Institut Pertanian Bogor • University of Wisconsin

GRADUATE EDUCATION PROJECT

Aid Project 497-0290

Report No. 42
Van Rennes

Report of Project Associate

on

Development of Science Curriculum

to

Institut Pertanian Bogor (IPB)
Bogor, Indonesia

by

Eve C. Van Rennes, Ed.D
IPB/UW Graduate Education Project
Cranbrook Institute of Science (on leave)
Bloomfield Hills, Michigan

December 1983 - May 1984

Counterpart:

Soedarsono, M.Sc.
Head, Physics Department
IPB

USAID Project No. 497-0290

TABLE OF CONTENTS

FOREWORD

Deep appreciation is expressed to the IPB administration, especially to the Rector, Dr. Edi Guhardja. Sincere thanks also go to Dr. John Murdock, Project Director, for his support and encouragement; and to Mrs. Fatma Rahardjo, whose smiling face and eagerness to help frequently smoothed the way.

Special gratitude is due my counterpart, Mr. Soedarsono, head of the Physics Department. We explored together, deeply, the philosophy of physics education; the author gained significant additional perspective from the process.

Dr. Jajah Koswara contributed a keen insight into how productive, in the right hands, a data retrieval system can truly be. And thanks to the skill and patience of fellow computer enthusiast Dr. Ikin Mansjoer, the computer usually behaved properly.

The author owes much to Dr. M. Anwar Nur for encouraging "physics with tin cans," and to Dr. Ir. Hidayat Pawitan for his invaluable help in surmounting the language barrier when interacting with the Bogor SMP and SMA teachers.

A warm "Thank You" to all of the IPB staff with whom I've interfaced. It has been a privilege and a pleasure to work with you.

I. INTRODUCTION

This covers the period between December 1982 and June 1984, when the author worked as a Project Associate on the IPB/UW Graduate Education Project. The broad objectives were to help in the development of the science curriculum, especially physics, and to help increase the use of microcomputers.

Physics

The Physics Department project was to increase student interest in the first year course by supplying demonstrations to be used with the lectures. Since the lectures occurred in many rooms, and covered an entire year's worth of material in 16 weeks, the addition of demonstrations was difficult. The author, and Darrell Skinner, project associates; and Soedarsono, head of the Physics Department, with Hanedi, physics staff, planned curriculum changes as well as the lecture demonstrations. The workshop on curriculum development held at IPB in January 1983 by Drs. O'Leary and Kean was a great help in the Physics Department planning.

To prepare for this planning, the author:

1. Attended physics lectures for almost the entire Spring semester of 1983, and read carefully the problem sets and some of the examination questions and student answers. There were many discussions with members of the Physics Department. Several books describing physics demonstrations were purchased, and used to help plan for the lecture-demonstrations.

2. Helped develop a course outline and find a suitable book. Soedarsono had the book translated into Indonesian.

3. Helped Soedarsono continue with the development of the physics club started by Darrell Skinner in the Spring of 1983. The club continued through the summer. There were some interesting conversations with these students, giving a picture of their understanding of physics. Demonstrations were planned and implemented during their weekly meetings.

Microcomputers at IPB

This work was done with one Apple II computer under the tutelage of Drh. Ikin Mansjoer, the head of the Planning Board. The author:

1. Helped organize the database project for Dr. Jajah Koswara's Academic Work Load Project, and continued the education of Endeh,

the computer operator and fledgling programmer begun by Darrell Skinner.

2. Gave a short computer course for approximately seven members of the biology department during the summer of 1983.

3. Helped Dennis Grossman, Project Associate, Tjahjono, head of the Ecology Department, and Ecology Department staff, plan an ecology laboratory computer project using a BASIC program written by the author, and a commercial spreadsheet program, VisiCalc.

4. Helped train Student Records Department employees in the use of dBase II on the Apple II.

Workshop for Upgrading Secondary School Science Teachers

During the period January through May of 1984, the author's role was to evaluate the junior high experiments and suggest supplements or replacements. In that time period, also:

1. Participation in the Saturday workshops to supply demonstration experiments and answer students' questions.

2. Delivering hands-on microcomputer demonstrations to groups of five or six high school and junior high school teachers in the workshops.

3. Visited three SMP schools in Bogor to observe facilities and equipment.

4. Presenting to and discussing with participating teachers, the basic principles and methods of science teaching.

5. Finally, supplying a list of possible experiments.

II. SCIENCE EDUCATION

What is the best way to teach beginning university students in any country? Lectures to large groupings? Small recitation groups? Text-books? Laboratories?

Educators all agree that no one teaching method is correct, nor possible, all of the time. The method used depends on the subject matter, the student background, and teacher preference. If the material is facts that need merely to be memorized, then a large lecture is fine. If the course is to give students experience with laboratory equipment, it must happen, actively, in the laboratory. If the students are not uniform in background and ability, and the course is to introduce them to new concepts, then some form of student-teacher interaction must occur. The easiest way to get this interaction is in a relatively (30 or 40 students) small class. Each student is different, and the teacher must use many different approaches with much feedback.

None of us can learn new concepts without integrating those concepts into previous knowledge. This integration is learning, and the student must actively participate in the process. The activity can be merely intellectual, but active the student must be. If this is true for students in the developed world, it is doubly true in developing countries like Indonesia. Students must actively participate in the learning process in order to be able to absorb and use concepts.

Large lectures appear to be very efficient, but in truth, the time is often wasted. If words are only being learned and parroted back by the students, if they cannot make the intuitive jump, assimilating new knowledge, perhaps the large groups are not really efficient after all.

How can a developing country conserve and best utilize its human resources? Only by using the educational technology that is now available. Of course, the large lecture is necessary, but it must be supplemented with textbooks, videotapes, tape recorders, demonstrations, film strips, computers, etc. Indonesia, with its small number of educated people cannot afford to do otherwise. All of these supplements serve to extend the reach of a good teacher, the results eventually growing into greater and greater numbers of skilled citizens.

The following is an attempt to help extend the reach of the fine staff at IPB.

A. First Year Physics Course at IPB

The first year physics course.at IPB is an example of the problems met in developing country higher education. All entering agricultural students, from areas with diverse cultural and educational backgrounds, must enroll in the same physics course. All of physics is covered in a 16-week period with two hours of lecture per week and three hours of lab every other week. This year there are 1650 new students and 300 repeaters from previous years. There are approximately 175 students in each lecture, and 45 in each laboratory. The number of students is expected to increase by ten percent every year. The Physics Department also must teach seven advanced physics courses every year. To accomplish this there are three regular teachers, and one from another department who gives two lectures a week to the first year students.

The physics course is destined for agricultural students, and covers all the usual concepts taught in a year-long course. This is clearly difficult to do in 32 hours of lecture and 24 hours of laboratory. Therefore the course has to be one of memorizing, and plugging numbers into formulae. There is no textbook for the lecturer and students to follow. A large number of copies of an Engineering textbook (College Physics by Sears & Zemanski) are available in the library in English, or can be bought at a high price in Indonesian. A set of worked problems and a laboratory workbook are distributed every semester. The laboratory sessions are completely run by a group of approximately 60 upper-class students.

B. Ways to Improve Course

These improvements to the physics course were developed with Mr. Soedarsono, M.Sc., the head of the Physics Department, and with Darrell Skinner a University of Wisconsin Project Associate. The focus was to make physics more interesting for the first year students in order to attract more to the advanced physics courses. To this end: (1) a physics curriculum that fits into the available time was outlined; (2) a set of demonstrations to be used during lectures were pinpointed, and videotaped by Mr. Soedarsono at the University of Wisconsin; (3) a physics club was formed; and (4) a more conceptual and interesting physics textbook was chosen and translated from English into Indonesian.

The following are some relatively easy ways to make the physics course more interesting.

Problems and A Few Simple Solutions

Curriculum planning questions developed at the Workshop on Educational Planning held at IPB on January 21-22 (Drs. O'Leary and Kean) were used to plan changes in the physics course. This list of questions, as well as the resulting list of topics and time intervals mentioned in number 1 below are reproduced in Appendix A.

1. The physics program was previously changed from two semesters to one with no lessening of subject matter. There's too much material.

Solution: Increase the time to two semesters, or cut the material in half.

2. This is not a course for engineers, yet the only book available is a difficult text designed for engineers taking a two or three semester course.

Solution: A simpler, shorter, conceptual textbook has already been translated into Indonesian. It requires only editing and mimeographing or printing.

3. The test questions are only quantitative. The addition of qualitative questions would focus student attention more on concepts. The students will not bother learning concepts if they aren't going to be tested on them.

Solution: Add conceptual questions to the problem set and to the tests. Some examples are included later in this report.

4. It is impossible to plan and implement lecture demonstrations as there are approximately ten groups meeting in different buildings.

Solution: The actual demonstrations, or videotapes of demonstrations can be shown during the three hour laboratory. Or the necessary equipment for displaying the videotape demonstrations be installed in the lecture halls.

5. The first test is given after eight to ten weeks. The students and teachers have no feedback for this long period. A student needs to know he is failing, and the teacher needs to know how well the students are doing.

Solution: Give the first test very early in the semester.

6. The students are not required to work any homework problems. They are provided a book of worked problems, with a few unworked to be done voluntarily. Therefore most get no experience with solving problems themselves.

Solution: Assign problems, collect them, and check a few randomly, lowering the grade if absent. These problems should be practical, ones that the agricultural specialist is likely to face in the field.

More Ambitious Plan for Improvement

Physics is an important, but very difficult subject. To really be able to assimilate this material in such a short time, most university courses not only require lecture and lab, but recitation groups as well. The following outline for the development of recitations was developed with Mr. Soedarsono and Darrell Skinner in April 1983.

1. Add Recitation section of three hours every other week.

    Answer all questions
    Collect and record presence of homework
    Quiz at end of recitation
    Mechanics of the recitation

        18 recitation groups alternating with labs
        4 recitation groups from repeaters (try 25 students in 2)
        22 upper-class students to teach
        Money from IPB for above teachers

All of physics in 16 weeks
Initial test to separate the levels of student-knowledge

Further Suggestions

I. Physics Media Center

A. Collection of learning aids on hand

Videotape lecture demonstrations
Film strips that amplify appropriate subjects
Computer programs for self-help

B. TAs to help students having problems

Problem Sets
Questions about labs
Feedback to students
Feedback to lecturers
Monitor equipment use

C. Books and problem sets

II. Some, or all, of the tests and problem sets be multiple-choice

Give teachers more time to spend with students
Feedback to students and teachers faster
Force students to do, and hand in homework problems

III. Collect, and eventually reuse assigned problems

Uses less valuable teacher time
Will eventually collect and polish a good set of problems

IV. Use the computer to take care of "housekeeping" functions

Grades
Attendance
Statistics and correlations
Writing tests and homework sets (word processing)

Equipment inventory and purchase
Budget
Distribution of students in labs and lectures

C. Physics Educational Philosophy

1. Physics Demonstrations

Why "waste" valuable student and faculty time on lecture or laboratory demonstrations? Not only do demonstrations liven up a lecture, they have several fundamental educational purposes:

1. Display a phenomenon that is important and not ordinarily visible.

2. Display a puzzling phenomenon that forces students to think.

3. Clarification of a difficult concept.

4. An example of how science can be useful.

a. Display Phenomenon: e.g. Frictionless Motion

In the United States researchers have shown that many high school and college students hold faulty and troublesome preconceptions about physics. (see page 19). For example, many believe that the appearance of motion implies a force. The fact that an object will remain in motion without a motivating force does not seem intuitively correct; in the real world, where friction is present, one must push an object to keep it moving.

"The 'motion implies a force' preconception is not likely to disappear simply because students have been exposed to the standard view in their physics courses. More likely, Newtonian ideas are simply misperceived or distorted by students so as to fit their existing preconceptions; or they may be memorized separately as formulas with little or no connection to fundamental qualitative concepts. Discouraging as these implications may seem, it should be remembered that historically, pre-Newtonian concepts of mechanics had a strong appeal, and scientists were at least as resistant to change as students are." (Reference 2, this paper.) In this case, attention should be directed to demonstrations that show an object in motion remains in motion. Therefore, a frictionless air puck is a good demonstration for lecture or lab.

b. Puzzle (Momentum balls)

Students will resist thinking for themselves, preferring to memorize definitions and formulae. A demonstration which behaves contrary to expectations is one way to encourage thought. Resist the temptation to immediately explain the phenomenon. If it is a laboratory demonstration, require explanations within a written report. If in lecture, let students discuss the demonstration with a neighbor for a few minutes, and then hand in a short written discussion. The educators will learn a great deal from the answers. The momentum balls (used to show conservation of momentum and energy) might be a good example. On dropping two balls, two balls move on the opposite side. Question: why doesn't just one ball move at twice the speed? What happens if you drop one ball that has the weight of two? (I saw this one time--two balls did not move on the opposite side. Why?)

c. Clarification (Board of Nails)

The lecturer should sit on a board of nails. All the same length please. "Why is one nail painful and many nails not?" should address the concept of pressure. Make students write their ideas down, collect (and perhaps grade) the answers.

d. Science is Useful (Solar Collector)

The solar collector, (a concave mirror for example) is one way to use the sun's energy. Why not let students learn how to build one in a laboratory?

2. <u>Teaching Conceptual Physics</u>

In a recent article (1) Paul G. Hewitt contrasted physics taught conceptually with physics taught as applied mathematics. His definition of conceptual physics: "a qualitative study of the central concept of physics with emphasis on mental imagery that relates to things and events that are familiar . . ." He argues that physics should be taught on a conceptual level before analytical even for science and engineering students, noting a common illusion: "since science and engineering students can understand math, teaching them conceptual physics is not necessary." He claims that, "We are mistaken when we assume that because students can work out problems they therefore understand the concepts."

Recent university experimenters in the United States agree with Hewitt, having shown that many high school and college students hold faulty and troublesome preconceptions about physics. Many find that asking conceptual questions unmasks much student confusion. For example, at the University of Massachusetts (2), a group of engineering students were given the following problem to solve:

A group of beginning students were asked about a coin tossed from point A, straight up into the air and caught at point E on the way down. They were asked to draw, on the associated picture, one or more arrows showing the direction of each force acting on the coin when it was at another point B, still on the way up.

Of 150 beginning students (most had taken high school physics), 88 percent thought there was an upward force acting on the coin. Even after the course, 72 percent of those tested were incorrect. Surprisingly, 70 percent of a group of engineering students who had taken mechanics still believed that there was an upward force on the coin at point B. These students still believed that "if there is motion, there must be a force."

Similar misconceptions were encountered at the University of Washington (3). The tested group were members of an honors physics course. It consisted of "bright, highly motivated students." Class size was around 40 students, with a great amount of interaction with the instructor. The material was covered at a slow pace, and all homework was corrected to foster a greater depth of understanding by the students. Even so, the students had problems when asked to conceptualize!

For example, a final exam question relating to dynamics:

"A man pulls a block of stone across horizontal ground at constant velocity by exerting a force of 50 lb. on the block.

(a) Draw the free-body diagrams for the man, the block, and the ground. Indicate by label the action-reaction pairs."

Even though there had been much previous exposure, only 57 percent of the class correctly indicated the direction of the frictional force that the ground exerts on the man.

(b) "Comment on the statement, 'The block moves with constant velocity because the force the man exerts on the block is exactly equal, but opposite, to the force the block exerts on the man.' If the statement is correct, tell why it is correct. If it is wrong, tell why it is wrong and correct the statement."

The responses of 37 percent of the class were completely in error. For example, "Yes, the two forces are exactly equal. Man-on-block=block-on-man means constant velocity. If m.o.b. b.o.m then their (sic) would be acceleration, not constant velocity. . . ." etc.

At Southwest Missouri State University, Whitaker (4) found that students hold "common sense" ideas about motion that cause problems in beginning physics. One of the questions asked:

"A train is traveling along a smooth, straight track at a speed of 60 miles per hour. One of the boxcars has a small hole in the floor. Directly above the hole is a bolt in the ceiling. Suddenly the bolt comes loose and falls. The bolt will:

A. hit the floor in front of the hole.
B. fall through the hole.
C. hit the floor back of the hole.

Only 54 percent of the students who were enrolled in a calculus physics course (and had taken high school) got the correct answer. The students were asked to explain their answers. Some answers--"The train is moving forward and will force the bolt back some." "Since the train is in motion forward and the bolt will only be affected by gravity, the bolt will hit in back of the hole." . . .

Whitaker believes that "students must be given the opportunity to examine and be aware of the ways in which they think about concepts prior to the introduction of a more formal analysis. Students often enter introductory courses in physics with concepts which may differ considerably from the concepts they will encounter in class and in the textbook. . . . Confronting students with their misconceptions . . . will lead them to a fuller understanding of these concepts and promote the student's overall intellectual progress as well."

The above, and many other experiments have shown that students in the U.S. have serious conceptual difficulties with concepts in physics. Is the same true for agricultural students at IPB? These students were first introduced to mechanics when they began SMA. At that age are they able to handle concepts that are too difficult for American college students? They are experts at memorizing equations and correctly solving many problems, but they should be given the opportunity to answer conceptual questions qualitatively as well. These qualitative questions should be asked during labs, lectures, and on exams. If students do hold misconceptions, the teachers will be better able to correct them.

3. Examples of Conceptual Questions
From "Conceptual Physics, Second Edition," by Paul Hewitt.

Motion

1. What is the maximum acceleration possible for a freely rolling ball on an inclined plane? (9.8 m/sec/sec)

Newton's Laws of Motion

2. A heavy ball is hung from a support by a string, and being pulled from below by another string attached directly below the top string. Why is it that a slow continuous increase in the downward force breaks the string above the massive ball, but a sudden increase breaks the lower string?

3. Which has greater mass, 10 kg of lead or 10 kg of feathers?

4. Since action and reaction are exactly equal and oppositely directed, how can there ever be a net force on a body?

5. In what kind of path would the planets move if no force acted on them?

6. Why is it more difficult to push a stalled car from a position of rest than it is to keep it in motion?

7. If you drop a stone from the top of a tall mast on a moving ship, it will:

   a. hit the deck in front of the mast.
   b. hit the deck under the release point.
   c. hit the deck behind the mast.

8. If we find a body which we know to be acted on by a force, but which is not moving, what inference do we draw?

Energy

9. When the brakes of a car traveling 90 km/hr are locked, how much farther will the car skid compared to locking the brakes at 30 km/hr?

Momentum

10. Which has greater momentum, a heavy truck at rest or a moving roller skate?

11. What does it mean to say that momentum is conserved?

12. Can a rocket be propelled in a region completely devoid of an atmosphere? Explain.

13. In terms of impulse and momentum, why are padded dashboards safer in automobiles?

14. If only an external force can change the state of motion of a body, how can the internal force of the brakes bring a car to rest?

15. Can a body have energy without having momentum? Explain. Can a body have momentum without having energy? Explain.

16. Would you care to fire a gun that has a bullet ten times as massive as the gun? Explain.

Rotational Motion

17. Since centripetal and centrifugal forces are exactly equal and oppositely directed, how can there ever be a net force on a rotation body?

18. Why must you bend forward when carrying a heavy load on your back?

19. Why doesn't the centripetal force acting on a rotating system produce a torque?

20. Why is it easier to balance on a bicycle when it is moving?

21. Why is it easier to carry the same amount of water in two buckets, one in each hand, than in a single bucket?

22. Where is the center of mass of a doughnut?

23. Why are gun barrels bored with a spiral groove to make a bullet spin when fired?

The Law of Gravitation

24. Would it be correct to say that centrifugal force pulls outward on the moon and keeps it from falling?

25. By how much does the gravitational force between two bodies decrease when the distance between them is doubled? Tripled?

26. If you are in a car that drives off the edge of a cliff, why do you feel weightless?

27. The force of gravity acts on all bodies in proportion to their masses. Why then, doesn't a heavy body fall faster than a light one? Or does it?

References

(1) Hewitt, Paul G., "The Missing Essential--a Conceptual Understanding of Physics," American Journal of Physics, 51 (4), April 1983, pp 305-311.

(2) Clement, John, "Students' Preconceptions in Introductory Mechanics," American Journal of Physics, 50 (1), Jan. 1983, pp. 66-71.

(3) Peters, P. C., "Even Honors Students have Conceptual Difficulties with Physics," American Journal of Physics, 50 (6), June 1982, pp. 501-508.

(4) Whitaker, Robert, J., "Aristotle is Not Dead: Students Understanding of Trajectory Motion," American Journal of Physics, 51 (4), April, 1983, pp. 352-357.

III. COMPUTERS

A. Use In Universities

Within five years nearly all university students and teachers in Indonesia will be using computers. Do you think this is advisable? Do you think this is possible? Is it possible at IPB?

Advisable? The computer is a solution to one of Indonesia's biggest problems, lack of trained professionals in most fields. It is one way to extend the reach of all professionals, especially those in education. This extension can be achieved with computer-based work simplification; writing and planning with word processors and data-base managers, as well as using education programs for direct teaching of students. Good software is now available in many fields, and its use can make more efficient use of busy university faculty.

Also important, many students in other countries now have access to computers. Indonesian students will have a difficult time competing without similar experiences, as computers are rapidly becoming a necessary tool for students in all fields.

Possible? We are approaching a technological revolution, namely, the emergence of powerful microcomputers that are sufficiently inexpensive to be used by students. These new tools will revolutionize the production and dissemination of knowledge as much as did the printing press. Five centuries ago the technology of printing opened education for all, not just to those with the means to hire personal tutors. Five centuries ago, no one predicted the advent of paperback books and photocopiers, but now many students can be seen using photocopied books. Microcomputers are already being used by many Indonesians, and it is even easier to copy software than to copy books.

To be most effective, computer use must spread to all university departments, not just in mathematics, computer science, or engineering; and with access of available to students and faculty alike. Student and faculty use of computers in universities can be based on (a) central mainframe computers with many time-sharing terminals throughout university departments, (b) individual microcomputers in various departments, or (c) a combination of both. The combination is the most flexible and practical, universities can proceed to implement computerization bit by bit as funds become available. Eventually each staff member and student can have his or her own portable (perhaps pocket) computer which can stand alone, or be plugged into a mainframe when greater memory, computational capacity or access to large data-bases is required. Students and teachers can use their microcomputers for word processing, note taking, control of laboratory experiments as well as for scientific calculation and engineering design. Microcomputers can serve as communication terminals to link students to the university mainframes, to their busy professors, to commercial bibliographic databases, to the university library catalog, and to their families back home. Whenever possible the micros can stand alone, to avoid swamping the mainframes, and to be usable if there are problems with the main computer. When the student leaves the university, he will be able to take his computer and programs along.

B. Microcomputers at IPB

IPB is already moving rapidly along the microcomputer path, there are already a large number scattered around the campus, almost entirely for administrative purposes. The following are two ways that an Apple II microcomputer has been used at the Institute, on administrative, the other educational.

1. Education: Ecology Laboratory

The Biology Department, with the help of Mr. Dennis Grossman (University of Wisconsin project associate at that time), was making plans to include innovative educational technology in one of their upper-level ecology classes. Key personnel working on this project with Grossman were Dr. Tjahjono Samingan, Ibu Puspa Dewi Djontronegoro, and Muhadiono. The computer was to be one of these new technologies, to be used in a three-hour laboratory session.

The computer was to be used as a tool, to record data read from survey maps; to save, and finally compare ecological information from different parts of Indonesia. The students were to read the data; save that data on a floppy disk using VisiCalc, a commercial software package for the Apple II; and analyze the data using a BASIC program (in the Indonesian language).

Eventually this material is to be used in a class of 45 students in the last, or next-to-last undergraduate year. The needs for this laboratory will be:

1. Five maps containing five different types of data for the same area. For example, amount of rainfall, soil type, type of vegetation, etc.
2. At least three Apple II computers.
3. VisiCalc, a commercial spread sheet program for the Apple.

In this laboratory, the students will not only get experience using survey maps, and comparing different environments in Indonesia, but also with a microcomputer and a commercial microcomputer program. This use in the classroom will give the staff at IPB valuable experience for the further spread of microcomputers throughout the university. Detailed instructions on how to use the computer, and the computer printout are included in Appendix B.

2. Administration: Agricultural Facilities

Study of Academic Needs in Agricultural Higher Education

The Graduate School, IPB, starting in August 1983, used dBase II, a commercial database program to gather information about faculty age, educational background, and work load. The data was gathered through distribution of a questionnaire to twenty-nine agricultural faculties (59 percent of total). Eight hundred and seventy-eight people, or 52 percent of those questioned, responded--the data to be stored on an Apple II floppy disk. Dr. Ir. Jajah Koswara, the head of this project, provided the leadership, knowing exactly what questions to ask of the computer.

The results were enlightening; for example, in 1983, women consisted of about 22-24 percent of all faculties except forestry, which was only 4 percent. Sixty-eight of the staff have an undergraduate, 19 master's, and 13 percent a doctorate degree. The staff under thirty years of age are 15 percent of the total; between 31-40 are 47 percent; between 41-50, 31 percent; and over 51, 7 percent of the total.

The total work load of the participant was calculated and outlined. The results showed that the older members of the faculties were working much more than a full-time load, and the younger members were often working much less--perhaps not being given the opportunity.

Thus, a 64K microcomputer was able to give the Indonesian government important information about its human resources in higher education. One operator, under the guidance of Dr. Jajah Koswara, was able to accomplish this analysis.[1]

C. Training Computer Operators

Training Program

Use of computers in universities requires employees able to operate computers. If a complicated microcomputer program like dBase II is going to be used, then the staff must be able to operate this program. At IPB, student records are going to be stored on an IBM

[1] Proyek Pengembangan dan Pengadaan Tenaga Akademis 1984. Laporan Studi Kebutuhan Tenaga Akademik Program Pendidikan S_1 di Lingkungan Fakultas Ilmu Ilmu Pertanian. Dirjen Dikti, Depdikbud. Jakarta.

hard disk, using the commercial database program dBase II with an IBM PC (124 K memory). The training is being done now on the Apple II.

The Indonesian computer trainees are having several problems, the most prominent being that the already overworked faculty and administration has little time to learn about computers, or give any kind of aid. The use of a database is only as good as the questions that you ask of it; that must come from the administration. Assuming that the upper level staff will be able to find the time, the following is a description of the difficulties, and some steps that can ease the problems of the computer operators. The difficulties:

1. Language--all computer programs are in English.
2. Computer--this is probably their first introduction.
3. Database--the terminology and concepts are new.

Language

First, the instruction books for the sophisticated programs are all in English, voluminous, and usually difficult to understand, even for a native English speaker. The non-native speaker has a difficult time indeed. He or she may have studied English in school, but certainly not the vocabulary used for computers and databases. The students must either study the instruction books as a form of language lesson, or the books must be translated into Indonesian.

Secondly, English is embedded in the computer program and cannot be easily changed. The operators have a difficult time reading and understanding what is on the screen. But, it is relatively easy, and very important to make an English-Indonesian vocabulary listing for all of the phrases that are displayed on the screen. See Appendix C for such a vocabulary list. It is also very important for the student to make notes and use these notes. There is too much material for the neophyte operator to rely on memory alone. The computer itself can be used as a training aid. For example, by generating a vocabulary crossword puzzle as shown in Appendix C.

Computer

To start out, many clerks are unfamiliar with the functions of even a typewriter keyboard, like use of shift key and space bar. And added to this is the usual fearful adult response to the computer.

Those new to computers are afraid of "high technology," and afraid of making a mistake. It is difficult for adults to experiment and learn from their experiences; they have a great fear that they will break the computer, or are sure that they cannot possibly understand such a high-technology product. Familiarity will conquer that fear. Who now is afraid to use automobiles or television, yet how many people really understand those technologies? Children are much more flexible in their attitudes and adapt easily to computers. Thus the importance of introducing this technology into the schools.

Database

The concepts of database management must also be treated separately. A simple file card address book was used to clarify the meaning of database terms such as field, record, etc. The individual card is one record, the individual datum is one field. These concepts are best understood if concrete.

The microcomputer program, dBase II, has many levels of commands. The new operators were very confused about when to use what commands. Clarifications required concrete examples. For example, comparing the different levels to different rooms in a house. You do different things in different rooms--same with the database. You must enter the kitchen before you can draw water. Each "room" in the database program has its own rules and commands.

Outline for a Course

1. Translate the manual into Indonesian. Prepare an English-Indonesian vocabulary list for the on-screen instructions.

2. Teach some simple programming. Enough to dispel some of the magic. (This step can be omitted if not enough time.)

3. Set up a database on card files (an address list, for example). This will help the student learn some of the database terms such as "field" and "record."

4. Enter the material from No. 3 into a simple program like PFS (a simple, commercially available database program) to amplify what a database program does.

5. Enter same data above into the more sophisticated database program.

6. Finally each trainee must learn how to create the data structure, enter data, edit data, design reports, manipulate the base of information, make back-up disks, etc.

D. Suggestions to Further Increase Microcomputer Use

There is already a network of computer users developing at IPB, with Ir. Ikin Mansjoer as the leader. This process should be encouraged, otherwise everyone spends much time "reinventing the wheel." It would also be helpful to have a computer classroom to be used for educational purposes, both for staff members and for students. Learning how to use a computer requires active participation on the part of the trainee. Therefore it is absolutely necessary for this learning to be done on a computer. Since it will be much more efficient to be able to train ten people at a time, five microcomputers for one classroom will be an excellent investment.

There are three phases in the move to full micro usage:

Phase 1. Supply at least five micros in one room to be used in a controlled way by all staff and some students.

Phase 2. Each department have a computer center (perhaps departmental library).

Phase 3. Individual ownership and use of micro.

Elements of Phase 1

1. No more than two kinds of computers. These computers should be backed up by a large user group, and easily available repair services.

2. At least five microcomputers in one large room, with access for all.

3. Full-time person be hired. This person to assure proper maintenance, help find and use software, and educate staff and students.

4. Funds available for maintenance of equipment, software purchases, and materials (floppy disks, computer paper, etc.).

5. The staff able to reserve the microcomputer room in advance for use by an entire class (number of students limited by the size of room and number of computers).

6. Computers also be available for students needing special help, or with special projects.

7. The staff and students should be educated in the use of microcomputers (by employee in No. 3).

Phase 2

As each department develops a computer "expert" and computer needs, a departmental computer center be developed in one room (departmental library?), with financial backing. This "expert" can be a staff member. At least one computer expert (and probably more) still be maintained in the central microcomputer area. (At this time, some IPB departments have already advanced to this phase.) The departmental computers to be used in ways similar to the central micros.

Phase 3

With departmental usage, some faculty and students will own a microcomputer. This individual usage will spread throughout the entire school.

In the not-too-distant future the computer will be as common as the calculator is today!

IV. SMP AND SMA WORKSHOPS

Laboratory Workshop for Junior High Teachers

This workshop is an outgrowth of a program developed for the high and junior high schools by Program Kerja Guru (PKG) in Bandung. An outline of learning objectives, as well as SMP and SMA laboratory experiments to accomplish these aims was designed for chemistry, physics, and biology. Simple equipment was designed, and workbooks written for these three sciences. The workbooks were written to be used by the students and included: purpose of experiment, time required, list of equipment, and a list of questions to be answered during the course of the experiment. For the SMP physics, there were 9 experiments prepared for the second semester of physics, 13 for the fourth semester, and 5 for the sixth. The workshop was to amplify the courses that were being taught in the junior high schools January-June 1984.

The workshops were held on the campus of IPB, using IPB equipment. The organizers and instructors were SMP/SMA teachers who had attended the PKG workshop in Bandung, and also included Mr. Soedarsono, Chairman of the Physics Department and Dr. Hidayat Pawitan, physics staff at IPB. There were 45 physics workshop participants, 33 SMP, and 12 SMA.

A. Description of the Workshop

Saturday Workshops

The workshops were held in the new laboratory building, which was distant from the Physics Department. The equipment had to be carried to the building every Saturday, and returned to the physics laboratory when finished. Many days there was no water at the tap, so a huge tub of water had to be furnished. The equipment was from the IPB storeroom, unfortunately different from that to be used by the participants.

Both SMA and SMP teachers worked in the same room. I concentrated on SMP, the rest of this discussion concerns them.

Another complication, the room had no air conditioning, nor shades on the windows. Therefore many of the optics and static electricity experiments did not work. Of course the same is true for the participants' classroom, so was realistic.

The teachers were supplied with the student experiment booklet, and the IPB version of the laboratory equipment. They were eager to finish the work, so had few questions (teachers never want to appear ignorant, unfortunately). Several times it was apparent that they had misread the instructions, so this training session was necessary.

Some of the experiments were well designed, the correct level for junior high students. But others were obviously too complicated, or not interesting to children of that age. There were a few that used mathematics beyond the comprehension of young children. A discussion of the specific experiments is included in Appendix E.

There was little feedback from the participants. Few questions were asked during the class periods, even about the more difficult experiments. The participants' answers to the workbook questions were collected, and examined. Most, but not all of the answers were correct. For example, many could not answer the questions at the end of the "Manometer" experiment, yet no one asked for help. Every three weeks there was a discussion about the completed experiments. Most of the dialogue was about wording of the questions, little about science, or about pedagogy.

Towards the end of the workshop, the participants were given a written test. Among other questions; they were asked for the two experiments that they like best, the two they liked least, and their reasons. In almost all cases, the experiments they disliked were those that did not work, or for which there was no equipment. There was no criticism, or praise, for educational or scientific content. When the general question was raised: why one experiment was liked by many and another disliked by many, there was little enlightenment. When one teacher was quietly asked about the "Manometer" experiment, one not liked by many, she claimed that it would be too difficult and take too much time, her class period being only 45 minutes. She also felt that it would not be liked as well by the children, they would prefer experiments that are more gamelike.

This acceptance of educational material that would be too advanced for their students suggests that the material should be carefully preselected, and that many participating teachers are going to need help.

B. Microcomputer Demonstration

Dr. Hidayat first gave a lecture to the entire group, outlining the main part of computers and briefly describing what they can do. Groups of five or six at a time spent an hour and a half at the computer. The input (keyboard and disk drives), output (monitor), memory, and CPU were shown to each group. They all had an opportunity to look at the inside of an Apple microcomputer, and ask questions.

Programming was briefly described, and a BASIC program to record classroom grades was written. The participants then learned how to use VisiCalc, a commercial software package for the same purpose. Everyone was given a chance to enter names, grades, and equations in the VisiCalc program as well as how to compute averages and sums. If there was time and inclination, they designed a science vocabulary crossword puzzle. Each person was given an opportunity to interact with the computer.

C. Visit to Schools in Bogor

What is the junior high environment like? Do the students have desks or laboratory tables? Is there room for the storage of equipment for all the science courses that use the room? A trip was made to see the science classroom for three of Bogor's junior high schools.

Negeri-2

The single science room was large, with 5 or 6 tables running across the width. The water and gas facilities were inoperable, and there was little light. There are four teachers here, teaching 15 classes averaging 48 students each. The school itself is open construction and pleasant. About 50 students were in the laboratory, doing a chemistry experiment. There was plenty of room for the 50 students, but there appeared to be only enough equipment for approximately 5 groups. They were active and interested in their work, appearing to take it all quite seriously. They were also self-sufficient, going into the storeroom to get supplies on their own.

Negeri-1

The students were taking tests, so all was quiet and in order. The classrooms all opened onto a central walkway, quite pleasant. The science room was large and pleasant, though a little dark. The facilities were all operable in this room. The equipment was stored on the tables along the sides of the room, and there was also a storeroom for equipment. All was well-ordered. The students meet once a week for an 80-minute period. One week they study physics, the next biology. There are 3 teachers here, who teach 18 classes, which average 52 students apiece.

A stop at the library showed stacks of paperback school books that had just been returned (end of the school year). The students were mostly interested in biology according to the librarian. The books were very advanced--for example, the "green" biology high school series (translated into Indonesian). And there were what looked like college texts. Most of the books had been checked out by teachers, undoubtedly for themselves as well as for their students, but some students checked out books as well. Use of the books is considered important enough to have a large chart on the wall showing the number of student and teacher visitors for this and last year.

Negeri-4

Because the third-year students were in the middle of graduation ceremonies, there was only time for a quick look at the science room. It was similar to that of Negeri-1.

In all three schools the English teachers were present, the language help was greatly appreciated. The students were all well-mannered, of course neatly dressed, bright, and cheerful. The same held for the teachers. The three classrooms we visited were ample in size, and had very good laboratory tables. All three schools are going to be short on storage facilities since one room must take care of all science labs.

Next year all Indonesian SMP students will have their ordinary biology and physics classes three times a week each, and their laboratory for three hours once a week. They will take the biology laboratory one semester, and the physics the second.

D. Closing Day Discussion

A list of "Ten Commandments for Teaching Science" (see Appendix D) was distributed and translated on the last day. The commandment that elicited the most response was "Ask open-ended questions." One of the Bogor teachers who had taken the precursor workshop in Bandung commented that they had been taught about asking such questions of their students. Yet this was the first time the subject had been introduced (my comment). The teachers asked what open-ended questions were. An example was given using a color-mixing demonstration. Blue, red, and green light were mixed; and clearly visible to the eye were the colors blue, red, green, and yellow. "What colors do you see?" "From where comes the yellow color?" were the suggested kinds of questions. A group of women were in the middle of a lively and thoughtful conversation when one instructor came over with a carefully sketched drawing, explaining the entire subject. The words "open-ended question," had been mentioned, but not the reason--to initiate discussion and encourage students to think for themselves.

A second commandment was discussed--if you don't know an answer, admit it. The teachers asked what to do in this case. The suggestion from the Bandung workshop teacher--open the question to the class, and if the class doesn't know the answer, assign it as homework. It is not acceptable here for the teacher to admit "I don't know." (Is it different anywhere else in the world?) When asked if there was anyone in the world who knew everything, the participants had to admit there was not.

An extra experiment booklet and "certificates" were distributed, and a spirited, rousing talk was delivered by Mr. Soedarsono. The official ceremony will take place after Lebaran.

E. Conclusions and Suggestions

1. The equipment should work.

Laboratories in the science classroom have two main purposes; familiarize children with scientific equipment, and teach them to accurately observe and report on scientific phenomenon. The latter is important for people living in a technological world. But it is imperative that the experiments be successful. "Electroscope and electric induction" will not work in a humid environment, for example, so should be dropped.

2. All questions should be answerable by background information known to most junior high children, or should be observable in the science laboratory

Most of the questions included in the workbook are good, they give the student the opportunity to verbalize about what they see. But some are too difficult. For example, from the book: "When do we use an open manometer, and again when do we use a closed manometer?" How many junior high students know anything about manometers? Nor was the answer supplied by the experiment. Since they will not understand the material, the children will parrot the teachers words.

3. The material must be on a mathematical level that the junior high student can comprehend, or they will memorize words.

Even many college students have trouble with proportional reasoning, yet the student is asked in the thermometer experiment: "1 degree C:1 degree F:1 degree K = ... = ... = ..." A junior high student cannot possibly understand how to answer that question.

F. Recommendations

My recommendation is that all science teachers should be exposed to these workshops before including the equipment in their classroom. A few had never read a thermometer before, let alone the more esoteric equipment. Some of the concepts are difficult, and working together, and with a physicist must have been very useful to them.

A few changes would even improve the results:

1. The SMP classroom equipment should be used, enough so each group of 5 or 6 teachers has a set.

2. Science pedagogy should be included in the workshops. Before starting the experiments on Saturday morning, there should be a demonstration of how to use open questions.

3. If there is a class textbook, follow it, using the experiments suggested there. (Zat dan Energi 1, 2, and 3 by Departemen Pendidikan dan Kebudayaan)

4. Include SMA and SMP teacher suggestions in the subsequent workbooks and workshops.

APPENDIX A

Planning Objectives and Curriculum

for

First-Year Physics Course

Planning of First-Year Physics Course

I. Goals

A. What is the overall goal for course?

1. Prepare student for further physics courses

2. Final course, to be used in agriculture

3. Acquaint student with fields of physic

B. More specific goals?

1. Student knowledge: facts, concepts, principles, patterns of problem solving.

2. Student information processing skills

C. For each topic, what level of knowledge? Won't achieve same level for all topics.

1. Understand the phenomenon thoroughly.

2. Recognize the name of the phenomenon and have a limited understanding of the concept.

3. Know the phenomenon exists.

II. Students

A. Enrollments

1. How many students are currently/initially enrolled in the course.

2. How is this expected to change over the next 5 years?

B. Student Background

1. What method is used to assess knowledge and skill levels of entering students?

2. What is the knowledge level of incoming students?

3. What is the information-processing skill level of entering students and what is expected?

4. Is the course geared to average student?

5. What is done to help entering students who have deficient background?

C. Student Performance and Development

1. What prerequisites must students have?

2. How much independence is expected of students?

3. Do students have enough time available to do the required work?

4. What fraction of students successfully pass the course the first time, what fraction eventually?

5. What feedback is obtained from the students, and when?

6. What feedback do the students get, and when?

III. Institutional Resources

A. Staff

1. How many staff are currently involved in this program?

2. How many additional staff is needed, at what level?

3. What is the educational background of staff?

4. How much staff time is available for course, book and problem developing?

5. How much staff time is available for helping individual students?

6. What is being done to improve staff competence and efficiency?

B. Facilities

1. What classrooms and laboratory space are needed for this course?

2. What equipment and supplies are needed?

3. What library and computing resources are needed?

4. Which of the above are not currently available inside or outside the institution?

C. Resources and materials

1. What texts, annuals and problem sets are needed, and in what language?

2. Are the materials in No. 1 available, or must they be developed here? Can students obtain them?

3. What sources of help are available to students who have trouble?

IV. Course Development

A. Normal course of study.

1. Give title and brief description of each topic in course.

2. Do appropriate goals and outlines exist for each topic?

3. What is the normal sequence of topics?

4. How does this compare to similar courses in other institutions?

B. Background for Course

1. Is the necessary material supplied by the course?

2. Is there coordination between math and physics courses?

V. Evaluation

A. By Students

1. Are they able to pass the course?

2. Is the physics useful in further courses?

3. Is the physics useful in career?

B. By Staff

1. Are the class goals accomplished?

C. By Administration

1. Does course prepare students for following courses?

Physics Curriculum

I. Mechanics (6 weeks)

Units, etc. read in book

Translation statics and equilibrium

Rotational torque

Fluid pressure and hydrostatics

Kinematics & Dynamics

- Uniform motion
- Constant acceleration, gravity
- Newton's laws
- Work
- Inertia and moments of inertia

Momentum

Energy and work

Bernoulli

Pendulum (lecture & lab)

Rotational mechanics

Newton's law of gravitation

Kepler's laws

Simple harmonic motion

Waves

Sound (in order to understand waves)

Structure of atom - chemistry(?)

II. Heat and Thermodynamics (2 weeks)

- Define temp and heat
- Thermal Expansion (solids)
- Specific heat
- Calorimetry
- Gas laws (Charles 6 Boyles)
- Latent heat, conduction, etc.
- Refrigerator
- Entropy(?)

III. Electricity & Magnetism (4.5 weeks)

- Electrostatics
  - Electric field
  - Electroscope
  - Electric potential
  - Capacitance
- Electric Currents
  - Source
  - Resistance
  - Curcuits
  - Power & energy
- Magnetism
  - Bar magnet
  - Currents & magnetism
  - Force on moving charge
  - Flux
- Solenoids & Electromagnetic
- Galvonometer, ammeter, voltemter
- AC, lenz's law, self inductance
- RLC circuits, Impedance
- Phase difference

IV. Optics & Light (3.5 weeks)

- Geometrical Optics
  - Reflection of light
    - plane mirrors
    - concave & convex mirrors
  - Refraction of light
    - prisms (shown by slides)
    - lenses & combinations
    - microscopes
    - telescopes
    - spectroscopes
- Light
  - Velocity of light
  - Photometry
  - Color in sky (read)--or slides

Rainbow
Wave nature of light
- Huygens--ripple tank
- Interference
- Optical gratings
- Polarization
- Nature of light (read?)

APPENDIX B

Details of Ecology Laboratory

and

Computer Printout of Program

Apple II Program for Ecology Laboratory

Material on the disk is from an area between -5 and -6 degrees S latitude; 104.5 and 105.5 E longitude (Lampung Province in Sumatera).

The data is read from a 20 X 20 grid: (0-19). The data are from maps:

1. Tipe Vegetasi (Lamonier)
2. Agroclimatic (Oldeman)
3. Tegakan Hutan (Bina Program Kehutanan Deptan, 1980
4. Tanah

Data is stored on the disk under the following:

AVEG.DIF
AKLIM.DIF
AHUTAN.DIF
ATANAH.DIF

The students are to compare the data from this and other areas (blocks) in Indonesia statistically. The data should be also stored on the disk in the form:

BKLIM.DIF	CKLIM.DIF
BTANAH.DIF	CTANAH.DIF
etc.	etc.

Following is an outline of the methods:

A. Use VisiCalc to enter data onto the disk, for areas A,B,C . . .

1. Boot VC disk
2. Remove VC disk and insert Ecol disk
3. Decide which area to analyze, use data only from that area.
4. Type:
   / S L TEMPLATE (Return)
   Name of file (e.g. BHUTAN or DVEG)
   Note this is a title to accompany data, no .DIF suffix
5. Enter data into the 20 X 20 grid
6. If you want to stop before finished, type:
   / S S BHUTAN (Return) (or other name)
   Do the same for back-up disk.
7. After # 6, to resume entering data, type:
   / S L BHUTAN (Return)
8. When finally finished entering data, type:
   B3 (Return)
   / S # S BHUTAN.DIF (Return)
   U23 (Return)
   R

Disk drive should now operate and save the data under the name BHUTAN.DIF. With the .DIF suffix, the file will be read by a specially written BASIC program.

9. Remove the ECOL disk and insert the back-up ECOL disk.
   Type:
   / S # S BHUTAN.DIF (Return)
   U23 (Return)
   R

This step is very important! Always have at least one back-up!

10. After the data has been entered:

    Boot ECOL disk. Type:

    CATALOG (The catalog should contain BHUTAN.DIF & perhaps BHUTAN)

    Type:

    LOCK BHUTAN.DIF (Return)

If it contains BHUTAN:

    DELETE BHUTAN (Return)

Do the same for the back-up.

Congratulations, you have just entered the data for one variable, for one square degree.

Repeat the above process for all variables for a particular area, starting again at step A1, as well as for other blocks.

/ S L TEMPLATE (Return)

DVEG

etc.

B. Boot the ECOL disk. Type:

1. RUN ECOL (Return)
2. Choose area, and type A, B, C, or whatever.
   It takes the computer approximately 5 minutes to load data.
3. Answer all questions.
4. Record (on paper), appropriate data for each area.
5. Is there a statistically significant difference in data from different areas?

A program for analysis of variance or other statistical procedure can be purchased for the Apple II. Using this package, the students can determine which of the factors produce a significant effect on the forest stand, for example.

Variables Used in Ecology Program

A. diff : Tipe Vegetasi, Sumatera Selatan dan Lampung (Lamonier).

93 = Savanna dan semak savanna
92 = Hutan sekunder, terutama (bersemak)
19 = Tegalan/ladang, pertanian tanah kering berpindah-pindah.
23 = Kebun kopi
5 = Hutan hujan pegunungan 1000-1800 m. (sub montane)
8 = Hutan hujan dataran rendah, Semangka Gumai sampai Tembesi-rawas
33 = Kebun Lada
91 = Hutan sekunder, baru dibuka
24 = Sisa hutan dan hutan tanaman
28 = Sawah
30 = Tegalan/ladang, pertanian tanah kering menetap
32 = Kebun buah dan ladang
25 = Kebun kelapa dan kebun buah
3 = Hutan hujan dataran rendah blok Bengkulu
20 = Kebun karet
9 = Hutan kuiah dataran rendah dengan kecenderungan gugur daun
21 = Kebun kelapa sawit
18 = Rawa/(daerah terbuka dan tergenang) Pools?
14 = Hutan rawa rapat
27 = Kebun teh
17 = Hutan riparian?

B. Diff: Agroclimatic map - Oldeman, Sumatera Selatan - Lampung

1 =	Tipe Iklim	A,	Bulan basah	9,	bulan kering		2
21 =	" "	B1,	" "	7-9,	"	"	2
22 =	" "	B2,	" "	7-9,	"	"	2-3
31 =	" "	C1,	" "	5-6,	"	"	2
32 =	" "	C2,	" "	5-6,	"	"	2-3
42 =	" "	D1,	" "	3-4,	"	"	2
43 =	" "	D2,	" "	3-4,	"	"	2-3
43 =	" "	D3,	" "	3-4,	"	"	4-6
51 =	" "	E1,	" "	3,	"	"	2
52 =	" "	E2,	" "	3,	"	"	2-3
53 =	" "	E3,	" "	3,	"	"	4-6

C. Diff = Tegakan hutan, Bina Program Kehutanan Deptan, 1980

1. Hutan data tidak lengkap
2. Hutan rapat 80 m^3/Ha
3. Hutan sedang 49 - 79 m^3/ha
4. Hutan jarang 39 m^3/Ha
5. Hutan bakau
6. Belukar, perkebunan, tanah pemukiman dan lain-lain
7. Alang-alang, tagalan

8. Sawah
9. Rawa
10. Danau
39. Hutan rawa sedang

Tanah Diff

45. Asosiasi Podsolik Merah Kekuringan dan Podsolik Coklat Kekuningan; Sedimen Masam; Berombak sampai bergelombang.
29. Latosol coklat kemerahan; Tufa masam sampai intermedier: Berombak sampai bergelombang.
34. Latosol coklat kemerahan; Kompleks tufa dan batuan kukuh masam sampai intermedier; Bergelombang sampai bergunung.
24. Andosol coklat tua; Kompleks tufa dan batuan kukuh; intermedier; Bergunung.
9. Aluvial coklat; Kompleks endapan pasir dan liat; Datar.
31. Latosol Coklat Kemerahan; Kompleks tufa intermedier dan basis; Berombak sampai bergelombang.
28. Latosol coklat tua; Kompleks tufa intermedier dan basir; Bergelombang sampai bergunung.
42. Asosiasi Podsolik coklat kekuningan dan Podsolik Merah Kekuningan; Sedimen tufa masam; Datar sampai Berombak
48. Kompleks Podsolik Coklat Kekuningan, Podsolik Kelabu Coklat dan Litosol; Kompleks batupasir, batuliat dan batukapur.
21. Andosol Coklat; Kompleks tufa intermedier dan basis.
20. Andosol Coklat Kekuningan; Kompleks tufa intermedier dan basis; Bergelombang sampai bergunung.
27. Podsolik Coklat; Batupasir; Bergunung.
44. Asosiasi Podsolik Merah Kekuningan dan Litosol; Kompleks batuan kukuh litonik masam dan metamorf; Berbukit sampai bergunung.
39. Kompleks Litosol Merah Kekuningan; dan Litosol: Batuan Kukuh Intermedier; Bergelombang sampai berbukit.
23. Andosol Coklat; Kompleks tufa dan Batuan Kukuh intermedier; Bergunung.
38. Latosol Merah Kekuningan; Kompleks tufa dan batuan kukuh intermedier; Berbukit sampai bergunung.
19. Laterit Air Tanah; Tufa intermedier; Datar.
47. Asosiasi Podsolik Merah dan Podsolik Merah Kekuningan; Kompleks Sedimen tufa dan batuan metamorf; Datar sampai berombak.
43. Asosiasi Podsolik coklat kekuningan dan Podsolik Merah Kekuningan; Kompleks sedimen, fufa dan batuan metamorf; Datar sampai berombak.
41. Kompleks Podsolik Coklat Kekuningan dan Podsolik Coklat; Sedimen masam; Datar sampai berombak.
46. Asosiasi Podsolik Merah Kekuningan dan Podsolik Coklat Kekuningan; Kamploks batuan kukuh plutonik masam dan metamorf; berombak sampai bergelombang.
4. Aluvial Hidromorf; Endapan lakustrin (intermedier); Datar.

35. Latosol coklat kemerahan; Tufa intermedier; Berbukit sampai bergunung.
7. Aluvial kelabu; Endapan liat; Datar.
22. Andosol Coklat; Tufa intermedier; Bergunung.
30. Latosol Coklat Kemerahan; Tufa intermedier; Berombak sampai bergelombang.
18. Hidromorf Kelabu; Sedimen tufa masam; Datar sampai berombak.
12. Regosol Kelabu; Endapan pasir (berkerang); Datar.
2. Aluvial Hidromorf; Endapan sungai; Datar.
17. Hidromorf Kelabu; Sedimen tufa masam sampai intermedier; Datar sampai berombak.
36. Kompleks Latosol Coklat Kemerahan dan Latosol Merah; Batuan Kukuh Basis; Datar sampai Berombak.
33. Latosol Coklat Kemerahan; Batuan kukuh basis; Bergelombang sampai berbukit.
6. Aluvial Kelabu MudaKompleks endapan liat dan pasir; Datar.

Ecology Program Printout

```
LIST
5  REM     ***** ECOL4 *****
6  REM          ***** 9/19/83 ****
7  REM  ****** LATEST WORKABLE VERSION *****
50 D$ =  CHR$ (4)
90  DIM A(11),S(11)
100  DIM T %(4,20,21): DIM V %(4,20,21): DIM V$(4,20,21)
110  DIM QU %(400)
120  DIM ST %(400): DIM W%(400)
125  GOSUB 9100
130  GOTO 500
190  REM ********* INPUT, YES/NO **********
195 N1 = 0:Y1 = 0
200  POKE  - 16368,0
202  INPUT "? ";AN$
205 WRD$ = "BEGIN": GOSUB 355
208  IF M THEN POP : GOTO 730
210 WRD$ = "YA"
220  GOSUB 355
230  IF M THEN Y1 = 1
235  IF AN$ = "Y" THEN Y1 = 1
240 WRD$ = "TIDAK"
250  GOSUB 355
260  IF M THEN N1 = 1
265  IF AN$ = "N" THEN N1 = 1
270  IF N1 + Y1 = 0 OR N1 +Y1 = 2 THEN PRINT "YA ATAU TIDAK?": GOTO 190
280  RETURN
285  REM ********************************
290 M = 0: REM    LIST SEARCH
297  IF LEN (AN$)  30 THEN HOME : PRINT "I'M THINKING.........":
      PRINT
300  FOR K = 1 TO I
310  FOR J = 1 TO LEN (AN$) - LEN (LI$(K)) + 1
320  IF LI$ (K) = MID$ (AN$,J, LEN (LI$(K))) THEN M = K:  GOTO 350
330  NEXT J
340  NEXT K
350  RETURN
355  REM ***************************
356 M = 0: REM       WORD SEARCH
360  FOR J = 1 TO LEN (AN$) - LEN (WRD$) + 1
370  IF WRD$ =  MID$ (AN$,J, LEN (WRD$)) THEN M = 1
380  NEXT J
390  RETURN
400  REM *******************
405 AN$ = "": REM       INPUT
410  POKE - 16368,0
430 WRD$ = "BEGIN": GOSUB 355
435  IF M THEN POP : GOTO 730
```

```
450  RETURN
455  REM ******************
500  INPUT "WHICH AREA?";AR$
550 F$ (1) = AR$ + "HUTAN.DIF":P = 1
560  GOSUB 5000
570 F$ (2) = AR$ + "VEG.DIF":P = 2
580  GOSUB 5000
585 F$(3) = AR$ + "KLIM.DIF":P = 3
590  GOSUB 5000
600 F$ (4) = AR$ + "TANAH.DIF":P = 4
610  GOSUB 5000
620 NP = 4
630  REM  ******* DIST. HUTAN *********
640  FOR Q = 1 TO 11: REM  # VARIABLES
650 A(Q) = Q
660 P = 1
670  GOSUB 5500: REM  FIND %
680  NEXT Q
690  HOME : VTAB 4
700  PRINT "SIAPA NAMA?";
710  GOSUB 400
720 NA$ = AN$
730  HOME : VTAB 4
740  PRINT "DISTRIBUSI TEGAKAN HUTAN DALAM FILE.": PRINT
744  PRINT "VARIABLE"
745  PRINT TAB( 30) "PERSEN"
750  IF S(1) = 0 THEN GOTO 770
760  PRINT "1. "H1$;
765  PRINT TAB (30)S(1)
770  IF S(2) = 0 THEN GOTO 790
780  PRINT "2. "H2$;
785  PRINT TAB (30)S(2)
790  IF S(3) = 0 THEN GOTO 810
800  PRINT "3. "H3$;
805  PRINT TAB (30)S(3)
810  IF S(4) = 0 THEN GOTO 830
820  PRINT "4. "H4$;
825  PRINT TAB( 30)S(4)
830  IF S(5) = 0 THEN GOTO 850
840  PRINT "5. "H5$;
845  PRINT  TAB( 30)S(5)
850  IF S(6) = 0 THEN GOTO 870
860  PRINT "6. "H6$;
865  PRINT  TAB( 30)S(6)
870  IF S(7) = 0 THEN GOTO 890
880  PRINT "7. "H7$;
885  PRINT TAB(30)S(7)
890  IF S(8) = 0 THEN  GOTO 910
900  PRINT "8. "H8$;
```

```
905  PRINT  TAB( 30)S(8)
910  IF S(9) = 0 THEN GOTO 930
920  PRINT "9. "H9$;
925  PRINT  TAB( 30)S(9)
930  IF S(10) = 0 THEN GOTO 950
940  PRINT "10."U0$;
945  PRINT  TAB( 30)S(10)
950  IF S(11) = 0 THEN GOTO 970
960  PRINT "11."U1$;
965  PRINT  TAB( 30)S(11)
970  PRINT
980  PRINT "BAIKLAH ";NA$;", PILIH NOMOR.";
990  GOSUB 400
1000  IF VAL (AN$)  1 OR VAL (AN$)  11 THEN GOTO 730
1010 ON VAL (AN$) GOTO
1020,1020,1040,1050,1060,1070,1080,1090,1100,1110,1120
1020  PRINT "TIDAK ADA TITIK DENGAN NILAI ITO"
1030  GOTO 730
1040 HU$ = H3$:HU = 3:S% = S(3): GOTO 1130
1050 HU$ = H4$:HU = 4:S% = S(4): GOTO 1130
1060 HU$ = H5$:HU = 5:S% = S(5): GOTO 1130
1070 HU$ = H6$:HU = 6:S% = S(6): GOTO 1130
1080 HU$ = H7$:HU = 7:S% = S(7): GOTO 1130
1090 HU$ = H8$:HU = 8:S% = S(8): GOTO 1130
1100 HU$ = H9$:HU = 9:S% = S(9): GOTO 1130
1110 HU$ = U0$:HU = 10:S% = S(10): GOTO 1130
1120 HU$ = U1$:HU = 39:S% = S(11): GOTO 1130
1130  GOSUB 1500: REM  PILIH VARIABLE LAIN
1140  GOSUB 8500: REM  STATISTICS
1150  GOTO 730
1500  REM ******* MENU ************
1510  HOME : VTAB 4
1520  PRINT "TEGAKAN HUTAN: "HU$
1525  PRINT
1530  PRINT "VARIABLES LAIN:": PRINT
1540  PRINT "    1. TIPE VEGETASI": PRINT
1550  PRINT "    2. TIPE TANAH": PRINT
1560  PRINT "    3. TIPE IKLIM": PRINT
1580  PRINT "PILIH (1-3).";
1590  GOSUB 400
1600  IF VAL (AN$) = 1 THEN F$ = "TIPE VEGETASI":P1 = 2
1610  IF VAL (AN$) = 2 THEN F$ = "TIPE TANAH":P1 = 4
1620  IF VAL (AN$) = 3 THEN F$ = "TIPE IKLIM":P1 = 3
1630  HOME : VTAB 4
1632  ONERR GOTO 1510
1650  RETURN
2000  HOME : VTAB 2
2010  PRINT "FILES: ": PRINT
2015  FOR P = 1 TO NP
2020  PRINT " ";P;" ";F$(P)
2030  NEXT P
```

```
2035  PRINT
2037  ON R GOSUB 5505,8500,2040
2038  GOTO 1500
2040  PRINT "DEPENDENT VARIABLE";
2045  GOSUB 400
2048 P = VAL (AN$)
2050  IF P  1 OR P  NP THEN  GOTO 2000
2055 A(P) = - !
2060  FOR P = 1 TO NP
2070  IF A(P) = -1 THEN GOTO 2110
2080  PRINT "BERAPA NILAI ";F$(P);
2090  GOSUB 400
2100 A(P) = VAL (AN$)
2110  NEXT P
4000  REM  ******  STAT 3 VAR ****
4005  FOR P = 1 TO NP
4006  IF A(P) = -1 THEN GOTO 4055
4008 S = 0
4010  FOR I = 1 TO NT
4020  FOR J = 1 TO NV
4030  IF V%(P,I,J) = A(P) THEN T%(P,I,J) = 1:S = S + 1
4035  IF V%(P,I,J)     A(P) THEN T%(P,I.J) = 0
4040  NEXT J
4050  NEXT I
4052  PRINT 100 * S / (NT * (NV - 1))"% OF "F$(P)" HAVE THE VALUE "A(P)
4055  NEXT P
4060  FOR P = 1 TO NP
4070  IF A(P) = - 1 THEN  GOTO 4100
4080  NEXT P
4100  PRINT
4102 S = 1
4105  PRINT "THE VALUES OF ";F$(P)" ARE:"
4110  FOR I = 1 TO NT
4120  FOR J = 1 TO NV
4125  ON P GOTO 4130,4140,4150
4130  IF T%(2,I,J)     1 OR T%(3,I,J)     1 THEN GOTO 4230
4135  PRINT V%(1,I,J)
4137 QU%(S) = V%(1,I,J):S = S + 1
4138  GOTO 4230
4140  IF T%(1,I,J)     1 OR T%(3,I,J)     1 THEN GOTO 4230
4145  PRINT V%(2,I,J)
4147 QU%(S) = V%(2,I,J):S = S + 1
4148  GOTO 4230
4150  IF T%(2,I,J)     1 OR T%(1,I,J)     1 THEN GOTO 4230
4155  PRINT V%(3,I,J)
4157 QU%(S) = V%(3,I,J):S = S + 1
4230  NEXT J
4240  NEXT I
4280 S = S - 1
```

```
4285  INPUT "PRESS RETURN PLEASE. ";AN$
4500  REM   **** SORT *****
4505  PRINT "NILAI",
4506  PRINT "PERCENT
4510  FOR I = 1 TO S
4515  IF W%(1) = 1 THEN GOTO 4590
4520  FOR J = 1 + 1 TO S
4530  IF W%(J) = 1 THEN GOTO 4550
4540  IF QU%(I) = QU%(J) THEN ST%(I) = ST%(I) + 1:W%(J) = 1
4550  NEXT J
4552  IF S = 0 THEN GOTO 4590
4555  PRINT QU%(I),
4560  PRINT INT ((ST%(I) + 1) + 100 / S)
4590  NEXT I
4620  PRINT "PRESS RETURN PLEASE";
4630  GOSUB 400
4650  FOR P = 1 TO NP
4660 A(P) = 0
4665  FOR I = 1 TO NT
4670  FOR J = 1 TO NV
4680 T%(P,I,J) = 0
4690  NEXT J
4700  NEXT I
4710  NEXT P
4720  FOR J = 1 TO S
4730 W%(J) = 0
4740 ST%(J) = 0
4750  NEXT J
4760  RETURN
5000  REM **** INIT *****
5005  HOME : VTAB 6
5006  PRINT P
5010  PRINT "SEBENTAR LAGI"
5020  PRINT D$;"OPEN ";F$(P)
5030  PRINT D$;"READ ";F$(P)
5040 NV = 0
5050 NT = 0
5060  GOSUB 6000
5070  GOSUB 7000
5080  PRINT D$;"CLOSE "F$(P)
5090  RETURN
5500  REM  ****** 1 VARIABLE ****                         %Tegalan hutan
5505 S = 0
5650  FOR I = 1 TO NT
5660  FOR J = 1 TO NV
5670  IF V%(P,I,J) = A(Q) THEN QU%(S) = V%(P,I,J):S = S + 1
5690  NEXT I
5700 S(Q) = 100 + S / (NT * (NV - 1 ))
5740  RETURN
```

```
6000  REM ***READ HEADER *****
6010  INPUT T$
6020  INPUT S,N
6030  INPUT S$
6040  IF T$ = "VECTORS" THEN 6500
6050  IF T$ = "TUPLES" THEN 6600
6060  IF T$ = "DATA" THEN RETURN
6070  GOTO 6010
6500 NV = N
6520  IF NV    = 100 THEN 6010
6530  PRINT "TOO MANY VECTORS. ONLY 100, PLEASE."
6540  PRINT D$;"CLOSE ";F$(P)
6550  STOP
6600 NT = N
6620  GOTO 6010
7000  REM  GET ALL VECTOR ELEMENTS IN TUPLE
7005  FOR I = 1 TO NT
7010  INPUT T1,V1
7015  INPUT S$
7020  IF T1       - 1 THEN GOTO 7500
7025  IF S$       "BOT" THEN 7500
7030  FOR K = 1 TO NV
7035  INPUT T1,V1
7040  INPUT S$
7060  IF T1 = - 1 THEN 7500
7070 V%(P,I,K) = V1
7080 V$(P,I,K) = S$
7090 T%(P,I,K) = T1
7100  NEXT K
7105  NEXT I
7110  RETURN
7200  REM  GET NEXT DATA VALUE
7210  INPUT T1,V1
7220  INPUT S$
7230  RETURN
7500  PRINT "ERROR IN FILE FORMAT."
7510  PRINT D$;"CLOSE ";F$(P)
7520  STOP
7530  END
8000  REM  **** VAR FOR TANAH ******
8002  GOTO 8410
8005  PRINT K". ";
8010  IF QU%(I) = 2 THEN PRINT T0$;
8020  IF QU%(I) = 4 THEN PRINT T1$;
8030  IF QU%(I) = 6 THEN PRINT T2$;
8040  IF QU%(I) = 7 THEN PRINT T3$;
8050  IF QU%(I) = 9 THEN PRINT T4$;
8060  IF QU%(I) = 12 THEN PRINT T5$;
8070  IF QU%(I) = 17 THEN PRINT T6$;
```

```
8080  IF QU%(I) = 18 THEN PRINT T7$;
8090  IF QU%(I) = 19 THEN PRINT T8$;
8100  IF QU%(I) = 20 THEN PRINT T9$;
8110  IF QU%(I) = 21 THEN PRINT A0$;
8120  IF QU%(I) = 22 THEN PRINT A1$;
8130  IF QU%(1) = 23 THEN PRINT A2$;
8140  IF QU%(1) = 24 THEN PRINT A3$;
8150  IF QU%(1) = 27 THEN PRINT A4$;
8160  IF QU%(1) = 28 THEN PRINT A5$;
8170  IF 0U%(1) = 29 THEN PRINT A6$;
8180  IF QU%(1) = 30 THEN PRINT A7$;
8190  IF QU%(1) = 31 THEN PRINT A8$;
8200  IF 0U%(1) = 32 THEN PRINT A9$;
8210  IF QU%(1) = 33 THEN PRINT N0$;
8220  IF QU%(1) = 34 THEN PRINT N1$;
8230  IF QU%(1) = 35 THEN PRINT N2$;
8240  IF QU%(1) = 36 THEN PRINT N3$;
8250  IF QU%(1) = 38 THEN PRINT N4$;
8260  IF QU%(1) = 39 THEN PRINT N5$;
8270  IF QU%(1) = 41 THEN PRINT N6$;
8280  IF QU%(1) = 42 THEN PRINT N7$;
8290  IF QU%(1) = 43 THEN PRINT N8$;
8300  IF QU%(1) = 44 THEN PRINT N9$;
8310  IF QU%(1) = 45 THEN PRINT D0$;
8320  IF QU%(1) = 46 THEN PRINT D1$;
8330  IF QU%(1) = 47 THEN PRINT D2$;
8340  IF QU%(1) = 48 THEN PRINT D3$;
8400 K = K + 1
8410  PRINT  TAB( 5)QU%(I);
8415  PRINT  TAB( 8)"----------------------";
8420  RETURN
8500  REM  ***** 2 VARIABLES ****
8510  PRINT "TEGAKAN HUTAN: "HU$;" (";S%;"%)"
8515  PRINT
8520  PRINT F$;
8530  PRINT  TAB( 31)"PERSEN"
8595 S = 1:K = 1
8600  FOR I = 1 TO NT
8610  FOR J = 1 TO NV
8620  IF V%(1,I,J) = HU THEN QU%(S) = V%(P1,I,J):S = S + 1
8630  NEXT J
8640  NEXT I
8645 S = S - 1
8660  FOR I = 1 TO S
8670  IF W%(I) = 1 THEN GOTO 8800
8680  FOR J = I + 1 TO S
8690  IF W%(J) = 1 THEN GOTO 8750
8700  IF QU%(I) = QU%(J) THEN ST%(I) = ST%(I) + 1:W%(J) = 1
```

```
8750  NEXT J
8755 ST%(I) = INT ((ST%(I) + 1) * 100 / S)
8758  IF ST%(I) = 0 THEN GOTO 8800
8760  IF S = 0 THEN GOTO 8800
8762  IF P1 = 2 THEN GOSUB 9000
8765  IF P1 = 3 THEN GOSUB 8900
8770  IF P1 = 4 THEN GOSUB 8000
8780  PRINT  TAB( 35)ST%(I)
8800  NEXT I
8810  FOR J = 1 TO S
8815 W%(J) = 0:ST%(J) = 0
8816  NEXT J
8817  PRINT
8820  PRINT "TEKAN TUMBOL RETURN.";
8830  GOSUB 400
8850  RETURN
8900  REM  ****** VAR FOR IKLIM **********
8905  IF QU%(I)   20 THEN  PRINT "A";
8910 Q% = QU%(I) / 10
8920 AN% = QU%(I) - Q% * 10
8930  IF Q% = 2 THEN PRINT "B";AN%;
8940  IF Q% = 3 THEN PRINT "C";AN%;
8950  IF Q% = 4 THEN PRINT "D";AN%;
8960  IF Q% = 5 THEN PRINT "E";AN%;
8965  PRINT  TAB( 8) "----------------------";
8970  RETURN
9000  REM **** VAR FOR VEG *****
9010  IF QU%(I) = 93 THEN PRINT V0$;
9015  IF QU%(I) = 92 THEN PRINT V1$;
9020  IF QU%(I) = 19 THEN PRINT V2$;
9025  IF QU%(I) = 23 THEN PRINT V3$;
9030  IF QU%(I) = 5 THEN PRINT V4$;
9035  IF QU%(I) = 8 THEN PRINT V5$;
9040  IF QU%(I) = 33 THEN PRINT V6$;
9045  IF QU%(I) = 91 THEN PRINT V7$;
9050  IF QU%(I) = 24 THEN PRINT V8$;
9055  IF QU%(I) = 28 THEN PRINT V9$;
9060  IF QU%(I) = 30 THEN PRINT E0$;
9065  IF QU%(I) = 32 THEN PRINT E1$;
9068  IF QU%(I) = 25 THEN PRINT E2$;
9070  IF QU%(I) = 3 THEN PRINT E3$;
9072  IF QU%(I) = 20 THEN PRINT E4$;
9075  IF QU%(I) = 9 THEN PRINT E5$;
9080  IF QU%(I) = 21 THEN PRINT E6$;
9082  IF QU%(I) = 18 THEN PRINT E7$;
9085  IF QU%(I) = 14 THEN PRINT E8$;
9087  IF QU%(I) = 27 THEN PRINT E9$;
9088  IF QU%(I) = 17 THEN PRINT G0$;
9090 PRINT " (";QU%(I);")";
9095 RETURN
```

```
9100  REM    **** STRING ASSIGNMENT ***
9130 H1$ = "HUTAN (DATA TAK LENGKAP)"
9140 H2$ = "HUTAN RAPAT"
9150 H3$ = "HUTAN SEDANG"
9160 H4$ = "HUTAN JARANG"
9170 H5$ = "HUTAN BAKAU"
9180 H6$ = "BELUKAR, PERKEBUNAN, DLL."
9190 H7$ = "ALANG-ALANG/TEGALAN"
9200 H8$ = "SAWAH"
9210 H9$ = "RAWA"
9220 U0$ = "DANAU"
9230 U1$ = "HUTAN RAWA SEDANG"
9300  REM   ****** STRINGS FOR VEG *******
9310 V0$ = "SAVANNA"
9320 V1$ = "HUTAN SEKUNDER (BERSEMAK)"
9330 V2$ = "TEGALAN/LADANG"
9340 V3$ = "KEBUN KOPI"
9350 V4$ = "HUTAN HUJAN (SUB MONTANE)"
9360 V5$ = "HUTAN HUJAN"
9365 V6$ = "KEBUN LADA"
9370 V7$ = "HUTAN SEKUNDER (BARU DIBUKA)"
9380 V8$ = "SISA HUTAN"
9390 V9$ = "SAWAH"
9400 E0$ = "TEGALAN/LADANG (TETAP)"
9410 E1$ = "KEBUN BUAH DAN LADANG"
9420 E2$ = "KEBUN KELAPA DAN BUAH"
9430 E3$ = "HUTAN HUJAN BENGKULU"
9440 E4$ = "KEBUN KARET"
9450 E5$ = "HUTAN HUJAN DAT.REND."
9460 E6$ = "KEBUN KELAPA SAWIT"
9470 E7$ = "RAWA"
9480 E8$ = "HUTAN RAWA RAPAT"
9490 E9$ = "KEBUN TEH"
9500 G0$ = "HUTAN RIPARIAN"
9510  RETURN
9600  REM  ****** STRING,TANAH *****
9610 T0$ = "ALHDMRF;DAPSUNG;DTR"
```

APPENDIX C

Vocabulary List and Crossword Puzzle

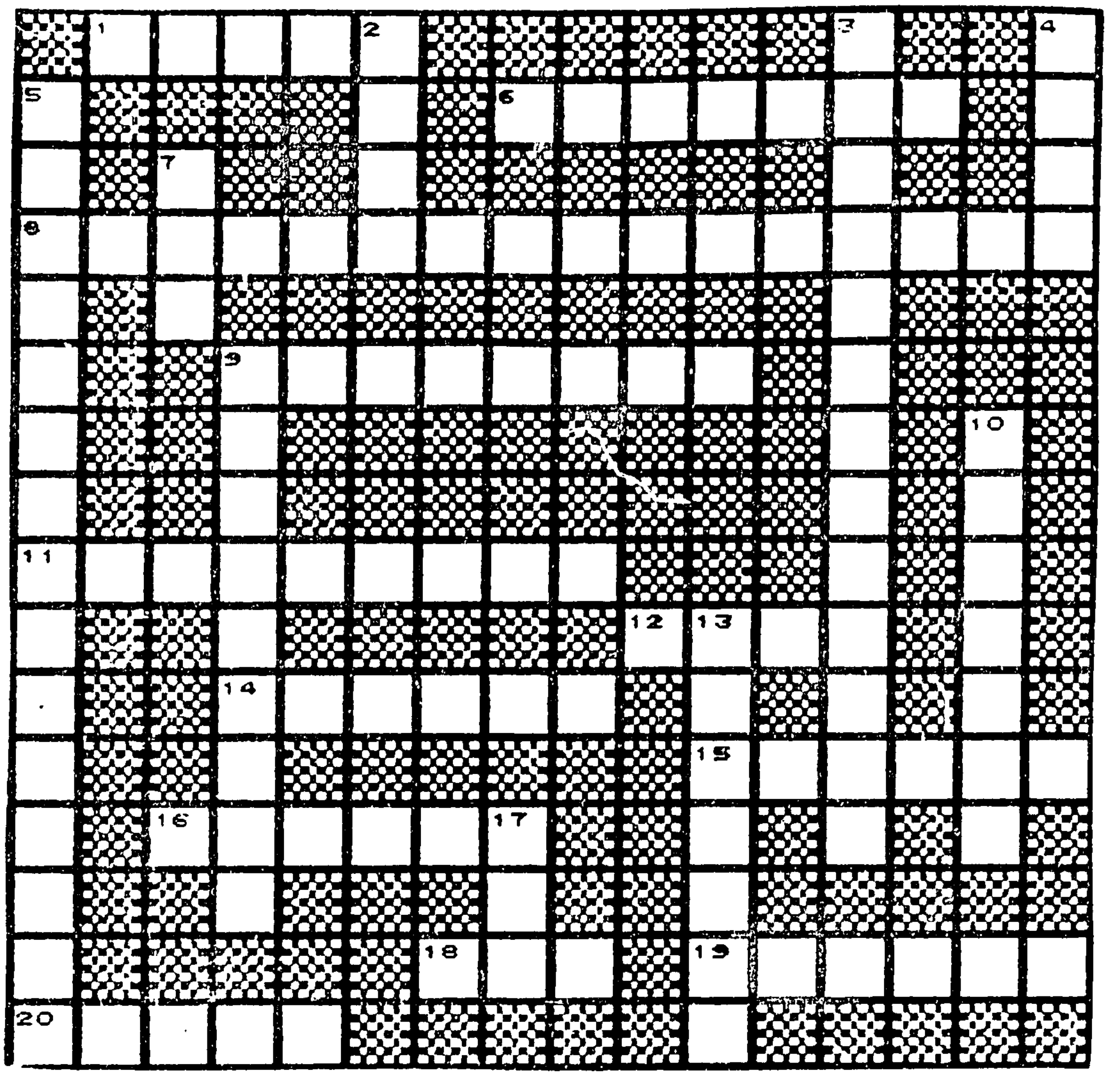
for

Database Education

Vocabulary List and Crossword Puzzle

Change from	Merubah dari
Change to	merubah ke
Character	Angka dan/atau huruf
Correct and retry (Y or N?)	Memperbaiki dan coba lagi (Y atau N?)
Count for	Jumlah untuk
Create	Membuat
Decimal	Desimal
Decimal places	Angka-angka desimal
Delete (a record)	Menghilangkan
Display for	Pameran untuk
Do while .not. EOF	Mengerjakan sambil daftar tidak habis
Enter filename	Masukan nama file (daftar)
Enter record #	Masukan nomor record
Enter record structure as follows:	Masukan struktur record (catatan) sbg. berikut:
Enter today's date as	Masukan tanggal hari ini seperti
Erase (the screen)	Menghapus (layer)
Field	Dasar
File does not exist	File tidak ada
Goto top	Pergi ke permulaan
Input data now? (Y or N)	Masukan data sekarang? (Y or N)
List for	Mendaftarkan untuk
List files on B	Mendaftarkan files pada disk B

More corrections (Y or N)	Koreksi lagi? (Y or N)
<u>Modify command</u>	Berubah daftar pemerintah
Name	Nama
No database file in use	Tidak ada database dipakai
Numeric	Nomor, angka
<u>Report</u>	Laporan
<u>Sum (name field) for</u>	Tambah (nama) field untuk
Type	Macam
Unknown command	Perintah yang tak ditahui
Width	Lebar



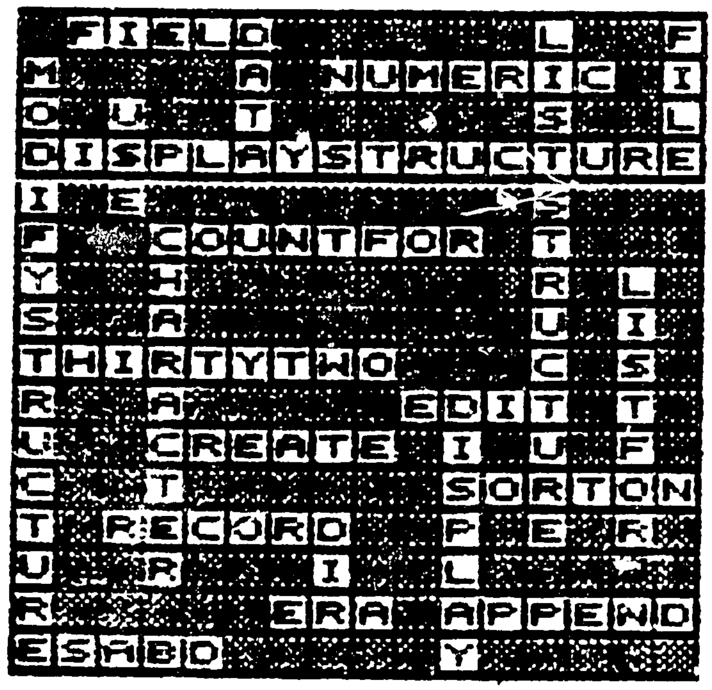
Across Clues

1. Sebagian dari informasi tentang satu mahasiswa.
6. Data berupa angka saja.
8. Memperlihatkan struktur.
9. -----NMR)2. Berapa mahasiswa punya NRP lebih besar dengan 2.
11. Paling banyak keterangan dari satu mahasiswa.
12. Memperbaiki data.
14. Membuat database baru
15. -----NPR to SEMENTARA, Susun menurut abjad ke file baru.
16. Semua informasi tentang satu mahasiswa.
18. Bukan di dalas dBase; Menghapus file (mengikuti nama file).
20. Kata terbalik nemakai untuk mulai program.

Down clues

2. Informasi tentang mahasiswa?.
3. Memperlihatkan struktur file.
4. Arsip.
5. Merubah struktur file.
7. Mengetik ini untuk memilih data base.
9. Kalau data--------, mengetik C.
10. ---NMR(2. Memperlihatkan mahasiswa yang punya NMR lebih kecil dengan 2.
13. Memperlihatkan semua data.
17. Bukan di dalam dBASE. File apa pada disk?

ANSWERS: DBASEII



APPENDIX D

Ten Commandments for Science Teachers

in

English and Indonesian

Ten Commandments for Teaching Science

1. Be enthusiastic

2. Base science lessons on observation

   These observations should, as much as possible, be made by the student.

3. Relate science to the real world

4. Ask open-ended questions

   To be useful, new knowledge must be connected to past knowledge. Only through questioning can you sample your students' beliefs.

5. Listen to students' answers

   Give students time to think about your questions, and then listen to their answers. It is possible that their ideas are better than yours.

6. Be prepared

   Learn as much as possible about the subject matter, but don't expect to know everything. (See Commandments 7 and 8).

7. Admit ignorance

   No one knows everything!

8. Admit mistakes

   No one is always correct!

9. Don't tell your students everything

   Let them find out for themselves. Don't teach them more than they want to know.

10. Teach your students to be self-sufficient.

    Instruct them in problem solving, then let them make their own mistakes.

Sepuluh Perintah Untuk Mengajarkan Ilmu Alam

1. Bersemangatlah!
2. Berdasarkan ilmu pengetahuan dalam pengematan.

   Pengamatan ini kemungkinan dilakukan oleh siswa.
3. Hubungkan ilmu pengetahuan dengan dunia nyata.
4. Tanyakan pertanyaan2 yang terbuka yang dapat berante.(?)
5. Mendengarlah ke jawaban2.

   Sebelum jawaban siswa selesa kita sebaiknya jangan memontong.
6. Selalu siap sedia.
7. Kita tidak serba tahu.
8. Mergahui kesalahan.
9. Tidak selalu memberi semua jawaban pada siswa.
10. Ajarkan pada siswa utuk mandiri.

Appendix E

Report: SMP Laboratory Workbook

Discussion

and

Additions

Lembaran Kerja Siswa
Fisika SMP - Semester 2

Pascal's Principle

Exp. 1: from Zat dan Energi,
Buku 1. 7.1 and 7.2 on pp. 109-110 page E1

Students should build, and use the alat Hartl in 7.2 to convince themselves that the water pressure is the same in all directions. This equipment will be useful in following experiments.

Archimedes Principle

Exp. 2: from Zat dan Energi, Buku 1
Experiment 7.4 on pp. 114-115. page E2

This experiment is the basis for the experiments that follow.

Exp. 3: "Now It Sinks, Now it floats." from Nature and Science, May 17, 1965, p. 14. page E3

There are questions in the article:

1. What happens to diver while you press the rubber?
2. What happens when you stop pressing? Why?
3. What does pressing on the rubber do to (the pressure in) the water in the jar?
4. What does the water do to the (volume of the) air in the diver?

Exp. 4: "Model Galangan Kapal," from workbook, FP/II.4.3/E

My only comment: Are the students to know the answers to this from the textbook? Are they to read the book before, after or while performing the experiment?

Air Pressure

Exp. 5: "Tekanan Udara", from workbook, FP/II/1.3.3.1/E

Comments:

Activity "A" leads to the understanding of the manometer, so more time should be spent considering it.

1. Amati . . . Apakah yang nampak olehmu?

Now use Alat Hartl to answer the following questions:

1.1 How does the pressure just under the surface of the water within the glass compare with that outside in the tub?

1.2 Is the pressure in the water within the glass and above the tub water level greater than, less than or the same as the pressure just under the surface in the tub? Why?

Would water in a taller glass be supported?

Boyles Law

Exp. 6: "Ideal Gas Laws" from 101 Classroom Demonstrations by David Kutliroff, p. 142 page E4

Great care must be used in formulating questions, is it about force or pressure.

P = W/A (A is cross-sectional area)
V = h x A
PV = Constant
therefore:
W/A (h x A) = Constant
W x h = Constant

Recent studies have shown that many beginning college physics students have trouble with proportional reasoning similar to the above, students in SMP are certainly going to have problems.

It would be better to discuss how the weight on the handle affects the height of the air column inside the tube. Double the weight, what happens to the height? Use, but don't mention the fact that the cross-sectional area drops out of the equation. We can't teach everything known about the world--so limit what we teach to being true and being understandable.

Exp. 7: "Macam-Macam Pompa" from workbook, FP/II/1.4.1.2

Good examples to show usefulness of above material.

Question 5: When the piston is pulled up, the water doesn't push the valve open. The pressure decreases above, while the pressure below is the same, so the valve opens.

Between Question 8 and 9, a question should be asked that calls attention to the fact that the space above the piston is open to the room, and at room pressure.

Exp. 8: "Manometer" from Workbook, FP/II/1.4.1/E

Please emphasize to all teachers that mercury is very poisonous, do not use!

In part B, it is not clear that the left-hand side of the tube is open until after the water has been added.

Part B is very difficult to understand, omit.

Heat

Exp. 9: "Suhu dan Pengukurannya" from Workbook, FP/II/1.6.1/E

A good experiment to show the need for a thermometer, and the basic principle of the thermometer.

Exp. 10: "Termometer" from Workbook, FP/II/1.6.1.9/E

Good experiment.

The Celsius scale should be sufficient for SMP. Celsius, Fahrenheit, and the Kelvin scales are too much. I would leave the Kelvin to high school or college.

SMP students would not understand question 15:

1 Skala C : 1 Skala F : 1 Skala K = ...=.....=..... (see discussion of exp. 6 in regard to problems with proportional reasoning.)

Exp. 11: "Investigating Spring Temperatures" from Nature and Science, May 4, 1970. Page E5

After introducing thermometer, give students practice in its use. Remove references to Spring, perhaps discuss musim panas and musim hujan.

Do project in the box, and also record temperatures in student's city. (Is there a record for Jakarta?)

Exp. 12: "Kalor Suhu dan Pengukurannya" from workbook FP/II/1.7.1.1/E

Introducing the energy required to convert water to vapor.

Exp. 13: "Keeping Cool" from Nature and Science, May 6, 1968, pp. 10-11. Page E6, E7.

Examples and usefulness of the concept in Exp. 13. There are two projects and a list of questions.

Exp. 14 & 15: "Kalor" & "Kapacitas Kalor" from workbook FP/II/1.7.1.4 & 5

These are very complicated and abstract for SMP students. Don't use.

Lembaran Kerja Siswa
Fisika SMP - Semester 4

Waves

Exp. 1: "Gelombang" from workbook, FP/IV/1.8.1.1/E

Good experiment, the slinky will be easier to manage if hung as on page E8.

Exp. 2: "Radio Waves" from Nature and Science, Dec. 16, 1968, p 10. Page E9

An example of other kinds of waves.

Sound

Exp. 3: "Bunyi" from workbook, FP/IV/1.8.1.2/E

Good activities

Exp. 4: "Bell in Jar" from Physics Experiments for Children p. 66 page E10

Does sound really need a medium for propagation?

Exp. 5: "Sonometer" from workbook, FP/IV/1.8.1.3/E

Exp. 6: "Turut Bergetar" from workbook, FP/IV/1.8.1.3/E

The drawing in the workbook makes the supporting string look like it is a stick or stiff rod. The picture in the textbook has it drawn that way. The experiment will work much better if the four weights are suspended from something flexible.

Electricity

Exp. 7: "Muatan Listrik" from workbook, FP/IV/2.6.1.1/E

Good, experiment with familiar materials and effects.

Exp. 8: "Jenis Muatan" Listrik from workbook, FP/IV/2.6.1.2/

Good, although climate in Indonesia is too moist.

Elekroskop dan Induksi Listrik from workbook, FP/IV/2.6.1.7 did not work. Don't use this experiment.

Exp. 9: "Konduktor dan Isolator", from workbook, FP/IV/2.6.1.3/E

Good

Sumber Tegangan from workbook, FP/IV/2.6.2.2/E. This experiment is dangerous (sulphuric acid) and too abstract, don't use. Instead try the following experiment.

Exp. 10: Investigation with a Lemon from Nature and Science, Feb. 19, 1968, p. 3. Page E 11

Use materials that are common, like a lemon to give electricity. Also interesting to cut apart a flashlight battery.

Exp. 11: "Making Electricity with Magnets", Nature and Science, Mar 16, 1970, p. 3. Page E 11.

Another interesting and common way to make electricity.

"Hukum Ohm dan Hambatan Listrik, " and "Kuat Arus Dalam Suatu Rangkaian, " from workbook, FP/IV/2.6.2.4 and 5. Too abstract for junior high. For circuits, let them build simple buzzer circuits, or light up some bulbs.

Exp. 12: "Descillating Charge Carrier" from 101 Classroom Demonstrations, p. 178. Page E 12

An interesting effect, and a good challenge for students.

Lembaran Kerja Siswa

Fisika SMP - Semester 6

Optics

Exp. 1: "How the World Looks Under Water" from The Physics Teacher, October 1982, p. 474. Pages E 17, E 18.

Interesting activity to begin discussion of refraction.

Exp. 2: "Pembiasan Cahaya" from workbook, FP/VI/2.10.2.1 and FP/VI/2.10.2.2

Very abstract, will children understand?

Exp. 3: "Use a Fish Tank to Make a Water Prism", from 101 Classroom Experiments, pp. 35-6. Page E 16

Familiar equipment leading into study of prisms.

Exp. 4: "Deviasi dan Dispersi" from workbook, FP/VI/2.10.2.4 and FP/VI/2.10.3.1/E

Further study of prism.

Exp. 5: "The Ways of Rays" from Nature and Science, Feb. 17, 1969, pp. 3-5 page E13-E15

The ray box to be built in semester 5. Page E 14 begins with rays. Gives children a chance to experiment qualitatively, with familiar material.

Exp. 6: "A Look at Lenses" from Nature and Science, Feb. 7, 1969 page E 20-E 22.

Start out with familiar, then qualitative discussion, only then get qualitative.

Exp. 7: "Pembentukan Bayangan Pada Lensa Cembung" from workbook, FP/VI/2.10.25/E

There will be problems for this experiment and the preceding two, if the classroom cannot be darkened.

Exp. 8: "Make an Air Lens" from 101 Classroom Demonstrations, p. 38 page E23.

This experiment will challenge the students understanding of lenses.

Exp. 9: "Alat-alat Optik" from workbook, FP/VI/2.11.1.4-6.E

Exp. 10: "Make a Periscope" from Nature and Science, Aug. 1964, p. 7. Page E 19.

References

Departemen Pendidikan dan Kebudayaan, Zat dan Energi, PN. Balai Pustaka, Jakarta, 1982.

Kutliroff, David, 101 Classroom Demonstrations and Experiments for Teaching Physics, Parker Publishing Company, Inc., West Nyak, New York, 1975.

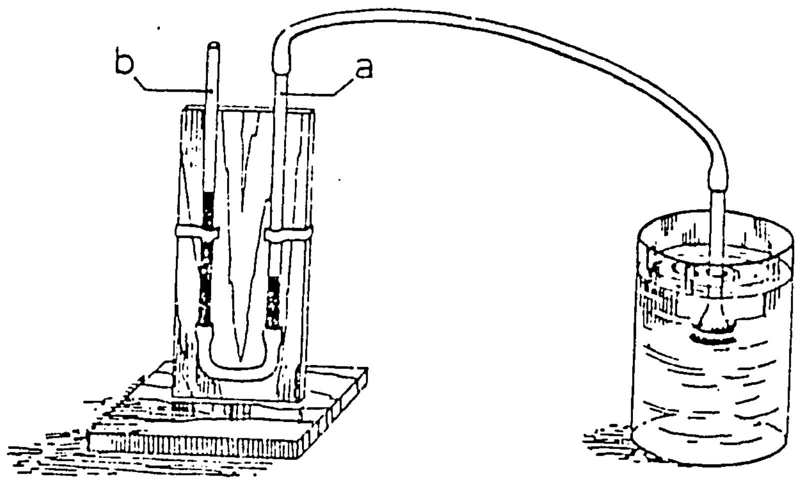
Mandell, Muriel, Physics Experiments for Children, Dover Publications, Inc., Inc., New York, 1968.

Nature and Science, published for the American Museum of Natural History by The Natural History Press, Doubleday & Co. (May no longer be published.)

The Physics Teacher, published by the American Association of Physics Teachers, Graduate Physics Bldg., SUNY, Stony Brook, NY 11794.

PERCOBAAN 7.1

Buatlah sebuah alat Hartl seperti gambar 7.6 Masukkan alat itu ke dalam air. Corongnya dihadapkan ke atas. Apa yang terjadi terhaaap permukaan air dalam pipa di a dan b, apabila alat itu dimasukkan makin dalam? Terangkan sebabnya!

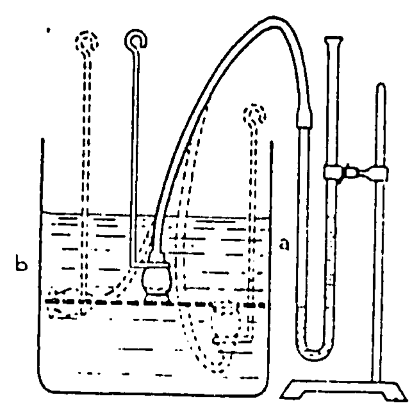


Gambar 7.6
Tekanan dalam zat cair

Biarkan corong itu menghadap ke atas pada ke dalaman 10 cm di bawah permukaan air. Berilah tanda yang menyatakan permukaan air dalam pipa di b. Hadapkan corong itu ke bawah pada ke dalaman yang sama, yaitu 10cm di bawah permukaan air. Lihat tinggi permukaan air di dalam pipa b. Berubahkah kedudukan permukaan air di b itu? Sekarang hadapkan corong itu ke kiri dan ke kanan pada ke dalaman yang sama seperti di atas, sedangkan titik pusatnya tetap 10 cm di bawah permukaan air. Berubahkah kedudukan permukaan air di b itu?

PERCOBAAN 7.2:

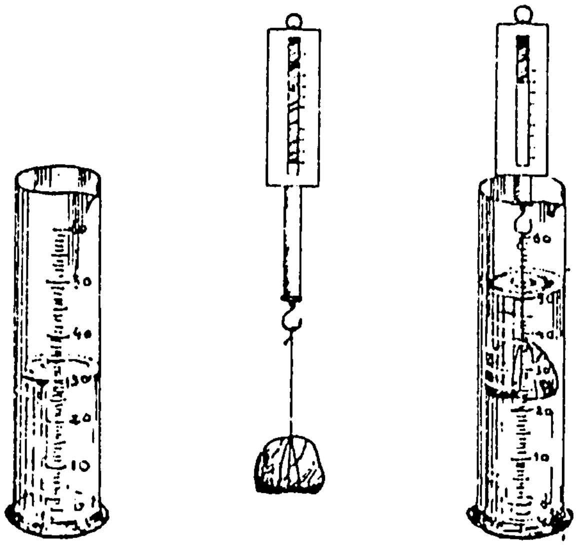
Ukur tekanan air dalam bejana yang berbentuk seperti pada gambar 7.7 dengan alat buatan Hartl. Apakah tekanan di a sama dengan di b? Jelaskan apa sebabnya. Tunjukkan pada gambar itu jarak antara permukaan air dengan mulut corong itu di a dan di b.



Gambar 7.7

PERCOBAAN 7.4:

Isi sebuah gelas ukuran dengan air (gambar 7.15). Gantungkan sepotong besi yang volumenya 50 cm^3 pada kaitan sebuah neraca pegas.



Gambar 7.15

(1) Catat berapa berat besi itu! Catat pula banyak air dalam gelas ukuran.

(2) Celupkan besi itu sebagian perlahan-perlahan ke dalam air sehingga banyaknya air yang terdesak ke atas 20 cm^3. Lihat pada skala neraca pegas itu; berapakah berat besi itu kini? Hitung berapakah berat besi itu berkurang, karena gaya ke atas air?

(3) Bandingkan berat air yang terdesak oleh besi (20 cm^3) dengan berkurangnya berat besi.

(4) Cleupkan besi itu seluruhnya ke dalam air. Lihat pada akala neraca pegas itu, berapakah kini berat besi itu? Hitung berapakah berat besi itu berkurang?

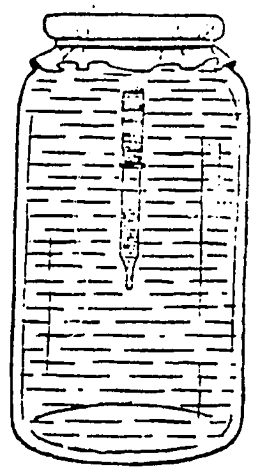
(5) Bandingkan berat air yang terdesak oleh besi dalam percobaan kedua (50 cm^3) dengan berkurangnya berat besi.

NOW IT SINKS, NOW IT FLOATS

Have you ever wondered how a fish can "float" at any depth in a fish tank without moving its fins even the slightest bit? By making something called a Cartesian diver you can find out.

Get a clear, wide-mouthed glass bottle that holds about a quart, and fill it with water. Then draw some water into a medicine dropper so that the glass part of the dropper is about half full. Lower the dropper gently into the jar of water. If it sinks, lift it out and squeeze two or three drops of water out of it. If it floats too high, lift it out and draw a little more water into it.

You want the dropper to just barely float. You can tell when it has just the right amount of water in it, because a very gentle poke will make it sink, then it will slowly rise by itself. Your medicine dropper, by the way, is the Cartesian diver, named after the 17th century French scientist Rene Descartes.



Stretch a piece of thin rubber, from a balloon or the flat part of a rubber glove, over the mouth of the jar. Hold the piece of slightly stretched rubber in place with a strong rubber band around the mouth of the jar (see diagram). Now press gently on the rubber over the mouth of the jar. What happens to the diver? When you take your finger away, what does the diver do? Why does this happen? Hint: There is some air in the diver. Air can be squeezed, or compressed, so that a given amount takes up less space. Water cannot be compressed so that a given amount takes up less space.

What happens when you press the covering? What does this do to the water in the jar? What does the water do to the air in tne diver?

A fish has an air bladder inside its body and can control the amount of air in its bladder. In what way is your Cartesian diver like a fish?

USE OLD THROW AWAY HYPODERMIC SYRINGES TO ILLUSTRATE THE IDEAL GAS LAWS

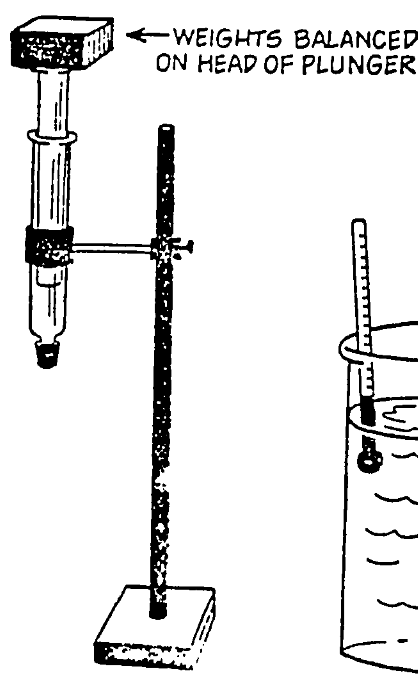
The ideal gas laws are usually treated in chemistry courses with discussions of Charles's law, Boyle's law, etc. In a physics course, it is necessary for students to understand the behavior of gases in order to complete their study of the thermal energy.

I have obtained used, throw away hypodermic syringes from a local doctor. The needle is thrown away and the bottom of the syringe is inserted into a one-holed rubber stopper. The other side of the stopper hole is plugged up with a piece of glass stirring rod.

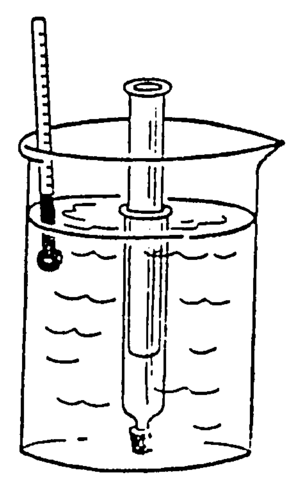
The syringe can then be supported on a ring stand. By placing various weights (books, etc.) on the piston handle and measuring the resulting volume, one can plot the relationship between volume and pressure.

It is also possible to demonstrate volume-temperature relationships by immersing the plugged up syringe in boiling water, water at room temperature, ice water and other known temperature fluids you might have available.

A carefully plotted graph of volume vs. temperature can lead to an extrapolation of the absolute temperature scale.



SEALED HYPODERMIC SYRINGE SUPPORTED ON RING STAND.



SEALED HYPODERMIC SYRINGE IMMERSED IN CONSTANT TEMPERATURE WATER IN BEAKER.

INVESTIGATING SPRING TEMPERATURES
BY DAVID WEBSTER

Take an inexpensive alcohol thermometer outdoors on a sunny day and measure the temperature of the air in different places. Try it in the sun, in the shade, inside a car, in the garden, up in a tree, and in a hole.

Leave the thermometer in each place for three or four minutes so it can have time to reach the temperature of the air there. Where is the air warmest? Do you know where the thermometer that measures air temperature for the local weather report is placed?

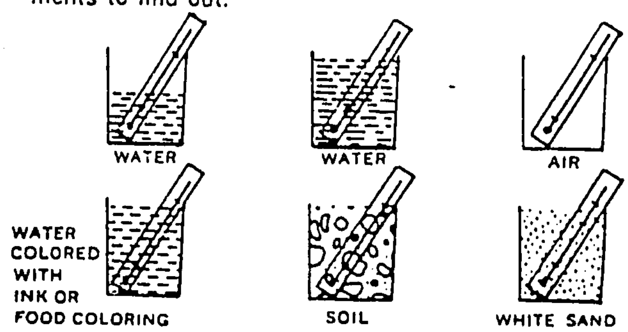
Temperatures at Different Places

As the earth is warmed by the sun, some substances are heated more than others (see Project). The air gets its heat mainly from the substances that are near it.

A blacktop driveway absorbs more of the sun's heat than a grass lawn absorbs (see "Getting Water from Glaciers," N&S, February 2, 1970). For this reason, the air an inch above the driveway is much warmer than the air just above the lawn. Would there be as much difference on a cloudy day? Use your thermometer to find out.

PROJECT

Suppose the six jars shown here were placed in the sun for several hours. What would you guess the temperature in each jar would be? Try some experiments to find out.



Water absorbs heat very slowly. Measure the temperature of the water in a lake or pond. Is the water cooler than the air? Take the temperature of the surface water at the very edge, and also a few feet from the shore. Is there a difference? Lower the thermometer on a string into deep water. After a minute, pull the thermometer up quickly and read it. Why are winter temperatures milder at places near the ocean than at places far from a large body of water?

Temperatures at Different Times

About noon, when the sun is highest in the sky, the ground absorbs more heat from the sun's rays than at any other time of day. (Do you think the angle at which the rays reach the ground has anything to do with this?) Yet the warmest time of day is not at noon.

Since the soil heats up slowly, it continues to get warmer during the afternoon. Try to make temperature readings in the shade, at the same height above the same kind of ground, every hour from 9 a.m. until 6 p.m. When is the air warmest? Will it be warmest at the same time the next day?

When would you guess was the coldest time during a 24-hour day? The table on the next page shows the hourly temperatures in Boston on three different days. Was it always coldest at the same time?

You can get figures like these for you area from the weather bureau. Call up the United States Weather Bureau in the city that is nearest you. Ask for the hourly temperatures for the same days listed in the table. How do your temperatures compare with Boston's?

HOURLY TEMPERATURES RECORDED ON

TIME	MAY 15, 1969		AUGUST 15, 1969		JANUARY 15, 1970	
	Boston	your city	Boston	your city	Boston	your city
midnight	51°	___	73°	___	30°	___
1 a.m.	50°	___	73°	___	29°	___
2 a.m.	50°	___	73°	___	28°	___
3 a.m.	50°	___	72°	___	28°	___
4 a.m.	50°	___	70°	___	27°	___
5 a.m.	50°	___	69°	___	28°	___
6 a.m.	50°	___	72°	___	27°	___
7 a.m.	52°	___	75°	___	27°	___
8 a.m.	55°	___	76°	___	28°	___
9 a.m.	58°	___	78°	___	28°	___
10 a.m.	59°	___	81°	___	30°	___
11 a.m.	57°	___	80°	___	30°	___
noon	57°	___	80°	___	31°	___
1 p.m.	56°	___	81°	___	32°	___
2 p.m.	56°	___	83°	___	33°	___
3 p.m.	57°	___	82°	___	31°	___
4 p.m.	56°	___	81°	___	30°	___
5 p.m.	55°	___	79°	___	30°	___
6 p.m.	54°	___	78°	___	28°	___
7 p.m.	52°	___	76°	___	28°	___
8 p.m.	51°	___	75°	___	28°	___
9 p.m.	51°	___	75°	___	29°	___
10 p.m.	51°	___	75°	___	28°	___
11 p.m.	51°	___	74°	___	27°	___

NATURE AND SCIENCE
May 4, 1970

KEEPING COOL

Find out what makes moving air feel cooler than still air, and you can make a simple, inexpensive air conditioner.

On a summer day when you feel uncomfortably hot and you don't have an electric air conditioner to pump heat out of the air around you, what can you do to cool off?

Since moving air makes you skin feel cooler, you might look first for a breezy place outdoors or a drafty place indoors. Or you can make a breeze by fanning yourself with a foldea newspaper or an electric fan. If you are in a moving car or bus, you can open a window to let air flow over you. When the air stops moving across your skin, though, the cooling stops, too. Do you think that air is cooler when it is moving than when it is still?

You can find out by using an inexpensive alcohol or mercury thermometer. Note the temperature shown by the thermometer in still air, then hold it in the breeze from an electric fan. If you don't have an electric fan, just tie a string to the end of the thermometer and swiftly swing it around in circles through the air. Does the temperature go up, or down, or stay the same? Do you think that moving air alone cools your skin?

The Water Treatment

Another way to cool off is to go swimming, take a shower, or wet you skin in the spray from a hose or sprinkler. If the water is cooler than your body, some of your body heat will be used up in heating the water on you skin. You may have noticed that when your skin is wet, a breeze sometimes cools it so much that you get a chill. Do you think this would happen if the water were warmer than your body to begin with?

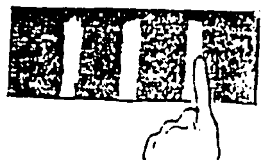
Spread some lukewarm water (warm to you touch) on the palm of one hand, keeping the other hand dry. Swing both hands through the air swiftly in large circles. Which palm feels cooler?

Use your thermometer to find out whether moving air really changes the temperature of a moist object. Soak a strip of thin cloth in lukewarm water and wrap it around the bottom of the thermometer. wait for the liquid in the thermometer tube to stop moving. Note the temperature, than hold the wrapped thermometer in the breeze from a fan or whirl it around through the air on a string for a few minutes. What happens to the temperature? Does the cloth feel as wet as it did before the air moved across it?

You might think that the moving air simply blew the water out of the cloth. It probably did blow off a few drops, but it also carried away many particles of water too tiny for you to see. The tiniest particles of any substance are called molecules, and they are always moving around in the substance. In a liquid, some of the fastest-moving molecules are always escaping from the surface of the liquid to become a gas. If the gas can move away from the liquid, the liquid slowly disappears. This is called evaporation. Since the fastest-moving molecules in a liquid are also the warmest ones, the liquid tends to get cooler as they escape from it.

Do you think that moving air across the surface of a liquid makes it evaporate faster? If so, why?

PROJECT



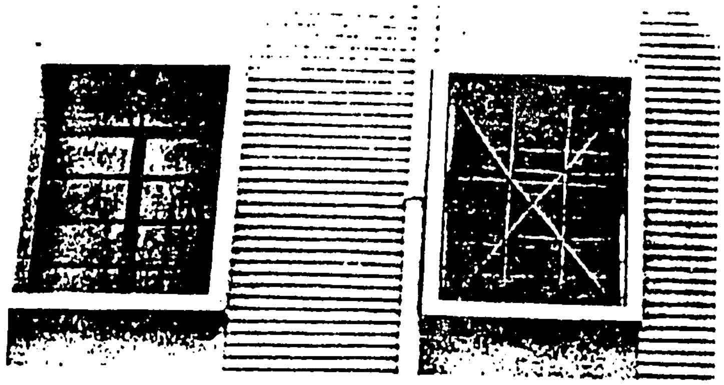
Make some streaks of water, rubbing alcohol, and cooking oil side by side on a strip of aluminum foil *(see diagram)*. Make the streaks all the same size. Which liquid evaporates first? Which stays the longest? Can you predict from your findings which liquid will produce the greatest cooling effect in moving air? You can compare their cooling effects by rubbing one liquid on each palm and swinging your hands in wide circles, or by using your thermometer with strips of cloth dipped in the different liquids.

Homemade Air Conditioners

In parts of the world where the air gets very warm and few if any people have electric air conditioners, the cooling effect of evaporating water is put to work. The photograph on this page shows the windows outside a classroom at the Regional College of Education in Ajmer, India.

Some Things To Think about and Look for

1. Why is it helpful to perspire on hot days?
2. How do animals that have few sweat glands, such as dogs, keep cool on a hot day?
3. Under what conditions will clothes dry fastest on a clothesline?
4. How does the water that falls as rain get into the air?
5. If a fan does not cool the air, why does it make you feel cooler?
6. Can you explain why open bottles of water and alcohol have the same temperature even though alcohol evaporates faster?
7. After a rain, look for some puddles around your house. Can you predict which ones will disappear fastest? Will it matter whether they are in the sun or shade? How about those that are protected from the wind and those that aren't?. Will wide shallow ones evaporate faster or slower than narrow deep ones?



The straw panel covering the righthand window of this building in India is soaked with water every hour or so, during the day. Can you guess why?

One window is covered with a panel made of straw. The straw is soaked with water every hour or so. This lowers the temperature in the classroom--which might be well over 100 degrees Fahrenheit--to a more comfortable level.

Can you explain how it works? If you used one in you house, in which window would you put it? What would you do when the wind changed direction?

You can see how such air conditioners work without making such a big one. Find the temperature of the air in you kitchen, or outside near a clothesline if the wind is blowing. If you do the experiment inside, you can use a strong fan to make a wind. Hang some wet straw, hay, newspaper, or cloth strips in front of the fan or on the

clothesline. Leave a little space between the wet strips so the air can get through. What happens to the temperature of the air as it passes through the wet material? Would the air conditioner work better if you used alcohol instead of water? How about cooking oil?--Robert Gardner

PROJECT

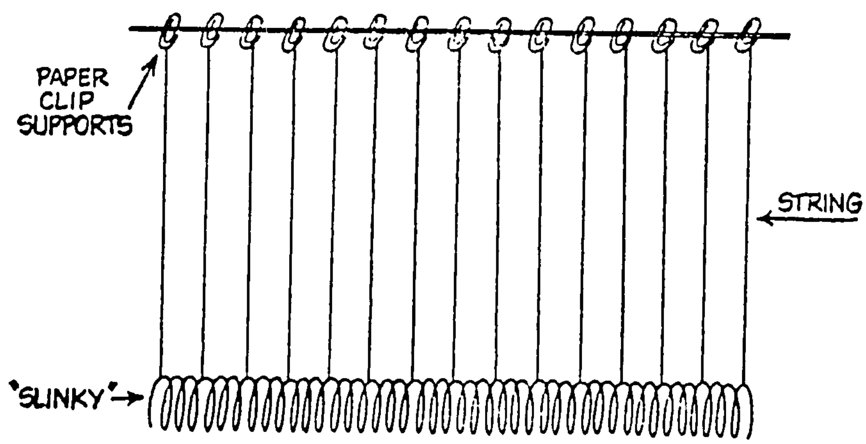
See if you can design experiments to find out how each of the following factors affects the speed at which a liquid evaporates:

- Temperature
- Movement of air (wind)
- Humidity (moisture in the air)
- Amount of liquid exposed to the air
- Kind of liquid

Remember that you will need at least two set-ups in each experiment so you can compare the results. For example, to test the effect of air movement, you could place some liquid in front of a fan and an equal amount in another place where the temperature and humidity were the same, but there was no wind.

OTHER WAVE DEMONSTRATORS

Hang a Slinky across the front of your room by suspending every third or fourth coil with a three foot length of string hung by a paper clip on a taut wire stretched across your room. This makes an excellent demonstration device for illustrating both transverse and longitudinal waves. By increasing the tension on the spring, the dependence of velocity on the medium is illustrated.



EXPLORING RADIO WAVES

When was the last time you made some radio waves?

Did you say "Never"? The fact is that every time you switch an electric light on or off you make radio waves.

You can test this with a flashlight cell, some copper wire, and a radio receiving set. A small portable set works best. Scrape the insulating material or coating off the ends of a short piece of wire, and tape one end to the flat bottom of the flashlight cell. Turn the receiver on as loud as you can, then tune out the static, so you hear no sound. Then hold the cell close to the set and rub the other end of the wire over the metal "button" on the top of the cell. Do you hear a noise from the radio? If not, try pressing the taped end of the wire tightly against the bottom of the cell as you rub the other end over the button.

The noise you hear, called static, is made by radio waves that are detected, or picked up by the receiver's antenna and changed into sound waves by other parts of the set. Does your radio transmitter, or sender, make waves while electric current is flowing through the wire, or just when the current starts or stops flowing? (In finding out, don't keep the wire connected to both ends of the cell very long; it uses up the cell's electricity too fast.)

Tracking Radio Waves

Turn the receiver in different directions as you make radio waves. Does this make any difference in the signal--the sound that you hear? Probably not, if the receiver has a metal rod antenna sticking out of it. But many portable radios have an inside antenna--a fine wire coiled around a flat iron bar. If the back of the set comes off easily, you can probably find this "bar" antenna. Does a bar antenna pick up waves better with its long side or with its short end? How can you tell?

Does the transmitter send you waves in all directions? You can find out by holding the "best" side of the receiver antenna toward the transmitter. What happens to the signal as you move the transmitter toward and away from the receiver?

By taping two or three cells together in series, as shown, you can make a battery of cells that produces a stronger current. Will a battery like this make stronger radio waves than a single cell does? How can you tell?

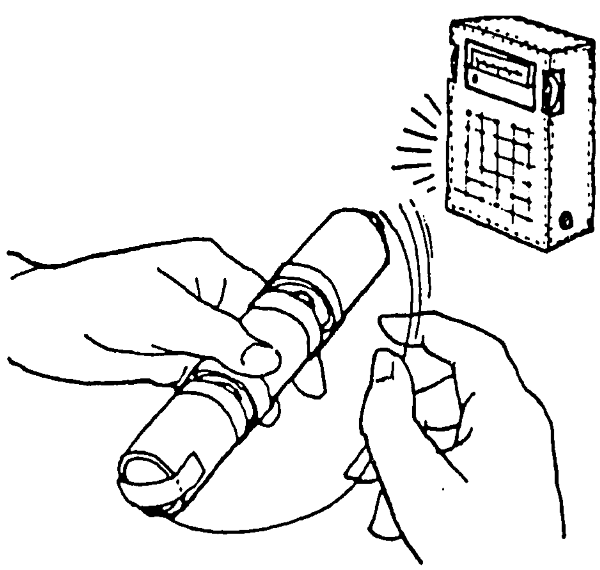
Do you think the radio waves come only from the point where the wire touches the cell's "button," or from the whole wire? Try a longer piece of wire and see if it changes the signal in any way. How about the shape and position of the wire? You might bend it into a loop, or a square and turn it up-and-down, sideways, and at different angles to the receiver.

What Blocks Radio Waves?

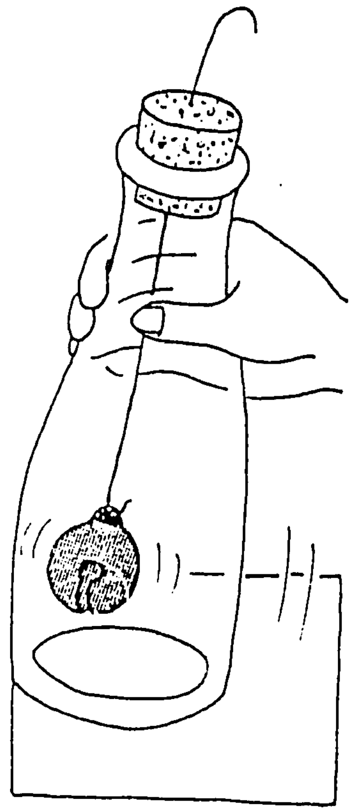
We know that radio waves, like light waves, can travel through a vacuum--a space with nothing in it. Do you think they can travel through materials such as wood, metal, cloth, glass, plastic, and so on? You can find out by placing a piece of such material directly between you transmitter and the radio. When you find a solid material that the waves pass through, get a container made of that material and fill it with sand, soil, water, or other liquids to see whether radio waves pass through them.

Try putting different-sized pieces of the same material between the transmitter and receiver and see whether their size or thickness seems to affect the signal. Also, try placing the same piece of material at different distances between the transmitter and receiver. From your finding, do you think that radio waves travel only in straight lines, or can they "bend" around a small piece of blocking material?

Can you think of other things that might affect the radio waves sent out by your transmitter? How about rain or snow, for example? Or trees? Or a brick wall? Use your portable radio to look for other sources of radio waves. Try an electric razor, a fluorescent lamp. Do they make radio waves while they are "on"? As they are switched on or off? Does lightning make radio waves?



CAN SOUND TRAVEL THROUGH NOTHING?



If there is no air to carry a wave from a vibrating object to our ears, can we hear a sound?

In this experiment you take the air out of an "empty" bottle to create a vacuum. Use a glass coffeepot or quart milk bottle fitted with a cork so that you can close it tightly. You'll also need a length of wire and a small bell or two. Thread the wire through the bell and attach it to the cork. Be sure the bell is free to ring without hitting the sides of the bottle when you shake it.

Tear a sheet of newspaper into shreds and put them into the bottle. Light a match and apply it to the paper. Quickly cover the bottle with the cork. The burning paper will use up the air and create a partial vacuum.

When the bottle cools, shake it and listen. Then open the cork and let in some air. Reseal the bottle and shake it again.

You will see that: After you remove most of the air, you are not able to hear the bell, though you see the clapper moving. When you let in the air, you hear the bell again.

Explanation: If sound is to travel from a vibrating object to your ear, there must be a substance to carry it. Sound cannot travel in a vacuum. Normally, the energy of sound travels in waves through the air. Though air is sound's most usual carrier, it is not its most effective.

PROJECT 2

Making Electricity with Magnets

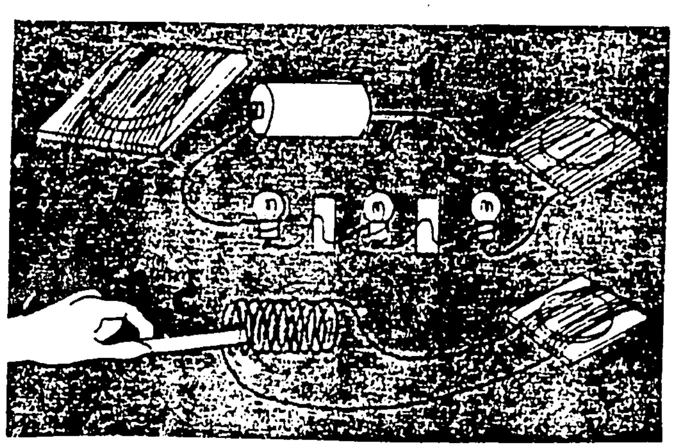
You can make electricity flow in a wire coil by moving it through a magnetic field. The currents you make will be very small, so you will need a sensitive current detector, called a galvanometer. You can make one with a pocket compass and some No. 24 enameled or cotton-covered copper wire. In a small square of stiff cardboard, cut a hole just large enough to hold the compass snugly. Turn the cardboard until the compass needle points to opposite sides of the square, then wind about 50 turns of wire around the center of the compass, in line with the needle (see Diagram A). Leave a few inches of wire at each end, and cut or scrape about an inch of insulation off the wire at each end.

To test your galvanometer, connect enough flashlight bulbs in series with a single dry cell so that they get too little current to glow. Now connect your galvanometer in the circuit (see Diagram B). Can you detect a current?

Now make a coil by wrapping 50 turns of wire around a flashlight cell. Leave several feet of wire at each end of the coil, and remove an inch of insulation at each end. (Some pieces of sticky tape will help you hold the coil together as you slip it off the cell.) Connect the ends of the coil to your galvanometer. If you have a strong bar magnet, try moving it in and out of the coil (Diagram C). (Or you can use the electromagnet you made by wrapping wire around a nail.)

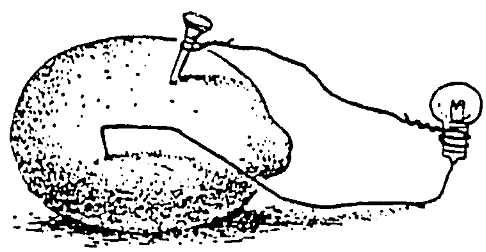
Does electricity flow in the wire when the magnet is not moving? When it is going into the coil? When it is coming out of the coil? Is the electricity always flowing in the same direction? (How can you tell?) What happens if you turn the magnet around?

Would electricity flow if you moved the coil above the magnet? Try it and see. Do you think the speed with which the magnet is moved makes any difference?



INVESTIGATION

You can make electric cells of many different materials. For example, roll a lemon on a table until it feels soft and juicy. Wrap the end of a copper wire around the head of an iron nail and tape it in place. Use the nail to make two holes in the lemon, about half an inch apart. Stick the nail in one hole and the end of another copper wire into the second hole. Can you make a flashlight bulb light by connecting it to the cell (see diagram)?



The current will probably be too weak to light a bulb, but here's a way to make sure the cell is producing current. Get an earphone--the kind that you plug into a transistor radio and stick in you ear will do. Wrap the end of one wire from you cell around the metal "jack" that plugs into the radio. When you touch the other wire from the cell to the tip of the jack, you will hear a clicking sound if the cell is producing electricity.

Can you find other substances that will work in place of the iron nail or the copper wire? Try the blade of a steel knife, a stick of pencil "lead" (carbon), a strip of zinc from a dry cell case, an aluminum screw, a dime, a penny, and so on. Which combinations produce the strongest current (making the loudest click)?

Try suspending two different metals in a glass of vinegar, salty water, cooking oil, and so on. (Be sure to wash and dry the metals between trials.) How many liquids can you find that work like the black paste in a dry cell?

THE OSCILLATING CHARGE CARRIER

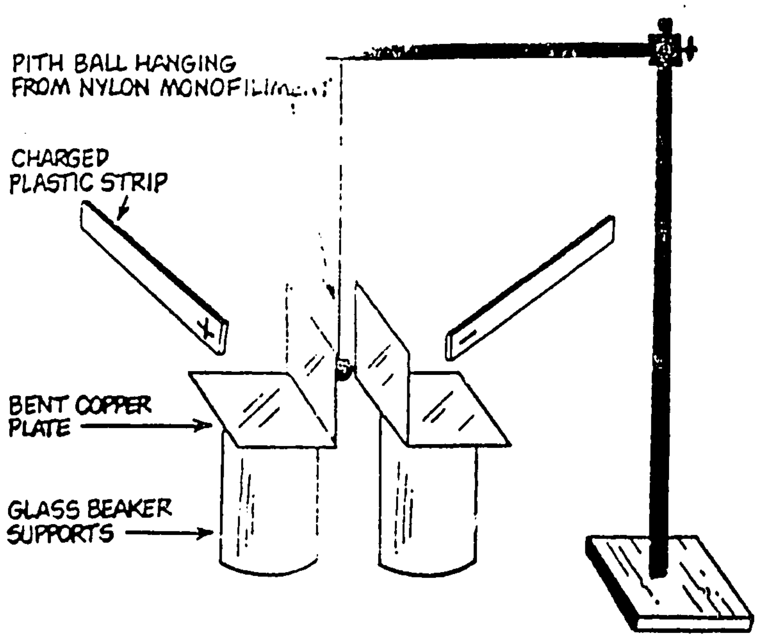
Hang a pith ball with a conducting surface from a nylon monofilament or other satisfactory non-conducting filament. Place between two upright plates of copper or aluminum.

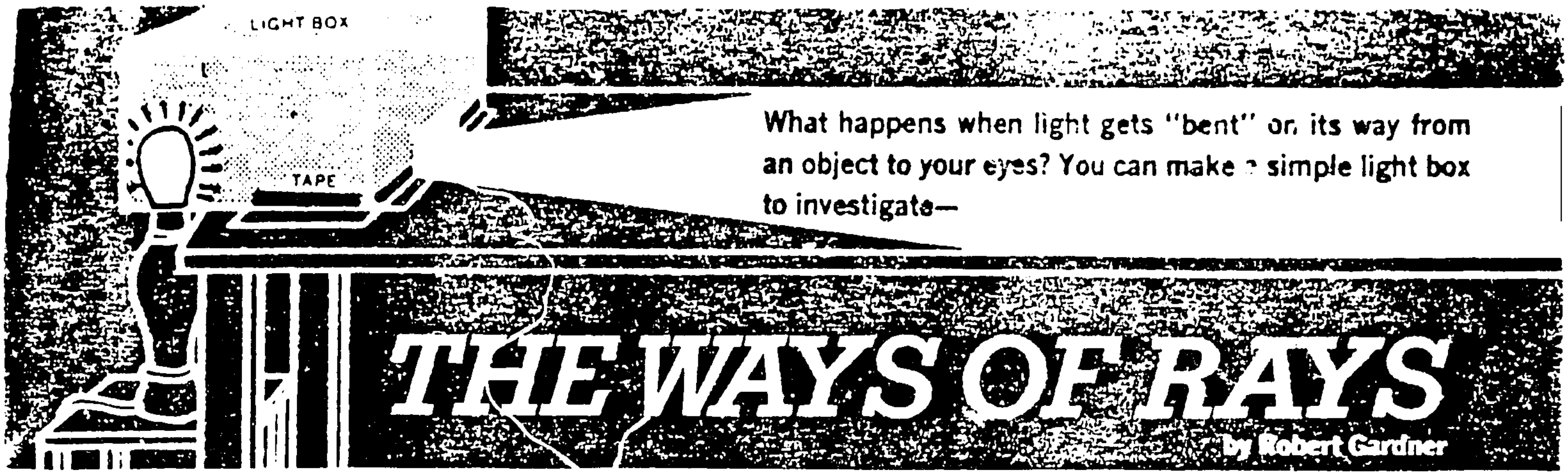
The upright plates are made by bending two metal rectangles across the middle into right angles forming a horizontal square and a vertical square in each. The horizontal squares are placed on a non-conducting support such as small glass beakers. (Weigh them down if necessary.) The upright positions of the metal plate are to face each other with just enough room between them so that the pith ball can oscillate back and forth visibly.

Charge up two plastic strips that take opposite charges. Hold the positively charged strip over the horizontal portion of one of the plates while you hold the negatively charged strip over the horizontal portion of the other plate. Do not touch the plates with the charged strips though you may have to approach them quite closely.

The pith ball will be seen to vibrate rapidly back and forth between the upright portions of the plates, then slow down and come to a stop. Remove the charged strips and the pith ball will again start oscillating between the plates returning the excess charge until the plates are again equally charged.

It is a demonstration that invariably excites the interest of my students and leads to good discussion regarding charge transfer, conductivity and the loading and unloading of a capacitor.





What happens when light gets "bent" on its way from an object to your eyes? You can make a simple light box to investigate—

THE WAYS OF RAYS

by Robert Gardner

Have you ever taken a close look at your image? Not at yourself, but at the "picture" of yourself that you see in a mirror? Do you think your image looks exactly like you? Wink your right eye, and see which eye your image winks. Raise your right hand, and see which hand your image raises.

Hold this page up facing the mirror and look at its image. How are the images of the words and letters different from the way the words appear when light travels directly from the page to your eyes, instead of going to the mirror first? Can you explain the difference?

Move to one side of the mirror and look into it. What do you see? If someone stands at the other side of the mirror, can you see his image? Can he see yours? Is it possible for you to see his image without having him see yours, if you are both looking at the mirror?

When you look into the mirror, where does your image seem to be? (Can it really be there?) Move back from the mirror, then toward it, and see how your image moves. Can you see the images of objects that are in front of you and behind you? Where do their images seem to be? How can you make the image of you finger touch the image of you nose?

You can investigate the images you see in a mirror by making a simple light box, as shown below. With it, you can trace the paths of just one or two "rays" (tiny beams) of light, instead of all the light you saw when you looked into the mirror.

Tracking a Ray of Light

When your box is ready, turn on the light inside it, and darken the room. Look at the beam that comes through the hole in the box. Why does it spread out? Can you reflect the beam with a small mirror?

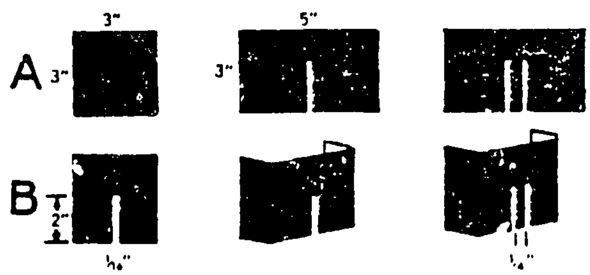
To get a narrow beam, or "ray," of light, tape the black square over the opening in the box as shown in Diagram 1. Then place the rectangle with the single slit about two or three inches in front of the first slit. When you put a mirror in the ray's path, which way does the ray go after it hits the mirror?

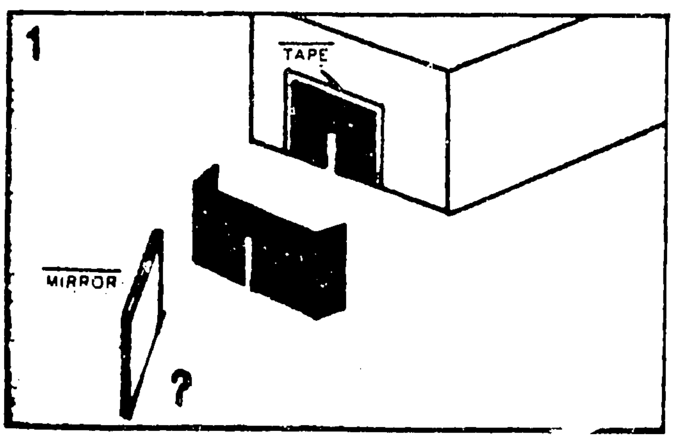
HOW TO MAKE A LIGHT BOX

You will need a cardboard box, a lamp with a 100- or 150-watt bulb, scissors, tape, a small pocket mirror, pencils, black paper, and aluminum foil. The diagram above should help you make your light box.

Cut a hole about two inches long and two inches high in one end of the box. Place the box on the end of a table, with enough of the box sticking out over the edge so that a light bulb will fit inside. The round part of the bulb should be just above the level of the tabletop and directly behind the opening at the other end of the box. *Be sure that the hot bulb is not touching the box.* So that the box won't move and bump the bulb, tape the box to the table.

From a sheet of black construction paper, cut out a square and two rectangles as shown in Diagram A. Then cut a slit about two inches long and 1/16 inch wide in the square (see *Diagram B*). Cut a similar slit in one of the rectangles. In the other rectangle, cut two such slits, about 1/4 inch apart. (It may be hard to cut narrow slits with scissors. If a slit is too wide to make narrow rays, you can cover part of it with masking tape.) Fold back the outside inch of each side of the two rectangles so that they will stand up.





The ray that hits the mirror is called the incident ray. How does the angle between the mirror and the incident ray compare with the angle between the mirror and the reflected ray? To find out, stand the mirror on a sheet of paper and draw a line along the front edge of the mirror, another line along the incident ray, and another along the reflected ray (see Diagram 2). Then either cut out the angles with scissors or measure them with a protractor. How do the angles compare?

Change the angle at which the incident ray hits the mirror. How does this change the angle between the mirror and the reflected ray? Do your findings help explain what you saw when you stood to one side of a mirror and looked into it?

Now place the rectangle with two slits several inches in front of the slit in the light box. Place the mirror as shown in Diagram 3. (You can use some pieces of clay to support it.) When the rays from the two slits reach the mirror, what happens to them?

You can see that if the two reflected rays were stretched out behind the mirror, they would meet. How far behind the mirror would they meet? How far is the mirror from the single slit in the front of the light box? Does this tell you anything about how you see images where they can't really be?

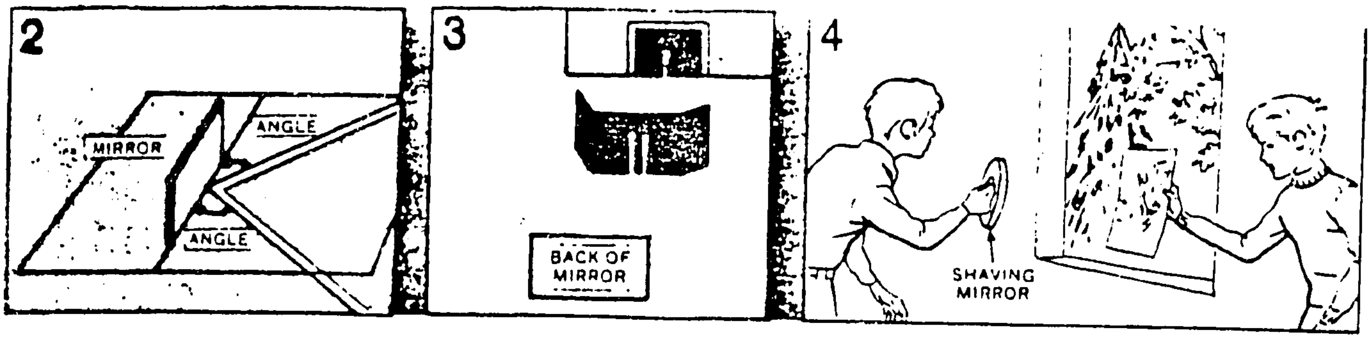
Suppose the two slits were your two eyes, and the rays coming from them were rays of light reflected from your eyes to the mirror. Which ray would be coming from your right "eye"? Now look from behind the mirror at the two reflected rays. Is the one that started at your right "eye" still on your right? Can you explain now why your image wink its left eye when you wink your right eye?

Reflections from Curved Mirrors

You have probably seen mirrors that are curved, instead of plane (flat). A curved mirror whose center bulges out toward you is called a convex mirror; one whose center curves inward is a concave mirror.

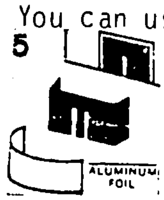
The most common concave mirrors are those used by men for shaving or by moment for putting on makeup. If you do not have one, you can probably buy one for 25 cents to $1 at a variety store. When you look at your image in a conclave mirror, how is it different from the image you see in a plane mirror? Can you see why a concave mirror is useful for shaving or putting on makeup?

Unlike a plane mirror, a concave mirror can form real images; that is, images that you can see on a screen. To "capture" such an image, have someone move a "screen" (a sheet of paper or cardboard) away from the front of the mirror while you hold the mirror facing a window (see Diagram 4). By turning the mirror, you can reflect light from the window onto the screen to form a real image of the window and the view outside. Is the image rightside up or upside down?



Try capturing the image of a lighted bulb. Can you make the bulb's image larger? Smaller? How?

From your investigation of reflections in plane mirrors, can you guess how a concave mirror will reflect two light rays from your light box? You can use a curved strip of smooth, shiny aluminum foil, as shown in Diagram 5, to find out. What happens if you curve the "mirror" more? Less? From your findings, can you explain how a concave mirror produces real images on a screen?



How will a convex mirror reflect the rays? To find out, curve the aluminum foil so its shiny side bulges toward the light source. Do you think a convex mirror will form real images? Why? Where will the images in a convex mirror appear to be?

Bending Light with Lenses

Do you think that light rays from, say, a tree outside your window are bent very much as they pass through the glass to your eyes? You can tell by comparing how the tree looks when you see it through the glass, then through the open window.

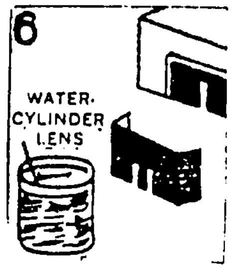
Now hold a magnifying glass at arm's length, and look through it at a tree (or at a lighted lamp across the room). Do you see the tree, or its image? How can you tell? (Because a magnifying glass bulges outward in the middle, it is called a convex lens.)

By holding a sheet of paper behind the lens, you can "capture" an image of the tree. (how does this image compare with what you saw when you looked through the lens at the tree?)

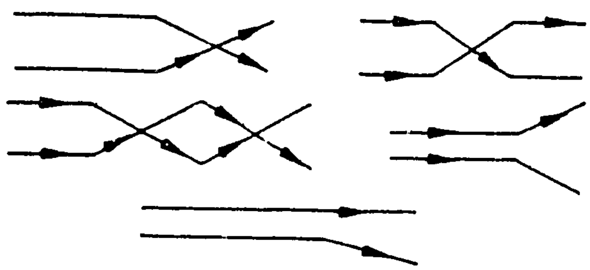
From these investigations, and from what you have learned about reflections from concave mirrors, can you explain how light rays change direction as they pass through a convex lens? You can test your explanation with your light box.

Find a clear plastic or glass jar, drinking glass, or pill bottle that has straight sides, and fill it with warm water. (How is this water cylinder like a convex lens?) Place it in the path of the two rays from the light box, as shown in Diagram 6.

What happens to the rays as they pass from the air into the water, and from the water back into the air? What happens if you use a water-cylinder that has a larger diameter? A smaller diameter?

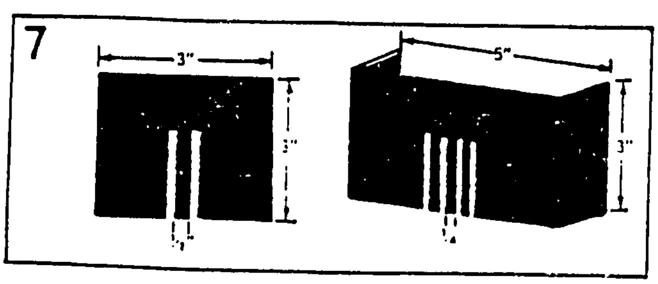


Using one or two "water lenses," see whether you can make ray patterns like these:

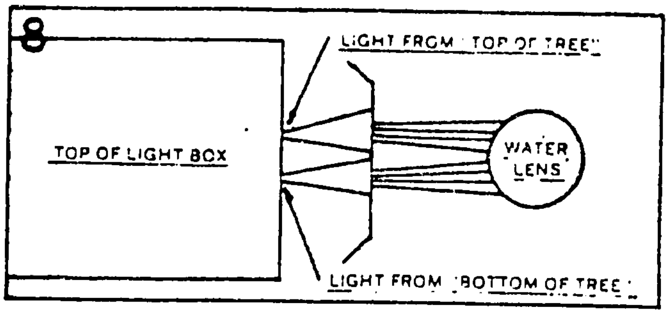


Can you get at least one of the rays to pass through the lens without being bent? How? What will happen to the point where the two rays cross if you move the lens closer to the light box? Farther from it?

To find out why the real images you captured with a magnifying lens were upside down, cut and slit two pieces of black paper as show in Diagram 7. Tape the piece that has two slits in it over the opening in the light box.



Then stand the four-slit piece so that two rays come through it from each slit on the light box. Place the water lens as shown in Diagram 8.



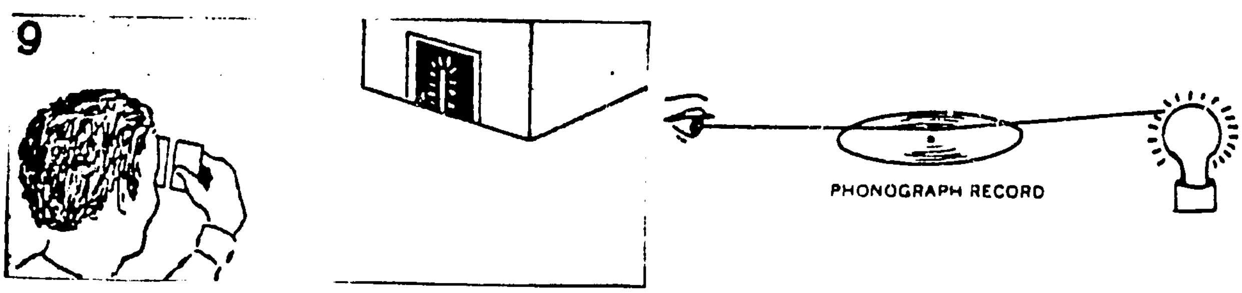
Now, looking straight downward at the rays, imagine that the top rays from the light box are coming from the top of a tree, and that the bottom rays are coming from the bottom of the tree (see Diagram 8). Where do the rays from the "top of the tree" come together? How about the rays from the "bottom of the tree"? (If you have trouble deciding which rays are which, slide a piece of black paper over one slit in the light box.) Can you explain now how a convex lens forms a real image of an object?

Another Way to Bend Light

You have seen how light is bent by reflection, and how it is bent as it passes through transparent materials such as water, glass, or plastic. (This kind of bending is called refraction.) There is still another way to bend light, called diffraction.

To see what happens when light is diffracted, cover the opening of your light box with the single-slit square of black paper. As you look straight into the slit, bring the edges of two mirrors (or other objects with straight edges) very close together in front of one eye (see Diagram 9). What do you see?

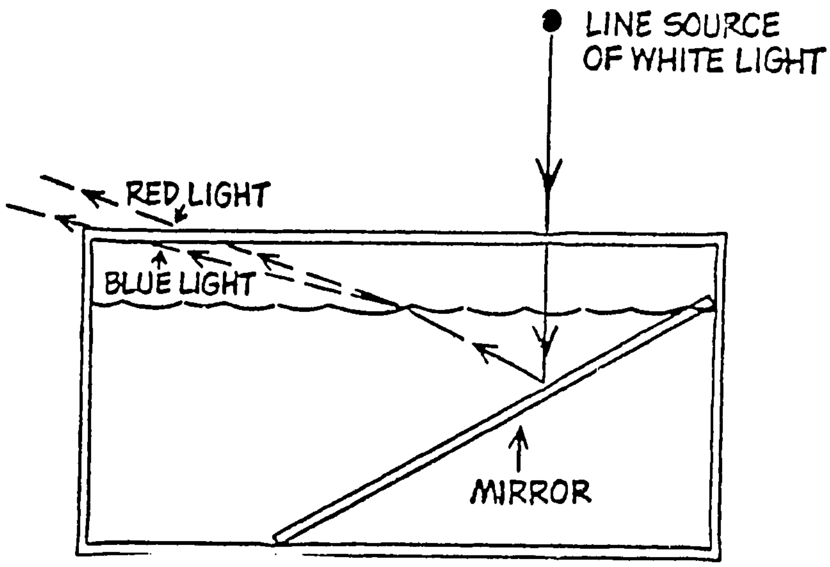
You can see even more clearly the colors produced when light is diffracted if you look at light that is reflected from the narrow grooves in a phonograph record. Hold the record up in front of your eyes so that the light from a lamp just skims the surface of the record, as shown.



There is nothing more that you can do with your light box top you understand diffraction. To fina out why light is bent as it passes through a narrow slit, you will have to think of light as something other than a group of "rays".

USE A FISH TANK AND A MIRROR TO MAKE A WATER PRISM

A rectangular fish tank can be used to demonstrate how a prism works to split a beam of white light into its color components. Place a large mirror in the tank so that one end of the mirror rests on the top edge of one of the sides of the tank while the other end of the mirror rests on the bottom of the tank. You now have a wedge of water between the surface and the mirror.



Direct a beam of white light onto the surface of the water. The beam may enter the water perpendicularly to its surface or on a path more approaching the normal to the mirror. The light will be refracted, reflected and refracted ɿain so that when it comes out of the water, dispersion can be demonstrated by a white screen held in the path of the emerging rays at some distance from the tank. The ceiling of your room might make a convenient screen if your source is intense enough and your room dark enough.

To spread the spectrum and make it more perceptible, you might add salt to the water to increase the index of refraction of the water.

A variation of the above, which might be easier to set up, is to look at the reflection of a white fluorescent tube placed over the tank perpendicular to the direction of the tilt of the mirror.

The spectrum on either side of the image of the tube is a good demonstration of the effect of the water wedge.

An additional refinement is to cover the mirror with aluminum foil and cut a slit in the foil. The resulting line source of reflection from the exposed part of the mirror will give a more satisfactory spectrum.

HOW THE WORLD LOOKS UNDERWATER--
A DEMONSTRATION FOR NONSWIMMERS

Samuel Derman
Department of Technology, City College of New York, N.Y. 10031

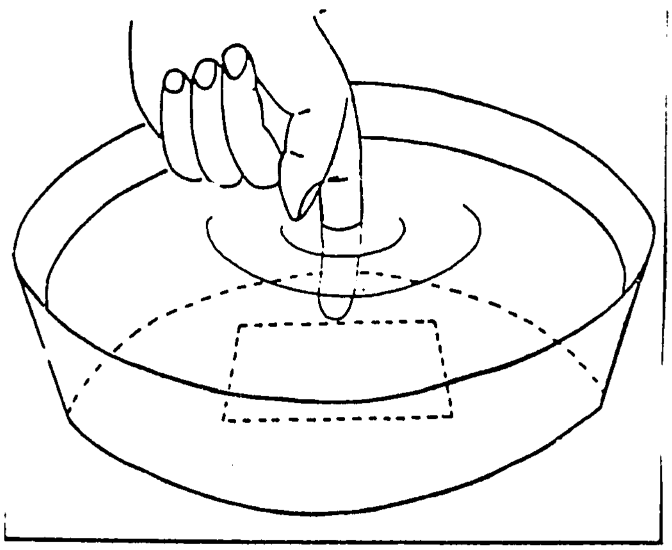


Fig. 1. Poke your finger into the water and look down into the mirror. You will see what a submerged fish would see – a finger pointing at you.

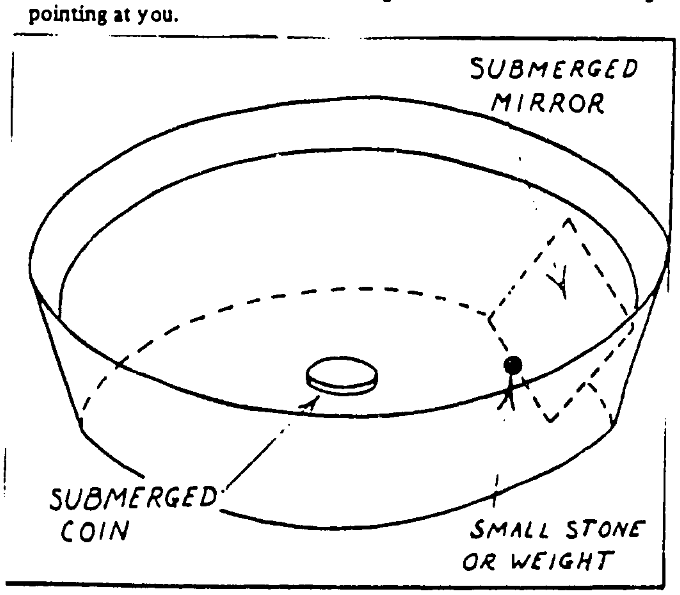


Fig. 2. Lean the mirror against the side and you can simulate what the fish sees when it looks obliquely towards the surface. At a particular angle of inclination total internal reflection occurs.

How does the world look to an underwater swimmer--or to a fish? The answer can be found in many basic physics texts. But it is possible to get a firsthand look yourself, and a bathing suit won't be necessary.

The apparatus to be described, although trivial to construct, nevertheless permits a variety of optical experiments to be performed, not only in class, but also by students at home.

Lay a pocket mirror face up at the bottom of a flat pan full of water (Fig. 1). Poke your finger into the water and the mirror will show by reflection how your finger appears to a submerged fish. The arrangement of Fig. 1 shows what the fish would see looking straight up, perpendicular to the surface.

But suppose the fish decides to direct its view at some arbitrary angle to the surface. That situation can be duplicated too.

Simply lean the mirror against the side of the pan (Fig. 2). As you change the angle of inclination of the mirror you simulate the variation in angle between the fish's line of sight and the water's surface. Looking into the mirror you see just what the fish sees as it looks up towards the surface (at some angle).

In fact, at a particular angle, total internal refection will occur. The surface of the water (viewed from underneath) will become mirror-like and will reflect any object situated below. Poke your finger through the surface again and the mirror will show you the odd-looking, symmetric object drawn in Fig. 3. Or place a coin at the bottom of the pan (Fig. 2), and you will be able to see it by looking into the mirror.

It's important to realize that you can see the top of the coin even though the mirror is tilted upward--an indication that light rays from the coin first traveled up towards the water's surface, then were totally reflected down towards the mirror, and finally were reflected up again, towards the eye.

To view the coin by total internal reflection it's best to proceed as follows. First, lay the mirror flat, near one wall of the pan. Next, lay the coin down flat also so that the distance between coin and mirror is about 3 1/2 inches (center of coin to nearest edge of mirror). Lastly, slowly tilt the mirror upwards until the coin comes into view.

Many interesting effects are possible. For example, once you've determined the proper angle for total internal reflection, set the mirror at that angle by leaning it against the side of the pan. Use a small stone or weight to prevent the mirror from slipping, as shown in Fig. 2.

Next, put your hand into the water and slowly raise the submerged coin until it's near the surface. To keep the coin in view while it is being raised, the angle of inclination of the mirror may have to be varied. The mirror will show you two coins, and two hands, because now, two reflections occur simultaneously (Fig. 4). One is direct reflection by the mirror. The other is the double reflection described earlier, that is, from the coin to the surface of the water, to the mirror.

Note, that the setup of Fig. 2 can be used as a simple solar spectroscope.[1] If sunlight from a window is allowed to fall obliquely on the water's surface, a full spectrum of colors will be observed on the ceiling or opposite wall of the room. The darker the room, the more dramatic is the effect. By varying the angle of inclination of the mirror you can shift the position of the image on the ceiling or wall.

Reference

1. S. Derman, Phys. Teach. 16,58 (1978).

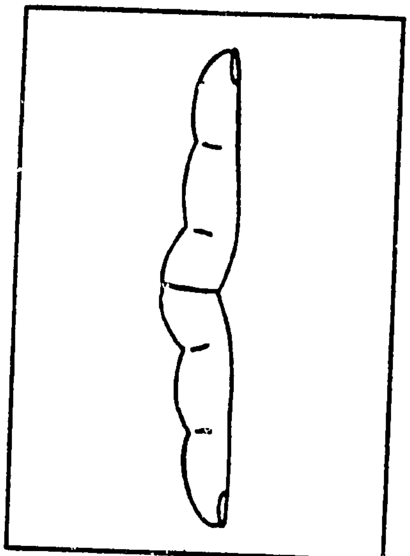


Fig. 3. Total internal reflection prevents the mirror from showing you anything above the surface. Poke your finger into the water, and this time you see only the part beneath the surface, together with its reflection.

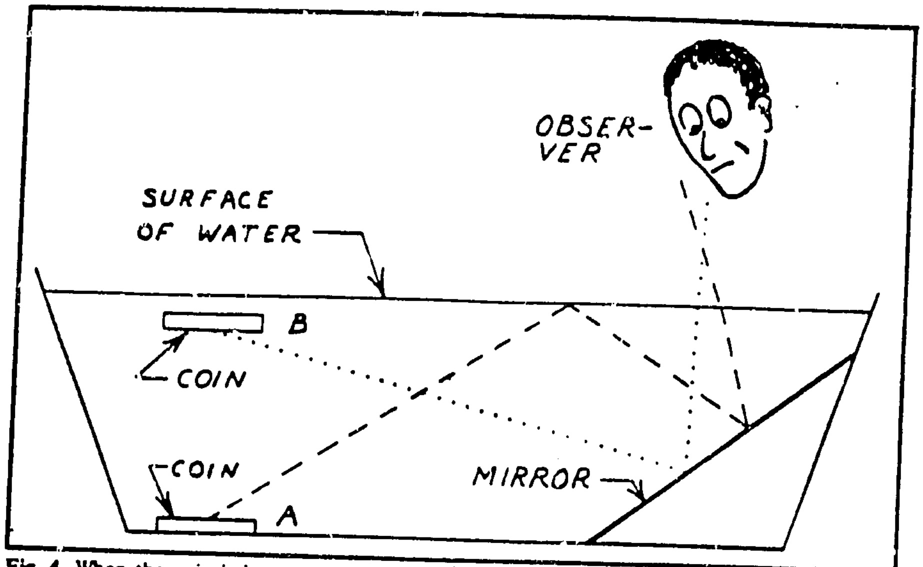


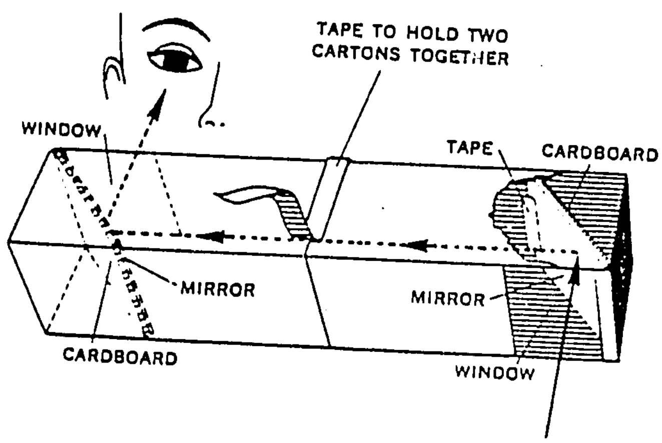
Fig. 4. When the coin is in position A (on the bottom), light rays (dashed lines) from its upper face undergo total internal reflection at the surface before striking the mirror. The rays are then mirror-reflected out to the observer. When the coin is raised to position B, rays leave from both its upper and lower faces. Rays from the upper face (not shown) are totally internally reflected as before, and reach the observer. However, now the lower face is also visible (rays shown dotted).

MAKE A PERISCOPE

Here is a way to build a periscope, which you can use to look over fences and around corners. You will need two one-quart milk cartons, two small mirrors, two pieces of cardboard measuring 2 3/4 by 3 3/4 inches, scissors, glue, and tape.

Cut the top off each carton, then tape the two open ends together to make one long, rectangular box. Cut a window in one side of the box near one end, and another window in the opposite side near the other end (see diagram). Glue the mirrors to the pieces of cardboard. Then tape the pieces of cardboard into the cartons so that the mirrors rest at a 45 degree angle opposite each window. Cover any light leaks with tape.

The dotted lines in the diagram show how an image strikes one mirror and is reflected to the other mirror and into your eyes.



A LOOK AT LENSES

A little distance makes a big difference in what you see through a magnifying lens. With a flashlight and some common materials, you can find out why.

Have you ever looked at nearby and distant objects through a reading glass or pocket magnifying lens as you moved the lens toward the object and away from it, or as you moved your eye toward the lens and away from it? Try it and you will see that a magnifying lens can make objects appear smaller as well as larger, turn them upside down, and even make them seem to disappear.

With a flashlight and some other common materials, you can investigate your magnifying lens and find out how it does all these different things. To begin with, though, it helps to know what a lens does to light beams as they pass through it.

PROJECT

Put a penny in a bowl, "sight" the penny over the tip of your finger, and see if you can put your fingertip directly on the penny. If you keep your fingertip moving in the straight line between your eye and the penny, you should hit the "bull's eye." Now fill the bowl with water, roll up your sleeve, and see if you can put your fingertip on the penny on the first try. Does it make any difference whether you are sighting straight down on the penny or from the side of the bowl?

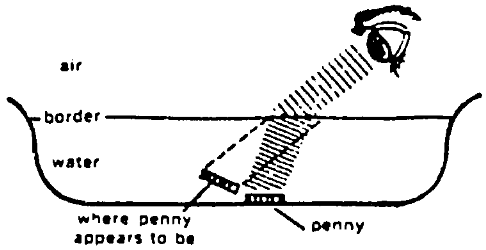
When you are looking straight down at the penny, a beam of light from the penny travels straight up through the water and the air to your eye. It follows a straight path that crosses the "border" between the water and the air at a right angle.

When your eye is near the side of the bowl, however, the light beam from the penny crosses the border at a slant. Instead of following the same straight path all the way from the penny to your eye, the beam changes direction as it crosses the border. Since you are used to receiving light in a straight path from an object, the bent beam fools you into thinking the penny is where it <u>appears</u> to be, instead of where it is.

The light beam is bent, or <u>refracted</u>, because light travels slower in water than in air. Diagram 1 shows what happens when the light beam from the penny moves from the water into the air at a slant to the border. The light at one side of the beam moves into the air and speeds up before the light at the other side of the beam gets out of the water. With one side moving faster than the other side, the beam is turned in the direction of the side that is still in the water.

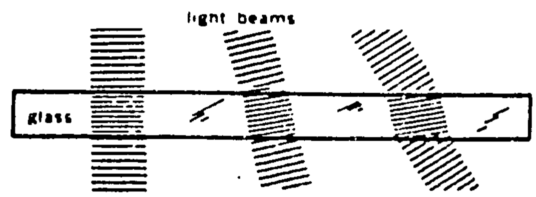
Light travels even more slowly through glass than through water. So a light beam is also refracted as it moves from the air into a block of glass and back into the air (see Diagram 2). Because of its shape, however, a magnifying lens refracts light in a special way Notice that the sides of your magnifying lens are curved outward, making the lens thickest in the center and thinnest around the edge. A lens that is curved this way is called a convex lens.

1



A beam from the penny changes direction as it moves from water into air, so the penny appears to be where it isn't.

2

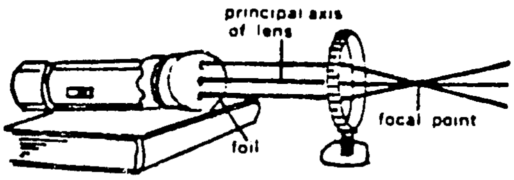


Light beams passing through a glass block are bent according to the angle at which they cross the "borders."

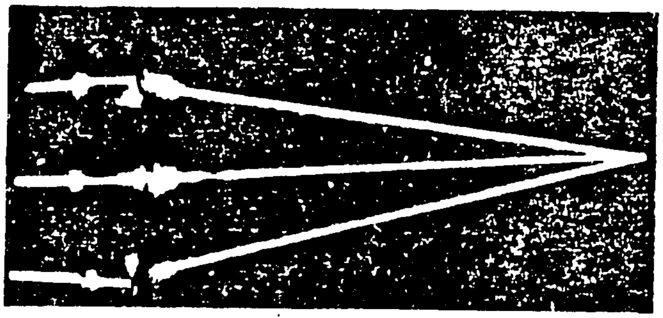
Focusing Light Beams

To see how your convex lens refracts light, wrap a piece of aluminum foil around the head of a flashlight so that the foil is stretched flat over the flashlight lens. Push a sharp pencil point through the foil to make three small holes, as shown in Diagram 3. Cover a table with wrapping paper or a newspaper, rest the lighted flashlight on a box, and pour a little talcum powder onto a sheet of paper.

Now, with the room darkened, hold the magnifying lens so the light from the center hole passes straight through the center of the lens, and gently shake a little powder into the air beyond the lens. Looking from the edge of the table, you should be able to see the three parallel beams of light from the flashlight brought together, or focused, at a single point beyond the lens, as shown in the photo. This is called the focal point of the lens, and it may be from a few inches to a foot or so beyond the lens, depending on how much the sides of the lens are curved.



3

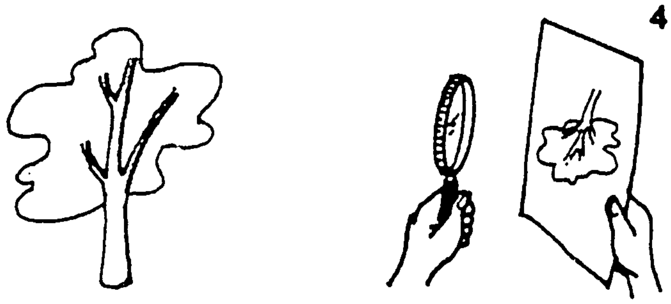


Beams moving parallel to the principal axis of a convex lens are brought together at its focal point beyond the lens, as shown in the diagram and photo.

A line running through the exact center of each side of the lens is called the <u>principal axis</u> of the lens. You can see that a light beam that passes through the lens along its principal axis is not bent at all. But light beams that are traveling parallel to the principle axis are brought together at the focal point of the lens. (Do you think the lens has a focal point on both sides? Turn the lens around and see if the light beams are brought together at the same distance from it.)

The distance from the focal point to the center of the lens is called the <u>focal distance</u> of the lens. It's hard to measure in the dark, but you can measure it easily by focusing the light from a distant tree or house on a sheet of paper held behind the lens (see Diagram 4). Move the lens toward the "screen," and away from it until the <u>image</u>, or picture, on the screen is as sharp as you can get it. The distance from the center of the lens to the screen is the focal distance of the lens.

4



When a sharp image of a distant scene forms on the sheet of paper, it is at the focal distance from the lens.

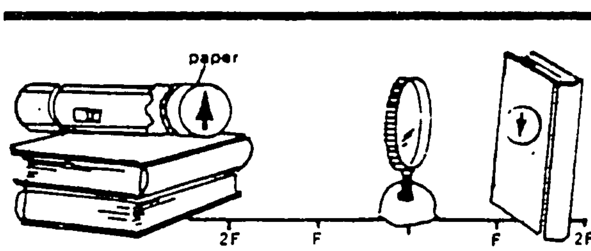
With this information and a tabletop at least four times as long as the focal distance of your lens, you can find out how different kinds of images are formed by your lens. Fasten a piece of white paper over the head of your flashlight with a rubber band so the paper is flat over the flashlight lens. Use a marking pen or crayon to draw a large arrow on the flat circle of paper (see Diagram 5).

Cover the table with paper. Place the flashlight on a few books at one end, and a white paper screen supported by a book at the other end. You might think the lighted flashlight would project an image of the arrow on the screen. Darken the room and you will see that it merely lights the screen a bit, without forming an image of the arrow. Remember that light beams are moving out in all directions from the same point on the flashlight face. At least two beams from the same point on the flashlight face must be brought together at the screen to form an image there.

Use some modeling clay to stand your lens near the middle of the table. On each side of the lens, measure the focal distance of the lens and mark it F on the paper. Also mark 2F at twice the focal distance on each side of the lens, as show in Diagram 5.

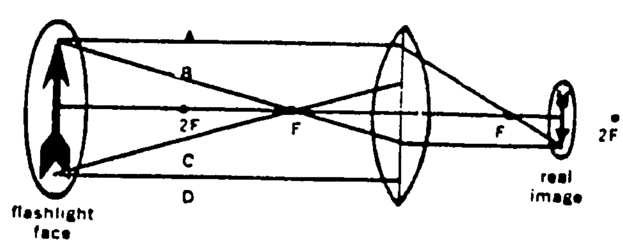
With the flashlight face several inches beyond 2F on one side of the lens, move the screen between 2F and F on the other side until a sharp image of the arrow forms on the screen. Diagram 6 shows how the image if formed.

5



With flashlight and screen as shown above, an image forms on the screen as shown below. Beam A moves parallel to the principal axis of the lens, so it is bent through the focal point on the other side. Beam B moves through the focal point on one side, so it leaves the lens moving parallel to the principal axis. Where A and B meet, an image is formed of the point on the flashlight face where both beams started. Can you draw in the paths of Beams C and D from the lens to the screen?

6



Now move the flashlight face to position 2F on one side of the lens and the screen to 2F on the other side. What happens to the image? Can you draw a diagram to show how this image is formed?

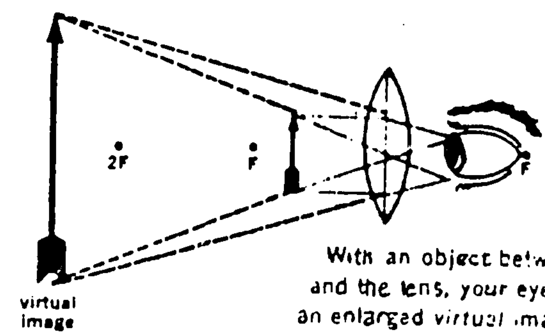
Try placing the flashlight face between 2F and F and move the screen back and forth on the other side of the lens until a sharp image of the arrow is formed. (A slide projector works this way, and you can see why the slide must be place upside down in the projector.) Can you diagram the paths of light beams that form this image?

Do you think that an image will form if you place the flashlight face at F, or closer to the lens? Try it and see. Can you explain your findings?

Suppose you put your eye in place of the screen in each of the above investigations. Try it with the arrow at each of the places you tried before. Move your head back and forth just as you moved the screen the sharpen the images.

Be sure to look for an image with the flashlight face placed between F and the lens. The image you see will be familiar, but different from the real images that you have been looking at. This one is called a virtual image, because it doesn't form on a screen. Diagram 7 shows how this image is formed. Does it remind you of the penny you saw where it wasn't in the bowl of water?--F.K.L.

7



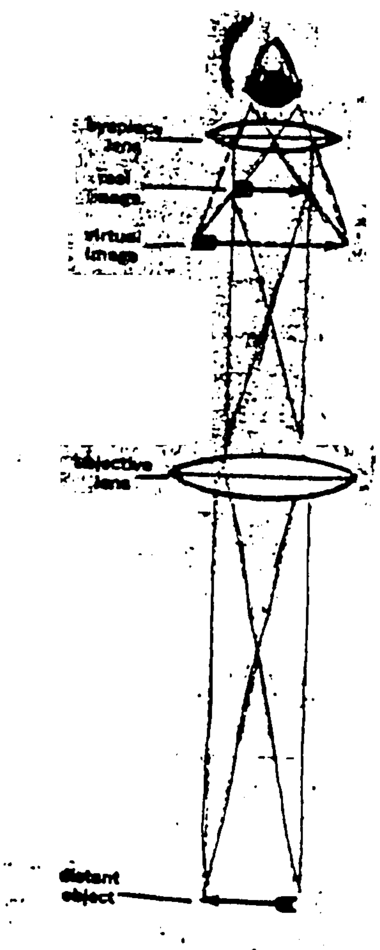
With an object between F and the lens, your eye sees an enlarged virtual image of the object through the lens.

HOW TO MAKE A SIMPLE TELESCOPE AND MICROSCOPE

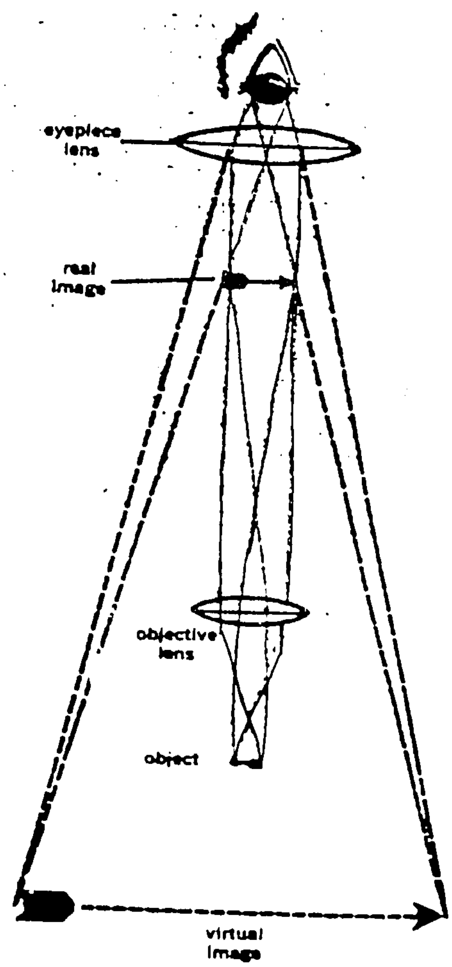
If you have two magnifying lenses with different focal distances, you can make a simple refracting telescope (see "Big Eyes on Space," N&S, February 3, 1969) and a microscope.

Hold the lens with the longer focal distance at arm's length, pointed toward an object across the room from you. Now hold the other lens to your eye and look through both lenses, moving the first lens back and forth until you can see the object clearly. What you see is a magnified virtual image of the real image projected by the first lens (see diagram).

By looking at the object through the telescope with one eye and at the same time with your unaided eye, you may be able to line up the image with the object and guess about how many times the telescope "enlarges" the object. You can figure out the magnifying "power" of your telescope more exactly, however, by simply dividing the focal distance of the eyepiece lens into the focal distance of the objective lens, at the far end of your telescope.



TELESCOPE



MICROSCOPE

Now hold the lens with the shorter focal distance (the objective ens for the microscope) near these words to form an enlarged real mage (upside down) of them at your eye. Hold the second (eyepiece) ens near your eye and move it up and down until you see an enlarged irtual image of the real image (see diagram).

The magnifying power of your microscope is harder to figure out han that of the telescope. To begin with, you have to find the istance of the real image from the objective lens and divide that igure by the focal distance of that lens. This tells how many times he real image is bigger than the object being viewed. Then you have o multiply this figure by the number of times the eyepiece lens nlarges the real image to find out how much bigger the object appears hen viewed through your microscope.

MAKE AN AIR LENS

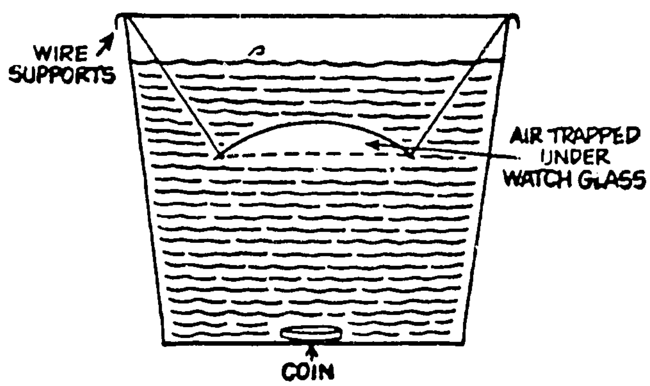
When we study geometrical optics, we conventionally draw ray diagrams of a convex lens in air showing how it converges light to produce real, upside down images.

It may be useful to show that this is only true because the index of refraction of the glass lens is greater than that of the air in which it is immersed.

We might then ask what would happen if the reverse were true. Suppose the index of refraction of the convex lens was less than the media surrounding it?

To produce such a situation, immerse a watch glass in a beaker of water trapping some air under the concave side. The trapped air will be shaped like a convex lens. Look through this air lens at a coin on the bottom of the beaker.

The coin will appear right side up and smaller. See if you can get a student to explain why.



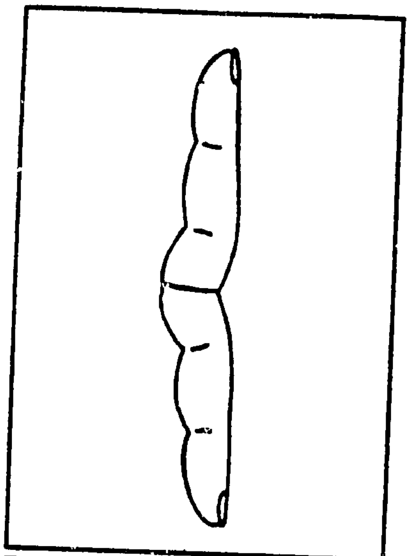


Fig. 3. Total internal reflection prevents the mirror from showing you anything above the surface. Poke your finger into the water, and this time you see only the part beneath the surface, together with its reflection.

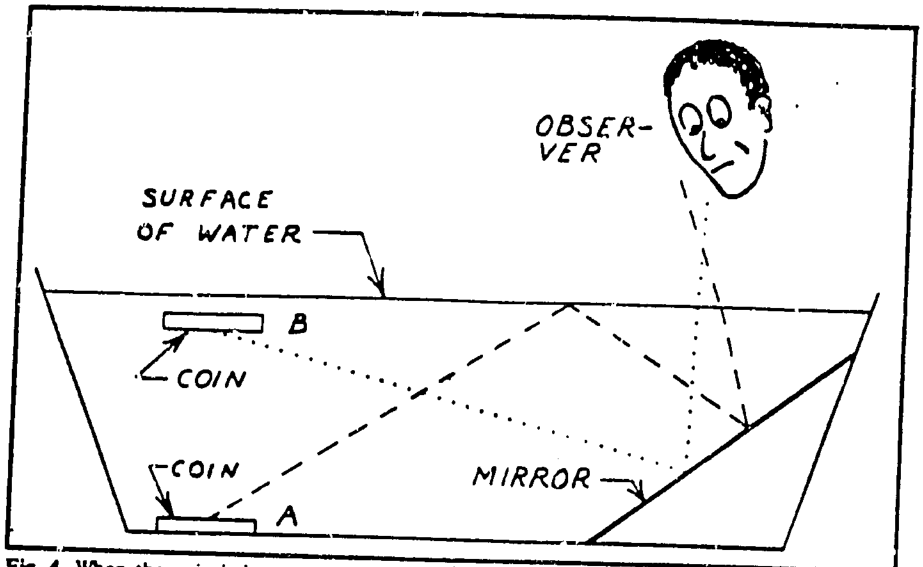


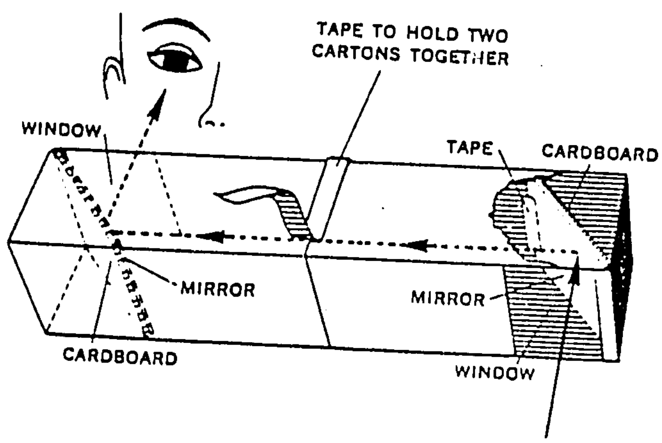
Fig. 4. When the coin is in position A (on the bottom), light rays (dashed lines) from its upper face undergo total internal reflection at the surface before striking the mirror. The rays are then mirror-reflected out to the observer. When the coin is raised to position B, rays leave from both its upper and lower faces. Rays from the upper face (not shown) are totally internally reflected as before, and reach the observer. However, now the lower face is also visible (rays shown dotted).

MAKE A PERISCOPE

Here is a way to build a periscope, which you can use to look over fences and around corners. You will need two one-quart milk cartons, two small mirrors, two pieces of cardboard measuring 2 3/4 by 3 3/4 inches, scissors, glue, and tape.

Cut the top off each carton, then tape the two open ends together to make one long, rectangular box. Cut a window in one side of the box near one end, and another window in the opposite side near the other end (see diagram). Glue the mirrors to the pieces of cardboard. Then tape the pieces of cardboard into the cartons so that the mirrors rest at a 45 degree angle opposite each window. Cover any light leaks with tape.

The dotted lines in the diagram show how an image strikes one mirror and is reflected to the other mirror and into your eyes.



A LOOK AT LENSES

A little distance makes a big difference in what you see through a magnifying lens. With a flashlight and some common materials, you can find out why.

Have you ever looked at nearby and distant objects through a reading glass or pocket magnifying lens as you moved the lens toward the object and away from it, or as you moved your eye toward the lens and away from it? Try it and you will see that a magnifying lens can make objects appear smaller as well as larger, turn them upside down, and even make them seem to disappear.

With a flashlight and some other common materials, you can investigate your magnifying lens and find out how it does all these different things. To begin with, though, it helps to know what a lens does to light beams as they pass through it.

PROJECT

Put a penny in a bowl, "sight" the penny over the tip of your finger, and see if you can put your fingertip directly on the penny. If you keep your fingertip moving in the straight line between your eye and the penny, you should hit the "bull's eye." Now fill the bowl with water, roll up your sleeve, and see if you can put your fingertip on the penny on the first try. Does it make any difference whether you are sighting straight down on the penny or from the side of the bowl?

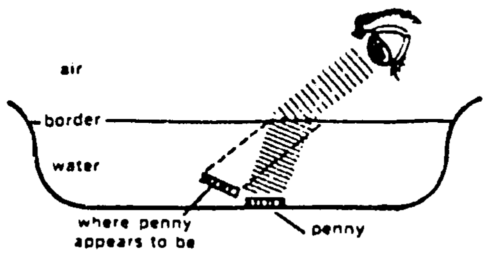
When you are looking straight down at the penny, a beam of light from the penny travels straight up through the water and the air to your eye. It follows a straight path that crosses the "border" between the water and the air at a right angle.

When your eye is near the side of the bowl, however, the light beam from the penny crosses the border at a slant. Instead of following the same straight path all the way from the penny to your eye, the beam changes direction as it crosses the border. Since you are used to receiving light in a straight path from an object, the bent beam fools you into thinking the penny is where it appears to be, instead of where it is.

The light beam is bent, or refracted, because light travels slower in water than in air. Diagram 1 shows what happens when the light beam from the penny moves from the water into the air at a slant to the border. The light at one side of the beam moves into the air and speeds up before the light at the other side of the beam gets out of the water. With one side moving faster than the other side, the beam is turned in the direction of the side that is still in the water.

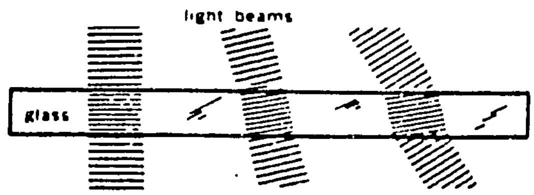
Light travels even more slowly through glass than through water. So a light beam is also refracted as it moves from the air into a block of glass and back into the air (see Diagram 2). Because of its shape, however, a magnifying lens refracts light in a special way Notice that the sides of your magnifying lens are curved outward, making the lens thickest in the center and thinnest around the edge. A lens that is curved this way is called a convex lens.

1



A beam from the penny changes direction as it moves from water into air, so the penny appears to be where it isn't.

2



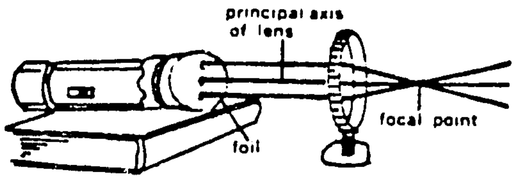
Light beams passing through a glass block are bent according to the angle at which they cross the "borders."

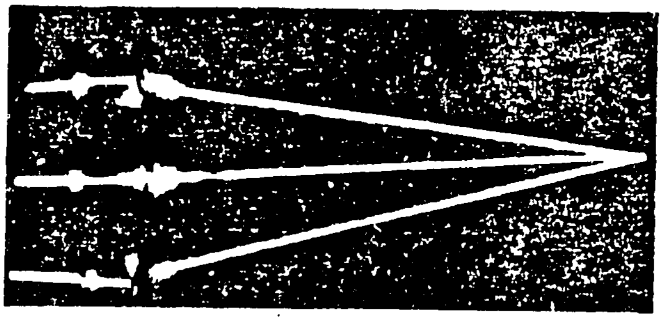
Focusing Light Beams

To see how your convex lens refracts light, wrap a piece of aluminum foil around the head of a flashlight so that the foil is stretched flat over the flashlight lens. Push a sharp pencil point through the foil to make three small holes, as shown in Diagram 3. Cover a table with wrapping paper or a newspaper, rest the lighted flashlight on a box, and pour a little talcum powder onto a sheet of paper.

Now, with the room darkened, hold the magnifying lens so the light from the center hole passes straight through the center of the lens, and gently shake a little powder into the air beyond the lens. Looking from the edge of the table, you should be able to see the three parallel beams of light from the flashlight brought together, or focused, at a single point beyond the lens, as shown in the photo. This is called the focal point of the lens, and it may be from a few inches to a foot or so beyond the lens, depending on how much the sides of the lens are curved.

3



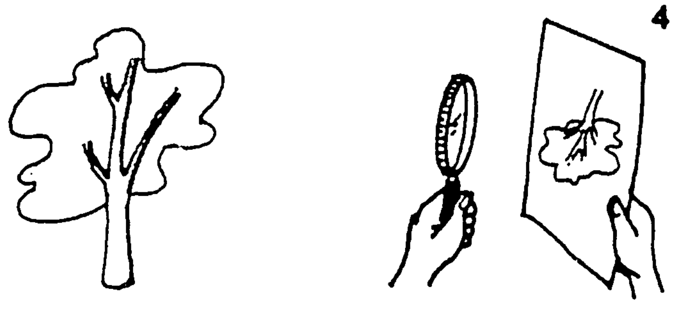


Beams moving parallel to the principal axis of a convex lens are brought together at its focal point beyond the lens, as shown in the diagram and photo.

A line running through the exact center of each side of the lens is called the principal axis of the lens. You can see that a light beam that passes through the lens along its principal axis is not bent at all. But light beams that are traveling parallel to the principle axis are brought together at the focal point of the lens. (Do you think the lens has a focal point on both sides? Turn the lens around and see if the light beams are brought together at the same distance from it.)

The distance from the focal point to the center of the lens is called the focal distance of the lens. It's hard to measure in the dark, but you can measure it easily by focusing the light from a distant tree or house on a sheet of paper held behind the lens (see Diagram 4). Move the lens toward the "screen," and away from it until the image, or picture, on the screen is as sharp as you can get it. The distance from the center of the lens to the screen is the focal distance of the lens.

4



When a sharp image of a distant scene forms on the sheet of paper, it is at the focal distance from the lens.

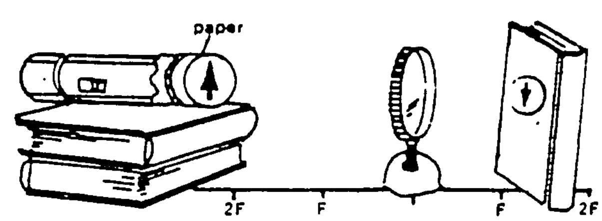
With this information and a tabletop at least four times as long as the focal distance of your lens, you can find out how different kinds of images are formed by your lens. Fasten a piece of white paper over the head of your flashlight with a rubber band so the paper is flat over the flashlight lens. Use a marking pen or crayon to draw a large arrow on the flat circle of paper (see Diagram 5).

Cover the table with paper. Place the flashlight on a few books at one end, and a white paper screen supported by a book at the other end. You might think the lighted flashlight would project an image of the arrow on the screen. Darken the room and you will see that it merely lights the screen a bit, without forming an image of the arrow. Remember that light beams are moving out in all directions from the same point on the flashlight face. At least two beams from the same point on the flashlight face must be brought together at the screen to form an image there.

Use some modeling clay to stand your lens near the middle of the table. On each side of the lens, measure the focal distance of the lens and mark it F on the paper. Also mark 2F at twice the focal distance on each side of the lens, as show in Diagram 5.

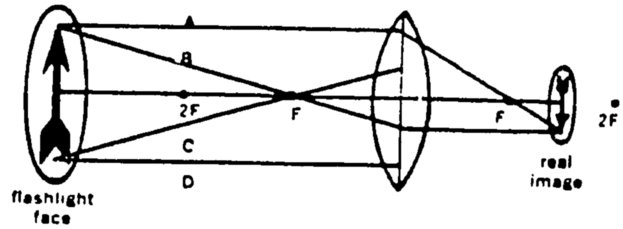
With the flashlight face several inches beyond 2F on one side of the lens, move the screen between 2F and F on the other side until a sharp image of the arrow forms on the screen. Diagram 6 shows how the image if formed.

5



With flashlight and screen as shown above, an image forms on the screen as shown below. Beam A moves parallel to the principal axis of the lens, so it is bent through the focal point on the other side. Beam B moves through the focal point on one side, so it leaves the lens moving parallel to the principal axis. Where A and B meet, an image is formed of the point on the flashlight face where both beams started. Can you draw in the paths of Beams C and D from the lens to the screen?

6



Now move the flashlight face to position 2F on one side of the lens and the screen to 2F on the other side. What happens to the image? Can you draw a diagram to show how this image is formed?

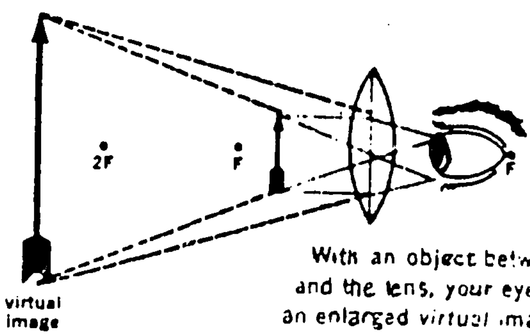
Try placing the flashlight face between 2F and F and move the screen back and forth on the other side of the lens until a sharp image of the arrow is formed. (A slide projector works this way, and you can see why the slide must be place upside down in the projector.) Can you diagram the paths of light beams that form this image?

Do you think that an image will form if you place the flashlight face at F, or closer to the lens? Try it and see. Can you explain your findings?

Suppose you put your eye in place of the screen in each of the above investigations. Try it with the arrow at each of the places you tried before. Move your head back and forth just as you moved the screen the sharpen the images.

Be sure to look for an image with the flashlight face placed between F and the lens. The image you see will be familiar, but different from the real images that you have been looking at. This one is called a virtual image, because it doesn't form on a screen. Diagram 7 shows how this image is formed. Does it remind you of the penny you saw where it wasn't in the bowl of water?--F.K.L.

7



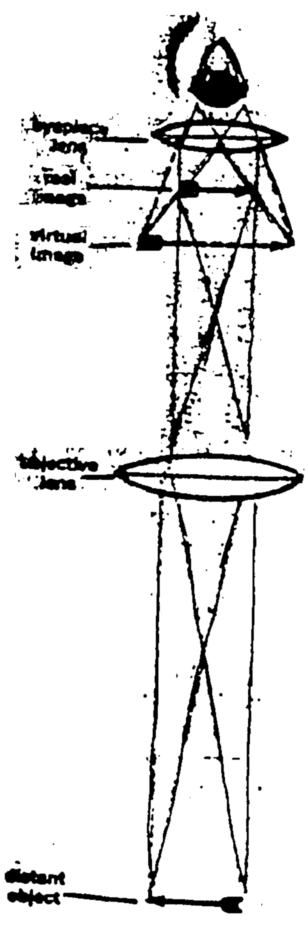
With an object between F and the lens, your eye sees an enlarged virtual image of the object through the lens.

HOW TO MAKE A SIMPLE TELESCOPE AND MICROSCOPE

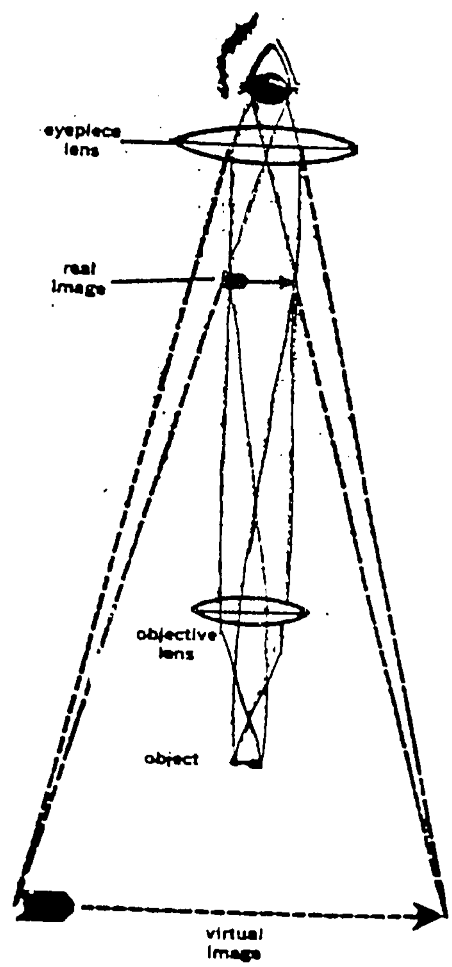
If you have two magnifying lenses with different focal distances, you can make a simple refracting telescope (see "Big Eyes on Space," <u>N&S</u>, February 3, 1969) and a microscope.

Hold the lens with the longer focal distance at arm's length, pointed toward an object across the room from you. Now hold the other lens to your eye and look through both lenses, moving the first lens back and forth until you can see the object clearly. What you see is a magnified virtual image of the real image projected by the first lens (see diagram).

By looking at the object through the telescope with one eye and at the same time with your unaided eye, you may be able to line up the image with the object and guess about how many times the telescope "enlarges" the object. You can figure out the magnifying "power" of your telescope more exactly, however, by simply dividing the focal distance of the <u>eyepiece</u> lens into the focal distance of the <u>objective</u> lens, at the far end of your telescope.



TELESCOPE



MICROSCOPE

Now hold the lens with the shorter focal distance (the objective lens for the microscope) near these words to form an enlarged real image (upside down) of them at your eye. Hold the second (eyepiece) lens near your eye and move it up and down until you see an enlarged virtual image of the real image (see diagram).

The magnifying power of your microscope is harder to figure out than that of the telescope. To begin with, you have to find the distance of the real image from the objective lens and divide that figure by the focal distance of that lens. This tells how many times the real image is bigger than the object being viewed. Then you have to multiply this figure by the number of times the eyepiece lens enlarges the real image to find out how much bigger the object appears when viewed through your microscope.

MAKE AN AIR LENS

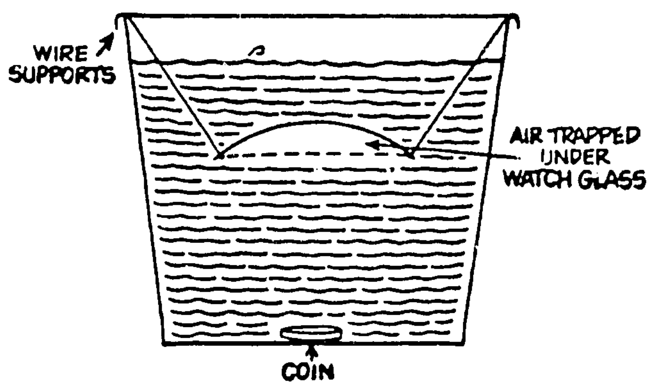
When we study geometrical optics, we conventionally draw ray diagrams of a convex lens in air showing how it converges light to produce real, upside down images.

It may be useful to show that this is only true because the index of refraction of the glass lens is greater than that of the air in which it is immersed.

We might then ask what would happen if the reverse were true. Suppose the index of refraction of the convex lens was less than the media surrounding it?

To produce such a situation, immerse a watch glass in a beaker of water trapping some air under the concave side. The trapped air will be shaped like a convex lens. Look through this air lens at a coin on the bottom of the beaker.

The coin will appear right side up and smaller. See if you can get a student to explain why.



38