) given by 
\[
 t_m = \frac{44.1}{9.81} = 4.4954 \text{ s}
\]

a) During that time, the average velocity is 
\[
 v_{av} = \frac{44.1}{2} = 22.05 \text{ m/s}. 
\]
Therefore, the height is given by 
\[
 y_m = v_{av} \cdot t_m = 99.12 = 99.1 \text{ m}
\]

b) Notice that for all "internal" calculations, more than the correct number of significant figures were kept. The final answer is then rounded off to the correct number of significant figures, which, in this case, is three.

6) To do this problem in a formal method, use the formula for distance \( y \) as a function of \( t \) if the acceleration \( a \) is constant. Do not substitute numbers, but work only with symbols until the end where
\[
y_o = 0 \text{ is the initial position, } v_o = 44.1 \text{ m/s is the initial velocity, and } a = -g = -9.81 \text{ m/s}^2 \text{ is the constant acceleration.}
\]
\[
y = y_o + v_o \cdot t + a \cdot t^2 / 2. 
\]
However, do not use the numerical figures at this point in the calculation. The maximum value of \( y \) is achieved when its derivative is zero; the time \( t_m \) of zero derivative is given by 
\[
 \frac{dy}{dt} = v_o + a \cdot t_m = 0 \rightarrow t_m = -v_o/a.
\]
The maximum height \( y_m \) is given by putting this value of \( t_m \) into the equation for \( y \):
\[
y_m = y_o + v_o \left( -\frac{v_o}{a} \right) + a \left( -\frac{v_o}{a} \right)^2 / 2 = y_o - \frac{v_o^2}{2a}
\]
Now substitute: \( y_o = 0, v_o = 44.1, a = -9.81 \).
The result is \( y_m = 0 + 0.5 \times (44.1)^2 / 9.81 = 99.1 \) m

7) Look over this problem and ask yourself if the answer makes sense. After all, throwing a ball almost 100 m in the air is basically impossible in practice, but Bob Feller did have a very fast pitch!

There is another consideration: If this same problem had been given in a chapter dealing with conservation of energy, you should not solve it as outlined above. Instead, you should calculate what the initial and final kinetic energy (KE) and potential energy (PE) are in order to find the total energy. Here, the initial PE is zero, and the initial KE is \( m \times v_0^2 / 2 \). The final PE is \( m \times g \times y_m \) and the final KE is zero. Equate the initial KE to the final PE to see that the unknown mass \( m \) cancels from both sides of the equation. You can then solve for \( y_m \), and, of course, you will get the same answer as before but in a more sophisticated manner.

8) To prepare for an exam, look over this problem and ask yourself how you can solve it as quickly as possible. You may be more comfortable with the concrete approach or with the formal approach; practice will tell. On an actual exam, you might not have time for a complete drawing or a complete listing of principles. By working this problem a couple of times, even after you've found the answer once, you will become very familiar with it. Even better, explain the problem to a friend of yours, and that way you really will have it!

b. Example #2: A one kilogram block rests on a plane inclined at \( 27^\circ \) to the horizontal. The coefficient of friction between the block and the plane is 0.19. Find the acceleration of the block down the plane.

1) The problem asks for the acceleration, not the position of the block nor how long it takes to go down the plane nor anything else. No mention is made of the difference between static or kinetic coefficients of friction, so assume they are the same. The mass is given, but you will eventually find that it doesn't matter what the mass is. (If the mass had not been given, that would be an indication that it doesn't matter, but even in that case you may find it easier to assume a value for the mass in order to guide your thoughts as you do the problem.)

2) Here is the first picture. Note that the angle is labeled \( \theta \), and the coefficient of friction is labeled \( \mu \). In addition, the use of \( m \) for the
mass and $a_{\parallel}$ for the acceleration down the plane are defined in the picture.

![Acceleration of a Block down an Inclined Plane](image)

3) There are two general principles that apply here. The first is Newton's Second Law:

$$F = m \, a$$

where $F$ is the net force, a vector, and $a$ is acceleration, another vector; the two vectors are in the same direction. The mass $m$ will eventually be found not to make any difference, and in that case, you might be tempted to write this law as $a = F / m$, since $a$ is what you want to find. However, the easiest way to remember Newton's Second Law is $F = m \, a$, and so that is the law to work with.

The second principle is that the frictional force is proportional to the normal force (the component of the force on the block due to the plane that is perpendicular to the plane). The frictional force is along the plane and always opposes the motion. Since the block is initially at rest but will accelerate down the plane, the frictional force will be up along the plane. The coefficient of friction, which is used in this proportionality relation, is $\mu$.

4) It is now time to draw the second picture. It helps to redraw the first picture and add information to it. In this case, a vector diagram is drawn and various forces are defined.
Note that in the vector diagram, the block has been replaced by a dot at the center of the vectors. The relevant forces are drawn in (all except the net force). Even the value assumed for the gravitational acceleration has been included. Some effort has been made to draw them to scale: The normal force is drawn equal in magnitude and opposite in direction to the component of the gravity force that is perpendicular to the plane. Also, the friction force has been drawn in parallel to the plane and opposing the motion; it has been drawn in smaller than the normal force. The angles of the normal and parallel forces have been carefully drawn in relation to the inclined plane. This sub-drawing has a title and labels, as all drawings should.

5) We will do this problem using the formal approach, leaving the concrete method for a check (See below).

6) Now for calculation using the formal approach (where you work with algebraic symbols rather than with the actual data): First, state what you are doing, and then write down the equation:

a) Magnitude of gravity force = weight = \( mg \)

b) Resolve gravity force into normal component and parallel component whose magnitudes are

\[ F_{G\|} = mg \sin \theta \] and \[ F_{GN} = mg \cos \theta \]

c) The magnitude of the normal force due to the plane is equal in magnitude (but the direction is opposite) to the magnitude of the normal component of the gravity force:

\[ F_N = mg \cos \theta \]
d) The frictional force opposes the motion, and its magnitude is equal to the coefficient of friction times the normal plane force:

\[ F_f = \mu m g \cos \theta \]

e) The net force (which is along the plane) is the difference between the parallel component of the gravitational force and the friction force; its magnitude is:

\[ F = m g \sin \theta - \mu m g \cos \theta \]

f) The acceleration is net force over mass:

\[ a_\parallel = g \sin \theta - \mu g \cos \theta = g \left( \sin \theta - \mu \cos \theta \right) \]

g) The numerical answer is (given to two significant figures since the given numbers have two):

\[ a = (9.8 \text{ m/s}^2) (\sin 27^\circ - 0.19 \cos 27^\circ) = (9.8) (0.454 - 0.19 \times 0.891) = 2.79 = 2.8 \text{ m/s}^2 \]

7) When you look over this answer to see if it makes sense, try doing the problem by substituting numbers at each step (the concrete approach). The weight of a kilogram, for example, is 9.8 N. The normal (perpendicular to the plane) component of the gravitational force is 9.8 \cos 27^\circ or 8.73 N. This makes sense, for if the angle were very small, the normal component of the gravitational force would be almost equal to 9.8 itself. Notice that although the final answer should be given to two significant figures, you should keep three in these intermediate calculations.

a) The parallel component of the gravitational force is 9.8 \sin 27^\circ = 4.45 N. The normal force due to the plane is equal in magnitude to the gravitational normal force (but opposite in direction), and so the frictional force is 0.19 times 8.73 or 1.66 N. The net force is down the plane and equal to the difference 4.45 - 1.66 = 2.79 N. Divide this value by 1 kg to get the acceleration 2.79 m/s^2 (which is rounded off to 2.8 m/s^2).

b) Again, examine your solution. It says that the block does accelerate down the plane because the final answer is positive. The acceleration is less than g, again a reasonable result. Notice that if the angle were more than 27^\circ, then its sine would be larger and its cosine smaller, so the acceleration would be greater. If the angle were less than 27^\circ,
then the opposite would be true, and the acceleration, as calculated above, could become negative. But a negative value for acceleration would be wrong. That answer would mean that the block would accelerate up the plane because the frictional force dominates, and that is impossible. Instead, if the calculation had produced a negative value for $a$, you would have had to change the solution to $a = 0$, meaning that the frictional force was enough to prevent sliding.

8) Now anticipate how you would do this problem on an exam. Is the concrete approach faster and easier for you? Or would you be more comfortable using the formal approach on an exam? It is a good idea to practice doing this problem when you study for an exam, especially if you think a similar problem will be asked.

6. **Memory Strategies and Test-taking:** See the Biology section of this handout and be sure to pick up the general study skills and test-taking skill handouts.

Now, do your best!
Information for this handout was taken from the following web-site sources:

http://apphysicsb.homestead.com/study.html
http://chat.wcc.cc.il.us/~dward/howtostudy.htm
http://cmap.coginst.uwf.edu/info
http://www.glenbrook.k12.il.us/gbssci/phys/Class/1DKin/U1L2c.html
http://godel.ph.utexas.edu/~larry/how/how.html
http://www.heptune.com/passchem.html
http://muskingum.edu/~cal/database/content/biology.html
http://www.physicsclassroom.com/Class/1DKin/U1L3a.html
http://wc.pima.edu/~carem/BIOREAD.html
http://wc.pima.edu/~carem/BIOSTUDY.html
http://wc.pima.edu/~carem/CHEMSKIL.html

http://www.glenbrook.k12.il.us/gbssci/phys/Class/newtlaws/u2L2c.html