GEORGIA INSTITUTE OF TECHNOLOGY

OFFICE OF CONTRACT ADMINISTRATION

# PROJECT ADMINISTRATION DATA SHEET

[X] ORIGINAL [ ] REVISION NO. ______

Project No. G-34-803 (T5094-2A1) GTRC/~~GIT~~ DATE 4 / 24 / 85

Project Director: A. D. Van Nostrand MSL School/~~Lab~~ English

Sponsor: Alfred P. Sloan Foundation

Type Agreement: Grant 85-4-15

Award Period: From 4/2/85 To 6/30/86 (Performance) 8/1/86 (Reports)

Sponsor Amount:

| | This Change | Total to Date |
|---|---|---|
| Estimated: | $ | $ |
| Funded: | $ 245,000 | $ 245,000 |

Cost Sharing Amount: $ ______ Cost Sharing No: N/A

Title: RETLA Extension

## ADMINISTRATIVE DATA

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Defense Priority Rating: ______

Military Security Classification: N/A

(or) Company/Industrial Proprietary: N/A

## RESTRICTIONS

See Attached ______ Supplemental Information Sheet for Additional Requirements.

Travel: Foreign travel must have prior approval – Contact OCA in each case. Domestic travel requires sponsor approval where total will exceed greater of $500 or 125% of approved proposal budget category.

Equipment: Title vests with GIT - However no equipment is proposed.

## COMMENTS:

Continuation of G-34-802. Overhead rate fixed @ 15%.

## COPIES TO:

SPONSOR'S I. D. NO. 02.500.015.85.002

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| Accounting | Research Communications (2) | Other A. Jones |

GEORGIA INSTITUTE OF TECHNOLOGY OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION/CLOSEOUT SHEET

Date 10/16/86

Project No. G-34-803

School/Lab English

Includes Subproject No.(s) N/A

Project Director(s) A. D. Van Nostrand GTRC / GIT

Sponsor Alfred P. Sloan Foundation

Title RETLA Extension

Effective Completion Date: 7/31/86 (Performance) 8/31/86 (Reports)

Grant/Contract Closeout Actions Remaining:

- [ ] None
- [X] Final Invoice or Final Fiscal Report
- [ ] Closing Documents
- [ ] Final Report of Inventions
- [ ] Govt. Property Inventory & Related Certificate
- [ ] Classified Material Certificate
- [ ] Other

Continues Project No. G-34-802 Continued by Project No.

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G-34-803

Resourceful Exchange: Technology and the Liberal Arts
Final Report
7 August 1986

7 August 1986

# INTRODUCTION

"Resourceful Exchange: Technology and the Liberal Arts" (RETLA) was a program within a program funded by the Alfred P. Sloan Foundation. A subset of the New Liberal Arts Program, which has engaged some fifty colleges and universities during the past five years, RETLA was organized as a network of eighteen historically black colleges and a supporting university, Georgia Tech. Twelve of these colleges remained active in RETLA over a two-year period from July 1984 through July 1986.

This final report presents a summary description of the tangible outcomes of RETLA, which are contained in a series of nine appendices. These outcomes include the final documentation of eleven modules of instruction in technology, all of which have been presented to students at least once. The nine appendices also contain proposals for sponsorship in computer-based instruction in a range of subjects. In addition, the appendices contain the records of governance and procedures in this network of institutions, in the form of minutes of the elected Advisory Board and the four issues of the RETLA Newsletter.

A final financial report, forwarded under separate cover, indicates that Georgia Tech is returning approximately $55,000 to the Foundation. This refund is consistent with the contingent funding plan of the grant.

## Program Perspectives

In August 1985, James Koerner, retiring Sloan Foundation Vice President, summarized the overall New Liberal Arts (NLA) Program as one of great difficulty and complexity. The difficulties and complexities, he said, stemmed from the experimental nature of the project, its broad conceptual scope, and the need for faculty members from different disciplines, different institutions, and different kinds of institutions to work together.

--First and foremost, the NLA had been conceived as an experimental program, with goals and activities that are continually evolving: "We have all been engaged in a process of trial and error, of exploration and discovery, of testing ideas and procedures" (The Weaver [Spring 1986], p. 2).

--Moreover, the NLA Program was both interdisciplinary and inter-institutional: the Foundation asked "faculty members from many fields to rethink their disciplines, to develop quantitative materials of a different kind, [and] to develop unprecedented ways of integrating technology" into the liberal arts curriculum.

All of these conditions were true of the RETLA program: its experimental nature, its broad conceptual scope, and its development of new interdiscipinary perspectives.

But in describing the current state of the overall NLA programs, Koerner had reservations. Most of the NLA colleges, he said, had not collaborated, among themselves or with engineering colleges, thereby arresting the process of experimentation and narrowing the conceptual range of the program: "We continue to be disappointed at the inability or unwillingness of the colleges to explore collaborative activities not only with each other but also with universities, particularly engineering schools. That has not happened. . . ."

In respect to such bold collaboration, however, the RETLA program was a notably different subset of activities; its participants achieved extraordinary, continuing interaction and a sense of community, and there is a strong possibility that these will continue.

When it funded the RETLA project, two years after it funded the NLA Program, the Foundation had the advantage of hindsight. RETLA was designed as a faculty development effort in which historically black liberal arts colleges would begin in a collaborative mode, with each other and with Georgia Tech. From this premise stems each of the RETLA activities--the technology modules, computer consulting, advisory board, and newsletter. These activities proceeded with continually changing sets of institutions and of individuals, each of whom helped to refine RETLA's goals through their limited, tactical objectives.

Some of the achieved outcomes of the collaborative effort are self-evident in the appendices to this report; other outcomes will become evident in the continuing enterprise on the campuses of the participating colleges during the coming year. This report indicates the complexity of the collaboration that led to these outcomes: in the preparation of instructional modules, in the exploratory plans for computer-assisted instruction, and in the governing procedures of the RETLA community.

## TECHNOLOGY MODULES

### Objectives and Contexts

The RETLA project evolved through four stages: a needs assessment (1983-84), a first operational phase (July 1984 to June 1985), a second operational phase (July to November 1985), and a concluding operational phase (December 1985 to July 1986). At each stage in the evolution of the project new participants modified the goals set by their predecessors.

Needs Assessment: Three activities for accentuating quantitative methods and studying technology were selected by participants from eighteen colleges in a referendum procedure (see Appendix 1):

--the preparation of technology modules, or instructional segments, for existing liberal arts courses,

--the updating of required service courses in mathematics,

--the updating of composition courses by word processing on microcomputers.

Originally we anticipated that these activities would begin in summer workshops. But the Foundation ruled out curriculum development in word processing, and since the timing of the first program grant made summer workshops infeasible, we combined the mathematics course activity with the development of technology modules in a format consisting of a series of workshops throughout the academic year.

During the 1983-84 needs assessment, representatives from RETLA colleges selected the module format (rather than new courses) for several reasons:

--modules can be implemented quickly and without invoking immediate curriculum change;

--new modules in current liberal arts courses would not affect the proportion of current enrollments;

--modules allow for the efficient pooling and testing of resources;

--technology modules would also provide opportunities for liberal arts faculty to continue the liberal arts tradition of providing the bases for understanding and integrating different kinds of historical events, be they technological, economic, political, or aesthetic.

These technology modules were meant to be self-standing units, of one to three weeks in length for a quarter or semester course, documented by a student handbook and a faculty handbook.

In the 1983-84 referendum, the colleges had identified five topics for technology modules:

--quantitative methods in engineering,

--technology forecasting and assessment,

--mathematical applications for nonscience students,

--general microbiology,

--information technology.

First Operational Phase: In 1984-85, participating faculty members undertook modules in the first three topics, but not the last two. No team working on topic 1 (Quantitative Methods in Engineering) finished a module, but teams working on topic 2 (Technology Forecasting and Assessment) and topic 3 (Mathematical Applications for Nonscience Students) did complete modules.

Second Operational Phase: Our objectives for 1985-86 included the completion and testing of the modules begun the previous year and also the initiation of several modules on engineering. When planning 1985-86 activities, we limited the new module teams to three engineering topics to redress an imbalance in the First Phase:

--engineering concepts and problem definition,

--engineering and public policy,

--the evolution of engineering procedures.

The participants showed more interest in preparing modules in topics 1 and 2, than in topic 3.

Second Phase teams began their modules with an orientation meeting at Georgia Tech in October 1985, but in November the Foundation notified participating colleges of the termination of the RETLA program. We converted immediately to a Concluding Phase in which we started no new activities but set about completing what we had begun.

Concluding Operational Phase: From December 1985 through July 1986, we accelerated deadlines for student handbooks to provide as much time for revision as possible; we also cancelled original plans to begin six to eight additional modules.

First Phase participants continued to revise student handbooks on the basis of field-testing; Second Phase participants submitted draft student handbooks in February for editorial and engineering review. Because we extended deadlines to accommodate three module teams, editorial activities--including conferences--became particularly heavy in May, June, and July. During April 1986, the Morris Brown team field-tested its phase-one module in art and mathematics at two other colleges.

**Experimental Design**

<u>The Team Approach</u>:

So that participating faculty members (see Appendix 2) could continue discussions begun at Georgia Tech and draft their module materials at their home campuses, we designed a team approach to module preparation.

--RETLA college faculty worked in teams of two: one team member--typically from the humanities--who was currently teaching the course for which the technology module was being prepared, and one member--typically from math or the sciences--who served as a resource for quantitative methodology. With this arrangement, team members used the resources supplied by one another.

--A third, part-time member of each team was a consultant from the Georgia Tech faculty. As field specialists, the sixteen consultants (see Appendix 3) supplied module teams with technical information and reports and facilitated the dialogue between humanist and scientist/mathematician. Their fields included Civil Engineering, Electrical Engineering, Engineering Science and Mechanics, Industrial and Systems Engineering, Nuclear Engineering, Textile Engineering, Geophysical Science, Technology Assessment, Industrial Design, Mathematics, Sociology, Philosophy, and English.

<u>Editorial Procedures</u>:

At the outset all participants endorsed the concept of a module bank, to which each team would contribute its modules for use and adaptation at other participating colleges. The need for a common form of documentation arose from this objective. The Georgia Tech project team drafted specifications for two basic documents, a student handbook and a faculty handbook, which guided each team in defining its module.

The first document specification consisted of category tags for generalizing information about all modules with questions under each category for defining any given module. During the first operational phase, this format helped each team and its consultant to exchange ideas about what might develop as a module.

Based on typical answers to these questions, the project team evolved three separate specification sheets at the beginning of the second operational phase of the program: engineering guidelines for the module and editorial guidelines for the student handbook and the faculty handbook (see Appendix 4). All three specification sheets were formative: they presented categorized questions for each team to answer about the substance and the presentation of its module. Each team with its consultant used the engineering guidelines as an agenda for forming each module, and each team addressed the editorial guidelines in consultation with the Georgia Tech editorial group.

**Procedure for Generating Modules**

In September and December 1984 (First Phase), all module teams assembled at Georgia Tech for orientation and introduction to engineering procedures. In Spring 1985, groups of teams working in the same general topic area met with their consultants at Georgia Tech. By late Spring, individual teams were meeting with their consultants according to individual needs, and this latter arrangement continued through 1986 until the teams completed their modules.

These module teams were evaluated during the summer; some who had not completed their modules by May 1985 were invited to continue; and some who had not yet finished even a first draft, outlining a series of classroom activities, were not invited to continue. But no team was denied the opportunity to continue if it had demonstrated interest in doing so.

In October 1985 (Second Phase), new module teams convened at Georgia Tech for an orientation meeting and then met individually with their consultants throughout the academic year (during the Concluding Phase). In composing their student and faculty handbooks, participating faculty used guidelines derived from the handbooks prepared by the first module teams.

**The Eleven Modules: Descriptive Summary**

Following are brief descriptions of the eleven modules. These descriptions will be distributed to all RETLA college participants and to the editor of the NLA Newsletter. For the complete modules, see Appendix 5. An overview is tabulated on p. 7 below.

**Artistic and Mathematical Components in Visual Composition**

Alma Adams (Art) and R. Lee Ponting (Mathematics), Bennett College, Greensboro, NC 27401. Student Handbook, 26 pages (including two handouts on graphing/plotting and analytical geometry); Faculty Handbook, 26 pages; audio-visual materials: filmstrip, slides, software (PC Paint, with mouse). Module requires fourteen class hours; originally developed for introductory studio art course.

| COLLEGE | MODULE TITLE | OUTCOMES | | | FEATURES | | | |
|---|---|---|---|---|---|---|---|---|
| | | Student Handbook | Field-test | Faculty Handbook | Mathematical Formulations | Computer Use | Technology as Subject | Audio-Visual |
| Albany State | Statistics for Social Science | X | X | | X | X | | |
| Bennett | Art and Mathematics | X | X | X | X | X | X | X |
| Bennett | Decision Analysis in Ethics | X | X | X | X | X | | |
| Dillard | Literature and Technology Assessment | X | X | | | X | X | |
| Dillard | Hazardous Chemicals | X | X | X | | | X | X |
| Morris Brown | Art and Mathematics: The Arch | X | X | X | X | | X | X |
| Paine | Augusta Canal | X | | | X | | X | X |
| Paine | Nuclear Waste Disposal | X | | | | | X | X |
| South Carolina State College | Industrial Revolution | X | X | X | | | X | |
| South Carolina State College | The Pill | X | X | | | | X | |
| Tuskegee | Computer Logic | [X] | | | | X | X | |
| TOTALS | | 11 | 6 | 8 | 5 | 5 | 9 | 5 |

Key: [X] denotes distribution only at authors' college

RETLA Module Overview

This module provides an introduction to artistic design and composition and to computer graphics. The module emphasizes mathematical principles in art, particularly in two-dimensional compositions. Activities include: free-hand sketching, computer simulation of free-hand sketches, graphing and plotting with and without the computer, devising algebraic expressions for creating geometrical designs with the computer, relating color properties to geometrical designs, preparing and mounting a final composition.

**The Beginnings of the Industrial Revolution in the Eighteenth Century**

Stanley Harrold (History) and Tom Whitney (Engineering Technology), South Carolina State College, Orangeburg, SC 29117. Student Handbook, 12 pages; Faculty Handbook, 13 pages. Module requires four class sessions; originally developed for sophomore-level humanities survey course.

This module provides students with factual knowledge about the Industrial Revolution and early modern machinery (in textiles, metallurgy, and transportation) and introduces students to a technology assessment model.

**Canal Design and the Augusta Canal**

Marva Stewart (English) and Jacquelyn Hill (Educational Media), Paine College, Augusta, GA 30901. Student Handbook, 34 pages (including six handouts and glossary) and six sample worksheets with solutions; audio-visual materials: filmstrip, slides, and topographical maps. Module requires six class sessions (and one field trip); originally developed as a research paper exercise for a freshman composition course.

This module introduces students to: (1) the economic and social factors that led to the construction of the Augusta canal; (2) engineering concepts, principles, and procedures that governed the construction of the canal; (3) mathematical computations that engineers have used to construct the canal; and (4) critical thinking skills that contribute to writing an essay about some aspect of the canal. Although the problem exercises are formulated in relation to Augusta canal specifications, the engineering concepts and mathematical computations (such as river flow and flow duration curves) used in the module are fundamental to all canals.

**Computer and Circuit Logic Design**

Marc R. Graney (Philosophy) and Hira Nirang (Computer Science), Tuskegee Institute, Tuskegee Institute, AL 36083. Student Handbook, 16 pages; calculator, software ("Logic," "Sandi," "Sylli"). Module requires six class sessions and two lab hours; originally developed for introductory logic course.

This module demonstrates the application of logic in the operations of a computer and in specific areas of programming (i.e., artificial intelligence, natural language programming, logic programming). Concepts include: digital and analogue, Boolean logic, truth tables, expert system, and trees.

**Contraceptive Technology: The Pill**

Maria Ricks (Humanities) and Judith Salley (Biology), South Carolina State College, Orangeburg, SC 29117. Student Handbook, 23 pages (including six handouts). Module requires seven class sessions; originally developed for a junior-level humanities survey course.

This module provides factual knowledge about the societal context in which the pill was developed. It also introduces students to the bio-chemistry of the pill and provides a variable model for engaging students in technology assessment.

**Decision Analysis in Ethics**

Helen R. Trobian (Philosophy) and Ray T. Treadway (Mathematics), Bennett College, Greensboro, NC 27401. Student Handbook, 28 pages (including six handouts) and 20 pages of readings ("Ethical Decision-Making," "The Decision Tree Technique," and "Decision Analysis"); Faculty Handbook, 44 pages; audio-visual materials: software (Decide: A Decision Tree Model). Module requires ten class sessions; originally developed for sophomore-level philosophy course.

This module engages students in decision-making simulations, decision-tree methodology, and elementary decision analysis in order to apply alternative systems of values in the management of moral dilemmas.

**Hazardous Chemicals, Computer Technology, and Public Policy**

Kathryn S. Aultman (Chemistry) and Gilbert L. Rochon (Urban Affairs), Dillard University, New Orleans, LA 70122. Student Handbook, 14 pages; Faculty Handbook, 12 pages; video-tape. Module requires six class sessions; originally developed for introductory chemistry course.

This module introduces students to (1) the regulation of manufacture, transport, storage, and disposal of hazardous chemicals, (2) the role of chemists in the regulatory process, and (3) the role of computers (data bases, mapping, modeling) in the management of hazardous chemicals and their spills.

**Interfacing Mathematics and Technology with Design and Architecture**

Lee Ransaw (Art) and Abiola Lawal (Mathematics), Morris Brown College, Atlanta, GA 30314. Student Handbook, 28 pages (including two handouts); Faculty Handbook, 13 pages; audio-visual materials: slides, calculators, drafting equipment (not included with Student or Faculty Handbook). Module requires at least nine class sessions and one field trip; originally developed for introductory studio art course; field-tested at Clark and Spelman.

This module provides factual information about the role of mathematics and technology in Gothic and Renaissance art and architecture, and it engages students in a series of problem-solving tasks that focus on the arch. Specific mathematical and engineering concepts include: volume, sphere, perspective, stress, strain, yield point, force, and weight.

**Literature as a Form of Technology Assessment**

Violet H. Bryan (English) and Kathryn Aultman (Chemistry), Dillard University, New Orleans, LA 70122. Student Handbook, 15 pages; audio-visual materials: slides, science kit, software (TEKASSES [by K. Aultman]). Module requires five class sessions; originally developed for an American literature course.

This module is designed to introduce (1) novels of social criticism which were written around the turn of the twentieth century in America, and (2) the concept and process of technology assessment. It compares the evaluative processes of the novel, The Octopus by Frank Norris, and a computer simulation program, TEKASSES, that enables students to perform a simulation of technology assessment based on qualitative values.

**Quantitative and Analytical Concepts for the Social Sciences**

Veula J. Rhodes (History) and Don Williams (Mathematics and Computer Science), Albany State College, Albany, GA 31705. Student Handbook, 23 pages (including one handout, three overviews); software (Frankenburger and Blakeman, Introductory Statistics [Addison-Wesley]). Module requires ten class sessions; originally developed for a sophomore-level introductory social sciences course.

This module introduces students to logical and quantitative methods for use in identifying, classifying, and discovering solutions to problem situations in the social sciences. Specific mathematical concepts include: frequency distibution, mean, median, standard deviation, correlation, and coefficient of correlation.

**Social and Legislative Responses to Nuclear Waste Disposal**

William Lawless (Math) and Ephraim Williams (English), Paine College, Augusta, GA 30910. Casebook of readings, approximately 220 pages; library research guide; videotape. Module originally developed as research paper exercise for freshman composition class.

The casebook is divided into three sections (1) The U. S. Department of Energy Waste Management Plan, (2) The Legislative Response, and (3) High-Level Radioactive Waste Tank Corrosive Pitting at the Savannah River Plant. Readings include memoranda, proceedings, reports, testimony, and transcripts from the U. S. DOE, the Government Accounting Office, court cases, the U. S. House of Representatives Subcommittee on Energy Conservation and Power, as well as pertinent House bills and articles from general and technical publications. An overview provides information about how each section is to be used; for each section, opposing viewpoints are represented and readings are typically arranged in an order that begins with general descriptions and concludes with more technical presentations.

**Findings**

<u>The Tangible Outcomes: Module Documents</u>:

Teams from eleven of the twelve active RETLA colleges completed module documents; no team from any of the four colleges receiving large grants from the Foundation completed any module materials.

--Participating faculty completed 6 of the 20 modules begun in the First Phase, 1984-85.

--Participating faculty completed 5 of the 6 modules begun in 1985-86.

As the overview (p. 7) indicates, one-third of the teams which completed a student handbook also completed a faculty handbook. Teams typically wrote faculty handbooks after field-testing the student handbooks. Thus, teams beginning modules in 1985 did not have sufficient time to complete faculty handbooks.

One-half of the modules include mathematical formulations, computer use, and audio-visual materials (from simple slides to a professionally-prepared video-tape of sophisticated computer software programs).

Nine of the eleven modules address some given technology--and its sociocultural context--as the primary subject; the remaining two use computer software to study certain traditional liberal arts subjects.

The modules exhibit great range in the number of class periods involved, in the length of documentation, and in the degree to which students are engaged in quantitative and/or engineering procedures. This range correlates with two factors: the context for the module and the individual teams.

--Where the context is a survey course with large enrollments, the module is primarily descriptive, with little opportunity for students to engage in calculations or modeling. Where the context is an elective course with a small enrollment, the module tends to be dense, with many opportunities for engaging students in hands-on activities.

--Some module teams resisted suggestions offered by the consultants and the editorial group aimed at making the modules adaptable by other instructors. The present form of the Tuskegee "Computer Logic" module, for example, is too dependent on material covered in a specific course to be used by other instructors.

The documentation of the modules enables other faculty to share in their use and to participate thereby in further faculty development.

--Two modules generated at South Carolina State College ("The Industrial Revolution" and "The Pill") were presented this year in a large, multi-section course in the humanities at SCSC, in which faculty members from different academic departments led the discussion sessions for each module.

--The authors of "Art and Mathematics" at Bennett College presented the module to eight faculty colleagues who played the role of students and critiqued the module. Extensive revision ensued.

The documentation also enables a module to be presented to other students at other colleges. This procedure was tested with "Interfacing Mathematics and Technology with Design and Architecture," developed at Morris Brown.

Lee Ransaw (Art) and Abiola Lawal (Mathematics) tested their module concurrently at Clark and at Spelman during the Concluding Phase of the RETLA program. The testing involved a total of eighteen students enrolled in art history (at Spelman) and studio design (at Clark). Ransaw's report of the procedure (attached as Appendix 6) offers an account of the experience that the students and teachers had with the module. Among other observations, Ransaw writes that:

--the art history students were apprehensive of the mathematical abstractions but were able to perceive the functional relation of the mathematical formulations to the architectural principles of the arch, and

--the design students were able to solve the math problems and convert two-dimensional drawings to three-dimensional structures.

Ransaw also reports that both classes also needed more time to complete all assigned tasks than had been anticipated. (This observation confirms a common experience of the authors of virtually all of the modules.)

## The Intangible Outcome: Faculty Development

Faculty development is a process involving many learning procedures. The most sustained of these procedures in the RETLA program was the editorial review and redrafting of the handbooks that described the modules. Most of these handbooks represent third or fourth drafts, and each draft was typically a substantive revision of its predecessor. The drafting was a strenuous discovery process.

The review procedure engaged the members of each team with both their consultant(s) and the editorial group at Georgia Tech and, inevitably, with one another. Each draft of a handbook represented its authors' best understanding of the module at that stage, and the review, carefully documented, typically extended that understanding by clarifying the implicit problems in the draft. Each draft was reviewed for its substantive focus and coherence, its readability, and its pedagogical congruence. Problems in readability were often symptomatic of substantive errors or misunderstandings; a lack of congruence among the concepts to be presented, the tasks to be assigned, and the skills to be assessed was often revealed by a given sequence of episodes in the module that needed to be changed.

Such problems were variously addressed in phone conversations, correspondence, visits to the team's campus, or the team's visit to Georgia Tech. The effort was intensive, and it yielded two significant outcomes: a new perspective of peer review and some continued activity in-kind.

The peer review procedure entailed an assessment by colleagues, which was a new experience for many of the participating faculty. Moreover, although the assessment was always specific to the product, the learning that ensued concerned the process of building other documents, other modules. As a result of the review procedure at least three of the faculty authors engaged in building second modules. These teachers have learned new strategies of problem definition and of information transfer, and their new skills have already grown beyond their original products.

## COMPUTER CONSULTING

### Objectives in Context

During the Needs Assessment (1983-84), the RETLA colleges requested that Georgia Tech establish a computer consulting service to provide advice, when requested by RETLA colleges, on setting up and operating maintenance capabilities for first echelon computer networks, setting up computer labs or terminal clusters, developing introductory courses for computer users, advising students and faculty on microcomputer acquisition, and assembling software libraries. In response to this request Professor Donovan Young (Industrial and Systems Engineering, Georgia Tech) undertook these responsibilities.

During the First Phase, at the suggestion of James Koerner, Professor Young expanded the computer consulting effort to include assistance in the preparation of proposals to third parties: to vendors for hardware and to foundations for additional funding. Proposal development led, in turn, to a sustained inquiry into how computers can best be used in liberal arts classrooms.

These exploratory activities were shaped, in part, by the goals of the New Liberal Arts program and, in part, by the special characteristics of RETLA colleges:

--At the outset of NLA discussions, the Foundation emphasized that support of computer-aided instruction (CAI) was not the intent of computer-related NLA activity. Another prohibition, implicit but unanimous, was that learning about computers per se, desirable as that might be in a liberal arts curriculum, was to be considered at most a side benefit. There were to be no RETLA "computer camps" or programming courses.

--Baseline computer surveys, conducted during the needs assessment (1983-84), indicated that at most RETLA colleges liberal arts students and teachers did not have easy access to microcomputers. In some cases, microcomputers were dispersed across campuses and dedicated to other users; in most cases, colleges simply lacked the hardware.

### Procedure

The RETLA computer consulting effort involved two kinds of activities:

--on-going consulting with individual colleges (answering questions, reviewing planning documents, helping design labs, and making recommendations on computer purchases, maintenance and software)

--development of joint proposals, first, to meet needs shared by all RETLA colleges and, second, to meet needs shared by subsets addressing narrower problems.

For this second activity, the procedure was to begin with surveys and then continue with draft proposals for review by the RETLA Advisory Board and colleges:

Word processing labs: In October 1984, the consulting team surveyed computer needs and resources at RETLA colleges to develop baseline information for proposals to computer vendors and foundations. The team found that the preferred and most cost-effective way to bring computer experience to all students was through microcomputer-equipped labs for freshman composition courses. These labs could be used primarily at first for word processing in composition courses. Such activity would develop new users who could then learn to work with other software for various courses. In this manner, general purpose labs could evolve.

After its November meeting with representatives from Apple Computers, the Advisory Board asked the team to prepare guidelines for the fair and simple allocation of hardware in its proposals to vendors. Presidents of eleven RETLA colleges endorsed the Board's guidelines. In February 1985, the Board sent its proposal to Apple Computers; Apple did not fund the proposal, citing microcomputer market conditions. The Foundation attempted to interest other potential sponsors in the proposal, but without success.

Studio Art Labs: In March 1985, twelve RETLA colleges joined in endorsing a joint proposal for computer art facilities--a high resolution color graphics machine in each design class. Here again, software development would not be required, and costs are rapidly declining. Potential sponsors were contacted, but without sponsorship, RETLA colleges did not submit a formal proposal.

Micro-VAX Computers: Through the Foundation, RETLA was invited by Digital Equipment Corporation to submit proposals for acquiring Micro-VAX computers at a deep discount, with the proposals to result in development of software that could be used at other colleges. The vendor's main aim was to bolster the catalogue of academic software that would run on the Micro-VAX, a new machine.

With faculty at North Carolina A and T, the team drafted a proposal for a 16-station Micro-VAX system. Detailed discussions were held with ten other RETLA college faculty groups, but in these cases we declined to submit proposal because of the potential sponsor's reluctance to support any faculty who did not have a proven track record in software development. The potential sponsor subsequently withdrew entirely.

After preparing proposals to meet these general needs and after negotiating with several potential sponsors, the consulting team turned to specific needs and to proposals that would involve software development that could be accomplished by small teams without previous software development experience. The proposals were to be limited to those that would provide a definite capability in support of a specific need in an identified course. The team's "Checklist for Class-Support Software Initiation" outlines the process of seeking a viable opportunity for beneficial use of a computer; it also lists steps in initiating a class-support idea, and an 18-point preliminary planning procedure that would provide the core of a proposal.

Copies of all RETLA computer proposals and supporting documents are included as sixteen exhibits in Appendix 7.

## Findings

The Computer in the Liberal Arts Classroom: The computer can best serve the liberal arts classroom as an incidental tool, whose capabilities can appropriate work that is already being done awkwardly or tediously or to do work of undoubted potential benefit that is impossible without the computer.

There are many opportunities, and they can be divided into two broad categories: use of the computer as a task engine or as a model exerciser. Word processing is a good example of using the computer as a task engine; document preparation with extensive revision--the specific aim of English composition pedagogy--can benefit greatly from electronic editing, cutting, pasting, revising, rearranging, and so forth, avoiding the time-wasting and error-introducing process of retyping passages. But model exercise is probably the richest potential use of computers in the humanities. If a student is to learn about a system that is difficult to demonstrate or exercise directly, a computer program that simulates its behavior can be very useful.

Computers and RETLA Colleges: It is disappointing that no sponsor for any of the RETLA proposals has been found. People unacquainted with the special needs of RETLA colleges evidently find it difficult to see that there is a need for support. Because RETLA colleges lack hardware, RETLA faculty members are ironically in no position to demonstrate their needs. As long as vendors and foundations tie software development to deep discounts or gifts, RETLA colleges will lag behind more well-endowed colleges.

## ADVISORY BOARD

### Objectives in Context

The RETLA Advisory Board evolved from the Ad Hoc Editorial Committee, which was selected at the November 1984 Editorial Workshop by RETLA college representatives to draft and circulate the needs assessment report and companion proposal to the Foundation.

Originally proposed as an elected board to represent RETLA colleges to other funding sources and to hardware and software companies and to provide program assistance to individual colleges in their efforts to implement RETLA programs, the Board developed in direct relation to RETLA activities. As a result, RETLA faculty voice in project management increased, and networking among RETLA colleges expanded.

### Procedure

The 1984-85 Board met seven times; the 1985-86 Board met four times.

The 1984-85 Board established procedures for its own succession. Under this plan, faculty representatives from RETLA colleges actively involved in RETLA activities selected two Board members from each of three geographical regions: west (Albany State, Dillard, Rust, Tuskegee), central (Morris Brown, Paine, Savannah State, Spelman), east (Bennett, North Carolina A and T, North Carolina Central, South Carolina State). The first elections took place in April 1985; second elections had been scheduled for April 1986.

During the First, Second, and Concluding Phases, the Board monitored the evolving nature of the project and recommended modifications in project activities. The Board spent a lot of time interpreting the Foundation's directives with respect to RETLA membership and funding. The Board also helped draft, reviewed, and contributed to all reports and proposals, including this one. During the Second Phase, the Board also monitored the selection of module topics and the progress of module teams.

Networking among colleges was consolidated through the Board's planning and drafting of joint proposals (including some or all RETLA colleges) for computer applications in art, composition, mathematics and for distribution policies (for RETLA resources and products). Some of these joint proposals required substantial institutional commitments of resources on the part of

RETLA colleges, and the Board was instrumental in securing these commitments. The Board also worked out a plan for apportioning any new income to RETLA colleges for computer development based on relative resources of the twelve RETLA institutions.

For a complete record of the RETLA Advisory Board's activities, see the RETLA Advisory Board minutes (Appendix 8) and the RETLA Newsletters (Appendix 9).

**Findings**

In its final meeting (April 1986), the Board identified two aspects of the project which it considered especially worth continuing:

--the team concept (in which RETLA faculty and Georgia Tech faculty collaborate as peers), and

--the network concept (in which all participating institutions pool their resources).

# NEWSLETTER

## Objectives

During the Needs Assessment, RETLA colleges proposed that the Georgia Tech project team prepare and distribute a newsletter, which would have two principal functions: to facilitate collaboration among RETLA colleges and to foster collaboration among the RETLA colleges and Georgia Tech.

## Procedure

The first RETLA *Newsletter* appeared in March, 1985; the second, in May, 1985. These and two subsequent issues (see Appendix 9) reported RETLA and RETLA-related activities and supplied bibliography updates for RETLA projects.

During the Second Phase, the first *Newsletter* appeared in October; with the termination of funding, plans for other issues were cancelled. These plans included a series of six 1,800-word essays that had already been commissioned. These essays were being prepared by RETLA college and Georgia Tech faculty members on recent changes in the liberal arts and engineering at their respective institutions.

The final *Newsletter* appeared in May, 1986.

## Findings

The *Newsletter* served to clarify the interrelation and progress of RETLA activities to several audiences: to participants in any one of the activities; to RETLA college administrators and colleagues of RETLA colleges faculty participants; and to other NLA members and other readers interested in comprehensive programs in faculty development.

APPENDICES

Appendix 1: 1984 Needs Assessment Report/Proposal

Appendix 2: RETLA College Participants

Appendix 3: Georgia Tech Participants

Appendix 4: Technology Module Guidelines:
Engineering and Editorial Review

Appendix 5: Technology Modules

Appendix 6: Module Field-testing Report
(Lee Ransaw, Morris Brown)

Appendix 7: Computer Consulting Report

Appendix 8: RETLA Advisory Board Minutes

Appendix 9: RETLA <u>Newsletters</u>

APPENDIX 1: 1984 Needs Assessment Report/Proposal

# RESOURCEFUL EXCHANGE: TECHNOLOGY AND THE LIBERAL ARTS

FINAL REPORT
9 APRIL 1984

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Resourceful Exchange: Technology and the Liberal Arts

Final Report
9 April 1984

INTRODUCTION

This Final Report culminates ten months of needs assessment activities undertaken by Georgia Tech on behalf of the Alfred P. Sloan Foundation.

We proposed to the Foundation "to support a cooperative, interactive effort to determine the needs and possibilities of informing the liberal arts with technology," in particular, the curricula of historically Black liberal arts colleges in the Southeast.

Our activities have occurred in three phases:

--planning and project design

--workshops

--reporting and proposal development.

This Report itemizes important activities within each of these phases and concludes with a proposal for addressing the needs we have identified.

THE PLANNING AND PROJECT DESIGN PHASE

Representing the Foundation, Dr. Dwight Lahr met with the Georgia Tech project staff, with representatives from local liberal arts colleges, and with representatives from SREB.

These meetings occurred on 2 June. Their purposes were:

--to gather information about other faculty development projects among Black liberal arts colleges

--to initiate a dialogue with liberal arts college faculty

--to review needs assessment activities.

These meetings led to:

--a list of Black liberal arts colleges to be invited to participate in the needs assessment project

--clarification of the role of Georgia Tech and the liberal arts colleges in the needs assessment

--adjustment of workshop organization to accommodate the need for increased participation of liberal arts faculty in the preparation of the needs assessment documents.

Between 2 June and 4 August, Georgia Tech invited thirteen additional colleges to participate, briefing college presidents, who, in turn, named faculty representatives.

The Georgia Tech team recruited additional Tech faculty to assist in workshops.

WORKSHOP PHASE

Georgia Tech hosted two Preliminary Workshops (28-30 September 1983 and 19-21 October 1983) designed:

--to model the ways technology might be delivered to liberal arts faculty

--to collect liberal arts college faculty responses.

Georgia Tech hosted a third, Editorial Workshop (9-11 November 1983) designed:

--to collect and categorize project ideas generated at the eighteen liberal arts colleges after the Preliminary Workshops

--to explore in detail the possibilities for networking and/or forming an association.

At the close of the Editorial Workshop, liberal arts college representatives elected an Ad Hoc

Editorial Committee to permit greater participation by the liberal arts colleges in preparing the final report.

REPORTING AND PROPOSAL DEVELOPMENT PHASE

The Ad Hoc Editorial Committee met three times--in December, January, and March--to revise successive drafts of this report and proposal.

The Committee members drafted sections of the Interim Report, polled all RETLA college representatives regarding project priorities, and revised the Interim Report accordingly.

In addition to compiling and distributing the results of the Ad Hoc Editorial Committee deliberations, the Georgia Tech project team sought commentary and advice from key Sloan project personnel and advisors.

Georgia Tech faculty also volunteered their time and services as consultants to Spelman, Morehouse, Morris Brown, Paine, and South Carolina State, providing advice on various aspects of their competitive proposals.

This Final Report is thus the result of a collaborative, interactive process in which the participation of the liberal arts colleges has been steadily increasing. The proposed activities indicate that such participation is to continue.

PROPOSED ACTIVITIES

We propose to meet the shared needs identified throughout this project.

Together we perceive the need for three kinds of program activities:

--designated workshops (for selected colleges within the RETLA group) to address specific problems

--coordinating activities (including all RETLA colleges) to sustain and coordinate the workshops

--Advisory Board activities to provide program assistance and to lobby on behalf of RETLA colleges for additional funding.

We propose a multi-year project period, with the attached cost analysis of proposed activities serving as the basis for a first year budget.

## THE DESIGNATED WORKSHOPS

The most critical activities for both faculty development and curriculum development are

--the preparation of technology modules for existing liberal arts courses

--the updating of required service courses in mathematics

--the updating of composition courses by word processing on microcomputers.

We propose faculty development workshops to provide liberal arts faculty with the information and assistance needed to prepare these course materials.

## FACULTY DEVELOPMENT WORKSHOPS: THE RANGE OF FORMATS

Technology module workshops should be 10-day workshops, at Georgia Tech, in which liberal arts faculty work jointly with technological resource persons to develop module materials. The 10-day format is appropriate for this activity because it requires sustained collaboration among faculty members from liberal arts and technological institutions. Such collaboration requires mutual education. Necessarily, it is a discovery process which takes time to develop.

Other workshops can be flexible in terms of length, location, and scheduling during the year. We need to develop on each liberal arts campus a critical mass of faculty members committed to solving the problems outlined in the Foundation's New Liberal Arts. This development cannot be achieved by simply bringing individual faculty from each college to Georgia Tech each summer.

Workshops should be geographically clustered wherever possible to maximize faculty participation.

TECHNOLOGY MODULE WORKSHOPS

The technology modules for liberal arts courses (cited above) should be self-standing units, of perhaps one-to-three weeks' length during the quarter or semester.

These modules should stress engineering methods and tools (the use of quantitative reasoning, computation, engineering), possibly through case studies; they should include audio-visual materials, hard copy, and/or soft copy.

The following modules have been selected by participating colleges in a referendum procedure:

(1) General Microbiology
--to show the applications of applied mathematics and elementary statistics to microbial processes

(2) Quantitative Methods in Engineering
--to demonstrate the use of concepts such as static equilibria, conservation of energy, conservation of mass, and momentum in engineering approaches to social problems

(3) Information Technology
--to bring the new information technologies into historical context by studying the effects of telegraph, typewriter, telephone, and computers on office work and management

(4) Technology Assessment and Forecasting
--to develop analytic skills in the procedures of assessment and forecasting

(5) Mathematical Applications

--to demonstrate the role of mathematics in consumer, business, and political economies

These modules should be developed as a technology module "bank," so that all participants can exchange, test, and modify materials. (For detailed project descriptions, see Appendices A-E.)

Technology modules are ideal starting points for the reconsideration of technology by liberal arts faculty because modules do not entail new course approval. With modules integrated into liberal arts courses, there would be no loss of current students from current liberal arts courses.

Technology modules would also provide opportunities for liberal arts faculty to continue the liberal arts tradition of providing the bases for understanding and integrating different finds of historical events, be they political, economic, aesthetic, or technological.

WORD-PROCESSING LABORATORY WORKSHOP

Computer technology has altered the way educators believe composing and communication take place. Although more and more students are expected by employers to be trained in electronic composition, colleges have been slow to provide such training. Since having the hardware does not automatically result in conceptually appropriate course instruction, we propose a workshop in setting up laboratories in electronic composition.

These labs should be supported by new instructional materials that stress two skills: (1) word-processing on the microcomputer, and (2) the manipulation of data files. (For detailed project description, see Appendix F.)

THE COORDINATING ACTIVITIES

The coordinating projects will sustain and coordinate the workshops; these coordinating activities should include a computer consulting team, a literature search service, a newsletter, and a limited, centralized administration.

The role of the administrative or coordinating staff would be (1) to facilitate follow-on and assessment activities that do not fall within the time-frame of the workshop periods, and (2) to prepare and disseminate workshop deliverables. The coordinating activities would also include logistic support for the workshops.

## THE ADVISORY BOARD

We propose an Advisory Board to represent RETLA colleges to other funding sources and to hardware and software companies and also to provide program assistance to individual colleges in their efforts to implement RETLA projects.

The Advisory Board should consist of six faculty elected by RETLA college representatives, two faculty from the Georgia Tech project team, and one representative each from the Southern Region Education Board and the Sloan Foundation.

## COST ANALYSIS

A Cost Analysis for these projects follows this Report. The Cost Analysis combines costs of resource services and expenses for participants and members of the Advisory Board.

## CONCLUSION

In conclusion, we have identified during our needs assessment period several kinds of needs which can be addressed through a combination of workshops and coordinating activities.

Our priorities lie in faculty development workshops aimed at specific problems in specific liberal arts courses, and in a networking program to reenforce and multiply our individual efforts.

The advantages of these collaborative efforts are many. All RETLA products will have standard documentation and evaluation so that they can readily be shared. And the effort we are prepared to invest at our individual campuses will be reenforced in every way by the efforts of the group throughout the range of project activities.

COST ANALYSIS SUMMARY

Designated Workshop Activities

| | |
|---|---|
| Developing Technology Modules | $51,721 |
| Developing Word-processing Labs | 21,444 |
| Workshop Activities Subtotal | 73,165 |

Coordinating Activities

| | |
|---|---|
| Computer Consulting Team | 20,664 |
| Newsletter | 14,718 |
| Literature Search Service | 4,976 |
| Preparation and Dissemination of Project Deliverables | 31,120 |
| Coordinating Activities Subtotal | 71,478 |

Advisory Board Activities

| | |
|---|---|
| Meetings and campus visits, travel, administrative support | 37,317 |
| Advisory Board Subtotal | 37,317 |
| Total Direct Costs | $181,960 |

COST ANALYSIS FOR EACH ACTIVITY

Workshop Activities:

Developing Technology Modules: We propose the preparation of five technology modules, which is the basis for the unit cost of each module as stated below. We propose a 10-day workshop, with suitable preparation, in summer, 1984. This would be followed by a period of testing each module in at least one college during the academic year. The results of this field testing would be basic preparation for a 3-day workshop for assessment and revision, to occur during spring, 1985.

| | |
|---|---|
| Preworkshop preparation (includes coordinator, 5 Georgia Tech faculty participants, support staff) | 5,605 |
| 10-day workshop to prepare 5 modules | 37,145 |

(includes stipend, travel, per diem expenses for 6-8 liberal arts faculty; 6 Georgia Tech faculty, support staff)

| | |
|---|---|
| Field testing | -- |
| 3-day assessment workshop (includes travel and per diem expenses for 6-8 liberal arts faculty; 4 Georgia Tech faculty, support staff) | 8,971 |
| Subtotal | 51,721 |
| Unit cost/module | 10,344 |

Developing Word-processing Labs: We propose a 5-day workshop to train liberal arts faculty to use microcomputers, to master word-processing, to provide "state of the art" information on the use of the microcomputer for student composing, and to train liberal arts faculty in techniques for establishing an electronic writing lab.

| | |
|---|---|
| 5-day workshop (includes coordinator, instructional personnel; stipend, travel, and per diem expenses for 12 liberal arts college faculty; materials, supplies) | 21,444 |

Coordinating Activities

Computer Consulting Team: We propose to establish a pool of computer consultants from among personnel of Georgia Tech and RETLA campuses to provide advice, when requested by RETLA colleges, on setting up and operating maintenance capabilities for first echelon computer networks, setting up computer labs or terminal clusters, developing introductory courses for computer users, advising students and faculty on microcomputer acquisition, and assembling software libraries.

| | |
|---|---|
| 3 Major service requests (includes personnel, 2 site visits, per diem, travel at $3,140/request) | 9,420 |
| 6 Minor service requests (includes personnel, 1 site visit, per diem, travel at $940/request) | 5,640 |
| 36 Limited advice requests (includes personnel, report at $139/request) | 5,004 |

| | |
|---|---|
| Telephone, supplies | 600 |
| Subtotal | 20,664 |

Newsletter: We propose a 6-page newsletter to appear 6 times/year which would report RETLA and RETLA-related activities, supply bibliography updates for RETLA projects, include special reports on information technology updates, history of technology and technology assessment updates, as well as updates on curriculum developments in quantitative studies for non-math and non-science students.

| | |
|---|---|
| Newsletter (one issue) (includes production, printing, mailing, telephone; editorial and support staff) | 2,453 |
| Newsletter (six issues) | 14,718 |

Literature Search Service: We propose to make the Georgia Tech Price Gilbert Library's computerized data-base search service available at cost to RETLA colleges.

| | |
|---|---|
| Cost for search to 2 data bases (includes search, processing, handling, mailing, personnel) | 92 |
| 3 Searches from each of 18 RETLA colleges | 4,976 |

Preparing and Disseminating Project Deliverables: We propose the preparation of a teaching guide, student syllabi, supporting materials (including audio-visual) for each technology module. We propose development of a standard documenting procedure so that modules can be readily exchanged and adapted.

| | |
|---|---|
| 300 Technology module packages/per module (includes 60 pages, supporting materials; editor, support staff; telephone, materials and supplies; printing, production, mailing) | 6,224 |
| 5 Module packages | 31,120 |

Advisory Board: We propose an Advisory Board to represent RETLA colleges to other funding sources and to hardware and software companies and to provide program assistance to individual colleges in their efforts to implement RETLA projects.

This Advisory Board will consist of six faculty members elected by RETLA college representatives, two faculty from the Georgia Tech project team, and one representative each from SREB and the Sloan Foundation. The Board will meet three times each year, at Georgia Tech, and will be supported with funds to permit twenty visits by individual Board members to RETLA colleges each year.

| | |
|---|---|
| Honoraria for meetings and campus visits<br>($100/day x Board members x 3 meetings;<br>$100/day x 20 visits x 2 day visit) | 7,000 |
| Administration and secretary | 14,007 |
| Travel | 16,310 |

## APPENDIX A: TECHNOLOGY MODULES IN GENERAL MICROBIOLOGY

**Description:** Workshop will be designed to assemble biology/microbiology instructors in order to develop laboratory/discussion demonstration materials to support instruction in a general microbiology (or biology) course. Stand-alone modules will be developed to show the applications of applied mathematics and elementary statistics to a microbial process such as growth. Skills to be developed include: (1) analysis and solution of numerical problems, (2) translation of numerical into word problems (and vice versa), (3) compilation and organization of data in tables, graphs, histograms, (4) data interpretation, (5) computer modelling of the growth of micro-organisms.

**Disciplines:** Biology and microbiology

**Colleges:** All RETLA colleges

**Deliverables:** (1) Several modules on cultural, environmental, and nutritional factors upon microbial growth, each showing the application of microbiological principles to the solution of problems of society, e.g., production of single cell protein as food/feed supplement, production of natural substances as therapeutic products, genetic engineering of microorganisms for the manufacture of drugs, (2) preparation of exercises to be used as supplemental materials in support of instruction or as mini-research projects for students.

**Follow-on:** Field testing; 3-day assessment workshop

**Format:** Standard 10-day summer workshop

**Personnel:** Standard

**Benefits:** (1) Infusion of quantitative literacy and analytic reasoning into microbiology and biology courses, (2) computer skills for students and teachers, (3) enrichment of general microbiology courses in a manner that enhances the competence of students and motivates them to learn more in this area, (4) application of engineering principles to clarify processes in microbial technology.

APPENDIX B: QUANTITATIVE METHODS IN ENGINEERING

| | |
|---|---|
| Description: | In responding to societal needs, engineers design facilities by using existing knowledge, and by organizing and using personnel, machines, materials, and money in ways that assure efficiency and safety. Among examples of engineering approaches to societal problems, that of water resources could be used as a case study. A water resource module project would introduce the utilization of existing information such as maps and historical data. The data could be treated in turn to introduce statistical tools as to its "goodness." Engineering concepts of static equilibria, conservation of energy, conservation of mass, and momentum would be used in a feasibility analysis. Other case studies from other engineering disciplines--Electrical Engineering, Mechanical Engineering, and Chemical Engineering--will also be developed. |
| Disciplines: | All liberal arts disciplines |
| Colleges: | All RETLA colleges |
| Deliverables: | Module with appropriate supporting materials, including audio-visual tapes of technology in Georgia Tech hydraulics lab and other engineering labs |
| Follow-on: | Field testing, 3-day assessment workshop |
| Format: | Standard 10-day summer workshop |
| Personnel: | Standard |
| Benefits: | Participants in the module development workshop would greatly benefit from direct interaction with engineering activities and would have first-hand knowledge in quantitative methods. |

APPENDIX C: INFORMATION TECHNOLOGY

| | |
|---|---|
| Description: | A module will be prepared on information technology for history teachers to use to illuminate the current information/computers/communication flowering. The aim will be to bring the new information technologies (e.g., office automation) into historical context by studying the already-experienced effects of telegraph, typewriter, telephone, carbon paper, mimeograph, shorthand, etc., in the rise of information work (office work) and management-at-a-distance. The rise of speech, writing, and printing will first be traced to establish the broader context; then each of the office technologies will be discussed. Finally, students will attempt to understand and extrapolate current computer and communication developments. |
| Disciplines: | History, either world or American, covering especially the second half of the nineteenth century |
| Colleges: | All RETLA colleges |
| Deliverables: | Self-contained materials suitable for being taught by any history teacher |
| Follow-on: | Field testing, 3-day assessment workshop |
| Format: | Standard 10-day summer workshop |
| Personnel: | Standard |
| Benefits: | Introduction of the study of current developments in information technology into the undergraduate curriculum. |

## APPENDIX D: TECHNOLOGY ASSESSMENT AND FORECASTING

| | |
|---|---|
| Description: | This workshop allows participating faculty to develop a basis of expertise in impact assessment and forecasting techniques which can be used for such purposes as: (1) developing a module for a course in such areas as history, contemporary society, or technology and society, and (2) developing joint faculty and student research projects on the historical, current, and/or future impacts of technologies. The ten-step approach of _A Guidebook for Technology Assessment and Impact Analysis_ (Porter, Rossini, et al.) will be used: bounding the inquiry, technology description, technology forecasting, social context description, social context forecasting, impact identification, policy analysis, and communication of results. Some sample technologies include: robotics, the birth control pill, genetic engineering, space exploration, office automation, and microelectronics. |
| Discplines: | Natural and social sciences, humanities |
| Colleges: | All RETLA colleges |
| Deliverables: | Self-contained teaching materials |
| Follow-on: | Field testing, 3-day needs assessment workshop |
| Format: | Standard 10-day summer workshop |
| Personnel: | Standard |
| Benefits: | Incorporation of the study of the consequences of technologies into undergraduate instruction and research; instruction of participating faculty in impact assessment and forecasting techniques |

## APPENDIX E: MATHEMATICAL APPLICATIONS MODULES FOR NON-SCIENCE MAJORS

Description: This workshop is designed to bring together mathematics faculty in order to develop new materials to be used in freshman level math courses required for non-science students. Stand-alone modules will be created to show the application of certain elementary mathematical concepts to problem-solving in the social sciences and humanities. Some modules will stress the role of mathematics in consumer, business, and political economies. Four kinds of skills will be stressed: (1) analyzing and solving word problems, (2) displaying data graphically and interpreting graphs, (3) compiling and analyzing data using elementary statistics, and (4) decision-making based on quantitative results. As one example, a module may extend basic algebra to the area of graphing linear inequalities. This new skill would then be applied to solve problems in economics where an optimum value must be determined.

Disciplines: Business, economics, political science, psychology, history

Colleges: All RETLA colleges

Deliverables: From the workshop should emerge a set of modules, each showing the application of mathematics to solve a particular type of problem. A typical module might do the following: (1) list skills prerequisite for its use, (2) present a problem with background material, (3) show how a mathematical model can be created for the problem, (4) give a solution, (5) pose related problems which may be used as exercises for students, and (6) give references for further study on the subject.

Follow-on: Participants must return to their schools and pilot a combination of modules that results in at least 5 weeks of class time in a first college level course for non-science majors. During the following term, the piloting should be extended to other sections and instructors. Comments/suggested revisions should be sent to the RETLA office and copies sent to module authors for updating. After the second piloting a plan should be devised for permanently updating the courses at participants' schools.

Format: Standard 10-day summer workshop

Personnel: Standard

Benefits: The proposed course modules will demonstrate to social science and humanities students the relevance of math in their disciplines and lives by showing how skills in problem-solving and decision-making are improved by improving quantitative skills.

APPENDIX F: DEVELOPING WORD-PROCESSING LABORATORIES

Description: The microcomputer is the ideal tool for teaching students that good writing, as the latest data support, is "process." The proposed workshop would use this tenet throughout and would begin (1) with a survey of the microcomputer in the teaching of composition across the country. The following additional segments would be covered: (2) word-processing on the IBM PC using the "Easy Writer" software package, (3) storage and retrieval of data--the art of electronic composing, (4) student strategies--pre-writing, the paragraph, the essay, the nine rhetorical modes, the research paper, (5) a survey of other software for word-processing (e.g., "Word Star") and composing (e.g., UCLA's "WANDA"), (6) establishing word-processing labs.

Disciplines: English (can be adapted for other disciplines)

Colleges: All RETLA colleges

Deliverables: (1) "State-of-the Art" information on the use of the computer in the teaching of composition, (2) hands-on use of the IBM PC, (3) mastery of word-processing, (4) current strategies for student composing at the microcomputer, (5) techniques for establishing a word-processing lab.

Follow-on: Teachers will return to their respective campuses to establish labs or update existing facilities and will convert their present courses to use the microcomputer. Workshop directors will serve as consultants, as needed, particularly to adopt the workshop techniques to other kinds of microcomputers.

Format: 5-day workshop, frequency determined by need, located where colleges are geographically clustered and where a lab is in operation (e.g., at Bennett College, Greensboro, NC)

Personnel: Workshop director, assistant; 10 participants

Benefits: (1) To introduce faculty and their students to a technology now considered the best hope for eliminating writing deficiencies, (2) to enhance the marketplace skills of students

APPENDIX 2: RETLA College Participants

(1) Participating Colleges (12):

Albany State College (Albany, GA)
Bennett College (Greensboro, NC)
Dillard University (New Orleans, LA)
Morris Brown College (Atlanta, GA)
North Carolina A and T University (Greensboro, NC)
North Carolina Central University (Durham, NC)
Paine College (Augusta, GA)
Rust College (Holly Springs, AL)
Savannah State College (Savannah, GA)
South Carolina State College (Orangeburg, SC)
Spelman College (Atlanta, GA)
Tuskegee Institute (Tuskegee, AL)

(2) Participating RETLA College Faculty (51):

Albany State College:

George Hill (Chemistry)
James Hill (English)
Leonard Minter (English)
Veula Rhodes (History)
Don Williams (Mathematics and Computer Science)

Bennett College:

Alma Adams (Art)
Lee Ponting (Mathematics)
Ray Treadway (Mathematics)
Helen Trobian (Philosophy)

Dillard University:

Kathryn Aultman (Chemistry)
Violet Bryan (English)
Gilbert Rochon (Urban Affairs and Public Policy)

Morris Brown College:

Abiola Lawal (Mathematics)
Fred Okoh (Mathematics)
Tyrone Price (Criminal Justice)
Lee Ransaw (Art)

North Carolina A and T State University

Donna Benson, History
Bob Davis, Sociology
Hsin-Yi Lau, Mathematics
Elvira Williams, Physics

North Carolina Central University

Mel Carver, Art
Eugene Eaves, Modern Languages
Kinney Kim, Physics

Paine College

Jacquelyn Hill, Educational Media
William Lawless, Mathematics
Carole Rychly, Mathematics
Marva Stewart, English
Ephraim Williams, English

Rust College

Paul Lampley, Social Sciences
Marjorie Marshall, Freshman Studies
Helen Oliver, Humanities
William Scott, Mathematics

Savannah State College

Obi Emeh, Biology
Jeffrey James, Chemistry
Dorothy Murchison, Mathematics
Ella Sims, Sociology

South Carolina State College

Stan Harrold, History
Maria Ricks, Humanities
Judith Salley, Natural Sciences
Johnnie Sharpe, Humanities
Tom Whitney, Engineering Technology

Spelman College

Lura Allheimer, Biology
Sylvia Bozeman, Mathematics
Marilyn Davis, Political Science
Haywood Farrar, History
Nagambal Shah, Mathematics

Tuskegee Institute

Ben Benford, History
Maurice Graney, Philosophy
John Kitchens, History
Hira Nirang, Computer Science

Francis Taylor, Social Work
Ollie Williamson, Biology

## APPENDIX 3: Georgia Tech Participants

Principal Investigators:

- Mel Kranzberg, Callaway Professor, Social Sciences
- John Lundberg, Callaway Professor, Textile Engineering (1985-86)
- Paul Mayer, Regents Professor, Civil Engineering (1984-85)
- A. D. Van Nostrand, English
- Donovan Young, Industrial and Systems Engineering

Coordinator:

- Jeffrey Plank, English

Consultants:

- Stanley Carpenter, Social Sciences (Philosophy of Science)
- Bernd Kahn, Nuclear Engineering
- John Lundberg, Textile Engineering
- Paul Mayer, Civil Engineering
- Lee Payne, Industrial Design
- Joan Pettigrew, Communications Research Group
- Kevin Phelps, Mathematics
- Alan Porter, Industrial and Systems Engineering
- Luther Roland, Geophysical Sciences
- Frederick Rossini, Social Sciences (Technology Assessment)
- William Sayle, Electrical Engineering
- Terry Sturm, Civil Engineering
- Ray Vito, Engineering Science and Mechanics
- Jay Weinstein, Social Sciences (Technology and the Third World)
- Edward Yeargers, Biology
- Donovan Young, Industrial and Systems Engineering

Southern Regional Education Board Consultant:

- William C. Brown, Senior Program Officer

## APPENDIX 4: Technology Module Guidelines

Engineering Quality Review Questions

Editorial Quality Review Questions for Student Handbooks

Editorial Quality Review Questions for Faculty Handbooks

8 August 1985 REVISED DRAFT

ENGINEERING QUALITY REVIEW FOR RETLA TECHNOLOGY MODULES

1. What technologies does this module focus on?

2. Why should these technologies be presented in this course?

   --What reasons does the instructor give?

   --Are these reasons presented in the written materials?

3. What major engineering concepts are presented in these technologies? (E.g., efficiency, modeling, optimization, fluid flow, structural analysis, feedback, risk analysis, unit operations, etc.)

4. How accurately does the module describe the technology it presents (with regard to both accuracy and coverage)?

   --Verbal description?

   --Visual representation?

5. What are the major mathematical and symbolic representations used in this module?

6. To what extent are these representations carried out by

   --arithmetic calculations?

   --statistical analysis?

   --computer applications?

7. If computer applications are used,

   --what programs are used?

--are the programs developed, or are they purchased?

--what language is used?

--for what computer?

8. How well do the materials link these technologies to other elements in the technolgical system?

9. How well do the materials relate the technologies to social, economic, and/or political contexts?

10. Does the module address both the positive and adverse consequences of the technologies?

Draft

3 September 1985

# Editorial Quality Review for RETLA Technology Modules:

# Evaluating Questions for Student Handbooks

**Brief Descriptive Summary of the Module**

Does this handbook include a brief summary of the module for the student?

**Brief Overview of the Student Handbook**

What is the purpose of the student handbook?

How is the student handbook organized?

**Learning Objectives**

Are the learning objectives of the student handbook stated in a way that enables achievement to be measured or demonstrated?

**Congruence**

Does the substance of the student handbook support the learning objectives? Specifically, do the following parts of the handbook support the objectives, and are they compatible with each other?

--the information to be presented
--the activities assigned to the students
--the evaluation of these activities

**Conceptual Emphasis**

Given the focus on technology, are appropriate concepts sufficiently emphasized?

**Sequence**

Is the logic of the sequence of information self-evident?

**Categories of Information**

Is the information presented throughout the student handbook appropriately categorized? That is, does the response to a specific question include only that information that qualifies as an answer to the question?

**Audience**

What probable questions might the students ask about the student handbook?

Does each section of the handbook address these probable questions?

**Class Hour Presentations**

Does the student handbook clearly indicate the kind of information that will be presented during each class hour?

Does the student handbook provide sufficient explanation as to how this information will be presented?

**Assignments**

Are the assignments appropriately classified (as reading assignments, oral reporting assignments, writing assignments, computer assignments, etc.)?

Is the relationship between the assignment and the course objectives clear?

**Deadlines**

Are all deadlines precisely stated?

**Hands-on Activities**

Are the hands-on activities adequately specified?

**Handouts**

Are all the handouts that are mentioned in the student handbook included in the handbook?

Are all handouts adequately labled?

Is the purpose of the handout stated?

**Evaluation**

Is the means of evaluation adequately specified?

Are the component parts of the evaluation weighted?

**Source References**

Are the assigned and recommended readings completely cited in the bibliography in the handbook?

Is software referred to by title, publisher, and date?

Are photographic slides collectively described or designated by some subject citation?

Draft

3 September 1985

# Editorial Quality Review for RETLA Technology Modules:

## Evaluating Questions

## for

## Faculty Handbooks

### Audience

The audiences for the faculty handbook are:

--prospective instructors of this module in this course in your college, and

--prospective instructors of this module in a different course at your college or at a different college.

Have you accommodated the needs and expectations of these audiences throughout the faculty handbook?

### Brief Descriptive Summary of the Module

What problem or situation does the module address?

How does the engineer define the problem?

How does the engineer solve the problem?

What axiom or scientific principles are entailed in the solution?

### Class Hour Presentations

In addition to the format (lecture, discussion, workshop/lab, field trip) that you have selected for each class hour, what other formats, if any, might be useful?

Have you included in the handbook or referred instructors to materials that will prepare them to deliver the kind of information you suggest?

What suggestions do you have about effective means of presenting the kind of information delivered in each class hour?

### Assignments

Have you included sufficient information about assignments so that other instructors will be able to reproduce them?

What other instructions do students need (beyond those in the student handbook) so that they are adequately prepared to do the assignments?

What function do these assignments have in the module? That is, how do they serve the objectives of the module?

What suggestions do you have about how to increase student participation in the tasks you have designated?

**Review**

What kind of information presented in this student handbook needs little, if any, review?

What kind of information needs to be reviewed?

At what stage, is such review needed?

What suggestions do you have about effective reviewing?

**Evaluation**

What kind of evaluation is appropriate? This distinction may be useful: summative evaluation (Students are given instructions and have one chance to demonstrate achievement) or formative evaluation (Students are given instructions and then, with the guidance of the instructor and/or student peers, students have a number of chances to demonstrate achievement).

What suggestions, if any, do you have about how students can help other students to learn?

What constitutes successful completion of the assignments? That is, what criteria do you use to judge successful completion?

**Resource Faculty and Space**

Does this module require the participation of resource faculty whose disciplines differ from those of the authors of the module?

Does this module require instructional space that is not generally allocated to the course for which this module is written?

What advice can you offer about how to coordinate resource faculty and/or newly allocated space?

**Allocated Time**

Is it possible to teach this module in time slots that are different from the ones you have suggested in the student handbook?

What advice can you offer about how to teach this module in time slots that are different from those designated in the student handbook?

**Equipment and Materials**

What kind of equipment and/or materials will be needed to teach this module?

For which class hour(s) will this equipment or these materials be needed?

What suggestions can you offer about effective use of equipment or materials?

**Course and Module Modifications**

What kinds of courses (in what different disciplines) might accommodate this module?

What modifications, if any, might have to be made in other courses, similar to yours, in order to accommodate this module?

What modifications, if any, might have to be made in this module in order to include it in a course in another discipline?

## APPENDIX 5: Technology Modules

Artistic and Mathematical Components in Visual Composition (Bennett)

The Beginnings of the Industrial Revolution in the Eighteenth Century (South Carolina State College)

Canal Design and the Augusta Canal (Paine)

Computer and Circuit Logic Design (Tuskegee)

Contraceptive Technology: The Pill (South Carolina State College)

Decision Analysis in Ethics (Bennett)

Hazardous Chemicals, Computer Technology, and Public Policy (Dillard)

Interfacing Mathematics and Technology with Design and Architecture (Morris Brown)

Literature as a Form of Technology Assessment (Dillard)

Quantitative and Analytical Concepts for the Social Sciences (Albany State)

Social and Legislative Responses to Nuclear Waste Disposal (Paine)

# Artistic and Mathematical Components in Visual Composition

by

Alma Adams

and

R. Lee Ponting

Bennett College
Greensboro, North Carolina

Student Handbook
for an Instructional Module
in Art and Technology

Resourceful Exchange: Technology and the Liberal Arts (RETLA)

1986

## Rationale

This module provides an early introduction to artistic design and composition and to a stimulating new technological tool: computer graphics. It emphasizes mathematical principles in art, thereby connecting subjects not normally associated with each other.

The basic principles applied throughout the course are introduced and emphasized by this module; thus, it connects to all other subsequent segments of the course. In particular, it supplies a tool which you can use in subsequent design projects if you find the computer graphics medium rewarding. Finally, you may use your completed compositions in a later segment of the course to produce a mural based on grid techniques.

## Learning Objectives

This module will help you:

--to learn to describe the basic principles of design and composition, including mathematical aspects present in the development of two-dimensional composition,

--to expand your knowledge of and experience with available tools to include computer graphics in two-dimensional composition, and

--to demonstrate the successive development of a composition and to describe an ordered sequence of works mounted for presentation.

At the end of the course you should be able:

--to understand the principles and elements of artistic design in two dimensions,

--to employ effective and creative applications of figure/ ground relationships in compositional arrangements,

--to compare various art works, styles, and artists, noting their commonalities and distinctions, and

--to use various tools and media, including computer graphics, in creating artistic compositions and developing design ideas.

## Dimensions of the Module

This module requires fourteen class hours. It consists of seven sessions, each representing two contiguous class hours. Some sessions include two different types of classroom activity; these sessions are sub-divided into "Hour 1" and "Hour 2."

## Instructional Formats

Lecture--three hours
Discussion/Seminar--three hours
Workshop/Lab--eight hours

## Session 1

### Brief Summary of Activities

Prior to Session 1, you will have done a preliminary pencil sketch, incorporating some geometrical forms, such as boxes and circles. In this session, your instructor will review your sketches and provide more examples of the use of these forms in art. Your instructor will also introduce the computer graphics system that will be the major artistic tool for this module.

### Classroom Presentation

Hour 1

The instructor will present some reproductions (prints) and slides for group discussion to help you develop a sense of composition through repetition and variation.

The instructor will also discuss with you individually your preliminary pencil sketches.

Hour 2

Your instructor will introduce a new, and perhaps unexpected, artistic tool: the computer. This introduction will include a demonstration of the mouse, focusing on two of its functions: control of the drawing of shapes and control of the commands of the computer graphics system.

### Classroom Activities

You will be experimenting with figure/ground relationships--the placement of shapes on a background to form a composition. With the materials provided you will be able to work on your composition. As you experiment, try to note your own response to the composition.

For roughly half the session you will use the tools and media provided to produce compositions which are variations or extensions of your pencil sketch. This activity will lead to a comparison of the different media in the design process.

## Instructional Materials

Hour 1

various slides and prints for discussion and comparison

Hour 2

the IBM-PC computer, the mouse, the color monitor, and PC Paint software

## Assignments

Reading

Preble, chapter two, "What is Art?"
Richardson, chapter two, "Grids, Mazes and Modules"

Reporting

Show the instructor the pencil sketches you brought to class. Formulate during the session a working definition of artistic composition.

Composition

Write a one-page definition of composition in art. Your definition should include a few references to the readings or other sources of information that you may have used.

## Assignment Deadlines

Chapter two of Preble and the pencil sketch are due prior to class. The written definition of artistic composition is due at the beginning of Session 2.

## Session 2

### Brief Summary of Activities

Hour 1

You will learn a method of locating points on a Cartesian axis (numbered grid) and practice locating points using pairs of numbers.

Hour 2

You will begin to learn how to use the mouse and the computer graphics package.

### Classroom Presentations

Hour 1

Your instructor will present mathematical information. This information will help you to use numbers to create figures by combining arithmetic and geometry.

Hour 2

Your instructor will provide detailed instruction about the use of the graphics system. This instruction will include a demonstration of the system by the instructor, a discussion of the system's manual, and a presentation of the basic command structure for the system.

Hours 1 and 2

During the first half of each class hour, your instructor will give directions that will help you to create points and shapes on paper and on the computer.

### Classroom Activities

Hour 1

You will create an x-y axis and label equal intervals with numbers. You will then find and plot points on this grid. For more information about this activity, see **Handout #1: Graphing/Plotting Exercise** on pp. 22-23 of this handbook.

Hour 2

You will work in pairs, one operating the computer while the other looks up commands in the computer manual and observes. You will switch roles roughly half way through the session.

**Instructional Materials**

Hour 1

pencil, graph paper, and a ruler

Hour 2

IBM-PC computer, mouse, and color monitor
PC Paint software
IBM-PC PC Paint Manual
diskette

**Assignments**

Reading

PC Paint Manual, chapter three, section one, "Relations and Ordered Pairs"

Handout #1, from Keedy and Bittinger

Composition

Hour 1

Develop a Cartesian axis and locate two-dimensional points relative to it from ordered pairs of numbers.

Hour 2

Draw lines and geometric shapes and fill in areas with color using the computer graphics.

Computer

In Hour 2 begin using color computer graphics as an art tool.

**Assignment Deadlines**

The composition of a sequence of points will be due at the beginning of Session 3.

Learning to be proficient at the computer will require practice outside of class time.

## Session 3

### Brief Summary of Activities

Hour 1

You will extend the mathematical calculations in the previous session to the production of geometric shapes.

Hour 2

You will use the computer to begin to design, modify, and create a composition.

### Classroom Presentations

Hour 1

Your instructor will show you examples of the use of an algebraic expression for creating a geometric design. (This is the beginning of analytic geometry.)

Then you will be given a formula and asked to generate x-y pairs of numbers and to plot these pairs on an axis.

Hour 2

Your instructor will encourage you to explore all aspects of the graphics package (menu options).

### Classroom Activities

Hour 1

Given an algebraic equation of the form $y = f(x)$, you will generate pairs of numbers $(x,y)$. Those numbers can be transferred to a grid to develop a shape. At least one variation of $y = f^*(x)$ will be calculated and plotted on the same grid. For more information about this activity, see **Handout #2: Analytical Geometry Exercise** on pp. 24-26 of this handbook.

Hour 2

After seeing the examples presented in Hour 1, you will work at the computer with a classmate (or alone if there are enough computers) to experiment with the complete range of the computer graphics package.

Hour 2 (continued)

By filling in shapes and moving and repeating objects, you will explore the capabilities of the system. You can investigate all of the tools in the menus so that you will have an initial experience with all aspects of the computer graphics package.

You will save an initial design.

**Instructional Materials**

all of the instructional materials used in Session 2
a simple pocket calculator

**Assignments**

Reading

Keedy and Bittinger, chapter three, section two, "Graphs of Equations"

Reporting

You and your instructor will review your individual work from the previous session.

Composition

Hour 1

Start to create a geometrical form using a supplied equation to generate numbers. Transfer the numbers to a grid. At least one variation will be assigned as homework.

Hour 2

Continue the development of a preliminary composition. Save the composition for later developments.

Computer

Utilize the graphics package fully during the second hour.

**Assignment Deadlines**

Complete all the work assigned for hour 1 by the beginning of the next session. Save a draft composition on diskette and, if possible, make a print of it by the beginning of the next session.

## Session 4

### Brief Summary of Activities

Hour 1

You will be introduced to the basic elements and principles of art. Through examples and illustrations you will learn to see artistic principles and their applications.

Hour 2

You will use the principles discussed in hour 1 to experiment with line and shape development and to create composition based on a model drawing.

### Classroom Presentations

Hour 1

By lecture and discussion your instructor will introduce you to the vocabulary of two-dimensional representation, including the terms (composition, design, plastic element) and the principles.

Hour 2

Your instructor will present a picture that will serve as a "problem" for you. You will solve the problem by recreating the picture, using the tools of the computer package. This solution will require that you use the principles presented in hour 1 and the computer techniques developed during the two previous sessions.

### Classroom Activities

Hour 1

After the lecture and discussion, you will trace the outline (principal lines) of a supplied art work.

Hour 2

You and a classmate will be given a composition to reproduce on the computer. Working as a pair, you and your classmate can take turns at the various activities involved.

**Instructional Materials**

Hour 1

Filmstrip, Parts I and II, "The Art of Seeing"

Slides emphasizing geometric form and mathematical techniques in classical composition

Hour 2

IBM-PC PC Paint software, manual, and your diskette

**Assignments**

Reading

Richardson *et al.*, chapter three

Reporting

From the assigned reading identify for discussion several artists whose works show applications of mathematical techniques.

Composition

Given a reproduction of an art work on tracing paper, track the lines and geometric shapes contained in it.

Computer

Use the computer graphics package to reproduce a composition. Since it may be necessary to complete this assignment outside of class time, be sure to title and save this design.

**Assignment Deadlines**

Oral reporting from the assigned reading is due at the beginning of this session. Your tracings will be due the first hour of session 5. Your computer produced reproductions should be saved at the end of the session and will also be due at the beginning of session 5.

## Session 5

### Brief Summary of Activities

Hour 1

You will be shown some of the properties which give two-dimensional art the appearances of depth and color.

Hour 2

You will begin the development of your final composition.

### Classroom Presentations

Hour 1

Using slides and a color-wheel chart, your instructor will demonstrate color, spatial definition, and texture. Discussion of these concepts will follow.

Hour 2

Your instructor will clarify the specifications for your final composition. Reference materials for the computer graphics package will continue to be available.

### Classroom Activities

After hearing and discussing the specifications, you can begin your final composition, using the full pictorial area and all of the design elements that have been discussed.

You will be expected to devote time after this session to developing your composition. Work time on a computer will be reserved for your use.

### Instructional Materials

a color-wheel chart and slides
the IBM-PC PC Paint computer graphics package

## Assignments

Reading

Review all notes for quiz in session 6.

Reporting

You will be given about fifteen minutes near the end of the second hour to make some written notes. These notes should describe your design idea and the basic form your composition will take.

Composition

You will create your own individual composition using all the tools available on the computer package.

Computer

You will now focus on the computer as an artistic tool. The reference materials and your instructor will be available for continuous assistance. Be sure to save your composition.

## Assignment Deadlines

The written description of your design idea will be due at the beginning of session 6.

Your final composition will be due at the end of session 6. (It must be printed.) Save a copy of your composition.

## Session 6

### Brief Summary of Activities

You will continue to develop your final composition. This session will be the last session available for help, critical response, and preparation.

### Classroom Presentation

At the beginning of the session your instructor will present a review of your notes on your design idea and comment on the strengths and weaknesses of your composition. The review and the comments should enable you to modify your composition during the session.

### Classroom Activities

Sharing terminals and printing time with your classmates, you will have the chance to make final modifications in your composition. (Note that printing ties up the terminal to the printer; each print takes five to ten minutes.)

Be sure to save your final copy before printing it.

### Instructional Materials

computers, PC Paint software, and reference materials

### Assignments

#### Reporting

Present your written descriptions and composition at the beginning of the session.

#### Composition

After the instructor's review, make final changes to your composition during the session.

## Computer

Use the computer and color graphics package to finish your composition, save it, and print it.

## Assignment Deadline

Your composition will be due at the end of this session. You will need to save a copy and print the composition. It may be necessary to print some compositions outside of the session if the process extends beyond the second hour.

## Session 7

### Brief Summary of Activities

You will mount your sketches and compositions and prepare a presentation. Following this activity, you will take a short quiz, present your mounted works, and participate in peer evaluation.

The instructor will present a writing assignment and then lead discussion about mural construction.

### Classroom Presentations

Hour 1

The instructor will help you with the mounting of your works and also offer some suggestions about techniques of criticism.

Hour 2

After a quiz and the peer evaluations of compositions, your instructor will explain the writing assignment.

### Classroom Activities

Hour 1

You will mount your compositions and attend to guidelines for the criticism session in the next hour.

Hour 2

There will be a quiz on elements and principles of art, followed by the presentation and criticism of compositions. Finally, the class will discuss future design projects, including the development of a class mural.

### Instructional Materials

information board, tape, and glue
slides or reproductions of murals
written quiz
attitudes survey

## Assignments

### Reading

Knobler, chapter three, "Art as Communication"
Devirk *et al.*, chapter two

### Reporting

Each of you will present your mounted work and explain the development and final composition. The instructor and the students will assess each work and presentation.

### Composition

You will take a short (fifteen minute) quiz at the beginning of the second hour. You will receive instructions for a writing assignment which asks you to compare the computer with other methods as a tool for design and composition.

## Assignment Deadlines

The quiz, presentations, and criticisms will occur during the second class hour. The writing and reading assignments will be due at the beginning of the next session. The completion date for the mural will be specified later in the course.

## Evaluation

You will demonstrate your achievement in the module by:

--taking a short quiz in session 7 to test your understanding of the meaning of design and composition,

--composing a written essay at the end of the module which compares the various tools you have used in composition development,

--constructing a project that includes several sketches and designs leading to a finished work, a mounted sequence of compositions, and the development of a mural based on the works of the whole class, and

--delivering an oral presentation in session 7 based on the sequence of mounted compositions.

## Weighting of Your Grade

| Activities | Percentage of Grade |
|---|---|
| Short Quiz | 10% |
| Written Essay | 10% |
| Construction of a Project | 55% |
| Oral Presentation | 25% |
| | 100% |

## Bibliography

### Reading Materials

Course Text:

Richardson, Coleman, and Smith. Basic Design. Prentice Hall, 1980.

Other Art References

Cavaliere, Barbara. "Barnett Newman's Vir Heroicus Sublimis: Building the Idea Complex," Arts. Volume 55. January 1981.

Cavaliere, Barbara. The Elements of Dynamic Symmetry. Yale University Press, 1948.

Clever, Dale. Introduction to Art. Harcourt, Brace, and Jovanovich, 1981.

Devirk, Stinson, and Bone. Art Fundamentals: Theory and Practice. W. C. Brown Company, 1982.

Hartt, Fredrick. Art: a History of Painting. Sculpture, Architecture: Volumes I, II. Prentice-Hall, 1976.

Knobler, Nathan. The Visual Dialogue. Holt, Reinhart, and Winston, 1980.

Mandelowitz, Daniel. A Guide to Drawing. Holt, Reinhart, and Winston, 1982.

Preble, Duane. Art Forms. Harper and Row, 1970.

Teague, Walter D. Design This Day.

Mathematics Reference

Keedy, Mervin L. and Bittinger, Marvin L. Algebra and Trigonometry: A Functions Approach. 3rd edition. Addison-Wesley Publishers, 1982.

## Audio-Visual Aids

Filmstrip: "The Art of Seeing." Parts I and II. Warren Schloat, Pleasantville, NY. Updated.

Slides: Selected Slides from American Library Color Slide Company, Inc. Grand Central Station, New York, NY. Book I (Architecture), Book II (Sculpture), and Book III (Painting). Current Catalog. Assortment chosen by subject through many periods to emphasize elements and principles of design.

Software: PC Paint by Mouse Systems tm, which includes a mouse, software, and an instructional manual. Mouse Systems Corporation, 2336H Walsh Avenue, Santa Clara, CA 95051

## Handout #1: Graphing/Plotting Exercise

### Development of a Coordinate Axis

A coordinate axis system is a method of relating the position of points on a plane through a set of numbers. Since a computer can understand only numerical information, it is necessary to have numbers describe the position of points for input (sending the information to the computer) and output (having the computer send out information to its screen, a printer, etc.). The advantage is that the computer can change the numbers very rapidly in any ordered fashion, which allows for easy manipulation of the images produced. I will discuss this process in more detail in Session 2.

For now, we will be learning a system which allows the identification of position with numbers. This will not be done in a fashion which is identical to the computer's numerical system for several reasons. The computer uses a different number system than we do. It also cannot process negative numbers. On the other hand, simple mathematical formulas cannot be presented in the computer's number system. So we will use our more familiar decimal number system to keep things as simple as possible. What we are doing here, therefore, is more like a simulation than actual programming of a computer graphics system.

To develop a number system relating points, we must have a starting point: an <u>origin</u>. We are using graph paper, so lines are already present. You will first choose a position where two lines cross as a starting point. A common place to start, if there are positive and negative values, is "in the middle" of wherever we intend to plot.

Start there and use a straight edge (ruler or other device with an appropriate border) for drawing lines. Make a line passing through the origin along one of the lines on the graph paper. If your line is horizontal (to the right and left), it should be labeled as the <u>x-axis</u>; mark an <u>x</u> near its end. The vertical (up and down) line is the <u>y-axis</u>; mark a <u>y</u> near its end. When finished, you will have produced an <u>axis system</u> with an origin and two perpendicular lines labeled <u>x</u> and <u>y</u>.

This may seem to be sufficient, but there is a further necessary step in the process which is very important. It is called <u>scaling</u>, which means choosing the values that each unit along the axes will represent. The unit size along the two axes need not be the same, but each axis must maintain its unit size along that axis. This means that you should look at the numbers you are given and then look at your axes and choose an appropriate unit size so that everything fits. Take care that the points of interest are not bunched together.

Having chosen your unit along each axis, it is desirable to mark numbers indicating the values on these axes. Each line need not be marked; you can choose to mark as many lines as will clearly indicate the scale on each axis. You should be consistent in your labeling, although you may mark at different intervals along the x and y axis.

## Using the Coordinate Axes to Locate Relative Positions

You should now have your origin marked, your axes drawn and labeled, and your scaling indicated. Once this is accomplished, you need to identify the positions of the chosen points. We have allowed positive and negative values on each axis, with negative being to the left on the x-axis and down on the y-axis. Label the values as (x,y), making the first number in the parenthesis the x value and the second number the y value. Thus, (-3,2) means that x is -3 and y is 2. Using this convention, I will give you eight points to plot. You will need the following equipment for graphing: graph paper, straight edge, and marking pen.

Use the above instructions to set up your axes. Then plot the point given below. After marking each point, label it with numerical values in the form (x,y). Place these labels in a way that clearly marks the point identified. When you have plotted each point, you may interconnect the points with lines to form a geometrical design if you choose.

I will ask that you turn this exercise in to me at the beginning of the next session. At that time, we will start a similar exercise, using points which are calculated by means of a function. Thank you for your attention and efforts.

## Points to be Plotted

| | |
|---|---|
| ( , ) | ( , ) |
| ( , ) | ( , ) |
| ( , ) | ( , ) |
| ( , ) | ( , ) |

## Handout #2: Analytical Geometry Exercise

### Production of Geometrical Shapes Using Functions

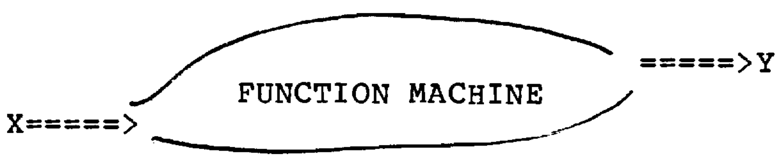
In the first part of this presentation, your instructor introduced or reviewed the location of points on a plane by using two numbers: the specification of an X and Y coordinate value. Although the computer uses a rather different system to locate the points (pixels) on its screen, this simulation gives you a fair idea of how numbers can locate points on a plane.

However, graphics programs can do more than create points (in color); they can create a variety of geometrical shapes. It is the purpose of this session to introduce you to some mathematical forms which are also capable of creating these same shapes: lines, rectangles, curves, and ellipses.

The type of mathematics which describes geometrical shapes is called Analytical Geometry. Since any line in two dimensions has an infinite number of points associated with it, the mathematics must be able to generate an infinite number of (X,Y) pairs. The mathematical form which can do this is called a function, and its general form is written:

$$Y = f(X) \text{ or } Y \text{ is a function of } X.$$

For any value of X which is put in to f, the function produces by some calculation a value of Y. This calculation is sometimes depicted as an image of a function machine:




Here is a description of the general procedure:

1. Choose appropriate values (numbers) for X.
2. Put them in the expression, and calculate a value for Y. (A pocket calculator will help.)
3. When enough pairs (X,Y) have been produced, plot them, and connect the points to form a figure.

When you use this function, for each value of X that you put in, the same value of Y comes out. The plot of this function on graph paper is a straight line passing through (0,0) which always has equal vertical and horizontal values. This is actually a special case of an important class of functions called linear functions. These linear functions have the general form:

$$Y = mX + b$$

In this equation, m and b are constants representing the slope and intercept of the line. These functions produce straight lines. Mathematically these lines go on as far as you can imagine, but on any limited plane (a piece of paper or a video screen), they can extend to the boundaries. Limitations can also be placed on the line length by limiting the X-values used; the so-called domain of the function.

A special kind of linear function can be used to create rectangles. Consider the form:

$$Y = \text{constant}$$

No X values are specified; any value of X can be used and the same value of Y occurs. A similar situation exists for the form:

$$X = \text{constant}$$

Here, any value of Y produces the same value constant for X. These forms produce lines which are perpendicular to the X-axis and Y-axis respectively. By using pairs of each of these with different values for constant, you can produce a closed rectangle; proper definition of the domains could eliminate the line segments extending beyond the corners.

The most obvious extension is to use powers of X and Y. To keep the mathematics simple, we will only consider extending our mathematics to the second power: squaring. Consider this form, which represents a quadratic function:

$$Y = aX \;\; + c$$

This function produces a form of curve known as a parabola, which is a smooth curve. You will be given numbers for a and c. then you will follow this procedure:

1. Pick values for X (positive and negative) and square them.

2. Multiply each by a and then add c.

3. Use the result as the value for Y.

This procedure creates pairs of (X,Y) values which can be plotted. Enough values should be used to give a good idea of the shape before the curve is drawn in.

The last equation which will be discussed here is a closed form which is expressed as:

$$(cX) + Y = d$$

This form produces smooth curved shapes called ellipses, which may look like footballs. Here c and d are constants which will be provided. To produce a form which can be used for calculation, some manipulation must be done. Moving the term cX squared to the other side of the equation produces:

$$Y = d - (cX)$$

The solution for values of Y is found by:

1. picking values of X and multiplying each by c,
2. squaring the results of step 1,
3. subtracting the result of step 2 from d,
4. if the result of step 3 is positive, taking the square root.

Only positive values of step 3 can be considered in real number space. Therefore, only values of X can be used which produce a result in step 2 which is less than d. Since the product (cX) is squared, both positive and negative values of X produce the same results. Finally, in step 4 both a positive and negative value for Y is produced in the square rooting process. That is, if a result of step 3 is the number 4, then:

$$Y = 4$$
$$Y = 2 \quad \text{or} \quad Y = -2$$

You will be given two functions to plot; both will be similar, but they will also be variations of the same form. Plot these on the same axis using the graph paper provided. It is hoped that this mathematical exercise will help you appreciate the type of representations that are produced by the computer graphics you are using.

**Artistic and Mathematical Components**

**in Visual Composition**

by

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Faculty Handbook
for an Instructional Module
in Art and Technology

Resourceful Exchange: Technology and the Liberal Arts (RETLA)

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## Introduction

This faculty handbook should help you understand the kinds of decisions that have to be made when an instructor decides to integrate technology into a course that has typically not addressed that subject. It is the product of interdisciplinary collaboration between an art instructor and a mathematics instructor who wished to provide a new learning experience for their students, an experience that would help them to learn content from an interdisciplinary perspective.

This faculty handbook was designed as one of two resources for an instructional module in art and mathematics, **Artistic and Mathematical Components in Visual Composition.** The other resource, a student handbook, helps prepare students for their adventure in learning. This faculty handbook should help you to decide whether or not you wish to take part in a similar adventure.

This handbook should help you to make the informed decisions that restructuring any course requires. Some of these decisions may be global, such as whether to adopt the module as it now stands or to adapt the module to fit a new context. Other decisions may be less global, but they are, nevertheless, significant. For example, such subjects as what to present in class or how to evaluate achievement need to be addressed early in the decision-making process.

Teaching technology across the curriculum is, assuredly, an exploration. Much is yet to be learned. This handbook represents our efforts, not our prescriptions. We hope that the information we provide facilitates your exploration, but we also realize that the most rewarding part of your exploration will be the discoveries that you make.

## Student Preparation Before Module is Introduced

Before the introduction of this module, students should experiment with design, employing geometrical figures, such as squares, rectangles, and circles. The media employed can be broad felt markers, cardboard cutouts placed on poster board, or any similar materials that are suitable for geometrical figure production. The emphasis should be on filling the space and creating a balanced figure/ground relationship.

Prior to Session 1, students should have developed pencil sketches, employing geometrical designs. The instructor should assess these sketches and provide feedback to the students. Students will use these sketches in the first two or three sessions of this module as a model for their first design projects. (For more information on the uses of this preliminary composition, see **Assignment Deadlines** in Sessions 2 and 3 of the Student Handbook.)

## Session 1

### Instructor Preparation for Session 1

Hour 1

During the first hour of Session 1, the instructor will need to set up a slide projector and to load slides that are appropriate to the presentation. Some sources for these slides are listed under **Audio-Visual Aids** in the Student Handbook. Slides, however, may be obtained from other appropriate sources as long as they emphasize the use of geometrical design in the figures and forms presented. An assortment of periods and subjects will enhance the generality of the presentation.

Hour 2

During the second hour, the instructor should be prepared to demonstrate the computer graphics design system. At least one computer must be available with appropriate software, a color monitor, and a mouse or other graphics control device. More computers will contribute to the effectiveness of your demonstration.

## Classroom Presentations and Activities

### Hour 1

During the first hour, the instructor uses slides to illustrate the use of geometrical design in various periods, focusing on forms and types of art. It is useful to emphasize different compositional arrangements of the same image and changes in visual appearance and character that result from adjustment and placement of objects. Examples should demonstrate the use of grids and geometrical forms in repetition and variation.

### Hour 2

During the second hour, the instructor demonstrates the loading of the graphics system, the use of that system for drawing and figure production, and the use of the file diskette for the storage of images. If time is available and sufficient workstations are available, the students may use the system to experiment with the mouse and graphics system.

## Reporting

The instructor should prompt the students to give oral interpretations of design elements and principles discussed during the slide presentation in Hour 1. They should be encouraged to develop working definitions of composition and design, expecially as these definitions relate to the use of the principles during the presentation.

## Assignment

Students may be asked to develop a working definition of "composition," based on the assigned readings, presentations, and discussion during Hour 1. They may present these definitions orally, if class time is available, or in writing.

Students need to spend time outside of class to develop proficiency with the graphics system. The instructor may assign computer activities after Session 1, provided that an appropriate setting is available. (See below, **Computer Use Outside of Class Hours**, for a detailed discussion of setting.)

## Computer Use During Subsequent Sessions

For subsequent sessions, students will need workstations. Each workstation should be composed of a microcomputer, an attached mouse or other interactive control device, a color terminal, a software diskette, which contains the design program, and reference materials describing the main operating features of the system.

In addition, each student should be assigned a formatted diskette for program storage. Other types of files, such as word processing files, can also be stored on this diskette.

## Computer Use Outside of Class Hours

Students should have access to at least one and preferably several workstations for practice and development of compositions outside of class hours. We suggest that:

--workstations be allocated for student practice for a minimum of several hours per week,

--these allocated workstations be equipped with the complete system (hardware and software), and

--supervisory personnel trained in the use of the system be available to students during the designated hours.

The development of such a setting depends on available resources and competing demands for use of microcomputers, but some form of "open lab" setting should be maintained at least until students have completed Session 6 and, preferably, throughout the module.

## Session 2

### Student Preparation

Students should have developed a working definition of composition and design and presented their definitions in either oral or written form. They should have composed a pencil sketch, which they will use as a model for development of the preliminary composition. They should also have completed the reading assignments in the Student Handbook.

### Instructor Preparation for Session 2

Hour 1

A handout that contains reference material for this session is included in the Student Handbook. (See Appendix 1, **Handout #1: Graphing/Plotting Exercise**, pp. 22-23). This handout also provides information for home study.

To complete the in-class exercise, students need graph paper, a ruler or straight edge for axis formation, and a pencil or felt-tip pen.

Hour 2

Since two students perform tasks at each workstation, the systems should be ready for student use in the exploration of the task and in the development, by each student, of a composition.

The instructor presents further instruction in system operation. This instruction can be presented in a brief lecture or by means of handouts. A good source of information is the PC Paint *tm Reference Manual or some excerpts from it which describe relevant functions and operations.

### Classroom Presentations and Activities

Hour 1

During the first hour, the instructor demonstrates how to develop a Cartesian axis system and point location from ordered number pairs. Students then have a chance to practice what has been demonstrated. Each student draws the perpendicular axes, scales these axes according to the points provided, and locates points.

A "practice run" may be the most desirable mode, with the instructor circulating to look at the axes, the scales, and the point placement. To help students understand the axis system, the instructor can provide a brief review of the demonstration or refer students to Handout #1.

At the end of Hour 1, the instructor assigns a set of points for homework. The student may complete the assignment either by using the axes and scales already developed or by developing a new set of axes and scales.

Hour 2

During the second hour, the instructor encourages pairs of students to learn as many of the features of the software system as possible and to become comfortable with the mouse or other device which controls the drawing and functions of the software system. An emphasis should be placed on getting acquainted with as many features of the system as time permits. It is useful to encourage students to switch roles so that each participates in two kinds of activities: the performing of tasks at the computer and the providing of references and aid.

## Reporting

Students present their definitions of compositions, orally or in writing. Students and instructor engage in discussions during the development of skills associated with the computer design system. As soon as the tasks are completed, the students show their designs to the instructor, relating them to their preliminary sketches. At this time the instructor encourages the students to use various aspects of the system to enhance or extend the designs.

## Assignments

Reading assignments are included in the Student Handbook. The instructor presents the homework assignment at the end of Hour 1. This assignment requires that the students plot an individual set of point pairs on graph paper. In addition to these formal assignments, students are encouraged to use computer graphics facilities during allocated lab time to develop their proficiency and to continue working on the composition of the preliminary design project.

## Session 3

### Student Preparation

Students will have developed their coordinate axes and plotted their individually assigned points, activities that were assigned in Session 2 at the end of Hour 1. Students will also have had an initial experience with the computer and an individual practice session.

### Instructor Preparation for Session 3

Hour 1

A handout for the Hour 1 presentation is included in the Student Handbook, pp. 24-26 (**Handout #2: Analytical Geometry Exercise**). This handout contains complete descriptions of the results of the use of all the functions.

The instructor describes how functions can be defined and used to plot figures, the beginning of Analytical Geometry. Students are then given individual assignments to plot.

To perform this task, students will need graph paper and a simple calculator (with the basic functions of add, subtract, multiply, divide, square root, and single register memory). Such a calculator provides sufficient calculating power to graph all the functions listed. If more sophisticated calculating tools are available, more complex forms could be assigned.

Hour 2

During Hour 2, students continue their development of skills and compositions, using the computer graphics system. If preliminary compositions are ready, the color printer will be needed.

### Classroom Presentations and Activities

Hour 1

During Hour 1, the instructor provides information about the way a function "generates" point pairs, which can then be plotted to form figures. Examples of relations which may be used are: a, b, c, and d constants.

## Demonstration for Hour 1

$y = a$; $y = b$; $y = c$; $y = d$ (enclosed area rectangle)

Sample Forms A

$Y = a(x) + b$ (This formula yields a line with + or − slope according to sign of a.)

$Y = a(x)^2 + b$ (This formula yields a parabola, a "bowl" if a is + or a "hill" if a is − .)

Sample Forms B

$Y = (a - x)^{2\ 1/2}$ (This formula yields a circle if both + and − values of square root are used.)

$Y = (a - bx)^{2\ 1/2}$ (This formula yields an ellipse if both + and − values of square root are used.)

Mathematical Tables (Calculated from Functions Listed)

For demonstration purposes: $y = 4$, $y = -2$ (for all x)
$x = -1$, $x = 3$ (for all y)

Sample Forms A

$y = -2x + 3$

| x | y |
|---|---|
| 4 | −5 |
| 2 | −1 |
| 0 | 3 |
| −2 | 7 |
| −4 | 11 |

$y = -2x^2 + 3$

| x | y |
|---|---|
| 4 | −29 |
| 3 | −15 |
| 2 | −5 |
| 1 | +1 |
| 0 | +3 |
| −1 | +1 |
| −2 | −5 |
| −3 | −15 |
| −4 | −29 |

Sample Forms B

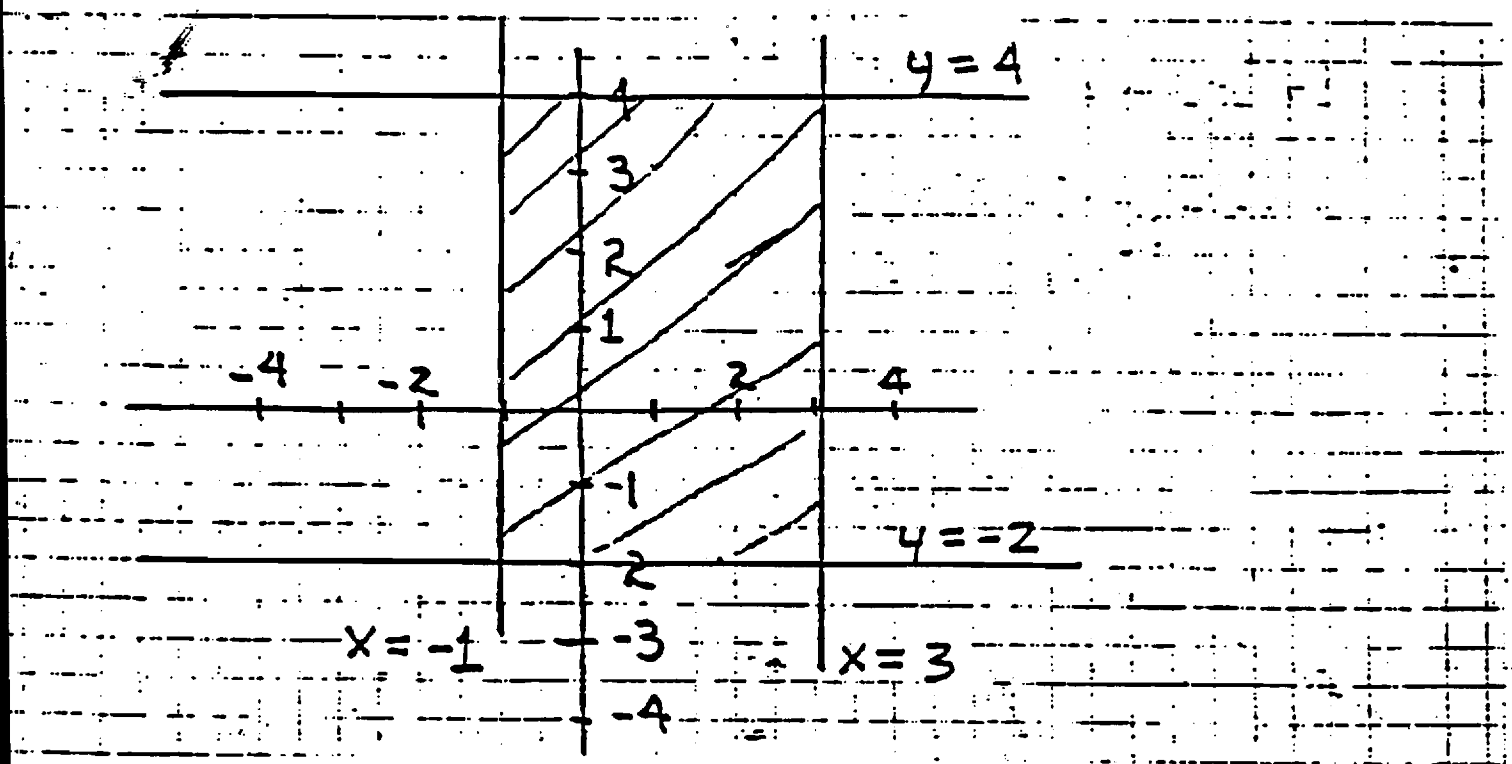
$y = (16 - x^2)^{1/2}$

| x | +y | -y |
|---|---|---|
| 4 | 0 | 0 |
| 3 | 2.65 | -2.65 |
| 2 | 3.46 | -3.46 |
| 1 | 3.87 | -3.87 |
| 0 | 4 | -4 |
| -1 | 3.87 | -3.87 |
| -2 | 3.46 | -3.46 |
| -3 | 2.65 | -2.65 |
| +3.5 | 1.94 | -1.94 |
| 4 | 0 | 0 |

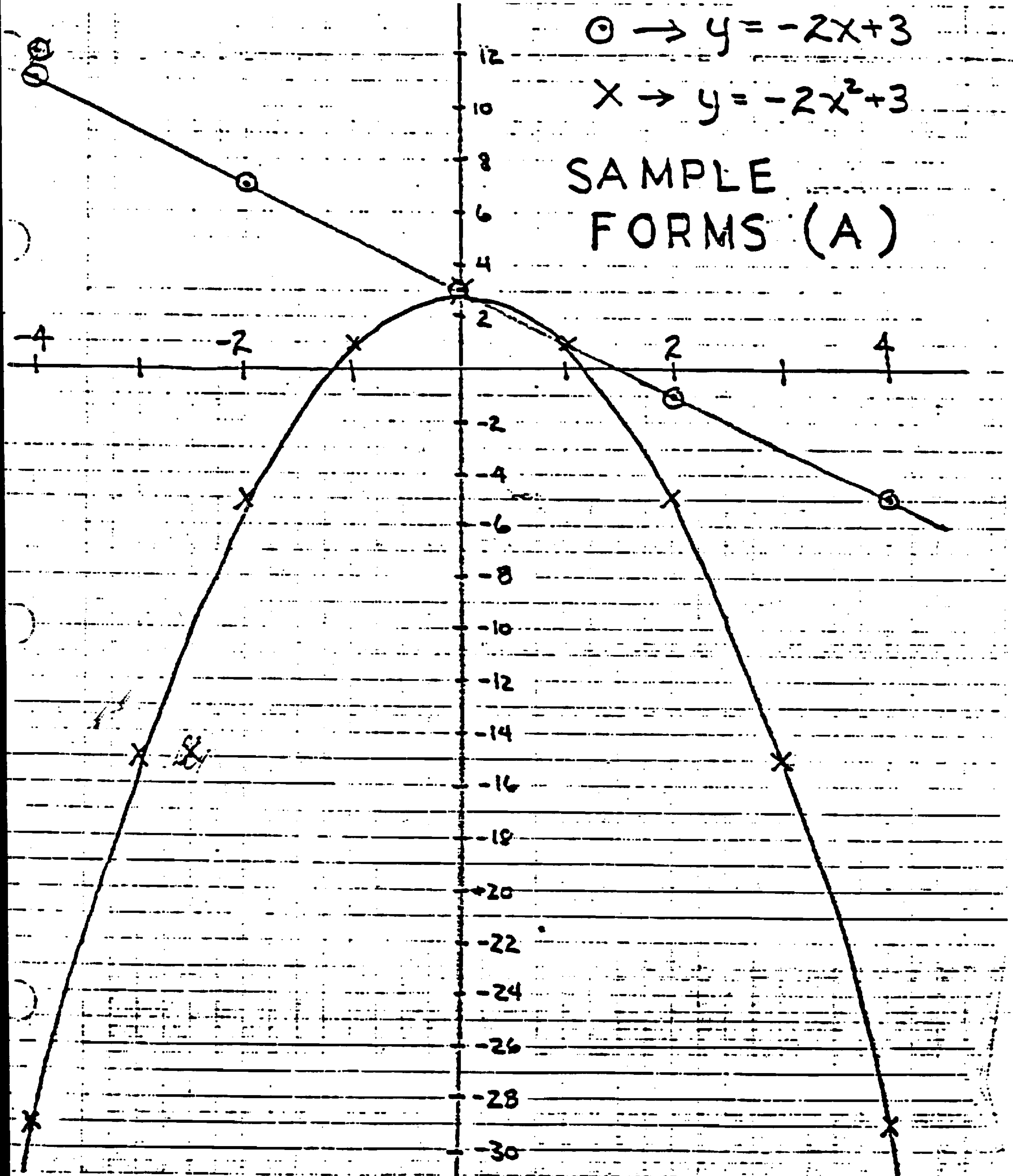
$y = (32 - 2x^2)^{1/2}$

| x | y | -y |
|---|---|---|
| 4 | 0 | 0 |
| 3 | 3.74 | -3.74 |
| 2 | 4.9 | -4.9 |
| 1 | 5.48 | -5.48 |
| 0 | 5.66 | 5.66 |
| -1 | ⋮ | ⋮ |
| -2 | ⋮ | ⋮ |
| -3 | ⋮ | ⋮ |
| -4 | 0 | 0 |

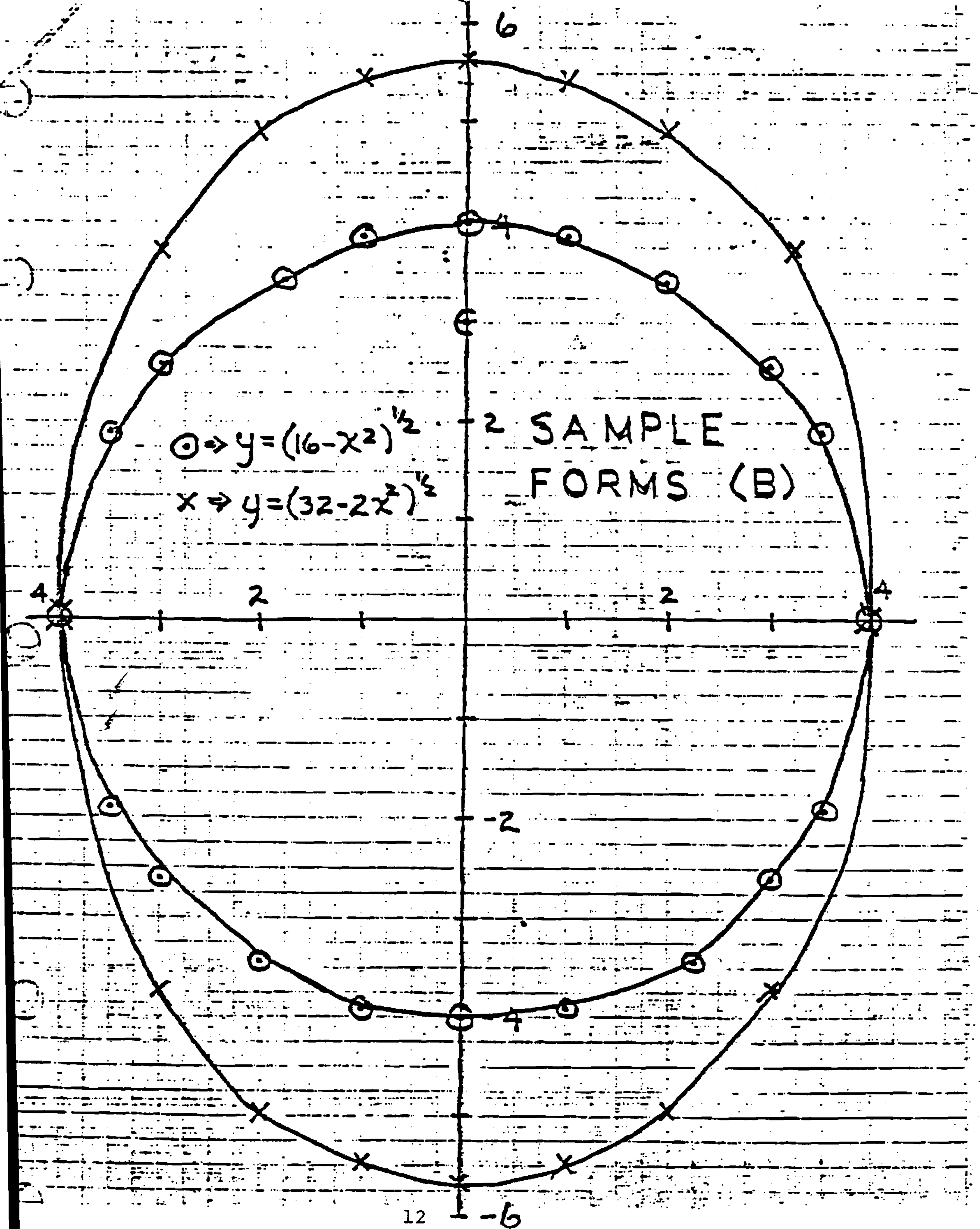
Translations can be easily demonstrated: add a constant to both y or both x values.



Sample Forms A



Sample Forms B



The instructor demonstrates ordered pair generation with at least two of these functions. These demonstrations should include a linear example and an example involving calculation using the square root. Some student practice during the class hour is desirable.

Hour 2

Students work in pairs using the graphics systems. At this stage some students will be proficient while others will only have some proficiency.

The instructor circulates and encourages growth and exploration on the part of all students. For students who have achieved proficiency, some of the more sophisticated features of the software can be introduced. These features include color change, picture storage and merger, and change in tools ("brush shape"). Other features, listed in the "pull down menus," may also be explored by either a pair of students or the whole class. Students should also be encouraged to investigate the saving of stages of a composition or the comparisons of design variations.

**Reporting**

Hour 1

Students will have handed in the asignment from Hour 1 of Session 2; the instructor should briefly assess these assignments so that any misunderstanding of the plotting methods can be corrected before the student begins the plotting exercise for this session. Questions and comments from the whole class help clarify this exercise, but some students need individual attention before they understand the generation of point pairs and the plotting of the resulting functions.

Hour 2

During the second hour, students informally present their preliminary compositions to the instructor. This presentation may include the printing of some or all of the preliminary compositions. Since printing requires at least five minutes per composition, some organization is necessary in order to print every student's work. It may be necessary to collect the students' diskettes so that some compositions can be printed outside of class time.

## Assignments

### Hour 1

Students are assigned individual variations on the functions described in classroom presentations above. Each student will plot at least two functions and variations before the beginning of Session 4. Specific numbers for "a," "b," "c," and "d" are included in the assignment. The students are also expected to generate enough points to plot these functions, to plot the resulting figures, and to compare them.

Some consideration of the student's mathematical background and abilities can be made in the assignment of these functions. Nonetheless, all students will profit from experimenting with several functions and variations on these functions, such as lines with equal positive and negative slopes.

### Hour 2

Students should be encouraged to continue their exploration and composition on the computer graphics system during allocated time in the lab. The development of new designs will help the students with compositional assignments later in the course.

## Session 4

### Student Preparation

Students turn in their plots, assigned during Session 3. They also turn in a print of the preliminary composition.

### Instructor Preparation for Session 4

Hour 1

The instructor leads a discussion of the basic elements and principles of visual art. A useful resource to supplement this discussion is "The Art of Seeing," a filmstrip/record which is generally available in libraries. Various slides from different historical periods can also be used to supplement this presentation or to provide additional examples.

Hour 2

During Hour 2, the instructor hands back both of the plotting assignments. While students present their preliminary compositions, the instructor assesses them and provides specifications and directions for the final compositions.

Students begin a preliminary exercise in contour drawing and modeling at their workstations. The instructor provides drawings or prints which the students can use as models.

### Classroom Presentations and Activities

Hour 1

Hour 1 is devoted to an in-depth discussion of artistic form, including the terms "element" and "principle," and the techniques of "seeing" (as opposed to merely "looking at") the forms and content expressed by the artist. If "The Art of Seeing" is not presented, an alternative method of defining and discusssing the concepts "composition," "design," "plastic elements," and other appropriate basic principles of art can be used. During discussion, emphasis should be placed on the meaning and modes of expression of the basic principles of art.

The use of the Golden Rule(s) and Root 5 Triangles and the relationships among mathematics, science, and the tools and techniques of artists should also be part of this discussion. Some examples are the use of grids and their role in the compositional development of specific artists. (Examples can be found in the course text, Basic Design, by Richardson, Coleman, and Smith. See Chapter 2, entitled "Grids, Mazes, and Modules.")

Hour 2

During Hour 2, discussion focuses on specific properties of form and content, such as shading, value, contour, and modeled forms, with reference to the students' preliminary compositions. It is useful to emphasize the following concepts:

--biomorphic and geomorphic shapes,
--definitions and physical characteristics of line and shape,
--physical utilization of shape in representational and abstract works,
--line as continuous shape, and
--relationship of line and space to other elements.

The instructor may make a formal presentation of responses to the students' compositions or include these responses as part of the discussion. In either case, the aim is to proceed toward a set of directions and specifications for students that will help them develop an original modeled drawing, using at least three different value tones and original images.

During part of this second hour, students work in pairs with the computer design program, using the skills they have developed to create a contour drawing and a model drawing based on a painting or picture that the instructor provides. (Examples of this process are included in the PC Paint *tm software and in the IBM-pc junior Colorpaint *tm Manual.)

**Reporting**

As the students work on the contour and model drawings during the second hour, the instructor circulates, eliciting comments from the students about their skills and the model compositions they are producing. The instructor also provides brief assessments of the students' works.

**Assignments**

Students should complete the contour and model drawing in allocated time in the lab and present these completed assignments to the instructor before attempting the final composition.

The instructor can usefully reinforce student understanding of the elements and principles discussed in Hour 1 by announcing that a short quiz on this discussion will be given at the beginning of Session 5.

By the end of the second hour, the students have been given the specifications and expectations for a final composition. This final composition will be the principal focus of the course for the next two sessions. It also accounts for a major part of the final evaluations of the students.

## Session 5

### Student Preparation

Students turn in the completed model drawing that they began working on in Session 4. They take a short quiz on the elements and principles discussed in the previous session.

Most students have begun design work on their final compositions, presenting their sketches or initial drawings for review.

### Instructor Preparation for Session 5

The instructor has a slide projector and color chart available for this last lecture of the module. The computer workstations and the printer are available for use during Hour 2.

### Classroom Presentations and Activities

<u>Hour 1</u>

After the short quiz on elements and principles, the instructor lectures on the elements of color, space, and texture, using examples from slides and the color chart. The importance of combining these elements in an effective and aesthetic manner is emphasized; a selected number of preliminary compositions may serve as examples. Following the lecture, a discussion focuses on the development of the final compositions from a design idea.

<u>Hour 2</u>

Students work in pairs on the development of the initial design of the final composition. The instructor circulates among the students, discussing on an individual basis the development of design ideas and expressions. If appropriate, the instructor assigns an "element problem," which emphasizes one of the elements in a design problem. These interactions help students to become aware of weaknesses in their compositions. The interactions also encourage students to use all the capabilities of the computer graphics system in the development of the final composition.

### Assignments

The principal assignment is the final composition. Completing this task entails the development of a complete, coherent, and aesthetic composition, utilizing the unique capabilities and tools of the computer graphics system.

Since this composition must be completed by the beginning of Session 7, a significant amount of work must be done before Session 6, in which the instructor provides feedback on the work.

In order to provide appropriate feedback, the instructor informs the students that they should turn in the following materials, which will be commented on during Session 6:

--preliminary images, which emphasize the major design themes in the final composition,

--versions and drafts of the compositions, which students stored on diskettes and which the instructor will compare and comment on,

--assignments which emphasize a particular element, and

--summary of notes on discussion during the last fifteen minutes of Session 5.

## Session 6

### Student Preparation

Students have completed the major work on their final compositions so that they can make modifications and complete their projects by the end of this Session. Students either bring to this session or produce early in this session a work in progress print of their final compositions.

### Instructor Preparation for Session 6

The instructor is prepared to review the preliminary prints and notes describing each student's design. These notes are not graded; instead, they provide the basis for the instructor's comments, which help the student to make appropriate changes.

### Classroom Activities

Instead of a formal presentation or discussion, the instructor and students engage in commentary, revision, and completion of the final compositions. Students display and print their compositions; the instructor gives advice about the development of the final project.

During Hour 1, the instructor provides feedback on the preliminary prints and notes. Students then recall, review, and modify versions or progressive file drawings of their final compositions; the instructor provides brief assessments.

As prints are made of compositions in various stages of completion, they are placed on a bulletin board or in a display area, where they are assessed by instructor and students. These assessments may be formal (students are directed to the display area and required to take notes) or informal (students are merely encouraged to participate).

### Assignments

All final compositions are due at the end of this session. Students may be responsible for printing their files, or, if facilities and personnel are available, the student may turn in a diskette, indicating the file that contains the final composition. A laboratory instructor or assistant could then print out the final compositions after the session is over.

Students will take a short quiz during Hour 2 in Session 7. To prepare for this quiz, they should read the assigned texts and review all notes from lectures.

## Session 7

### Student Preparation

Students turn in prints of both their preliminary and final compositions as well as any element studies included in the module. They are also prepared for a quiz that tests their understanding of all the information contained in their notes and the reading assignments.

### Instructor Preparation for Session 7

Preparation for this session entails being ready to perform the following activities:

--administering a quiz addressing the reading assignments and classroom presentations,

--administering an attitude survey on the use of the computer graphics package,

--providing materials for display of student works, such as an illustration board in an appropriate size and support materials (ruler, glue, etc.),

--presenting guidelines for the assessment session to take place during Hour 2, and

--delivering instructions, oral or written, about the development of a mural, which would include some or all of the compositions developed throughout the module. (This mural would be produced later in the course.)

### Classroom Activities

<u>Hour 1</u>

During Hour 1, students will be given materials and instructions for the mounting of all their prints. If appropriate, these displays on illustration board may include dates and titles. The work should be placed in some orderly sequence, such as progression or date completed.

Hour 2

After the quiz, individual students present their mounted works. After each student presents his or her compositions, several students, selected by the instructor, comment on the use of elements and principles, compositional arrangement, and organization of the works. The instructor participates in these sessions, delivering closing comments.

### Reporting

Student presentations include a statement of the method of organization and placement as well as some comment on each work. Students will be graded on the quality of their presentations and on the quality of their critiques of the works of other students.

### Assignments After the Module is Completed

Although the module is completed at the end of Session 7, several possibilities for the continuation of assignments related to the module exist:

--Students may produce a mural during subsequent class meetings, including some or all of the compositions produced throughout the module.

--Students may compose a written essay on any or all of the following topics:

--a comparison of the computer as tool with manual tools for design and composition,

--possibilities for enhancement of compositions developed on the computer by means of other methods,

--definitions of composition and design, employing the computer graphics package as an example,

--speculations about the use of mathematics and mathematical forms as they relate to various artists, artistic periods, and styles.

--Students might be encouraged to use the computer graphics package for other design and composition projects within the course; they might be encouraged to use the package as a medium for other projects throughout the semester or year.

## General Comments

### Classroom Presentations

#### Format

The workshop setting for the presentation and use of computer materials is essential. Therefore, a computer graphics laboratory and trained personnel who can guide the students are necessary.

The format of other presentations could be modified. The information about elements and principles of art, delivered by lecture in Session 4, and the presentation of mathematical information in Session 2 could be presented in a variety of formats, such as pre-taped lecture or discussions of assigned readings.

#### Materials for Presentations

We found that the materials we used for presentations and as background information for the students were generally sufficient. The handouts for the mathematical presentations were also adequate. Alternative sources for this material, however, are available and should be explored.

Although students could use reference materials for their tasks at the computer after they had some experience, we found that these materials did not take the place of trained personnel in the initial stages.

### Assignments

The type and number of assignments included in the student handbook provide the students with a complete and thorough experience. Adaptations, however, may be appropriate.
If students are not competent at functional analysis, you may need to reconsider the mathematical problems. You can also adapt the final project to fit the needs of students by establishing appropriate specifications.

Although students did not have much difficulty with the computer graphics system after their initial experiences, they need to have access to this equipment to adequately explore the options of the system.

Student participation in the assignments is virtually guaranteed because students are inherently interested in the computer as an art/design tool. They are also capable of being quite innovative when the instructor, appropriate materials, and facilities are available to them.

## Review

In general, sufficient review of content is built into the module. Because the basic principles of art and mathematics are reviewed at various point throughout the module, the students seem to have little difficulty in understanding these principles.

References for the computer graphics system, however, require detailed review. Sound references, such as manuals and handouts, must be available during class hours and in the lab. The instructor must be active, particularly during the students' initial experiences with the computer, in order to help them understand the available options for their design work on the computer.

## Evaluation

### Formative Evaluation

Formative evaluation (assessment of a student's progress, without assigning a final grade) is useful throughout the module. The mathematical information, for example, is absorbed better by the students when they receive some feedback from the instructor about their grasp of mathematical concepts. Students may even be given a second chance to redo an assignment, such as a graph, receiving credit for their efforts.

Student understanding of the artistic concepts also improves with feedback from the instructor and other students in the class. Opportunities for providing such feedback are built into the module. We have found this support to be beneficial to our students, although other instructors may decide to modify these evaluation procedures, as appropriate.

### Summative Evaluation

Information about how to weight the assignments is included in the student handbook. Variations may be in order for other adaptations, but we found that this weighting served our purposes well. Since all of the assignments help prepare the students for the final project, the allocation of a significant portion of the grade to this final effort seemed especially appropriate.

## Resource Faculty and Space

An art instructor and a mathematics instructor can readily present and reinforce appropriate concepts from their disciplines. Support for these instructors, however, may be necessary because a significant amount of information in this module pertains to computer hardware and software. This support is especially necessary if the art and mathematics instructor do not have sufficient expertise in delivering information about the computer system and in helping novice users to understand it.

Faculty coordination should begin with a practice session on the computer several weeks or more before the module begins. All faculty and support persons should go through the steps that the students will later go through. We found that working in pairs and supporting each other helped us to become a team and to learn the rudimentaries of the system with a minimum of frustration.

PC Paint requires from four to six hours of practice before proficiency is achieved. Two sessions in the computer lab or at a computer store are probably sufficient.

Once the instructors are familiar with the system, decisions can be made about space allocation and the setup of facilities. The system requires significant setup time and needs to be carefully tested. Since these activities must be performed in coordination with other uses of the facilities, careful planning is necessary. We recommend that you test the system at least a week before students actually use it (especially if this is the first time the hardware/software package is used).

## Allocated Time

The total time allotted, fourteen contact hours, was adequate for the presentation of the artistic and mathematical concepts and the hands-on experiences at the computer. However, students need time to practice at the computer outside of class time, and lab time must be allocated for this purpose. Another alternative is to schedule practice hours if conficts among student schedules can be readily resolved.

## Equipment and Materials

Essential computer equipment includes microcomputers equipped with appropriate hardware (a mouse or similar control device), color monitors, and appropriate software. This equipment should be readily available to students from Session 1 to Session 6.

The use of computer art in the design and development of student compositions is not generally taken into consideration when computer facilities are established. Competing uses of computer facilties will have to be considered until this use of the computer is well established.

## Course and Module Modifications

This module is specifically designed for an art and mathematics course and probably fits this interdisciplinary type of course best. It could be readily modified to fit a variety of introductory art courses. The content of the mathematical and artistic presentations could be modified to suit a fairly wide range of students.

This module could also be used in a mathematics or computer science course. A math course that uses the computer to help students visualize the functions could be created. A more technical appproach, utilizing commands in mathematical language (program statements in BASIC or PASCAL) is also feasible. Designing a segment of a course that addresses the creation of computer art by means of programs that continuously vary the geometry is also possible. Some three-dimensional representations are already available (the language GrafORTH, for example).

A computer science application is within the scope of this module. Such application entails simulation, rather than merely number crunching applications. Another, more technical approach, might include investigating the hardware and software that goes into the development of an interactive graphics system.

# The Beginnings of the Industrial Revolution in the Eighteenth Century

by

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for an Instructional Module
in History and Technology Assessment

Resourceful Exchange: Technology and the Liberal Arts (RETLA)

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## Rationale

This module focuses on the Industrial Revolution, one of the most important developments in the formation of modern civilization. It emphasizes the importance of technological change in shaping society and culture.

This module will:

--provide factual knowledge about the Industrial Revolution,

--introduce you to how early modern machinery was built, and

--enable you to understand the relationship between technological developments and changes in society and culture.

## Learning Objectives

This module should help you to demonstrate:

--factual knowledge of the major developments of the early Industrial Revolution in the eighteenth century: textiles, metallurgy, and steam power,

--factual knowledge of some of the major human contributions to the early Industrial Revolution,

--factual knowledge of the construction, operation, and purposes of early modern machinery,

--the ability to use a technology assessment model to reveal the interconnectedness of technology, society, and culture, and

--the ability to describe the impact of technology on modern society.

## Dimensions of the Module

This module requires one week of class time. Four class sessions will be devoted to the module; each session will be fifty minutes long.

## Instructional Formats

Lecture--two hours
Discussion/Seminar--two hours

## Session 1

### Brief Summary of Activities

At a large group lecture, the instructor will provide an historical overview of the early Industrial Revolution in England in the eighteenth century.

### Classroom Presentation

The instructor will present the causes of the Industrial Revolution. This presentation will focus on the Age of Reason and its emphasis on the scientific method, capitalism, earlier machines, economic institutions, means of transportation, and population growth.

### Classroom Activities

While listening to the lecture, your aim should be to develop a broad framework of understanding of the topics addressed in the lecture. Developing such a framework will facilitate activities in the small group meetings that take place later in the module.

### Instructional Materials

slides of individuals, places, and technology
lecture outline
bibliography of relevant readings

### Assignments

Reading

Read Burns and Ralph, World Civilization, volume 2, pp. 813-26.

### Assignment Deadline

The reading assignment in Burns and Ralph must be completed by the time of the first small group meeting.

## Session 2

### Brief Summary of Activities

Your instructor will lead a discussion of the large-group lecture and reading assignment.

The instructor will introduce you to a technology assessment model. Following this introduction, you will discuss the model and its application.

### Classroom Presentation

The instructor will introduce you to the technology assessment model that you will later apply to the technology and culture of eighteenth-century England. See p. 7 of this student handbook for a representation of that model and a brief description of the complex relationship that it portrays between society and technology.

### Classroom Activities

This session should help you to clarify your understanding of the information presented in session 1. You will participate in discussion of both the lecture and the readings.

This session should also help you to apply the technology assessment model because you will be encouraged to actively participate in trial applications of the model.

You and your classmates will be assigned to groups. The size of these groups will depend on the number of students in the small group meetings. Once assigned to a group, you and the other members of that group will choose a specifc eighteenth-century technology to assess by using the technology assessment model. To help you make your choice, a list of selected technologies and social phenomena related to technology has been included in this handbook. See Selected Technologies and Social Phenomena Suitable for Student Research, p. 8.

### Instructional Materials

worksheet, entitled "Technology Assessment Model Worksheet"

handout, entitled "Selected Technologies and Social Phenomena Suitable for Student Research"

## Assignments

### Reading

Dickison, H. W., A Short History of the Steam Engine, selected chapters

Cardwell, D. S. L., Steam Power in the 18th Century

Rolt, L. T. C., James Watt

### Reporting

You and the members of your group will make decisions about the technology or social phenomena that you plan to assess, and you will begin doing research on your group report.

### Writing

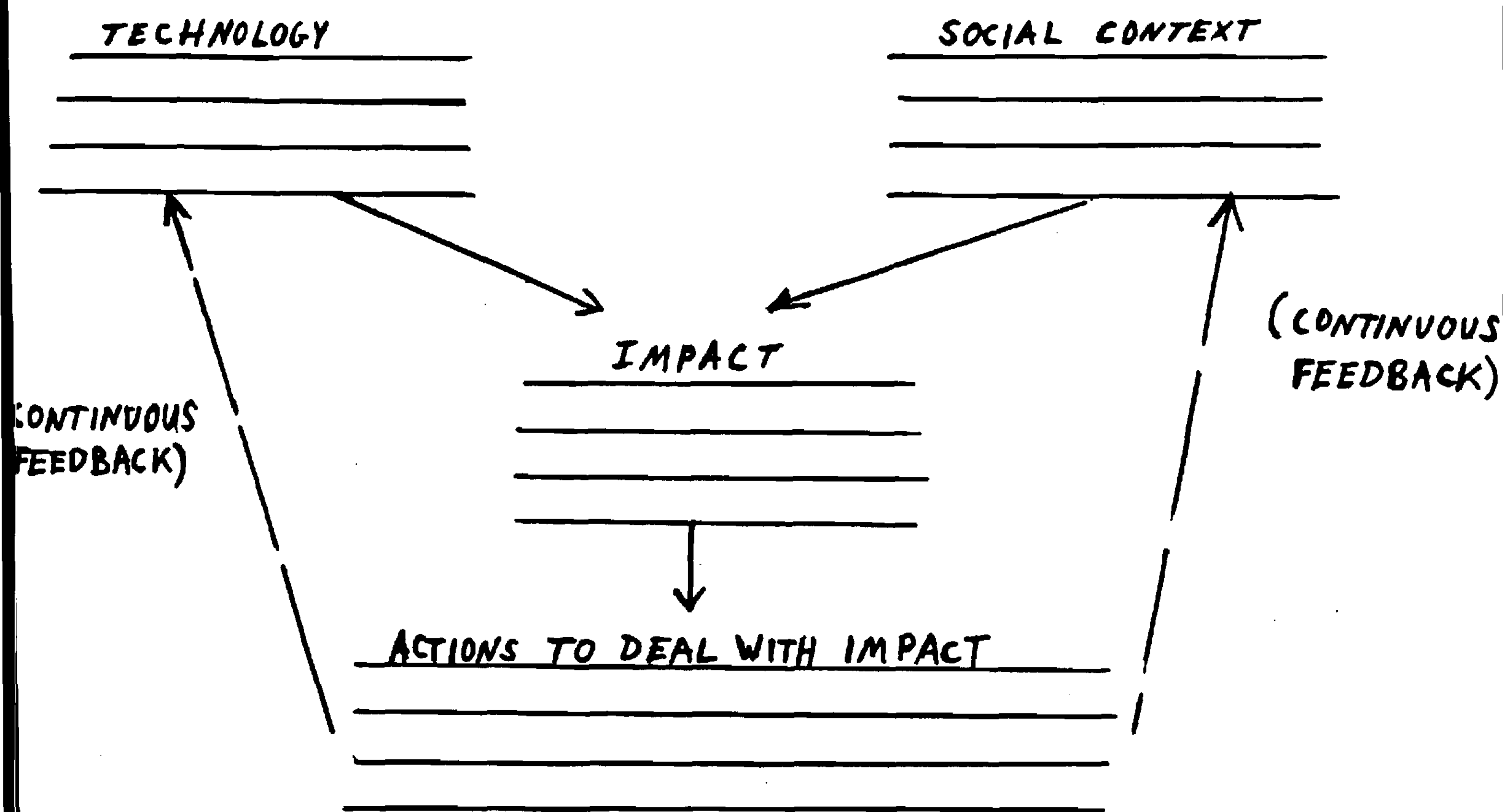
You, as an individual, will begin research on a brief written assessment of a particular technology, its impact on society and culture, and the impact of society and culture on it. In your assessment, you should stress the ramifications of this technology.

## Assignment Deadlines

You should begin reading the prescribed texts; the deadline for these readings is Session 4. Group reports are due at the small group meeting in Session 4. The written assignments will be due after the module is completed; the deadline will be announced later.

## TECHNOLOGY ASSESSMENT MODEL WORKSHEET

In abstract form this model attempts to portray the complex relationship between society and technology. It indicates that the social context and technology are not independent variables but instead constantly impact on one another. In other words, society continuously demands changes in technology, and technological change in turn forces changes in the social context. This interaction indicated in the model as impact leads directly to organized human actions to deal with the impact on the part of families, businesses, and governments. These organized efforts take many forms. Families may relocate or change their form or function, businesses may act similarly, and governments may attempt to protect obsolete industries or to stimulate the growth of new ones. In any case such actions bring about further changes in both technology and the social context as indicated in the model by the dashed line labled continuous feedback. The model is therefore dynamic and the process is perpetual.



SELECTED TECHNOLOGIES AND SOCIAL PHENOMENA SUITABLE FOR STUDENT RESEARCH

spinning wheel

hand loom

"putting out" system

factory system

flying shuttle

spinning jenny

water frame

the "mule"

power loom

cotton 'gin

coke

rolling mill

canon-boring drill

nail-making machine

circular saw

Savery's engine

Newcomen's steam pump

Watt's steam engine

canals

sailing vessels

gravity railroads

early locomotives

early steamships

mercantilism

wage labor

population growth

capitalists

rotation of crops

fertilizer

horse hoe

selective breeding

## Session 3

### Brief Summary of Activities

At a large group lecture, your instructor from the Department of Engineering Technology will present information about the development of the steam engine and the effect of this development on society.

### Classroom Presentation

The instructor will focus on early developments that led to the invention of the steam engine, how the early steam engines worked, the purposes they served, their limitations, later innovations, and the role of the steam engine in the Industrial Revolution. He will use slides or projections to illustrate the workings of early steam engines and the development of steam engine technology.

### Instructional Materials

slides or projections

### Assignments

Reading, Reporting, and Writing

You should continue the reading assignment presented in session 2. You should also continue to work on your group report and the writing assignment.

## Session 4

### Brief Summary of Activities

Your instructor will lead a discussion of the large-group lecture presented in session 3 and the readings.

Student groups will deliver their reports on the specific eighteenth-century technologies that they have assessed.

### Classroom Activities

You will demonstrate your understanding of the steam engine by participating in discussion.

Your group will report on its assessment. The instructor will offer suggestions and criticisms.

### Instructional Materials

Students may illustrate their reports.

## Evaluation

You will demonstrate your achievement in this module by:

--taking a short quiz,

--writing an essay that is a brief assessment of a particular technology, and

--delivering a group oral report.

## Weighting of Your Grade

Because this module is part of a larger course, it is not likely that an isolated grade for it can be produced. The figures below, therefore, are only approximate.

| Activities | Percentage of Grade |
|---|---|
| Short Quiz | 20% |
| Written Essay | 40% |
| Group Oral Report | 40% |
| | 100% |

## Bibliography

### Reading Materials

Ashton, T. S. and J. Sykes, The Coal Industry of the Eighteenth Century (1929).

Ashton, T. S., Iron and Steel in the Industrial Revolution (1968).

Bradley, Ian, A History of Machine Tools (1972).

Cardwell, D. S. L., "Science and Technology in the Eighteenth Century," in Cardwell, History of Science (1962).

Cardwell, D. S. L., Steam Power in the Eighteenth Century (1963).

Deane, Phyllis, The First Industrial Revolution (1965).

Derry, T. K. and M. G. Blakeway, The Making of Pre-Industrial Britain (1969).

Dickison, H. W., A Short History of the Steam Engine, 2nd Edition (1963).

Flinn, M. W., Origins of the Industrial Revolution (1966).

Harrison, J. F. C., The Birth and Growth of Industrial England, 1714-1867 (1973).

Hart, Ivan, James Watt and Steam Power (1949).

Montoux, Paul, The Industrial Revolution in the Eighteenth Century (1961).

Rolt, L. T. C., James Watt (1962).

Rolt, L. T. C. and J. S. Allen, The Steam Engine of Thomas Newcomen (1977).

### Audio-Visual Aids

Slides, projections, and films

### Other Sources of Information

Field trips

# The Beginnings of the Industrial Revolution in the Eighteenth Century

by

Stanley Harrold

and

Tom Whitney

South Carolina State College
Orangeburg, South Carolina

Faculty Handbook
for an Instructional Module
in History and Technology Assessment

Resourceful Exchange: Technology and the Liberal Arts (RETLA)

1986

## Introduction

This faculty handbook should help you understand the kinds of decisions that have to be made when an instructor decides to integrate technology into a course that has typically not addressed that subject. It is the product of interdisciplinary collaboration between a history instructor and an engineering technology instructor who wished to provide a new learning experience for their students, an experience that would help them to learn content from an interdisciplinary perspective.

This faculty handbook was designed as one of two resources for an instructional module in history and technology assessment, **The Beginnings of the Industrial Revolution in the Eighteenth Century**. The other resource, a student handbook, helps prepare students for their adventure in learning. This faculty handbook should help you to decide whether or not you wish to take part in a similar adventure.

This handbook should help you to make the informed decisions that restructuring any course requires. Some of these decisions may be global, such as whether to adopt the module as it now stands or to adapt the module to fit a new context. Other decisions may be less global, but they are, nevertheless, significant. For example, such subjects as what to present in class or how to evaluate achievement need to be addressed early in the decision-making process.

Teaching technology across the curriculum is, assuredly, an exploration. Much is yet to be learned. This handbook represents our efforts, not our prescriptions. We hope that the information we provide facilitates your exploration, but we also realize that the most rewarding part of your exploration will be the discoveries that you make.

## Responsibility for Presentations

This module is designed to be taught by a history instructor and an engineering technology instructor. Here is a workable division of responsibility for classroom presentations:

Session 1--(Historical Overview of the early Industrial Revolution in England in the Eighteenth Century)--History Instructor

Session 2--(Discussion of Session 1 Lecture and Reading Assignment and Introduction of Technology Assessment Model)--History Instructor

Session 3--(Overview of the Development of the Steam Engine and Its Effects on the Development of Society)--Engineering Technology Instructor.

Session 4--(Discussion of Session 3 Lecture and Delivery of Student Reports on Eighteenth-Century Technologies)--History Instructor or Engineering Technology Instructor.

## Classroom Presentation for Session 1

Lecture on The Beginnings of the Industrial Revolution in the Eighteenth Century

In Session 1 the history instructor delivers a fifty-minute lecture which provides an overview of the early Industrial Revolution in England during the eighteenth century. Included here is a brief outline of that lecture and some annotations that address the points that might usefully be emphasized:

I. Introduction

--Provide a brief overview and set the time and place.

II. Age of Reason

--It was a prerequisite for the Industrial Revolution.
--It placed an emphasis on progress, individualism, and human reason.

III. Capitalism

--It was another prerequisite.
--It encouraged the accumulation of usable wealth.

**The Beginnings of the Industrial Revolution in the Eighteenth Century**

IV. Foundations of the Industrial Revolution

A. Machines

--The term revolution may be misleading.
--Labor-saving machines had existed for centuries.
--Examples (all made of wood) include the waterwheel, the windmill, shafts and gears, and clocks.

B. Economic Institutions

--The creation of a money economy was significant.
--Banks and joint-stock companies appeared during the Renaissance.

C. Transportation

--Transportation increased in speed, safety, and efficiency.
--Canals were built, and sailing vessels were improved.
--Transatlantic trade with Africa and America was increased.

D. Population Expansion

--Demand was increased for manufactured goods and for reduced labor costs.

V. England and the Industrial Revolution

--Describe England in the seventeenth century.

A. Textiles (wool and cotton)

--By the start of the eighteenth century the weaving of cotton cloth was England's principal industry.
--The textile industry spurred the Industrial Revolution.

1. Spinning Wheel and Hand Loom

--Describe these inventions.

2. The "Putting Out" and Factory Systems of Production

--The former was rural in character.
--The latter is characterized by reduced cost, better organization and greater quality control.

3. Mechanization

a. John Kay, "Flying Shuttle," 1733

--This invention permitted faster weaving.
--It increased the demand for thread.

b. James Hargreaves, "Spinning Jenny," 1770

--This invention met the demand for thread caused by the flying shuttle.

c. Richard Arkwright, "Water Frame," 1760s and 1770s

--These efforts demonstrate the replacement of human power with water power in the textile industry.

d. Eli Whitney, "Cotton `Gin," 1793

--This invention played a role in filling the increased demand for cotton fiber caused by the technological advances in the British textile industry.
--It contributed to the use of slave labor in North America.

B. Metallurgy (iron and steel)

--The industrial revolution could not have gone far with machines made of wood.
--Metallurgy was crucial, but it had been retarded by lack of a proper fuel in the refining process.

1. Abraham Darby, "Coke," 1709

--This invention provided a method for removing coal's impurities so that it could be used to smelt iron and steel.

2. John Wilkinson, "Canon-Boring Drill," 1774; Thomas Gifford, "Nail-Making Machine," 1790; "Circular Saw," 1777.

--These are all examples of the improved machine tools that a superior metallurgy engendered.

C. Steam Power

--Both textiles and metallurgy required power.
--Because water power was not always available, new sources were sought.

1. Thomas Newcomen, "Newcomen's Steam Pump," 1708

--The steam engine had been understood in principle since ancient times, but it had not been put to practical use until the Renaissance when primitive steam engines were used to pump water from mine shafts.

--Newcomen's use of a piston within a cylinder set the pattern for all later steam engines and most internal combustion engines.

2. James Watt, "Steam Engine," 1769

--Its method of transforming the up and down motion of a piston into the rotary motion needed to run machinery made steam power applicable to both industry and transportation.

VI. Social Impact

__A debate exists as to whether the social impact was positive or negative.
--Workers faced hardships and misery; urban problems and pollution were created.
--Many benefits were also derived from the Industrial Revolution.

<u>Resources for Lecture on The Beginnings of the Industrial Revolution in the Eighteenth Century</u>

See Bibliography in Student Handbook of this module.

**Classroom Presentation for Session 2:**

Introduction of the Technology Assessment Model

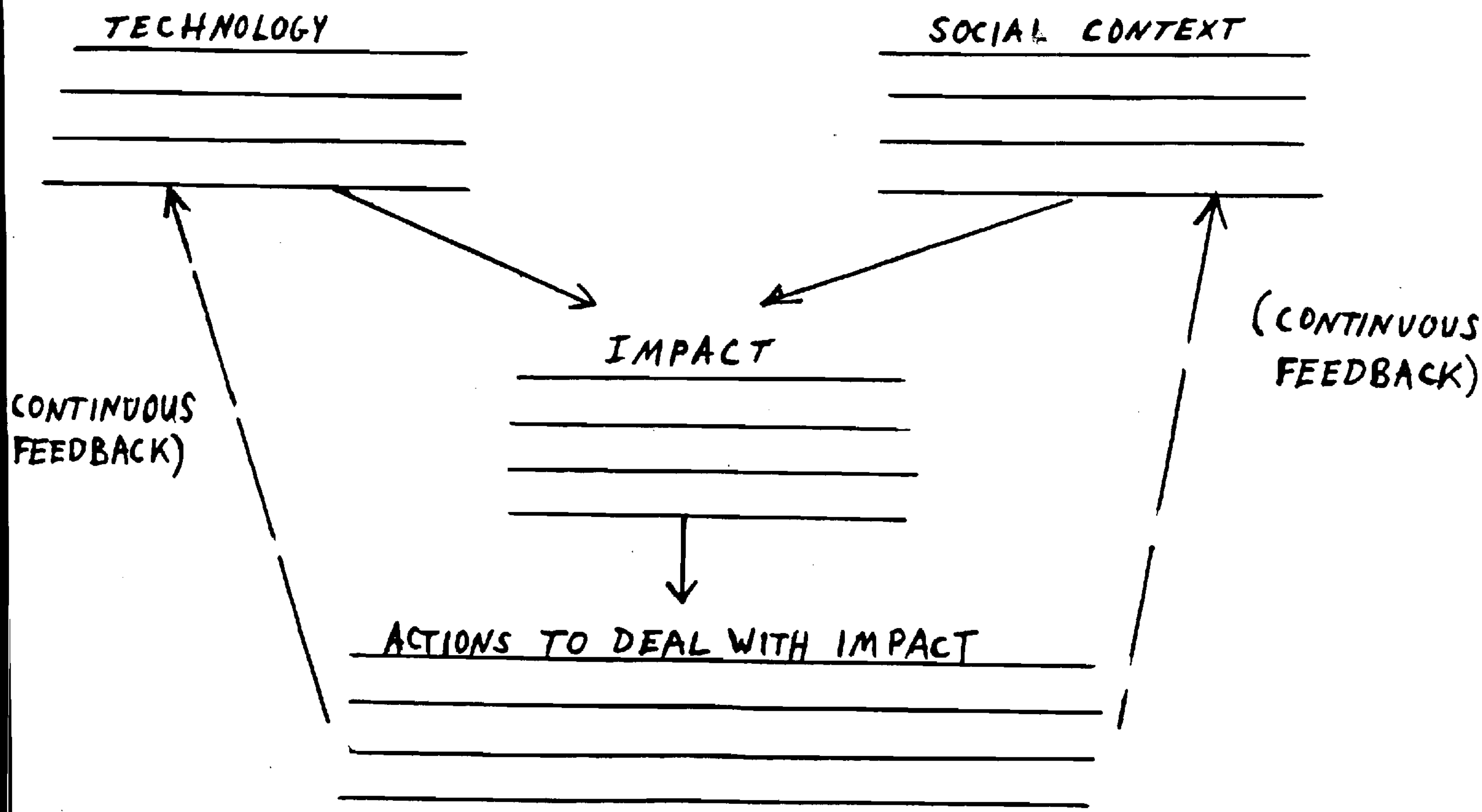
In Session 2 the history instructor introduces the technology assessment model that the students will later apply to the technology and culture of eighteenth century England. What follows is a brief description of the cultural context and some information about the technology assessment model.

Western civilization faced broad and complicated problems in the seventeenth and eighteenth centuries that involved demographics, economics, and politics. The population had greatly increased, the agricultural economy of the manor was collapsing, and decentralized government institutions could not deal effectively with the crisis. The Industrial Revolution provided a technological solution to the problem by harnessing population resources, beginning an industrial economy, and encouraging active government involvement in the economy.

This situation involved a great deal of interaction and feedback between technological development and the developing character of modern civilization. This interaction and feedback may be examined by students who use the technology assessment model which is depicted on the next page:

TECHNOLOGY ASSESSMENT MODEL WORKSHEET

In abstract form this model attempts to portray the complex relationship between society and technology. It indicates that the social context and technology are not independent variables but instead constantly impact on one another. In other words, society continuously demands changes in technology, and technological change in turn forces changes in the social context. This interaction indicated in the model as impact leads directly to organized human actions to deal with the impact on the part of families, businesses, and governments. These organized efforts take many forms. Families may relocate or change their form or function, businesses may act similarly, and governments may attempt to protect obsolete industries or to stimulate the growth of new ones. In any case such actions bring about further changes in both technology and the social context as indicated in the model by the dashed line labled continuous feedback. The model is therefore dynamic, and the process is perpetual.



## Technology Assessment Assignments

Students may test this model by inserting a specific technology and the social context of late seventeenth and early eighteenth century Britain. Or they may test it by concentrating on a social phenomenon in the technological context of that time and place. In either case they must do research to ascertain the mutual changes technology and society generated in each other as a result of their impact on each other. They must investigate the actions of family, business, or government to deal with the changes and the further impact of these actions on technology and the social context.

The technology assessment model is flexible and will allow students a great deal of leeway in pursuing their research. This is illustrated by the following examples.

First, a student might investigate one of the earliest steam engines--such as Savery's engine--that were used to pump water from mines. The student will find that the engine's performance was not adequate. The inadequacy led to tinkering that produced Newcomen's engine. The Newcomen engine was adequate for pumping but not for producing the rotary motion required to drive machinery. It nevertheless impacted the social context as it made mines more productive. More men were employed as a result, and the availability of mined coal and iron provided feedback that stimulated further technological development. That feedback led to James Watt's more scientific approach that produced an engine that could provide the rotary motion required for more sophisticated machines.

Second, a student might investigate an entire industry and its relationship to eighteenth century British society. The textile industry provides an especially good example. British society in the early eighteenth century was rural and agricultural. It was characterized by an apparent population excess, unemployment, poverty, and cheap labor. This cheap labor encouraged capitalists to introduce a hand-operated textile technology into the British countryside.

During the years that followed, the interaction of British society and textile technology in turn led to actions that transformed both society and technology. By 1750 the factory system had been established, huge cities began to appear, the demand for cheap cotton goods expanded, a new mechanized machine technology developed, and all levels of government had to respond to the new economic and social realities.

Third, a student might investigate the relationship between technological development and the broadest forms of economic, social, and political organization. The developing Renaissance technology of ocean-going vessels, metallurgy, tanning, and weaving impacted with the political goals of empire building to produce the economic theory of mercantilism in which governments actively sought to increase their wealth by encouraging manufacturing and protecting the home market. The mercantilist system of granting monopolies, paying bounties, and excluding imported goods in turn provided feedback that both encouraged technological development and changed economic and political thought.

Nurtured by mercantilist policies British capitalists began to demand more economic freedom and less government control. Adam Smith spoke for them in The Wealth of Nations, and the free market system of economics that Britain gradually adopted in the nineteenth century opened barriers that had restricted capitalists. It gave them more money to invest in new technologies and greater freedom to deal ruthlessly with their competitors and workers. Since that time, government economic policy and technology have gone hand in hand in shaping modern society.

## Classroom Presentation for Session 3

### Lecture on The Development of the Steam Engine and the Effect of This Development on Society

In Session 3 the engineering technology instructor delivers a fifty-minute lecture which addresses the development of the steam engine and the effects of this development on society. This lecture usefully focuses on the operations of inventions that led to the development of the steam engine. (See below for a bibliography of relevant literature and graphics.) The lecture also emphasizes the role that each of these inventions played in the development of the steam engine. Here is a brief outline of that lecture:

I. Early Developments That Led to the Invention of the Steam Engine

A. Syringe

--The idea of a vacuum originated from the use of the syringe by Egyptians in the mummification process.

B. Air Pump

- --The invention of an air pump to create a vacuum was crucial.
- --Performed in 1672, Van Guericke's air pump experiment led to the invention of the steam engine.

C. Papin's Experiment

- --He made a connection between the creation of a vacuum in a cylinder and mechanical work.
- --His experiment laid the foundation for the steam engine.

D. Savery's Engine

- --Savery's invention (1699) was the first steam engine to transcend the scale of a working toy.

II. Early Use of Steam Engine Principle

A. Use of Savery's Invention in Underground Mining

- --Savery's invention was called the "Miner's Friend" because steam engines were first used to pump water from coal mines.
- --It made mines more productive, supporting the Industrial Revolution.

B. Newcomen's Atmospheric Engine

- --Newcomen's Atmospheric Engine (1705) was the first practical and useful piston steam engine.
- --It generated and used steam at atmospheric pressure, whereas Savery's engine used steam under pressure.
- --It led to safer operation.

III. James Watt's Steam Engine

A. Increase in Efficiency

- --The invention of a separate condenser increased the efficiency of the steam engine by a factor of four or more.
- --This increase produced a device of enormous industrial ability, rather than a clever but impractical device.

IV. Role of the Steam Engine in the Industrial Revolution

--With the advent of the steam engine, large quantities of energy were now available for production.
--The steam engine was used to power various types of machines: sewing machines, land and sea transport machines, and industrial machines.

<u>Resources for Lecture on The Development of the Steam Engine and The Effect of this Development on Society</u>

Following are readings that provide information about the workings of the inventions cited above as well as some graphics which depict the operations of these inventions.

Cardwell, D. S., <u>Technology, Science and History</u>, (1968).

Daumas, Maurice, <u>A History of Technology and Invention</u>, Volume II, (1964).

Kemper, John D., <u>Introduction to the Engineering Profession</u>, (1985).

Rochlin, Gene I, <u>Reading in Scientific American: Science Technology and Social Change</u>.

Strandh, Sigvard, <u>A History of the Machine</u>, (1979).

**Classroom Activities**

During the lectures in Sessions 1 and 3, students take notes to gain broad understandings of the addressed topics. To help students focus on the emphasized materials, we provide abridged versions of the lecture outlines included in this handbook.

In Session 2, in which the technology assessment model is introduced, students should be encouraged to participate in trial applications of the model.

**Equipment and Materials**

The instructors' lectures are designed to include slides that focus on individuals, places, and technology. These slides should supplement the lecture and add interest to the material being presented. Too many slides, however, might confuse, rather than enlighten, the students.

## Evaluation of Technology Assessment Assignments

Evaluation of both the group oral reports (in Session 4) and the individual writing assignments (after the completion of the module) should take into consideration two characteristics of the completed assignments: how well the chosen subject lends itself to technological assessment and how well the subject is developed.

## Student Evaluation of the Module

To monitor student response, we created a questionnaire which we distributed to students at the end of the module. We include that questionnaire as an appendix to this faculty handbook.

GENERAL HUMANITIES 202
SOUTH CAROLINA STATE COLLEGE
FALL 1985

Module Title: The Beginnings of the Industrial Revolution in the 18th Century
by
Dr. Stanley Harrold, History
and
Dr. Tom Whitney, Civil Engineering

South Carolina State College and Georgia Institute of Technology are developing modules for the RETLA (Resourceful Exchange: Technology and the Liberal Arts)Project. This activity which involves several predominately Black Institutions is funded by the Alfred P. Sloan Foundation.

DIRECTIONS: Complete this questionnaire by checking one response under each statement below.

1. How would you rate your comprehension of the purpose of the module, The Beginnings of the Industrial Revolution in the 18th Century?

______ Excellent

______ Very Good

______ Good

______ Fair

______ Poor

2. How would you rate your comprehension of the lecture presented by Dr. S. Harrold?

______ Excellent

______ Very Good

______ Good

______ Fair

______ Poor

3. How would you rate your comprehension of the lecture by Dr. T. Whitney?

______ Excellent

______ Very Good

______ Good

______ Fair

______ Poor

4. How would you rate the follow-up class discussion in terms of how well you became aware of the impact of technology on society during the 18th Century?

______ Excellent

______ Very Good

______ Good

______ Fair

______ Poor

5. How would you rate the extent to which you will be able to apply technology assessment to technological advances in our society today?

______ Excellent ______ Fair

______ Very Good ______ Poor

______ Good

1 2 3 4 5 6

# Canal Design and the Augusta Canal

by

Marva Stewart

and

Jacquelyn Hill

Paine College
Augusta, Georgia

Student Handbook
for an Instructional Module
in Civil Engineering and English

Resourceful Exchange: Technology and the Liberal Arts (RETLA)

1986

## Rationale

This module focuses on the Augusta Canal. It introduces you to:

--the economic and sociological factors that led to the construction of the canal,

--engineering concepts, principles and procedures that governed the construction of the canal,

--mathematical computations that engineers have used to construct canals, and

--critical thinking skills that will help you to write an essay about some aspect of the canal.

## Learning Objectives

After completing this module, you will be able to:

--trace the history of the Augusta Canal, a local landmark,

--trace the history of the early development of canals,

--define the economic and sociological problems that were solved by building the Augusta canal,

--define the engineering problems that must be solved in the planning and designing of a canal,

--solve mathematical problems related to the construction of canals, and

--write an expository essay about the Augusta Canal that addresses an economic, sociological, or engineering problem.

## Dimensions of the Module

This module consists of six sessions, each requiring fifty minutes of class time, and a field trip.

## Instructional Formats

Lecture/Discussion--one session
Discussion/Seminar--one session
Workshop/Lab--four sessions
Field Trip--one-half day

## Preparation for Session 1

### Assignments

Reading

Read the following material, which is on reserve in the library:

Carter, Sydney and the Augusta-Richmond County Planning Commission. "The History of the Canal" in The Augusta Canal Environs Study. Prepared for the Mayor and City Council of Augusta, Ga., March, 1973. pp. 5-7.

Read **Handout #1: History of the Early Development of Canals** on p. 2 of the reading packet.

### Assignment Deadline

Complete these readings by Session 1.

## Session 1

### Classroom Presentations

This session provides an introduction to the Augusta Canal and to the early development of canals in general. Your instructor delivers a lecture and makes a slide/tape presentation that helps you to understand the social, economic, and historical factors that led to the construction of the Augusta Canal.

Following the presentations, you participate in a discussion of the problems in the community, both economic and sociological, that were solved by the building of the canal. This discussion also includes a review of the early development of canals.

### Classroom Activities

While listening to the presentations, you should pay attention to problems in the community that can be solved by the construction of a canal. Make a list of the community problems that you identify.

## Assignments

### Reading

Read **Handout #2: River Flow and the Flow Duration Curve** on pp. 3-6 of the reading packet.

Refer to the **Glossary** on pp. 28-33 of the reading packet for any terms that you do not understand. This glossary will help you understand all of the handouts.

### Oral Reporting

Review the problems that you have identified which can be solved by canal building. Prepare for a discussion of these problems as well as possible solutions to them.

## Assignment Deadlines

Be prepared to discuss your definitions of community problems and your solutions to these problems in Session 2.

Be prepared to discuss the reading, **River Flow and the Flow Duration Curve,** in Session 2.

## Session 2

### Classroom Discussion

You participate in a discussion of the problems in the community that are solved by canal building. Be prepared to define the problems you present and to suggest possible solutions. Take notes on these problems for later reference.

You also participate in a discussion of river flow and flow duration curves. This discussion should help you to understand the importance of flow duration curves. It should also help you to determine some of the problems that canal builders must solve when they design canals. Take notes on these problems for later reference.

### Classroom Presentation

Your instructor lectures on the topography of the Augusta area and introduces you to the reading of topographical maps.

### Classroom Activities

You and your classmates practice reading a topographical map. See next page of this student handbook.

### Assignments

Reading

Read **Handout #3: Canal Appurtenances** on pp. 7-9 of the reading packet.

Read **Handout #4: Power Generation** on pp. 10-15 of the reading packet.

Oral Reporting

Be prepared to participate in a discussion of the problems that canal builders must solve when they design canals.

### Assignment Deadlines

Be prepared to discuss in Session 3 the problems that canal builders solve when they design canals.

Be prepared to discuss the readings, **Canal Appurtenances** and **Power Generation** in Session 3.


Murray Hill
Westwick
EXTENSION
Forest Hills
WALTON
Walker Cem
Water
VETERANS ADMINISTRATION HOSPITAL
Golf Course
Beach
Pumping Sta
St Marys Ch
HIGHLAND
ROAD
DANIEL FIELD
Golf Course
ROAD
V A HOSPITAL
GEORGIA
High Sch
Trailer Park
Wheless
Kissing Bower Lake
LANE
BORDON
Creek
Rosedale Pond
Bayvale
(BM 160)
Wilkinsons Pond
Adams Lake
Radio Towers
Park
Wheless Road
St Josephs Mission

## Session 3

### Classroom Discussion

You participate in a discussion of the problems that canal builders solve by building canals. Take notes on these problems for later reference.

You participate in a discussion of canal appurtenances, such as dams, heads, intake structures, gates, sedimentation structures, culverts, flumes, and locks. Take notes on this discussion because it will help you to identify appurtenances of the Augusta Canal during the field trip, which occurs in Session 4.

You also participate in a discussion of **Power Generation,** which focuses on water wheels, reaction turbines, pumped storage, and the computation of power generated by a hydroelectric installation. Take notes on this discussion because it will help you to identify whichever of these features are appropriate when you visit the Augusta Canal in Session 4.

### Classroom Presentation

Following these discussions, your instructor presents the film Canals West. This film dramatizes the construction of a canal and provides visual reinforcement of some of the problems typically involved in planning and constructing canals.

### Assignment

Reading

Begin to read **Handout #5: Canal Design** on pp. 16-19 of the reading packet.

### Assignment Deadline

Be prepared to discuss the reading, **Canal Design,** in Session 5.

## Field Trip Preparation

Session 4 includes a field trip to the Augusta Canal. At the conclusion of Session 3, your instructor briefly previews the trip, providing such details as time and the place you will meet. Transportation will be provided.

## Session 4

### Field Trip Activities

You and your classmates conduct an on-site investigation of the Augusta Canal. Your instructors provide maps of the canal to guide your observation. They also help you to identify features of the canal that are similar to the features you discussed in Session 3.

### On-Site Assignment

Take notes of the features you identified, such as dams, gates, and heads. These notes will help you to complete the writing assignment, described below.

### Assignments

Writing

Your purpose is to describe one operational feature of the canal for a student at Paine who has not taken this course. You will, therefore, need to define any terms that this student would not be familiar with.

Name one operational feature of the canal and write:

--a brief description of that feature, clarifying any terms that you use, and

--a description of its operation.

Reading

Continue to read **Handout #5: Canal Design** on pp. 16-20 of the reading packet.

## Preparing for a Quiz

Study the following handouts:

--Handout #1: **History of the Early Development of Canals**

--Handout #2: **River Flow and the Flow Duration Curve**

--Handout #3: **Canal Appurtenances**

--Handout #4: **Power Generation**

Consult the **Glossary** on pp. 28-33 of the reading packet to review the terms used in these handouts.

## Assignment Deadlines

Complete the writing and the reading before Session 5.

Be prepared to take a quiz in Session 5 that tests your understanding of the terms that are used in the first five handouts, cited above.

## Session 5

### Classroom Discussion

You and your classmates participate in a discussion of canal design, focusing on the three design variables: the shape of the excavated cross section, the stability of the bed and banks with respect to the flowing water, and the depth of the canal based on both hydraulic and economic factors.

Your instructor helps you:

--to understand the terms included in the handout on canal design and

--to use the tables that will help you to gather the information you will need to make mathematical calculations in Session 6.

Taking notes on this discussion will help you to engage in practicing the use of these tables, later in this session.

### Classroom Activities

You and your classmates practice using the tables to gather the information that you will need in Session 6.

You also take a brief quiz that tests your understanding of the terms used in the assigned readings.

### Assignments

Reading

Read **Handout #6: Explanation of Formulas and Procedure for Determining the Depth of Flow of a Canal** on pp. 20-26 of the reading packet.

Review the handout on canal design and the notes that you took during this session.

### Assignment Deadline

Be prepared to apply the information contained in the handout on canal design and the knowledge you have gained while practicing the reading of tables to the mathematical calculations you will perform in Session 6.

## Session 6

### Classroom Presentation

Your instructor introduces the formulas and procedure for determing the depth of flow in a canal. Following this introduction, your instructor works through an example that entails the application of these formulas and this procedure.

### Classroom Activities

You and your classmates perform calculations designed by a civil engineer. These calculations require that you use the formula and procedure explained in **Handout #6: Explanation of Formulas and Procedure for Determining the Depth of Flow of a Canal.** Performing these calculations will help you to synthesize the information about the three design variables pertaining to canal design.

### Assignments

Mathematics

Your instructor assigns problems that you will solve independently.

Reading

Review all the handouts in your reading packet. While reviewing these handouts, try to select a topic that interests you and that you are willing to explain to a student who has not taken this course.

### Assignment Deadlines

Complete the mathematical problems by Session 7.

Be prepared to select a topic of your interest to write an expository essay about during Session 7. The first draft of your essay will be written in class.

## Session 7

### Classroom Discussion

You and your classmates participate in a discussion that summarizes the knowledge you have gained in Sessions 1-6. The aim of this discussion is to help you select a topic that addresses engineering problems encountered in the construction of canals.

Your instructor suggests some suitable topics and evaluates the topics that you and your classmates name.

### Classroom Activities

You select an appropriate topic and begin to write the first draft of an expository essay of at least five paragraphs.

This expository essay must address an economic, sociological, or engineering problem that you wish to explain to students who read the school newspaper.

Your essay should include:

--a brief statement about the problem you have selected,

--several paragraphs that clarify your explanation, and

--brief definitions of any terms your reader would not be familiar with.

At the end of Session 7, your instructor presents a Writing Checklist that helps you to assess whether or not you need to revise this draft.

### Assignment Deadline

Your first draft is to be written in class. The final draft is due at the session following this module.

## Evaluation

You demonstrate your achievement in this module by:

--taking a quiz on the readings,

--performing mathematical calculations,

--writing description paragraphs on an operational feature of the dam,

--writing an expository essay that addresses an economic, sociological, or engineering problem and presents a solution, and

--participating in classroom discussion.

## Weighting of the Grade

| Activities | Percentage of the Grade |
|---|---|
| Quiz on Readings | 20% |
| Mathematical Calculations | 20% |
| Description Paragraphs | 10% |
| Expository Essay | 40% |
| Classroom Participation | 10% |
| | 100% |

## Bibliography

"The Augusta Canal" in Richmond County History. Vol. 2, No. 2, p. 16; Vol. 5, No. 2, p. 6, p.23; Vol. 7, No. 2, p. 47; Vol. 9, No. 1, p. 5, p. 7; Vol. 9, No. 2, p. 18.

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Robertson, Thomas H. Boat Ride Down the Canal. Slides and Notes. Augusta, Georgia. Unpublished.

"Special Report" by the Augusta Canal Company. Richmond County History. Vols. 1-10.

Spude, Robert L. "Augusta Canal," Historic American Engineering Record, undated.

United States Department of the Interior, Geological Survey. 7.5 Minute Series (Topographic). Washington, D. C. Storys Millpond Quadrangle, McBean Quadrangle, Shell Bluff Landing Quadrangle, Hephzibah Quadrangle, Mechanic Hill Quadrangle, Jackson Quadrangle, Augusta West Quadrangle, Augusta East Quadrangle, Hollow Creek Quadrangle, Martinez Quadrangle, North Augusta Quadrangle, Graniteville Quadrangle.

# History of the Canal

Throughout history, settlers and pioneers have settled close to bodies of water. Settlers did this not only to provide for a source of water, but to make use of these waterways as a means by which people and goods could be transported.

Even before the English arrived at Yamacraw Bluff overlooking the Savannah River at what was to become the Savannah Colony of James Oglethorpe, South Carolinians had constructed Fort Moore at Savannah Town, on the left bank of the river, just opposite of what is now Augusta. Fort Moore served as a trading post with the Indians and a gateway to the Indian country to the west. In 1735, General Oglethorpe sent a party up the river to establish another trading post on the opposite side of the river at the head of navigation. To protect this trading post, Fort Augusta was constructed in 1736, and the building of Augusta had begun. There were two basic reasons for its establishment--to serve the Indian trade for the Georgia Colony, and to defend the western edge of the settlement. Until the outbreak of the Revolutionary War, Augusta was to operate as a center of the fur trade that reached as far west as the Mississippi River.

Due to its location on the Savannah River, Augusta gained prominence as a distribution center. There was an already flourishing tobacco market when Eli Whitney invented the cotton gin. The availability of easy water transportation helped to make Augusta one of the World's largest inland cotton centers.

With the coming of the railroads, river traffic diminished and the competition among the many railroads that were being formed resulted in much of Augusta's business being carried elsewhere.

Credit for the Augusta Canal must be given to Colonel Henry H. Cumming, who saw the potential for creating the necessary power to operate textile manufacturing plants. The concept was based on the development of the area as a cotton farming region and the strong demand for cotton textiles. Colonel Cumming, along with several Augusta banks and citizens, urged that a canal be constructed for the purpose of providing power for factories and creating a plentiful supply of water for the City.

The Canal, as first surveyed in 1844, was to be five feet deep, 20 feet wide at the bottom, and 40 feet wide at the top. The Canal was to have an output of 600 horsepower along its planned seven-mile length. Work on the Canal began in May, 1845. On November 23, 1846, the gates were opened, and the work was completed in 1847. The Augusta Cotton Mill was organized and was to become the first plant to use water from the Savannah River to power a textile mill operation.

Five years after the completion of the Augusta Canal, the City's population had almost doubled to more than 12,000. A great textile manufacturing center had its beginning. The building of the Augusta Canal was the first major industrial enterprise for Augusta. During its inception, anti-progressives tried to stop the construction of the Canal, but the courts decided that the City Charter gave the authority for the City Council to undertake such enterprises. In 1849, the managers of the Augusta Canal Company were authorized to transfer the Canal to the City Council of Augusta which still owns the Canal today.

The original purpose of the Canal was to act as an incentive for attracting industry to Augusta. By the early 1870's there were some 14 plants using power provided by the Augusta Canal. In addition to providing inexpensive water power, the waterway also provided barge transportation. It was probably the only Canal in the country to serve both power and transportation needs.

As might be expected, in time it was realized that the Canal was too small for the many demands being made upon it. In 1872, work was begun under Major Charles Estes to enlarge the waterway. The work was completed in 1875. Many Chinese, Irish, and Blacks were brought into Augusta as laborers on the Canal expansion project. At one time, it was estimated there were 200 Chinese brought in from the west. After completion of the Canal, most of the Chinese laborers elected to remain in Augusta. These laborers became the nucleus of the present Chinese community of Augusta which has made many contributions to the City.

The Canal expansion resulted in a new length of nine miles to the Augusta Canal, with a general right-of-way width of 150 feet, a depth of 11 feet, and an estimated 14,000 horsepower. Added impetus was given to the textile manufacturing industry as well as other industries. Overall, industrial development in the Augusta area has been substantial. Traditionally, as in most areas of the South, emphasis was on textiles and brick and tile manufacturing. In the 1950's, with the establishment of the Savannah River Plant, the chemical industry also became a vital part of the Augusta area industrial-economic picture. In the 1960's, agri-chemical and paper products were added to the economic base.

The Augusta Canal has great historical significance and continues to provide water and power for the City of Augusta. It is a unique scenic and cultural landmark. In 1971, the Augusta Canal was placed on the National Register of Historic Places.

Carter, Sydney and the Augusta-Richmond County Planning Commission. "The History of the Canal" in The Augusta Canal Environs Study. Prepared for the Mayor and City Council of Augusta, Ga., March, 1973. pp. 5-7.

# Readings for Canal Design and the Augusta Canal

**Handout #1: History of the Early Development of Canals**

**Handout #2: River Flow and the Flow Duration Curve**

**Handout #3: Canal Appurtenances**

**Handout #4: Power Generation**

**Handout #5: Canal Design**

**Handout #6: Determining the Depth of Flow in a Canal**

From Canal Design by T. W. Sturm

**Glossary**

Compiled by Jacquelyn Hill and Marva Stewart in collaboration with T. W. Sturm

Resourceful Exchange: Technology and the Liberal Arts (RETLA)

1986

## Handout #1: History of the Early Development of Canals

Canals are artificial conveyances which are used to deliver water for water supply, irrigation, power production (mechanical or electrical), drainage, and navigation. In the United States in the first half of the 19th century, the development of canals in the Northeast was stimulated by the need for transportation. Although canals were quickly supplanted by railroads, they continued to be important throughout the 19th century for drainage, water supply, and power production by water wheels.

The engineers responsible for the early development of canals in the United States were trained primarily as military engineers at the then fledgling academy at West Point, but experience became the best teacher, particularly for those who participated in the successful completion of the Erie Canal. The services of these engineers were much in demand in other parts of the country.

The construction of canals and aqueducts to provide a safe water supply for the growing cities of the 19th century was an engineering triumph which rescued many Americans from the ravages of water-borne diseases, such as cholera. By mid-19th century, the first safe water supply for New York was provided by the Croton Aqueduct. The chief engineer of this undertaking had been a resident engineer on the Erie Canal project.

Canals played an important role in providing water power for the industrialization of New England. The canal delivered water from an impoundment to water wheels 18-20 feet in diameter which provided the mechanical power to drive industrial equipment, such as the equipment used in cotton spinning and weaving mills. These water wheels were essentially driven by the weight of water falling through a height or "head" that was determined by the maximum diameter of wheel which could be built. They were used until the middle of the 19th century when the development of the turbine allowed much greater heads to be utilized with very high efficiency.

While the use of canals as water delivery systems is much less widespread today, those systems in use or under development involve very large scale transfers of water for beneficial uses, such as irrigation, water supply, and navigation. Modern day examples of the work of the canal builder include the California Water System and the Tennessee-Tombigbee Waterway.

## Handout #2: River Flow and the Flow Duration Curve

### River Flow

Because river flow is the runoff of water from the land resulting from a meteorological event, there is inherent uncertainty in the occurrence of any given magnitude of flow. River flow is commonly measured in units of volume per unit time passing a specified cross section of the river. A unit of river volume flux is often given in "cfs," which is an abbreviation for cubic feet per second. For example, the mean river flow in the Savannah River as measured by a gaging station 12 miles downstream from Augusta is 10,000 cfs for a period of record from 1884 to 1969. The maximum river flow during this time period was 350,000 cfs in 1929; the minumum flow was 650 cfs in 1939.

Reservoirs built on the Savannah River upstream of Augusta tend to reduce this wide range of flow by temporarily storing flood flows and releasing them at a slower rate over a longer period of time than could occur naturally. The Savannah River is currently regulated by Lake Burton, Mathis Reservoir, Hartwell Lake, and Clarke Hill Reservoir upstream of Augusta.

### Flow Duration Curve

One useful way of quantifying the effect of upstream regulation on river flow is the flow duration curve. This is effectively a cumulative histogram of daily flows. It is obtained by counting the number of river flows within fixed class intervals over the entire flow range. For example, we might count 100 daily flows that fall within the class range of 4000 to 5000 cfs. Then by accumulating the number of flows greater than or equal to a particular flow rate and dividing by the total number of daily flow rates in the period of record, we have a crude estimate of the likelihood that any particular flow rate will be equalled or exceeded.

The flow duration curve is illustrated in Figure 1 for the Savannah River near Augusta.

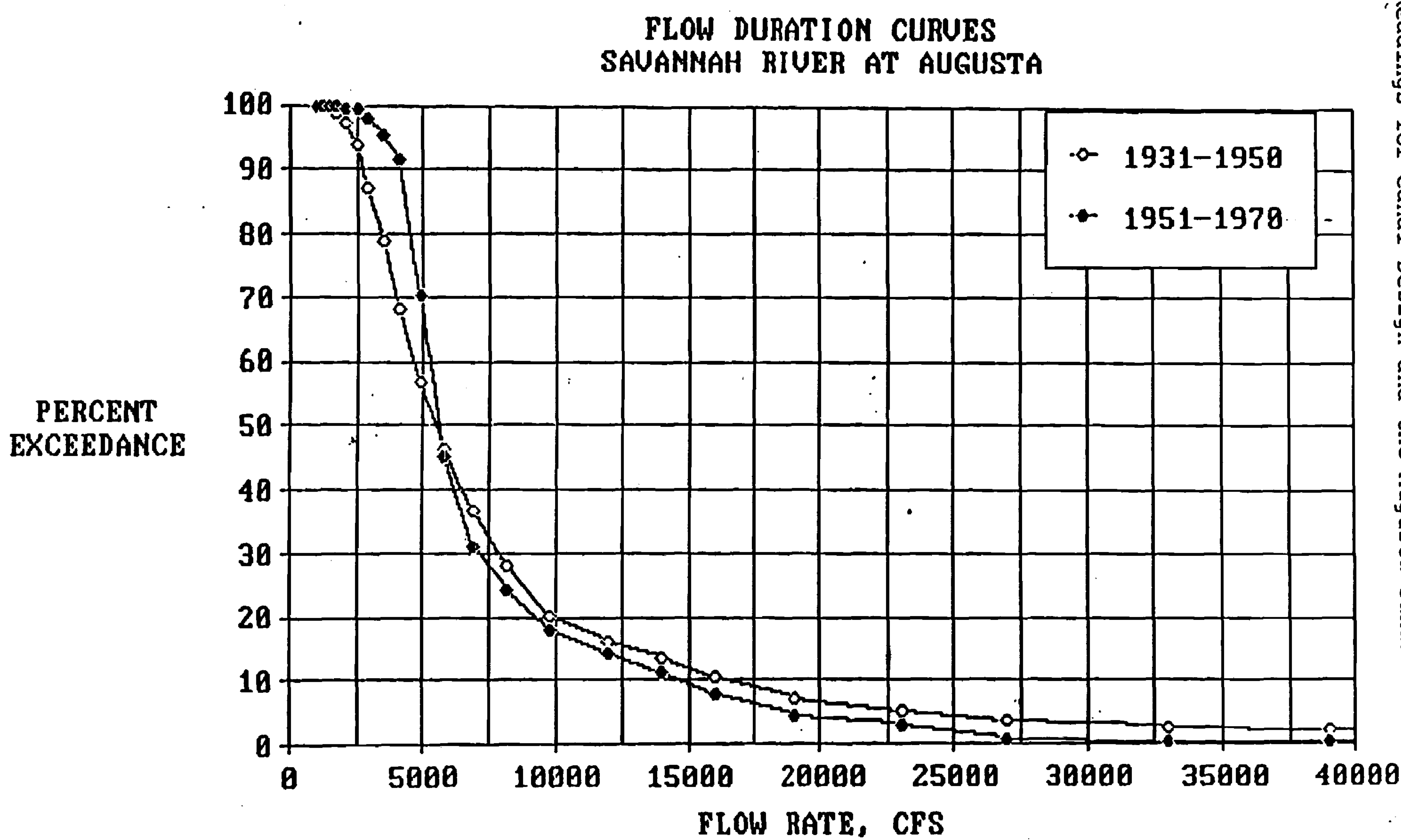



Fig. I - Flow Duration Curves

One of the flow duration curves (identified by -o-o-o- on the histogram) was determined for the period of record from 1931-1950 before regulation by Clark Hill and Hartwell Reservoirs. The other curve (identified by -•-•-•- on the histogram) is for the following 20 year period during which Clark Hill Reservoir (1951) and Hartwell Reservoirs (1961) began regulating the flow in the Savannah river.

These flow duration curves reveal that the small flow rates which are exceeded or equalled most of the time are more likely to be exceeded after reservoir regulation. For example, the flow rate of 5000 cfs was equalled or exceeded 58 percent of the time before regulation and nearly 70 percent of the time after regulation. In other words, the reservoirs have increased the minimum flows in the river because of their releases.

These curves also reveal that very large flow rates are less likely to occur after reservoir regulation because the reservoirs store very large flood flows and release them at a lower rate over an extended period than would have occurred naturally.

## Uncertainty of Flow Rates and Risk of Failure

Regardless of the purpose for which canals are built to deliver water, they must be capable of supplying a relatively constant flow rate. This can be accomplished by building a low-head dam on a river and diverting flow to the canal through a gate control structure called a headworks.

The dam causes water to back up behind it so that it can store water and increase its available potential energy, or head. During times of flooding the headworks must be closed so that flows pass over the dam or spillway, instead of into the canal.

The design of the dam and the reliable flow rate which can be supplied by the canal is dependent on the uncertainty of runoff events as illustrated by the flow duration curve. In the case of designing the dam for flood flows, only peak flow rates from a large number of floods are analyzed to determine the likelihood of any given flood magnitude being equalled or exceeded.

Engineers refer to the design flood that the dam can safely pass without failure as an n-year event. For example, if a dam is designed for the 100-year flood, that means it can safely pass the flood magnitude which occurs on the average of once every 100 years.

Because this is an estimate based on a long-term average, the actual probability of occurrence of this flood or a greater one at least once in the first 100 years of the project is only 63 percent; the probability of its occurrence over a 500-year period is 99 percent.

The probability of winning in an annual lottery serves as a useful analogy for this probability of occurrence. Suppose that 100 tickets to this lottery are sold each year. You buy 1 ticket each year. Your chances of winning in any one year are 1 out of 100. Your chances of winning <u>at least once</u> in 100 years are 63 out of 100.

The following formula represents your chances of winning in a 100-year period:

$$J = 1 - (1 - .01)^{100} = 0.63$$

The engineer must select a design flood based on such estimates of probability so that he can assess the risk of failure. Of course, if loss of life is involved in a failure, then the selection of the design flood would be much more conservative to minimize the risk of failure. Therefore, the dam would be designed to pass a much larger flood.

## Handout #3: Canal Appurtenances

Figure 2, below, represents a typical layout of a canal system. In order to provide water storage upstream that is sufficient to maintain the water level above the entrance to a canal, a diversion dam is often built. The dam, itself, is often a low head, concrete overflow strucure. In other words, floods in the river flow directly over the dam, which is designed for this purpose. The dam may also have a provision for a sluiceway, or drain, for the purposes of flushing excess sediment from behind the dam and of providing water discharge during times of low flow.

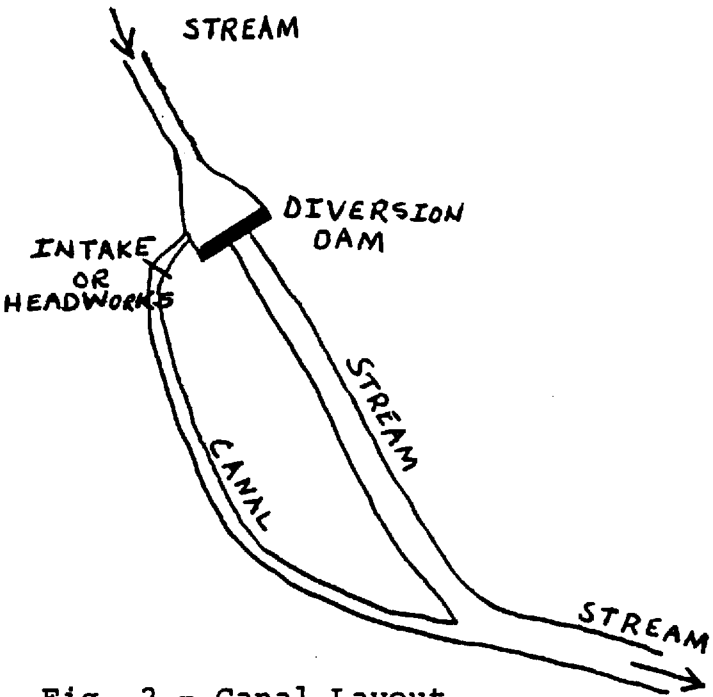
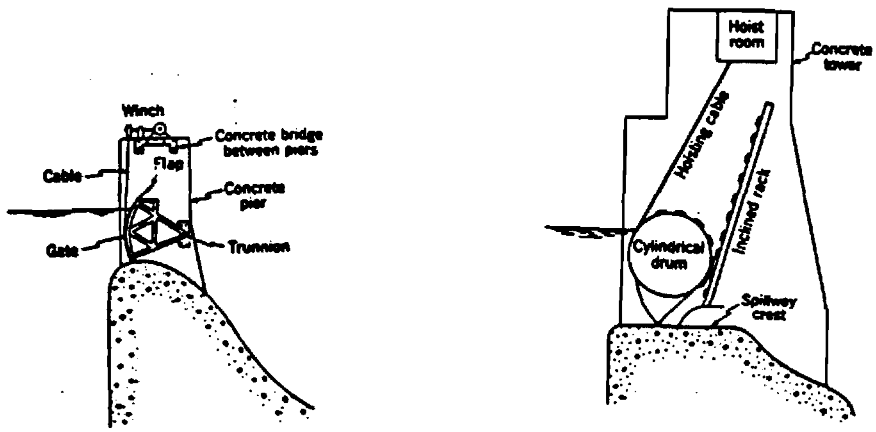



Fig. 2 - Canal Layout

Early canals depended on the generation of mechanical power by water wheels which could handle only small heads. While early canals of the type shown in Figure 2 were used in conjunction with relatively low-head overflow dams, more recent structures are very high with a separate overflow spillway to pass flood flows. These high structures take advantage of modern turbines which are designed for very large heads in the production of hydroelectric power. The amount of power is directly proportional to the head, or height of water above the turbines.

High head dams require some control structures to regulate the flow into the canal. These take the form of electrically operated gates of various shapes which are easily opened and closed by the operator.

Figure 2 depicts the canal intake or headworks. The canal intake structure requires some type of control to regulate the flow into the canal. On small installations, these controls may be very simple slide gates which can be raised or lowered manually. On larger canals, more sophisticated electrically operated gates of the type on high head dams may be used. Figure 3 presents examples of a radial, or Tainter, gate and a roller gate.




Radial Gate    Roller Gate

Fig. 3 - Gate Structure (Linsley and Franzini)

Many other types of structures may be found in a canal system. In the case of irrigation canals, a sedimentation structure may be necessary to allow excess sediment to settle out of the diverted flow before delivery to the canal system. If the canal must cross a hill, a culvert or tunnel through the hill can be used. If the canal must cross a depression, a flume or elevated channel can be used. The types of structures required are unique to each canal project and must be designed so that the canal will function as intended.

On navigation canals, locks are very specialized structures built to allow passage of boats through abrupt changes in water surface elevation such as dams, waterfalls, or other obstructions. Their size is governed by the vertical drop in water surface elevation and the draft of the boat. The filling and emptying mechanism of locks is their most critical design feature. As shown in Fig. 4, in the case of small locks, leaf gates are opened and closed slowly. If the gates are opened too rapidly during filling of the lock, surges can develop in the lock which may cause the boat to break loose from its moorings. A more uniform and less abrupt filling of a lock can be achieved by pipe diffusers under the floor of the lock or in its walls.

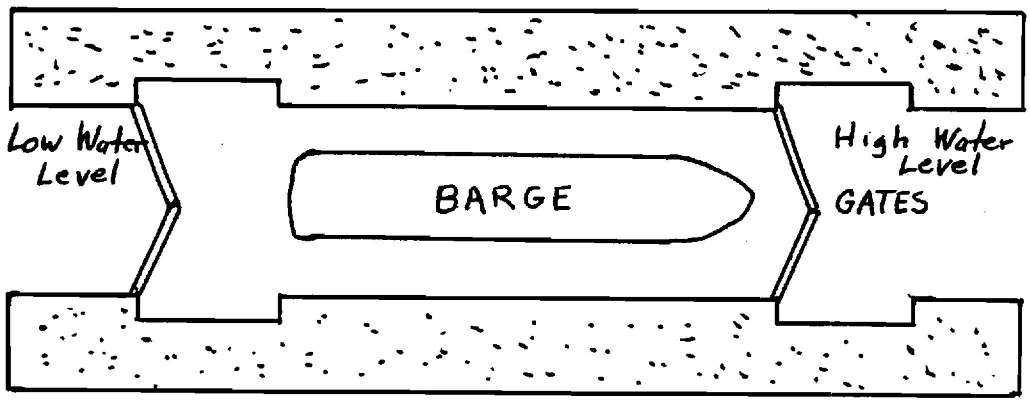



Fig. 4 - Simplified Top View of a Lock with Leaf Gates.

The V formed by the paired gates points upstream so that water pressure keeps them tightly sealed. For filling or emptying, gates are cracked open or small orificies in the gate itself are opened by removing a cover plate.

## Handout #4: Power Generation

As mentioned in **Handout #1: History of the Early Development of Canals**, p. 2, water wheels were used extensively in the first half of the nineteenth century to generate mechanical power that was transferred directly to the machinery involved. These water wheels were of several types, depending on the point at which water was introduced at the periphery of the wheel. Figure 5 illustrates two kinds of water wheels: the breast wheel and the overshot wheel. In the breast wheel, water was admitted to the wheel above the center but below the top. In the overshot wheel, water was brought across the top of the wheel where it dropped onto the wheel, causing it to spin in a direction opposite to that of the breast wheel.

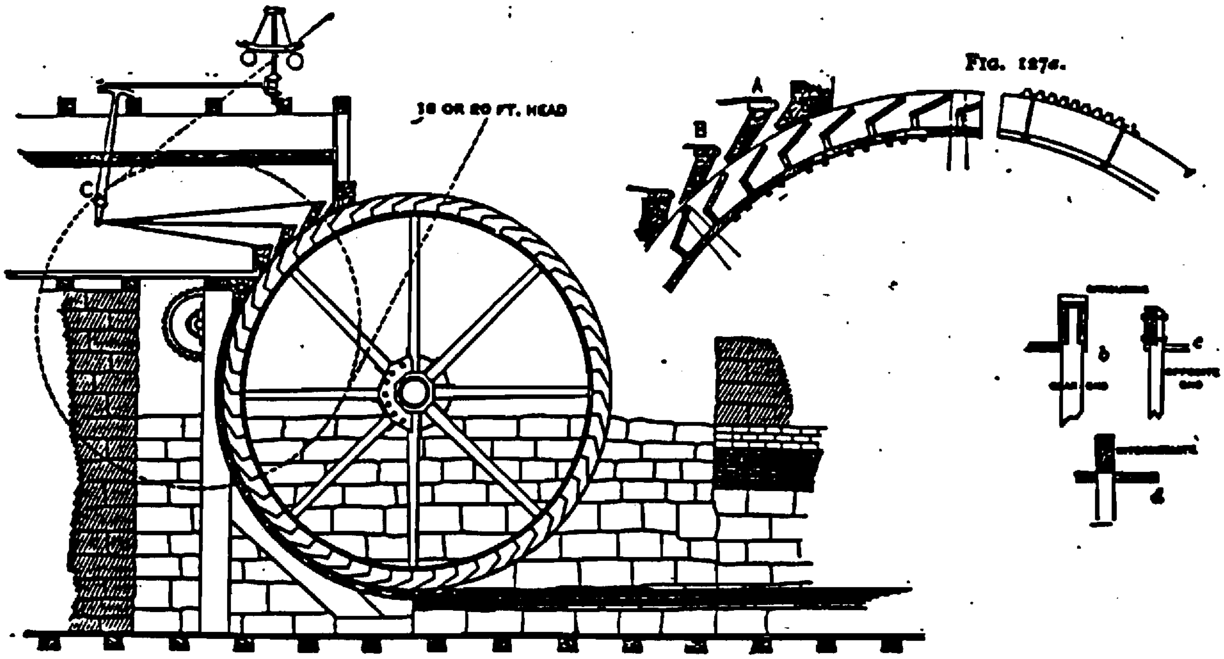
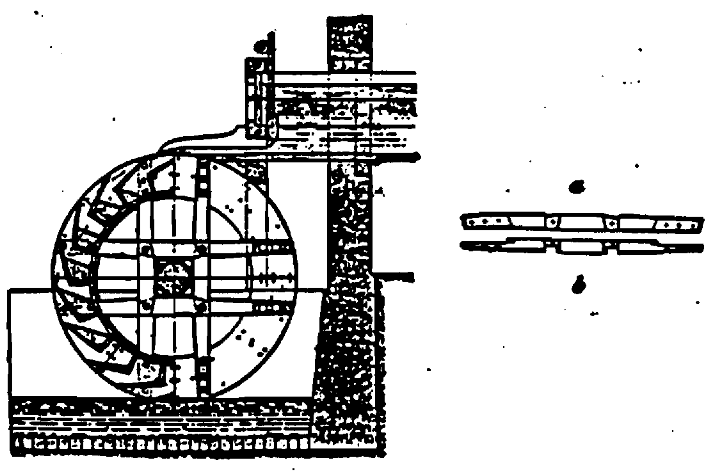



FIG. 127.

Breast Wheel




Overshot Wheel

Fig. 5 - Water Wheels (Frizell)

The water wheel is primarily a gravity device in which the weight of the water passing through the wheel transfers a torque to that wheel that causes it to rotate and provide power to mechanical machinery. The wheel rotates at a relatively slow speed and is limited in the power that it can produce because of its size.

The invention of the reaction turbine around 1850 made the water wheel obsolete. The reaction turbine is a hydraulic machine that can operate under a very high head of water and produce large quantities of electrical power by being coupled to a generator. (See Figure 6.) Water at very high pressure is admitted to the turbine runner at its periphery and passes through the runner with a considerable change in direction: from primarily tangential to radial in direction.

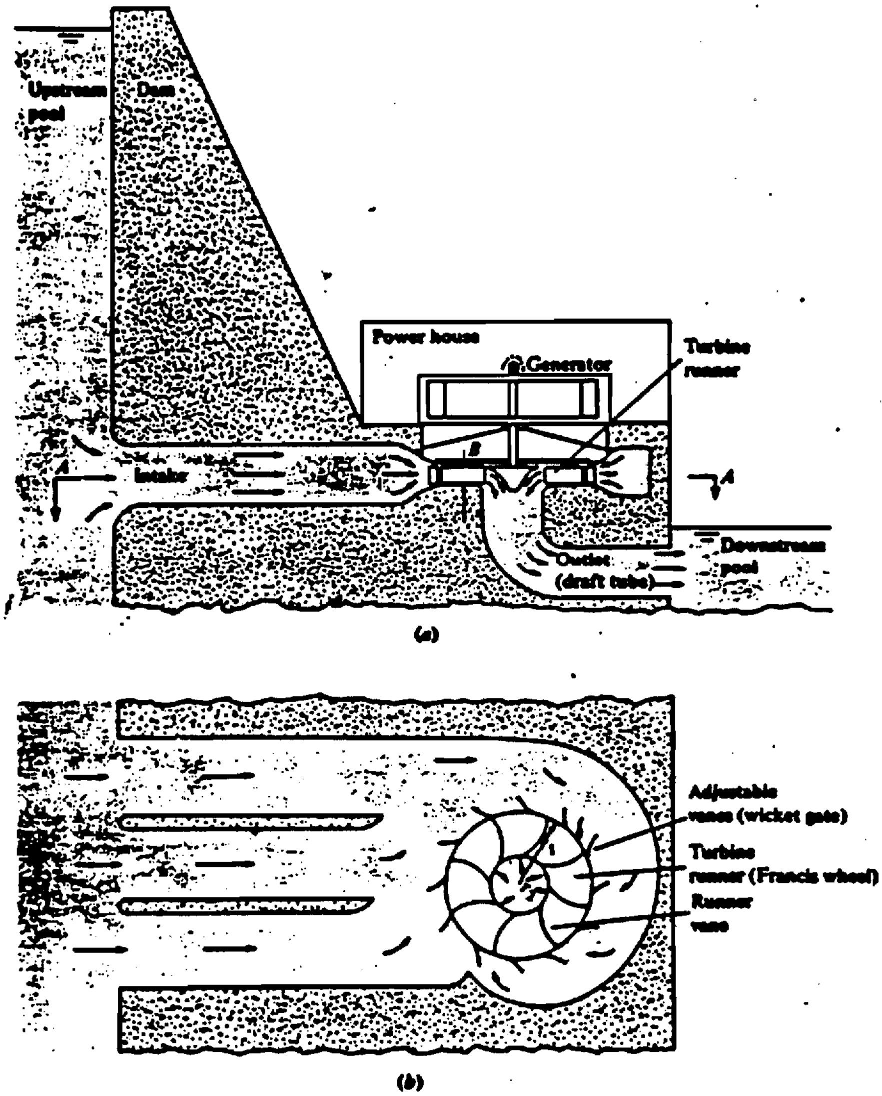



Fig. 6 - Reaction Turbine
(Roberson and Crowe)

The result of this change in direction is a torque applied to the turbine runner. The higher the head, or height of the water above the turbine entrance, the greater the power that can be produced. Hence, hydroelectric power plants may operate on heads of several hundred feet created by constructing very high dams. The efficiency of reaction turbines is usually greater than 90 percent, which means that at least 90 percent of the available water energy can be transformed into usable electrical energy.

A recent innovation in the use of hydroelectric power is called pumped storage. Hydraulic machines capable of acting either as pumps or turbines can be installed in the hydroelectric plant. An upper reservoir of water is built several hundred feet above the lower reservoir to provide stored energy. During times of peak demand, when electrical power is very valuable, the turbines are quickly brought on line to produce peak power in a matter of a few minutes. They are driven by water that has been released from the upper reservoir. During the night when cheap "dump" power is available, the turbines are operated as pumps to pump water from the lower reservoir back up to the upper reservoir to be used to generate peak power again the next day.

Although canals were once used to deliver water directly to water wheels for power generation, they are more often used in modern hydroelectric installations to transport water to a forebay, or small holding pond. Figure 7 illustrates this modern use of canals. From the forebay, water is transported to the turbines through penstocks, or large, enclosed conduits or pipes, causing the water to undergo a large, vertical drop to the turbines below.

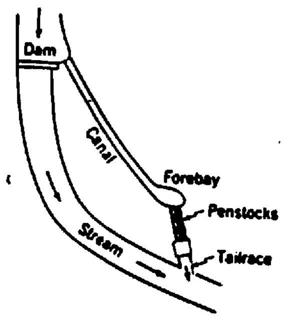



Fig. 7 - Schematic Layout of Hydroelectric Installation (Linsley and Franzini)

The amount of power which can be generated by a hydroelectric installation is easily calculated by the following formula:

$$P = 62.4 \times Q \times H / (550 \times e)$$

In this formula:

--P is the power produced in horsepower,

--Q is the flow rate in cfs,

--H is the head in ft., and

--e is the efficiency as a decimal fraction.

If Q = 5000 cfs and H = 30 ft., then a turbine with an e (efficiency) of 0.93 is capable of producing approximately 18,000 horsepower, or 13.4 megawatts. (1340 horsepower = one megawatt.) In contrast to a hydroelectric installation, a typical nuclear power plant can produce 1000 megawatts.

The reliability of this power production depends on the uncertainty of river flow rates. A flow duration curve similar to the one illustrated in Figure 1 can be used to estimate the percent of time that the flow rate of 5000 cfs is equalled or exceeded, thus providing an idea of the reliability of the production of 13.4 megawatts of power.

## Handout #5: Canal Design

Canals are designed to deliver a selected flow rate of water without overtopping their banks. In addition, their beds and banks must be stable with respect to erosion and deposition as well. Finally, the choice of the best cross-sectional shape is guided by practical considerations and by hydraulic and economic efficiency.

### The First Design Variable: Shape

The first design variable of interest in designing a canal is the shape of the excavated cross section. While the cross section of the canal can be rectangular if it is excavated through rock, it must be trapezoidal in shape for slope stability in the case of excavation through earth. Figure 8 illustrates a trapezoidal cross section of a canal.

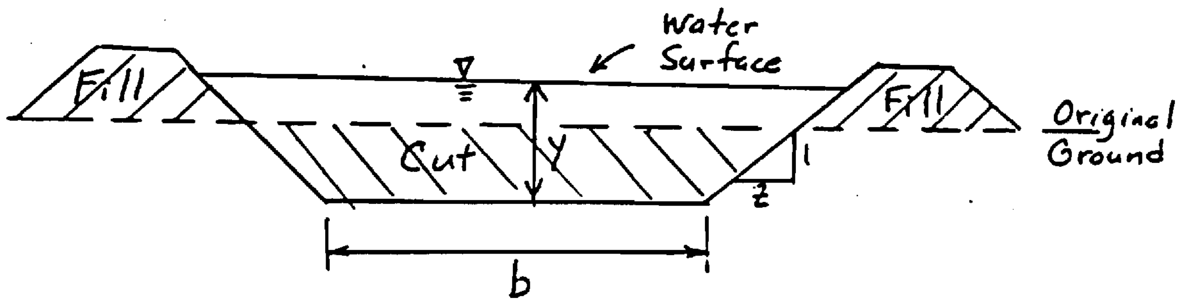



Fig. 8 - Trapezoidal Canal Cross Section

The trapezoidal cross section has a bottom width, b, and side slopes which are indicated by the notation z:1 (z to 1). For example, a canal with 3:1 side slopes is one for which the banks of the canal slope gradually upward at the rate of one foot of vertical rise for each three feet of horizontal distance. This is necessary to prevent sliding of the earthern material on the banks. In general, side slopes of canals vary between 3:1 and 1:1 (a forty-five degree angle).

Figure 8 also illustrates the relation between canal cross-sectional shape and excavation volume. It is most economical when possible to be able to balance cut and fill. In other words, the material excavated from the earth is just sufficient to form the "fill" or banks of the canal. Creating this balance eliminates the necessity of borrowing fill from other areas or the necessity of disposing of excess fill materials. Although other considerations may prevent a balanced cut and fill from being achieved in all cases, it is a desirable feature of canal excavation.

Hydraulic efficiency means that the channel can deliver the design flow rate at the minimum possible value of cross-sectional area of flow. The most economical cross-section shape from the standpoint of hydraulics is either a semicircle or that cross section that most closely approximates a semicircle. The best rectangular shape is the one which has a bottom width that is twice its depth. Other considerations, such as those discussed above, however, may cause the final design to differ from the best hydraulic cross section.

## The Second Design Variable: Stability of Bed and Banks

The second design variable of good canal design is the stability of the bed and banks with respect to the flowing water. If the velocity of the water is too great, scour or erosion of an earthen canal may occur which can lead to eventual failure. On the other hand, if the velocity is too small, deposition or settling of suspended sediments may occur. This can result in the canal becoming choked by excess sediment and vegetation.

Engineers have some control over the velocity in their choices of the slope of the canal, which is the rate of drop in elevation of the canal bottom per unit horizontal distance in the flow direction. For example, a slope of 0.001 means that the canal bottom drops 0.001 ft. for each foot of horizontal distance, or that it drops one foot over a distance of 1000 ft. If a given canal is excavated at a larger slope, it will carry the same design flow rate at a smaller depth but at a greater velocity.

In contrast with railroads or highways, a canal must generally slope downward in the flow direction. In addition, frequent changes in slope are undesirable. The alignment of the canal is usually a compromise between a straight line from the dam to the point of water use and a much longer route along the side hill to minimize excavation or fill. The choice of route results in differences in canal length and thus in slope for a given drop in elevation of the canal bottom.

Engineers have developed tables of maximum allowable velocities for erosion stability based on experience. Table 1 illustrates the maximum allowable velocity for channel materials ranging from fine sand to cobbles.

**Table 1: Maximum Permissible Velocities**

| Materials | Maximum Velocity Feet per Second |
|---|---|
| Fine sand | 1.50 |
| Sandy loam | 1.75 |
| Silt loam | 2.00 |
| Volcanic ash | 2.50 |
| Fine gravel | 2.50 |
| Stiff clay | 3.75 |
| Coarse gravel | 4.00 |
| Cobbles | 5.00 |
| Shale | 6.00 |

In any case, the velocity should not be less than 1.5 ft. per second in order to prevent deposition. While more sophisticated methods exist today for designing stable canals, these maximum velocities first introduced by Fortier and Scobey in 1926 present a clear picture of canal stability as a design issue.

In some cases, it is simply not possible to limit the velocity to the maximum values given in Table 1. In this case, the canal can be lined with concrete, stone paving, or riprap (dumped, loose rock). Lining with concrete may also be necessary to prevent large seepage losses through the bed and banks of the canal. Early canal builders used a mixture of clay, sand, and water to form a natural canal lining.

## The Third Design Variable: Determination of the Depth of the Canal

The third and final design consideration for canals is the determination of the depth of the canal based on both hydraulic and economic factors. Hydraulically, the canal will flow at one specific depth for given values of the design flow rate, the slope, the roughness of the canal, and the geometry of the cross section. The value of this depth is determined by the Manning's formula, which is a relation for the depth of flow derived primarily from field and laboratory experiments. The principal difficulty in using Manning's formula is to estimate the roughness factor called Manning's n. This n value is a measure of the resistance of the canal bed and banks to the flow of water. Its value for concrete is approximately 0.015.

Manning's formula is given by:

$$Q = \frac{1.49}{n} A R^{2/3} S^{1/2}$$

In this formula,

$A = y(b+zy)$
$R = A/(b+2y\sqrt{1+z^2})$
Q is the volumetric flow rate in cfs
n is Manning's roughness coeffecient
A is the cross-sectional area of flow
R is the hydraulic radius (the area divided by the wetted perimeter)
S is the slope of the channel in the flow direction
b is the bottom width of the channel
z is the side slope
y is the depth.

(See Fig. 9.)

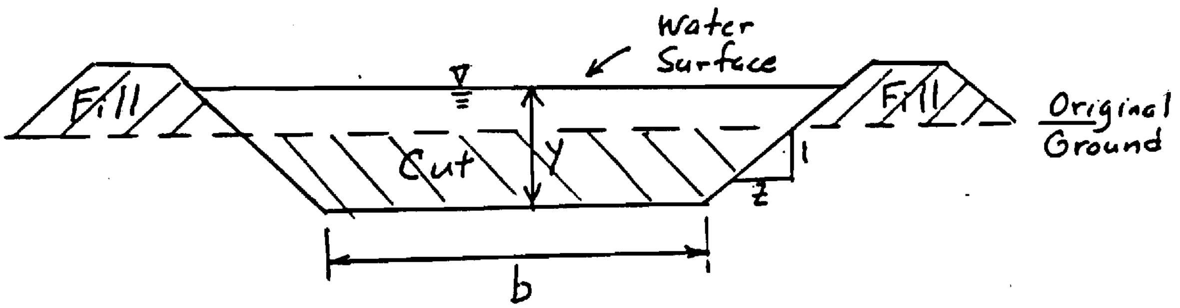



Fig. 9 - Trapezoidal Canal Cross Section

If we were to attempt a solution of Manning's formula for the depth, given n, Q, S, and the channel bottom width and side slope, a very complicated equation would result which would have to be solved either by trial and error with a calculator or by more sophisticated techniques on a computer. Alternatively, the equation can be solved in a universal form by using ratios of variables that generalize the solution for all cases. These general solutions are placed in a table and a specific solution is found by the method of table "look-up." This is the method that we will illustrate, not only because it is easy to accomplish without an extensive mathematics background but also because this is the method which was used before the invention of hand-held calculators and computers.

Table 2 lists the Manning's n values for the earthen materials included in Table 1.

**Table 2: Maximum Permissible Velocities**

| Materials | Maximum Velocity Feet per Second | Manning's n |
|---|---|---|
| Fine sand | 1.50 | .020 |
| Sandy loam | 1.75 | .020 |
| Silt loam | 2.00 | .020 |
| Volcanic ash | 2.50 | .020 |
| Fine gravel | 2.50 | .020 |
| Stiff clay | 3.75 | .025 |
| Coarse gravel | 4.00 | .025 |
| Shale | 6.00 | .025 |
| Cobbles | 5.00 | .030 |

## Handout #6: Determining the Depth of Flow in a Canal

The following procedure will help you to determine the depth of flow in a canal.

1. Select a bottom width of the canal, b, in ft. and a side slope that is stable, say 2:1.

2. Choose a canal slope and determine, for the selected value of b, the value of X from Table 3.

3. Determine the roughness of the canal, n, and select the design flow rate, Q, in cfs.

4. Multipy them together and divide by X to obtain nQ/X, which we call F.

5. Interpolate in Table 4 with the values of F and the side slope 2:1 in order to determine the value of y/b, which is the depth of flow divided by the bottom width of the canal.

6. Multipy the value of y/b by the width, b, to obtain the depth of flow, y, in ft.

The following example illustrates the procedure. The first mathematical formula that you need is $F = nQ/X$.

Given this formula, your first task is to:

> Select a bottom width of the canal, b, in ft. and a side slope that is stable:

Suppose that you have selected a canal with a width of 40 ft. and side slope of 2:1.

Your second task is to:

> Choose a canal slope and determine, for the selected value of b, the value of X from Table 3.

Suppose you decide that the canal is to be constructed at a slope of 0.0001. If you look at Table 3, you will see that if b = 40 ft., the value of X is 187.

## Table 3: Values of X

| Width b, ft | Canal Slope 0.0001 | 0.0002 | 0.0005 | 0.001 | 0.002 | 0.005 | 0.01 |
|---|---|---|---|---|---|---|---|
| 5 | 0.73 | 1.03 | 1.63 | 2.31 | 3.27 | 5.17 | 7.31 |
| 10 | 4.64 | 6.56 | 10.38 | 14.68 | 20.76 | 32.82 | 46.42 |
| 15 | 13.69 | 19.35 | 30.60 | 43.28 | 61.20 | 96.77 | 136.86 |
| 20 | 29.47 | 41.68 | 65.91 | 93.20 | 131.81 | 208.41 | 294.74 |
| 25 | 53.44 | 75.58 | 119.49 | 168.99 | 238.99 | 377.88 | 534.40 |
| 30 | 86.90 | 122.89 | 194.31 | 274.80 | 388.62 | 614.47 | 868.99 |
| 35 | 131.1 | 185.4 | 293.1 | 414.5 | 586.2 | 926.9 | 1310.8 |
| 40 | 187.1 | 264.7 | 418.5 | 591.8 | 837.0 | 1323.3 | 1871.5 |
| 45 | 256.2 | 362.3 | 572.9 | 810.2 | 1145.8 | 1811.7 | 2562.1 |
| 50 | 339.3 | 479.9 | 758.8 | 1073.0 | 1517.5 | 2399.4 | 3393.3 |
| 60 | 551.8 | 780.3 | 1233.8 | 1744.9 | 2467.6 | 3901.7 | 5517.8 |
| 70 | 832.3 | 1177.1 | 1861.1 | 2632.0 | 3722.3 | 5885.4 | 8323.3 |
| 80 | 1188 | 1681 | 2657 | 3758 | 5314 | 8403 | 11883 |
| 90 | 1627 | 2301 | 3638 | 5145 | 7275 | 11504 | 16268 |
| 100 | 2155 | 3047 | 4818 | 6813 | 9636 | 15235 | 21546 |

Your third task is to:

> Determine the roughness of the canal, n, and the design flow rate, Q, in cfs.

Suppose you decide that the canal is to be constructed of stiff clay. If you look at Table 2, you will see that the value of Manning's n for stiff clay is .025.

If you accept the determination that the design flow rate for a power plant is 5000 cfs, you now have all the information you need to complete the first formula.

Your fourth task is to:

> Multipy these figures together and divide by X to obtain nQ/X, which we call F.

$$F = nQ/X = .025 \times 5000 / 187 = 0.668.$$

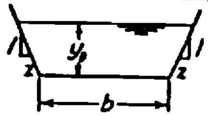
Your fifth task is to:

> Interpolate in Table 4 with the values of F and the side slope 2:1 in order to determine the value of y/b, which is the depth of flow divided by the bottom width of the canal.

# Table 4 (Rouse, 1950)

## Uniform Flow in Trapezoidal Channels by Manning Formula [4]

Values of $\frac{Qn}{b^{8/3}S_0^{1/2}} = F$




| $\frac{y_0}{b}$ | z = 0 | z = 1/4 | z = 1/2 | z = 3/4 | z = 1 | z = 1 1/4 | z = 1 1/2 | z = 2 | z = 2 1/2 | z = 3 | z = 4 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.02 | 0.00213 | 0.00215 | 0.00216 | 0.00217 | 0.00218 | 0.00219 | 0.00220 | 0.00221 | 0.00222 | 0.00223 | 0.00225 |
| 0.03 | 0.00414 | 0.00419 | 0.00423 | 0.00426 | 0.00429 | 0.00431 | 0.00433 | 0.00437 | 0.00440 | 0.00443 | 0.00449 |
| 0.04 | 0.00661 | 0.00670 | 0.00679 | 0.00685 | 0.00690 | 0.00696 | 0.00700 | 0.00707 | 0.00715 | 0.00722 | 0.00735 |
| 0.05 | 0.00947 | 0.00964 | 0.00980 | 0.00991 | 0.0100 | 0.0101 | 0.0102 | 0.0103 | 0.0104 | 0.0106 | 0.0109 |
| 0.06 | 0.0127 | 0.0130 | 0.0132 | 0.0134 | 0.0136 | 0.0137 | 0.0138 | 0.0141 | 0.0143 | 0.0145 | 0.0149 |
| 0.07 | 0.0162 | 0.0166 | 0.0170 | 0.0173 | 0.0176 | 0.0177 | 0.0180 | 0.0183 | 0.0186 | 0.0190 | 0.0196 |
| 0.08 | 0.0200 | 0.0206 | 0.0211 | 0.0215 | 0.0219 | 0.0222 | 0.0225 | 0.0231 | 0.0235 | 0.0240 | 0.0250 |
| 0.09 | 0.0240 | 0.0249 | 0.0256 | 0.0262 | 0.0267 | 0.0271 | 0.0275 | 0.0282 | 0.0289 | 0.0296 | 0.0310 |
| 0.10 | 0.0283 | 0.0294 | 0.0305 | 0.0311 | 0.0318 | 0.0324 | 0.0329 | 0.0339 | 0.0348 | 0.0358 | 0.0375 |
| 0.11 | 0.0329 | 0.0342 | 0.0354 | 0.0364 | 0.0373 | 0.0380 | 0.0387 | 0.0400 | 0.0413 | 0.0424 | 0.0448 |
| 0.12 | 0.0376 | 0.0393 | 0.0408 | 0.0420 | 0.0431 | 0.0441 | 0.0450 | 0.0466 | 0.0482 | 0.0497 | 0.0527 |
| 0.13 | 0.0425 | 0.0446 | 0.0464 | 0.0480 | 0.0493 | 0.0505 | 0.0516 | 0.0537 | 0.0556 | 0.0575 | 0.0613 |
| 0.14 | 0.0476 | 0.0501 | 0.0524 | 0.0542 | 0.0559 | 0.0573 | 0.0587 | 0.0612 | 0.0636 | 0.0659 | 0.0705 |
| 0.15 | 0.0528 | 0.0559 | 0.0585 | 0.0608 | 0.0628 | 0.0645 | 0.0662 | 0.0692 | 0.0721 | 0.0749 | 0.0805 |
| 0.16 | 0.0582 | 0.0619 | 0.0650 | 0.0676 | 0.0699 | 0.0720 | 0.0740 | 0.0776 | 0.0811 | 0.0845 | 0.0912 |
| 0.17 | 0.0638 | 0.0680 | 0.0717 | 0.0748 | 0.0775 | 0.0800 | 0.0823 | 0.0867 | 0.0907 | 0.0947 | 0.103 |
| 0.18 | 0.0695 | 0.0744 | 0.0786 | 0.0822 | 0.0854 | 0.0883 | 0.0910 | 0.0961 | 0.101 | 0.105 | 0.115 |
| 0.19 | 0.0753 | 0.0809 | 0.0857 | 0.0900 | 0.0936 | 0.0970 | 0.100 | 0.106 | 0.112 | 0.117 | 0.128 |
| 0.20 | 0.0813 | 0.0875 | 0.0932 | 0.0979 | 0.102 | 0.106 | 0.110 | 0.116 | 0.123 | 0.129 | 0.141 |
| 0.21 | 0.0873 | 0.0944 | 0.101 | 0.106 | 0.111 | 0.115 | 0.120 | 0.127 | 0.134 | 0.142 | 0.156 |
| 0.22 | 0.0935 | 0.101 | 0.109 | 0.115 | 0.120 | 0.125 | 0.130 | 0.139 | 0.147 | 0.155 | 0.171 |
| 0.23 | 0.0997 | 0.109 | 0.117 | 0.124 | 0.130 | 0.135 | 0.141 | 0.151 | 0.160 | 0.169 | 0.187 |
| 0.24 | 0.106 | 0.116 | 0.125 | 0.133 | 0.139 | 0.146 | 0.152 | 0.163 | 0.173 | 0.184 | 0.204 |
| 0.25 | 0.113 | 0.124 | 0.133 | 0.142 | 0.150 | 0.157 | 0.163 | 0.176 | 0.187 | 0.199 | 0.222 |
| 0.26 | 0.119 | 0.131 | 0.142 | 0.152 | 0.160 | 0.168 | 0.175 | 0.189 | 0.202 | 0.215 | 0.241 |
| 0.27 | 0.126 | 0.139 | 0.151 | 0.162 | 0.171 | 0.180 | 0.188 | 0.203 | 0.218 | 0.232 | 0.260 |
| 0.28 | 0.133 | 0.147 | 0.160 | 0.172 | 0.182 | 0.192 | 0.201 | 0.217 | 0.234 | 0.249 | 0.281 |
| 0.29 | 0.139 | 0.155 | 0.170 | 0.182 | 0.193 | 0.204 | 0.214 | 0.232 | 0.250 | 0.267 | 0.302 |
| 0.30 | 0.146 | 0.163 | 0.179 | 0.193 | 0.205 | 0.217 | 0.227 | 0.248 | 0.267 | 0.286 | 0.324 |
| 0.31 | 0.153 | 0.172 | 0.189 | 0.204 | 0.217 | 0.230 | 0.242 | 0.264 | 0.285 | 0.306 | 0.347 |
| 0.32 | 0.160 | 0.180 | 0.199 | 0.215 | 0.230 | 0.243 | 0.256 | 0.281 | 0.304 | 0.327 | 0.371 |
| 0.33 | 0.167 | 0.189 | 0.209 | 0.227 | 0.243 | 0.257 | 0.271 | 0.298 | 0.323 | 0.348 | 0.396 |
| 0.34 | 0.174 | 0.198 | 0.219 | 0.238 | 0.256 | 0.272 | 0.287 | 0.315 | 0.343 | 0.369 | 0.422 |
| 0.35 | 0.181 | 0.207 | 0.230 | 0.251 | 0.270 | 0.287 | 0.303 | 0.334 | 0.363 | 0.392 | 0.450 |
| 0.36 | 0.190 | 0.216 | 0.241 | 0.263 | 0.283 | 0.302 | 0.319 | 0.353 | 0.384 | 0.416 | 0.477 |
| 0.37 | 0.196 | 0.225 | 0.251 | 0.275 | 0.297 | 0.317 | 0.336 | 0.372 | 0.406 | 0.440 | 0.507 |
| 0.38 | 0.203 | 0.234 | 0.263 | 0.289 | 0.311 | 0.333 | 0.354 | 0.392 | 0.429 | 0.465 | 0.536 |
| 0.39 | 0.210 | 0.244 | 0.274 | 0.301 | 0.326 | 0.349 | 0.371 | 0.412 | 0.452 | 0.491 | 0.568 |
| 0.40 | 0.218 | 0.254 | 0.286 | 0.314 | 0.341 | 0.366 | 0.389 | 0.433 | 0.476 | 0.518 | 0.600 |
| 0.41 | 0.225 | 0.263 | 0.297 | 0.328 | 0.357 | 0.383 | 0.408 | 0.455 | 0.501 | 0.545 | 0.634 |
| 0.42 | 0.233 | 0.279 | 0.310 | 0.342 | 0.373 | 0.401 | 0.427 | 0.478 | 0.526 | 0.574 | 0.668 |
| 0.43 | 0.241 | 0.282 | 0.321 | 0.356 | 0.389 | 0.418 | 0.447 | 0.501 | 0.553 | 0.604 | 0.703 |
| 0.44 | 0.249 | 0.292 | 0.334 | 0.371 | 0.405 | 0.437 | 0.467 | 0.524 | 0.579 | 0.634 | 0.739 |
| 0.45 | 0.256 | 0.303 | 0.346 | 0.385 | 0.422 | 0.455 | 0.487 | 0.548 | 0.607 | 0.665 | 0.778 |
| 0.46 | 0.263 | 0.313 | 0.359 | 0.401 | 0.439 | 0.475 | 0.509 | 0.574 | 0.635 | 0.696 | 0.816 |
| 0.47 | 0.271 | 0.323 | 0.371 | 0.417 | 0.457 | 0.494 | 0.530 | 0.600 | 0.665 | 0.729 | 0.856 |
| 0.48 | 0.279 | 0.333 | 0.384 | 0.432 | 0.475 | 0.514 | 0.552 | 0.626 | 0.695 | 0.763 | 0.897 |
| 0.49 | 0.287 | 0.345 | 0.398 | 0.448 | 0.492 | 0.534 | 0.575 | 0.652 | 0.725 | 0.797 | 0.939 |
| 0.50 | 0.295 | 0.356 | 0.411 | 0.463 | 0.512 | 0.556 | 0.599 | 0.679 | 0.758 | 0.833 | 0.983 |
| 0.52 | 0.310 | 0.377 | 0.438 | 0.496 | 0.548 | 0.599 | 0.646 | 0.735 | 0.820 | 0.906 | 1.07 |
| 0.54 | 0.327 | 0.398 | 0.468 | 0.530 | 0.590 | 0.644 | 0.696 | 0.795 | 0.891 | 0.984 | 1.17 |
| 0.56 | 0.343 | 0.421 | 0.496 | 0.567 | 0.631 | 0.690 | 0.748 | 0.856 | 0.963 | 1.07 | 1.27 |
| 0.58 | 0.359 | 0.444 | 0.526 | 0.601 | 0.671 | 0.739 | 0.802 | 0.922 | 1.04 | 1.15 | 1.37 |
| 0.60 | 0.375 | 0.468 | 0.556 | 0.640 | 0.717 | 0.789 | 0.858 | 0.988 | 1.12 | 1.24 | 1.49 |
| 0.62 | 0.391 | 0.492 | 0.590 | 0.679 | 0.763 | 0.841 | 0.917 | 1.06 | 1.20 | 1.33 | 1.60 |
| 0.64 | 0.408 | 0.516 | 0.620 | 0.718 | 0.809 | 0.894 | 0.976 | 1.13 | 1.28 | 1.43 | 1.72 |

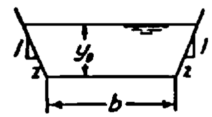




TABLE 4 (*Continued*)

## Uniform Flow in Trapezoidal Channels by Manning Formula [4]

Values of $\frac{Qn}{b^{8/3}S_0^{1/2}} = F$




| $\frac{y_0}{b}$ | z = 0 | z = 1/4 | z = 1/2 | z = 3/4 | z = 1 | z = 1 1/4 | z = 1 1/2 | z = 2 | z = 2 1/2 | z = 3 | z = 4 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.66 | 0.424 | 0.541 | 0.653 | 0.759 | 0.858 | 0.951 | 1.04 | 1.21 | 1.37 | 1.53 | 1.85 |
| 0.68 | 0.441 | 0.566 | 0.687 | 0.801 | 0.908 | 1.01 | 1.10 | 1.29 | 1.47 | 1.64 | 1.98 |
| 0.70 | 0.457 | 0.591 | 0.722 | 0.842 | 0.958 | 1.07 | 1.17 | 1.37 | 1.56 | 1.75 | 2.12 |
| 0.72 | 0.474 | 0.617 | 0.757 | 0.887 | 1.01 | 1.13 | 1.24 | 1.45 | 1.66 | 1.87 | 2.27 |
| 0.74 | 0.491 | 0.644 | 0.793 | 0.932 | 1.07 | 1.19 | 1.31 | 1.55 | 1.77 | 1.98 | 2.41 |
| 0.76 | 0.508 | 0.670 | 0.830 | 0.981 | 1.12 | 1.26 | 1.39 | 1.64 | 1.88 | 2.11 | 2.57 |
| 0.78 | 0.525 | 0.698 | 0.868 | 1.03 | 1.18 | 1.32 | 1.46 | 1.73 | 1.98 | 2.24 | 2.73 |
| 0.80 | 0.542 | 0.725 | 0.906 | 1.08 | 1.24 | 1.40 | 1.54 | 1.83 | 2.10 | 2.37 | 2.90 |
| 0.82 | 0.559 | 0.753 | 0.945 | 1.13 | 1.30 | 1.47 | 1.63 | 1.93 | 2.22 | 2.51 | 3.07 |
| 0.84 | 0.576 | 0.782 | 0.985 | 1.18 | 1.36 | 1.54 | 1.71 | 2.03 | 2.34 | 2.65 | 3.25 |
| 0.86 | 0.593 | 0.810 | 1.03 | 1.23 | 1.43 | 1.61 | 1.79 | 2.14 | 2.47 | 2.80 | 3.44 |
| 0.88 | 0.610 | 0.839 | 1.07 | 1.29 | 1.49 | 1.69 | 1.88 | 2.25 | 2.60 | 2.95 | 3.63 |
| 0.90 | 0.627 | 0.871 | 1.11 | 1.34 | 1.56 | 1.77 | 1.98 | 2.36 | 2.74 | 3.11 | 3.83 |
| 0.92 | 0.645 | 0.898 | 1.15 | 1.40 | 1.63 | 1.86 | 2.07 | 2.48 | 2.88 | 3.27 | 4.04 |
| 0.94 | 0.662 | 0.928 | 1.20 | 1.46 | 1.70 | 1.94 | 2.16 | 2.60 | 3.03 | 3.43 | 4.25 |
| 0.96 | 0.680 | 0.960 | 1.25 | 1.52 | 1.78 | 2.03 | 2.27 | 2.73 | 3.17 | 3.61 | 4.48 |
| 0.98 | 0.697 | 0.991 | 1.29 | 1.58 | 1.85 | 2.11 | 2.37 | 2.85 | 3.33 | 3.79 | 4.70 |
| 1.00 | 0.714 | 1.02 | 1.33 | 1.64 | 1.93 | 2.21 | 2.47 | 2.99 | 3.48 | 3.97 | 4.93 |
| 1.05 | 0.759 | 1.10 | 1.46 | 1.80 | 2.13 | 2.44 | 2.75 | 3.33 | 3.90 | 4.45 | 5.55 |
| 1.10 | 0.802 | 1.19 | 1.58 | 1.97 | 2.34 | 2.69 | 3.04 | 3.70 | 4.34 | 4.96 | 6.21 |
| 1.15 | 0.846 | 1.27 | 1.71 | 2.14 | 2.56 | 2.96 | 3.34 | 4.09 | 4.82 | 5.52 | 6.91 |
| 1.20 | 0.891 | 1.36 | 1.85 | 2.33 | 2.79 | 3.24 | 3.68 | 4.50 | 5.32 | 6.11 | 7.68 |
| 1.25 | 0.936 | 1.45 | 1.99 | 2.52 | 3.04 | 3.54 | 4.03 | 4.95 | 5.86 | 6.73 | 8.48 |
| 1.30 | 0.980 | 1.54 | 2.14 | 2.73 | 3.30 | 3.85 | 4.39 | 5.42 | 6.42 | 7.39 | 9.34 |
| 1.35 | 1.02 | 1.64 | 2.29 | 2.94 | 3.57 | 4.18 | 4.76 | 5.90 | 7.01 | 8.10 | 10.2 |
| 1.40 | 1.07 | 1.74 | 2.45 | 3.16 | 3.85 | 4.52 | 5.18 | 6.43 | 7.65 | 8.83 | 11.2 |
| 1.45 | 1.11 | 1.84 | 2.61 | 3.39 | 4.15 | 4.88 | 5.60 | 6.98 | 8.30 | 9.62 | 12.2 |
| 1.50 | 1.16 | 1.94 | 2.78 | 3.63 | 4.46 | 5.26 | 6.04 | 7.55 | 9.02 | 10.1 | 13.3 |
| 1.55 | 1.20 | 2.05 | 2.96 | 3.88 | 4.78 | 5.65 | 6.50 | 8.14 | 9.74 | 11.3 | 14.4 |
| 1.60 | 1.25 | 2.15 | 3.14 | 4.14 | 5.12 | 6.06 | 6.99 | 8.79 | 10.5 | 12.2 | 15.6 |
| 1.65 | 1.30 | 2.27 | 3.33 | 4.41 | 5.47 | 6.49 | 7.50 | 9.42 | 11.3 | 13.2 | 16.8 |
| 1.70 | 1.34 | 2.38 | 3.52 | 4.69 | 5.83 | 6.94 | 8.02 | 10.1 | 12.2 | 14.2 | 18.1 |
| 1.75 | 1.39 | 2.50 | 3.73 | 4.98 | 6.21 | 7.41 | 8.57 | 10.9 | 13.0 | 15.2 | 19.5 |
| 1.80 | 1.43 | 2.62 | 3.93 | 5.28 | 6.60 | 7.89 | 9.13 | 11.6 | 14.0 | 16.3 | 20.9 |
| 1.85 | 1.48 | 2.74 | 4.15 | 5.59 | 7.01 | 8.40 | 9.75 | 12.4 | 15.0 | 17.4 | 22.4 |
| 1.90 | 1.52 | 2.86 | 4.36 | 5.91 | 7.43 | 8.91 | 10.4 | 13.2 | 15.9 | 18.7 | 24.0 |
| 1.95 | 1.57 | 2.99 | 4.59 | 6.24 | 7.87 | 9.46 | 11.0 | 14.0 | 17.0 | 19.9 | 25.6 |
| 2.00 | 1.61 | 3.12 | 4.83 | 6.58 | 8.32 | 10.0 | 11.7 | 14.9 | 18.0 | 21.1 | 27.2 |
| 2.10 | 1.71 | 3.39 | 5.31 | 7.30 | 9.27 | 11.2 | 13.1 | 16.8 | 20.3 | 23.9 | 30.8 |
| 2.20 | 1.79 | 3.67 | 5.82 | 8.06 | 10.3 | 12.5 | 14.6 | 18.7 | 22.8 | 26.8 | 34.2 |
| 2.30 | 1.89 | 3.96 | 6.36 | 8.86 | 11.3 | 13.8 | 16.2 | 20.9 | 25.4 | 30.0 | 37.8 |
| 2.40 | 1.98 | 4.26 | 6.93 | 9.72 | 12.5 | 15.3 | 17.9 | 23.1 | 28.3 | 33.4 | 41.3 |
| 2.50 | 2.07 | 4.58 | 7.52 | 10.6 | 13.7 | 16.8 | 19.8 | 25.6 | 31.3 | 37.0 | 48.0 |
| 2.60 | 2.16 | 4.90 | 8.14 | 11.6 | 15.0 | 18.4 | 21.7 | 28.2 | 34.5 | 40.8 | 53.0 |
| 2.70 | 2.26 | 5.24 | 8.80 | 12.6 | 16.3 | 20.1 | 23.8 | 31.0 | 37.9 | 44.8 | 58.4 |
| 2.80 | 2.35 | 5.59 | 9.49 | 13.6 | 17.8 | 21.9 | 25.9 | 33.8 | 41.6 | 49.1 | 64.0 |
| 2.90 | 2.44 | 5.95 | 10.2 | 14.7 | 19.3 | 23.8 | 28.2 | 36.9 | 45.3 | 53.7 | 70.1 |
| 3.00 | 2.53 | 6.33 | 11.0 | 15.9 | 20.9 | 25.8 | 30.6 | 40.1 | 49.4 | 58.4 | 76.4 |
| 3.20 | 2.72 | 7.12 | 12.5 | 18.3 | 24.2 | 30.1 | 35.8 | 47.1 | 58.0 | 68.9 | 90.3 |
| 3.40 | 2.90 | 7.97 | 14.2 | 21.0 | 27.9 | 34.8 | 41.5 | 54.6 | 67.7 | 80.2 | 105 |
| 3.60 | 3.09 | 8.86 | 16.1 | 24.0 | 32.0 | 39.9 | 47.8 | 63.0 | 78.2 | 92.8 | 122 |
| 3.80 | 3.28 | 9.81 | 18.1 | 27.1 | 36.3 | 45.5 | 54.6 | 72.4 | 89.6 | 107 | 141 |
| 4.00 | 3.46 | 10.8 | 20.2 | 30.5 | 41.1 | 51.6 | 61.9 | 82.2 | 102 | 122 | 160 |
| 4.50 | 3.92 | 13.5 | 26.2 | 40.1 | 54.5 | 68.8 | 82.9 | 111 | 136 | 164 | 217 |
| 5.00 | 4.39 | 16.7 | 33.1 | 51.5 | 70.3 | 89.2 | 108 | 145 | 181 | 216 | 287 |

If you look in Table 4 at the column z = 2, you will find two values that are close to the value of F above: 0.652 and 0.679. Since 0.679 is closer to your F value (0.668) than is 0.652, you select this higher value (0.679).

Your sixth step is to:

> Multipy the value of y/b by the width to obtain the depth of flow, y, in ft.

For your value of F(0.679), the value in the left column is y/b = 0.50. Since your aim is to compute y, you multiply 0.50 x 40 ft. (the b value that you selected earlier). The result is 20 ft., which is the depth of flow of the canal.

The results of these computations represent one possible design of the channel: a trapezoidal channel with a bottom width of 40 ft., side slopes of 2:1, and a depth of flow of 20 ft.

Now you must determine whether or not this design meets the maximum permissible velocity criterion. If you refer to Table 1, you will see that this criterion is 3.75 ft. per second. In order to determine whether or not your design meets this criterion, you must first calculate the cross-sectional area of flow in the canal with a depth of 20 ft. Performing this calculation is no more difficult than calculating the area of a trapezoid. The following formula will help you to make this calculation:

$$A = y(b+zy)$$

In this formula, y = depth, b = bottom width of the channel, and z = side slope of the banks of the canal.

Making this calculation with the figures you have gathered results in the following:

$$A = y(b+zy) = 20 \times (40 + 2 \times 20) = 1600 \text{ square ft.}$$

Thus, the cross-sectional area A of the canal with a depth of 20.0 ft. is 1600 square ft.

To test whether or not the velocity is less than the permissible value (3.75 ft. per second), you need to perform one more calculation, which helps you to compute the velocity of flow (V) in the canal.

$$V = Q/A$$

The velocity of flow, V, in the canal is then simply the flow rate, Q, in cfs divided by the cross-sectional area of flow, A.

$$V = Q/A = 5000/1600 = 3.1 \text{ ft/sec}$$

Since the resulting value of velocity (3.1) is less than the permissible value (3.75), you could accept this design. Other designs are possible, however, and several of these have been summarized in Table 5.

TABLE 5. POSSIBLE CANAL DESIGNS
(Q=5000 cfs, n=0.025, Z=2)

| SLOPE | B,ft | X | F | Y/B | Y,ft | A,sqft | V,ft/s |
|---|---|---|---|---|---|---|---|
| 0.0001 | 10 | 4.64 | 26.930 | 2.549 | 25.49 | 1555 | 3.22 |
| 0.0001 | 20 | 29.47 | 4.241 | 1.168 | 23.35 | 1558 | 3.21 |
| 0.0001 | 30 | 86.89 | 1.439 | 0.715 | 21.44 | 1563 | 3.20 |
| 0.0001 | 40 | 187.14 | 0.668 | 0.495 | 19.80 | 1576 | 3.17 |
| 0.0001 | 50 | 339.30 | 0.368 | 0.368 | 18.40 | 1597 | 3.13 |
| 0.0001 | 100 | 2154.44 | 0.058 | 0.136 | 13.61 | 1732 | 2.89 |
| 0.0002 | 10 | 6.56 | 19.043 | 2.211 | 22.11 | 1199 | 4.17 |
| 0.0002 | 20 | 41.68 | 2.999 | 1.000 | 20.01 | 1201 | 4.16 |
| 0.0002 | 30 | 122.89 | 1.017 | 0.607 | 18.22 | 1210 | 4.13 |
| 0.0002 | 40 | 264.65 | 0.472 | 0.417 | 16.67 | 1223 | 4.09 |
| 0.0002 | 50 | 479.85 | 0.261 | 0.307 | 15.35 | 1239 | 4.04 |
| 0.0002 | 100 | 3046.83 | 0.041 | 0.112 | 11.17 | 1366 | 3.66 |
| 0.0005 | 10 | 10.38 | 12.044 | 1.827 | 18.27 | 850 | 5.88 |
| 0.0005 | 20 | 65.90 | 1.897 | 0.812 | 16.25 | 853 | 5.86 |
| 0.0005 | 30 | 194.30 | 0.643 | 0.486 | 14.59 | 864 | 5.79 |
| 0.0005 | 40 | 418.45 | 0.299 | 0.330 | 13.21 | 877 | 5.70 |
| 0.0005 | 50 | 758.70 | 0.165 | 0.241 | 12.05 | 893 | 5.60 |
| 0.0005 | 100 | 4817.47 | 0.026 | 0.086 | 8.61 | 1009 | 4.96 |

Now the question becomes: which of these designs is the best one? The answer to the question of the best design requires that we set some criterion for the choice of what "best" means. In many cases, least cost may be the criterion for our final choice. If cost of excavation is the primary cost, then the smaller the cross-sectional area of flow, the smaller the cost. The choice may also be subject to the constraint that no adverse environmental consequences will result and subject to the legal requirements of maintaining the canal within an established right-of-way. An example of an environmental constraint for a hydroelectric power canal is the need to restrict the entry of fish into the canal by installing a fish screen at the headworks of the canal.

Other practical criteria may enter into the final design decision. The depth of the canal may be limited by the method of excavation (shovels or draglines) or by the underlying soil material. Blasting a canal through solid rock located at a fixed distance below ground surface can prove to be quite expensive.

Navigational requirements can also play a role in the choice of canal width and depth. The depth requirements for navigation depends on the "draft" of the vessel, which is the depth to which the vessel sinks when fully loaded. According to Archimedes' Law, a floating object displaces it own weight of the fluid in which it floats. Thus a barge which is 30 ft. wide by 100 ft. long with a draft of 5 ft., for example, will displace 15,000 cu. ft. of water (30 x 100 x 5). Water weighs 62.4 pound per cubic foot, so this barge when fully loaded would weigh approximately 470 tons! (1 ton = 2000 pounds.) The total depth should be 3 to 5 ft. greater than the draft. Figure 10 illustrates this displacement.

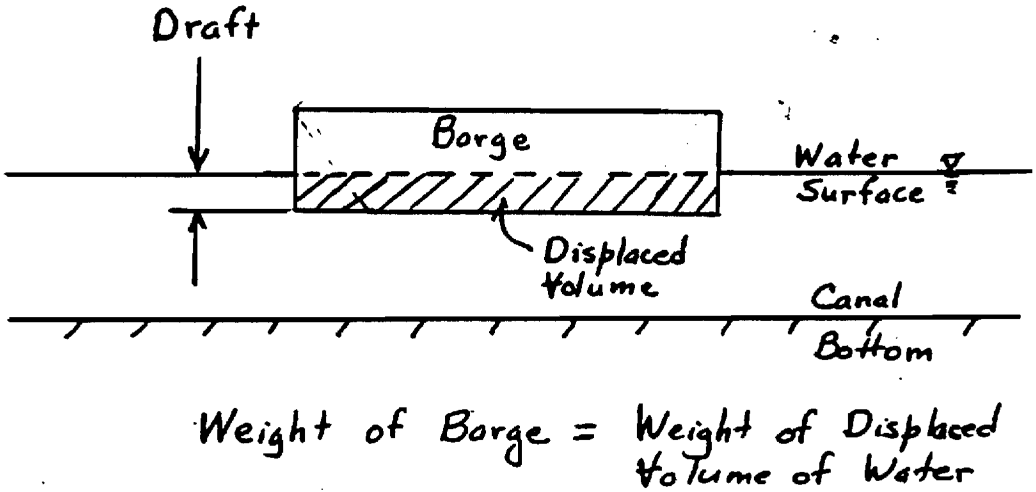



Fig. 10 - Water Displacement

If we evaluate our current design in view of these considerations, we see from Table 5 that decreasing the bottom width while maintaining the same slope will reduce the cross-sectional area and thus the size of the canal, but not by very much. At the same time, the depth will increase. Increasing the slope to 0.0005 greatly reduces the area, A, but the maximum permissible velocity is exceeded regardless of the width, b. An intermediate slope of 0.0002 would be suitable if the width, b, were at least 100 ft. In this case, the area has been reduced somewhat from our original design, and we still can meet the maximum velocity criterion. Furthermore, if construction methods limit the depth to not more than 15 ft., we might choose the 100 ft. wide channel with depth of 11 ft. and slope of 0.0002 as the final design.

If a canal is being designed by least cost considerations alone, the determination of least cost may be complicated by more than one type of cost. If we were calculating the least cost for excavation, for example, then that canal cross section which resulted in the smallest flow cross sectional area without exceeding the maximum permissible velocity would obviously be best. If, on the other hand, the canal was intended to deliver water to a turbine for the generation of electric power, the available "head" at the turbine is important. The amount of power generated is proportional to the available head which becomes smaller for a canal laid at a steeper slope. Thus, although a steeper slope results in a smaller depth of excavation and less cost, it also leads to less available power that can be generated, which might be interpreted as a greater cost because of the loss in power revenues. In this case, the least cost project is the one which minimizes the sum of the excavation cost and the cost due to loss of power revenues.

With this brief introduction to the technical aspects of canals, we have reviewed the design process and many of the factors which must be weighed to arrive at a final design. The basis of the design is a design flow rate which has an inherent uncertainty of occurrence. The design flow rate is selected based upon an acceptable risk of not being exceeded over the life of the project. Because of the many factors which enter into an engineering design, the design process becomes a set of compromises or tradeoffs which must be considered. The criteria involved in the engineering decision making process include economic efficiency and practical considerations and are subject to technical and legal constraints. This explains why good engineering decisions require judgment and experience as well as technical know-how.

## Glossary

NOTE: Many of the words in this glossary have more than one meaning. These definitions are the ones that relate to engineering and construction activities.

Adverse - Unfavorable or harmful.

Advent - Arrival of an important development.

Align - To place in line.

Alignment - The positioning or layout of the axis of a canal.

Appurtenance - A subordinate part.

Aqueduct - A large pipe or conduit made for bringing water from a distant source.

Canals - Artificial conveyances which are used to deliver water for water supply, irrigation, power production (mechanical or electrical), drainage, and navigation (Sturm, p. 1); an artificial waterway for transportation or irrigation; a river artificially improved by locks, levees, etc. to permit navigation.

CFS - An abbreviation for cubic feet per second; a unit of river volume flux. Flux is often given in CFS (Sturm, p. 3).

Conduit - A natural or artificial channel through which something (as a fluid) is conveyed.

Constant flow rate - A flow rate which does not change with time.

Constraints - The state of being checked, restricted, or compelled to avoid or perform some action.

Convey - To bear from one place to another; especially, to move in a continuous stream or mass.

Conveyance - A means or way of conveying.

Criterion - A standard on which a judgment or decision may be based.

Cross section - A cutting or piece of something cut off at right angles to an axis; also, a representation of such a cutting.

Culvert - A drain or waterway of pipe or masonry crossing under a road or embankment (Webster); a tunnel (Sturm, P. 20).

Cumulative - Made up of accumulated parts; increasing by successive additions.

Cut - That portion of earth excavated for a canal.

Dam - A barrier built to hold back flowing water.

Deposit - Something laid down; especially, matter deposited by a natural process.

Derive - To take or receive, especially from a specified source.

Design flood - (Sturm, p. 6)

Determination - The fixing or finding of the position, value, or magnitude of something; the act, process, or result of an accurate measurement.

Diffuser - A device for reducing the velocity and increasing the static pressure of a fluid passing through a system.

Displace - To remove physically out of position - the amount of water <u>displaced</u> by a floating object.

Dispose - To get rid of.

Divert - To turn from one course or use to another.

Draft - The depth of water a ship draws especially when loaded.

Dragline - An excavating machine in which the bucket is attached by cables and operates by being drawn toward the machine.

Efficient - Productive without waste.

Efficiency - Effective operation as measured by a comparison of production with cost; the ratio of the useful energy delivered by a dynamic system to the energy supplied to it.

Energy - Usable power (as heat or electricity); also, the resources for producing such power.

Engineer - A person skilled or occupied in some branch of engineering; as a mechanical engineer, an electrical engineer.

Engineering - The planning, designing, construction, or management of machinery, roads, bridges, buildings, fortifications, waterways, etc.

Erode - To wear away by the action of water or wind.

Erosion - The action or process of being eroded.

Estimate - To determine roughly the size, extent, or nature of. Estimate implies a judgment, considered or casual, that precedes or takes the place of actual measuring or counting or testing out.

Excavate - To dig out and remove.

Fill - The material excavated from the earth (which) forms the banks of the canal (Sturm, p. 7).

Fixed class intervals - Selected ranges of values of a variable which changes randomly.

Flow rate - A measure of the volume of water flow per unit time.

Flow duration curve - A cumulative histogram of daily flows (Sturm, p. 4).

Flume - An elevated channel (Sturm, p. 20); an artificial channel, usually an inclined chute or trough, for carrying water to furnish power...(Webster).

Flux - A continuous moving on or passing by (as of a stream); a continued flow.

Forebay - A reservoir or canal from which water is taken to run equipment.

Gaging station - A river flow measurement location.

Gate - A structure controlling the flow of water, as in a pipe, canal, etc.

Gauge - Measurement according to some standard system.

Generate - To bring into existence, as to produce electricity.

Head - A source of water kept at some height to supply a mill, etc. (Webster). The available potential energy of water (Sturm, p. 6).

Headgates - A gate that controls the flow of water into a canal, lock, sluice, etc.

Headworks - A gate control structure (Sturm, p. 6).

Histogram - A representation of a frequency distribution by means of rectangles whose widths represent class intervals and whose areas are proportional to the corresponding frequencies.

Hydraulics - The branch of physics having to do with the mechanical properties of water and other liquids and with the application of these properties in engineering.

Hydroelectric - Of or relating to production of electricity by water power.

Impound - To collect and confine (water) in or as if in a reservoir.

Impoundment - A body of water formed by impounding.

Industrialism - Social organization in which industries and especially large-scale industries are dominant.

Industry - Manufacturing activity as a whole. Example: the nation's industry...

Interpolate - To insert between other things or parts.

Interval - A space of time between events.

Lock(s) - Specialized structures built to allow passage of boats through abrupt changes in water surface elevation such as those at dams, waterfalls, or other obstructions (Sturm, p. 21); an enclosed part of a canal with gates so that the level of the water can be changed to raise or lower boats from one level to another.

Magnitude - A measure of size or extent.

Manning's N - A measure of the resistance of the canal bed and banks to the flow of water (Sturm, p. 11).

Meteorology - A science that deals with the atmosphere and its phenomena and especially with weather and weather forecasting.

Meteorological event - Rain, snow, hail, etc.

Navigation - The science of getting ships, aircraft, or spacecraft from place to place.

N-Year event - The design flood that the dam can safely pass without failure (Sturm, p. 6).

Obscure - Not clearly seen or easily distinguished.

Penstocks - A conduit or pipe for conducting water, especially from a reservoir to hydroelectric turbines.

Periphery - The external boundary or surface of a body.

Potential - Existing in possibility; capable of development into actuality as in potential energy.

Probability - A ratio expressing the chances that a certain event will occur.

Quantify - To determine, express, or measure the quantity of.

Radial direction - Along radii in circular motion.

Reaction turbine - A hydraulic machine that can operate under a very high head of water and provide large quantities of electrical power by being coupled to a generator (Sturm, p. 23).

Rectangle - A parallelogram all of whose angles are right angles; especially, one with adjacent sides of unequal length.

Regulate - To fix or adjust the time, amount, rate or degree of.

Reservoir - A place where anything is collected and stored, generally in large quantities; especially, a natural or artificial lake or pond in which water is collected and stored for use, as to supply the needs of a community.

Resistance - An opposing or retarding force.

Revenue - The total income produced by a given source.

Riprap - A foundation or sustaining wall of stones or chunks of concrete thrown together without order; also, a layer of this or similar material on an embankment slope to prevent erosion.

River flow - The runoff of water from the land resulting from a meteorological event (Sturm, p. 3).

Scour - To clear, dig, or remove by or as if by a powerful current of water.

Sediment - Material deposited by water, wind or glaciers.

Seepage - A quantity of fluid which has seeped (as through porous material).

Slope - Upward or downward slant.

Sluice - An artificial channel or passage for water, having a gate or valve at its head to regulate the flow, as in a canal or millstream; any channel, especially one for excess water.

Sluiceway - A drain for the purpose of flushing excess sediment from behind the dam and providing water during times of low flow (Sturm, p. 18); an artificial channel for water, with or without a floodgate (Webster).

Spillway - A passage for surplus water to run over or around an obstruction, as a dam.

Stable - Not changing or fluctuating.

Suspend - To keep from falling or sinking as by some invisible support.

Tangential direction - Along circumference in circular motion.

Torque - A force or combination of forces that produces or tends to produce a twisting or rotating motion.

Trapezoid - A quadrilateral having only two sides parallel.

Turbine - An engine or motor driven by the pressure of steam, water, or air against the curved vanes of a wheel or set of wheels.

Velocity - Quickness of motion; speed.

Water wheels - (Wheels) used...to generate mechanical power that was transferred directly to the machinery involved. (It) is primarily a gravity device in which the weight of water passing through the wheel transfers a torque to the wheel that causes it to rotate and provide power to mechanical machinery (Sturm, pp. 1, 2, 21); a wheel turned by running or falling water, usually for power (Webster).

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**Blank Copies of Mathematics Problems**

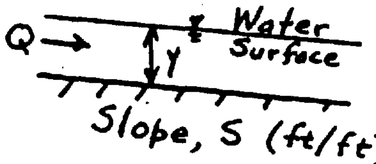
**for the Student**

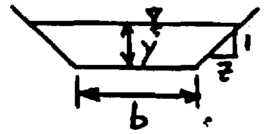
# WORKSHEET A

**Purpose:** To illustrate the calculation of depth of flow from Manning's formula.

**Given:** Flow rate, canal roughness, canal slope, canal bottom width, and canal sideslope.

**Definition Sketch:**




y=depth of flow
Q=design flow rate, cubic feet per second (cfs)
n=Manning's roughness coefficient
S=slope of canal in flow direction (feet of drop in bottom per foot of flow distance)
b=canal bottom width
z=canal side slope
A=cross-sectional area of flow
R=hydraulic radius

**Find:** Depth of flow in canal.

**Manning's Formula:**

$$Q = \frac{1.49}{n} A R^{2/3} S^{1/2}$$

in which
$$R = A/(b+2y\sqrt{1+z^2})$$
$$A = y(b+zy)$$

**Calculation:**

a) Suppose Q=5000 cfs, n=.025, S=.0001, b=40 ft, z=2.
b) For S=0.0001 and b=40 ft, determine X=187 from Table 2.
c) Calculate (n x Q)/X=(.025x5000)/187=0.668
d) For z=2 and F=nQ/X=0.668, look in Table 3 to obtain y/b=0.50.
e) Multiply y/b by b to get depth y: y=0.50 x 40 = 20 ft.

*******************************************************************

**Calculation Table**

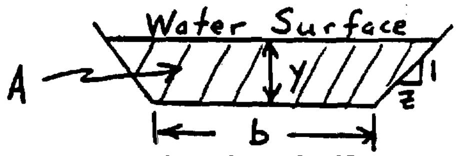
| (1) n | (2) Q cfs | (3) Slope S | (4) Bottom Width b, ft | (5) X Table 2 | (6) F Col.1xCol.2 ÷ Col.5 | (7) y/b Table 3 (z=2) | (8) Depth y, ft Col.4 xCol.7 |
|---|---|---|---|---|---|---|---|
| .025 | 5000 | .0001 | 40 | 187 | 0.668 | 0.50 | 20 |
| .025 | 5000 | .0001 | 100 | | | | |
| .025 | 5000 | .0002 | 100 | | | | |
| .025 | 5000 | .0005 | 50 | | | | |

# WORKSHEET B

**Purpose:** To illustrate the calculation of canal cross-sectional area.

**Given:** Trapezoidal channel bottom width, side slope inclination, and depth.

**Definition Sketch:**




y=depth of flow
b=bottom width
z=side slope (for each z feet of horizontal distance, the side slope rises one foot).

**Find:** Cross-sectional area of flow, A

**Formula:** $A = y(b+zy)$

**Calculation:**

a) Suppose b=40 ft, y=20 ft, and z=2 (2 to 1 side slopes).

b) Substitute into formula:
$A = 20 \times (40 + 2\times20)$

c) Solve:
$A = 20 \times (40 + 40)$
$= 20 \times 80$
$= 1600$ square feet

********************************************************************

**Calculation Table**

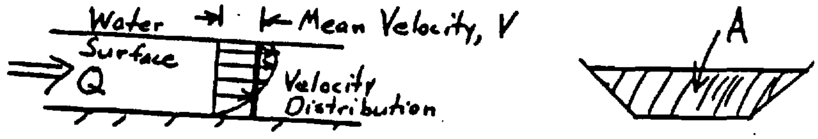
| (1) Bottom Width, ft b | (2) Sideslope z | (3) Depth ft y | (4) Col. 3 x Col. 2 | (5) Col. 1 + Col. 4 | (6) Col. 5 x Col. 3 Area, sq ft |
|---|---|---|---|---|---|
| 40 | 2 | 20 | 40 | 80 | 1600 |
| 100 | 2 | 14 | ___ | ___ | ___ |
| 100 | 2 | 11 | ___ | ___ | ___ |
| 50 | 2 | 12 | ___ | ___ | ___ |

# WORKSHEET C

**Purpose:** To determine the erosional stability of a canal by calculating the velocity of flow and comparing with permissible velocities.

**Given:** Flow rate, type of soil, cross-sectional area of flow

**Definition Sketch:**




A=cross-sectional area of flow
Q=volumetric flow rate
V=mean velocity of flow passing any cross-section
$V_p$=permissible velocity which must not be exceeded

**Find:** Stability of Canal (i.e. Will the canal bed and banks erode?)

**Formula:** $V = Q/A$

$V \leq V_p$

**Calculation:**

a) Suppose Q=5000 cfs, A=1600 sq ft, and canal is to be constructed in stiff clay.
b) Look up permissible velocity in Table 1.
$V_p$=3.75 ft/sec
c) Calculate actual velocity of flow:
$V=Q/A=5000/1600=3.12$ ft/sec
d) Compare velocity with permissible velocity.
If $V \leq V_p$, then the canal will be stable.

******************************************************************

**Calculation Table**

| (1) Flow Rate Q, cfs | (2) Area A, sq ft | (3) Velocity V, ft/sec | (4) Soil Type | (5) Permissible Velocity $V_p$, ft/sec | (6) Stable? |
|---|---|---|---|---|---|
| 5000 | 1600 | 3.12 | Clay | 3.75 | Yes |
| 5000 | 1792 | ____ | Clay | ____ | ____ |
| 5000 | 1342 | ____ | Clay | ____ | ____ |
| 5000 | 888 | ____ | Shale | ____ | ____ |

**Solutions to Mathematics Problems**

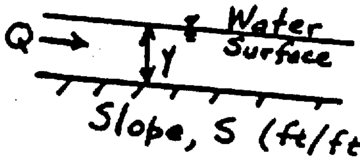
**for the Instructor**

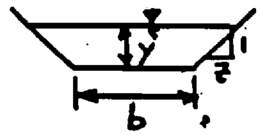
## WORKSHEET A

**Purpose:** To illustrate the calculation of depth of flow from Manning's formula.

**Given:** Flow rate, canal roughness, canal slope, canal bottom width, and canal sideslope.

**Definition Sketch:**




y=depth of flow
Q=design flow rate, cubic feet per second (cfs)
n=Manning's roughness coefficient
S=slope of canal in flow direction (feet of drop in bottom per foot of flow distance)
b=canal bottom width
z=canal side slope
A=cross-sectional area of flow
R=hydraulic radius

**Find:** Depth of flow in canal.

**Manning's Formula:**

$$Q = \frac{1.49}{n} A R^{2/3} \cdot S^{1/2}$$

in which $R = A/(b+2y\sqrt{1+z^2})$
$A = y(b+zy)$

**Calculation:**

a) Suppose Q=5000 cfs, n=.025, S=.0001, b=40 ft, z=2.
b) For S=0.0001 and b=40 ft, determine X=187 from Table 2.
c) Calculate (n x Q)/X=(.025x5000)/187=0.668
d) For z=2 and F=nQ/X=0.668, look in Table 3 to obtain y/b=0.50.
e) Multiply y/b by b to get depth y: y=0.50 x 40 = 20 ft.

**Calculation Table**

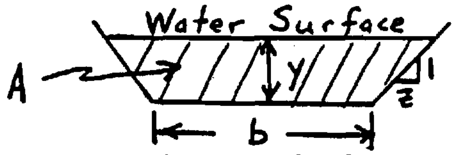
| (1) n | (2) Q cfs | (3) Slope S | (4) Bottom Width b, ft | (5) X Table 2 | (6) F Col. 1xCol. 2 ÷ Col. 5 | (7) y/b Table 3 (z=2) | (8) Depth y, ft Col. 4 xCol. 7 |
|---|---|---|---|---|---|---|---|
| .025 | 5000 | .0001 | 40 | 187 | 0.668 | 0.50 | 20 |
| .025 | 5000 | .0001 | 100 | 2155 | .0580 | 0.14 | 14 |
| .025 | 5000 | .0002 | 100 | 3047 | .0410 | 0.11 | 11 |
| .025 | 5000 | .0005 | 50 | 758.8 | .165 | 0.24 | 12 |

## WORKSHEET B

**Purpose:** To illustrate the calculation of canal cross-sectional area.

**Given:** Trapezoidal channel bottom width, side slope inclination, and depth.

**Definition Sketch:**




y=depth of flow
b=bottom width
z=side slope (for each z feet of horizontal distance, the side slope rises one foot).

**Find:** Cross-sectional area of flow, A

**Formula:** $A = y(b+zy)$

**Calculation:**

a) Suppose b=40 ft, y=20 ft, and z=2 (2 to 1 side slopes).

b) Substitute into formula:
$A = 20 \times (40 + 2 \times 20)$

c) Solve:
$A = 20 \times (40 + 40)$
$= 20 \times 80$
$= 1600$ square feet

**********************************************************

### Calculation Table

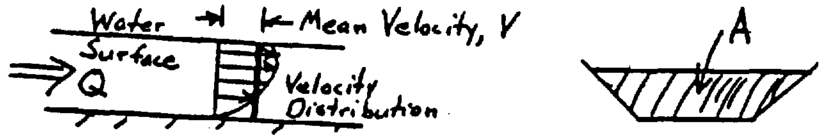
| (1) Bottom Width, ft b | (2) Sideslope z | (3) Depth ft y | (4) Col. 3 x Col. 2 | (5) Col. 1 + Col. 4 | (6) Col. 5 x Col. 3 Area, sq ft |
|---|---|---|---|---|---|
| 40 | 2 | 20 | 40 | 80 | 1600 |
| 100 | 2 | 14 | 28 | 128 | 1792 |
| 100 | 2 | 11 | 22 | 122 | 1342 |
| 50 | 2 | 12 | 24 | 74 | 888 |

## WORKSHEET C

**Purpose:** To determine the erosional stability of a canal by calculating the velocity of flow and comparing with permissible velocities.

**Given:** Flow rate, type of soil, cross-sectional area of flow

**Definition Sketch:**




~~A=cross-sectional area of flow~~
Q=volumetric flow rate
V=mean velocity of flow passing any cross-section
$V_p$=permissible velocity which must not be exceeded

**Find:** Stability of Canal (i.e. Will the canal bed and banks erode?)

**Formula:** $V = Q/A$

$V \leq V_p$

**Calculation:**

a) Suppose Q=5000 cfs, A=1600 sq ft, and canal is to be constructed in stiff clay.
b) Look up permissible velocity in Table 1.
$V_p$=3.75 ft/sec
c) Calculate actual velocity of flow:
V=Q/A=5000/1600=3.12 ft/sec
d) Compare velocity with permissible velocity.
If $V \leq V_p$, then the canal will be stable.

**************************************************************

### Calculation Table

| (1) Flow Rate Q, cfs | (2) Area A, sq ft | (3) Velocity V, ft/sec | (4) Soil Type | (5) Permissible Velocity $V_p$, ft/sec | (6) Stable? |
|---|---|---|---|---|---|
| 5000 | 1600 | 3.12 | Clay | 3.75 | Yes |
| 5000 | 1792 | 2.79 | Clay | 3.75 | Yes |
| 5000 | 1342 | 3.72 | Clay | 3.75 | Yes |
| 5000 | 888 | 5.63 | Shale | 6.00 | Yes |

# Computer and Circuit Logic Design

by

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and

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Student Handbook
for an Instructional Module
in Art and Technology

Resourceful Exchange: Technology and the Liberal Arts (RETLA)

1986

Computer and Circuit Logic Design

## Rationale

This module is designed to provide an understanding of the relationships that currently exist and are being developed between logic and computer technology. The module is applicable to an introductory logic course covering both categorical (traditional) logic and symbolic logic.

## Learning Objectives

This module will help you:

--understand and demonstrate applications of logic in the operation of a computer and in circuit design and

--understand and demonstrate the applications of logic in specific areas of programming, i.e., artificial intelligence, natural language programming and logic programming.

## Dimensions of the Module

This module consists of six one-hour sessions. The sessions will include presentations by the instructor, demonstrations of applicable technology, student reports and class discussion. The student will spend approximately two hours outside of class performing logic calculations on a computer.

[The six one-hour sessions are not contiguous. Sessions 1 and 2 will be offered as the last part of categorical logic (the end of Chapter 2 in your course text, The Elements of Logic). We will then cover Chapter 3 of the text on symbolic logic. The remaining module sessions will be treated after our study of Chapter 3.]

## Instructional Formats

Lecture/Report Presentation--six hours
Workshop/Lab--two hours

## Session 1

### Brief Summary of Activities

Prior to session one, you will have completed that part of the introductory logic course dealing with categorical logic. In session one, the instructor will provide a historical sketch of the development of symbolic logic as a basis for the binary logical operation of the computer.

### Classroom Presentation

Your instructor will present a brief history of the development of logic as it leads to the design of computer technology and circuit logic, including the basic ideas of major philosopher-logicians, such as Aristotle, William of Ockham, Descartes, Leibniz, Frege, Russell, and Boole.

The instructor will also demonstrate the logic principles that govern the operation of a mechanical or electronic calculator.

### Classroom Activities

You will be involved in a discussion of the necessary connection of each phase of historical development in logic in order for binary operation to emerge.

You will also be involved in discussion of the impact of science, from the time of Descartes, on the historical development of logic.

### Instructional Materials

Introductory logic text covering both categorical and symbolic logic (i.e., Barker, Stephen. Elements of Logic, McGraw Hill Co., 1985)

Mechanical or electronic calculator

Readings on the history of logic (i.e., Descartes, Rene. Discourse on Method and Meditations, Library of Liberal Arts Inc., 1985).

## Assignments

### Reading

Review of readings on categorical logic from text, pp. 33-80.

Library reading assignment from Descartes' Discourse on Method, pp. 81-91.

## Assignment Deadlines

Reading assignment should be completed prior to session 2.

## Session 2

### Brief Summary of Activities

Your instructor will explain the nature of a computer as a logic machine, indicating the extent to which the computer uses logic in its basic operation. Your instructor will then discuss the computer as a logic calculator. With this understanding in mind, you will use the computer to perform logic calculations. The session will end with a discussion on the significance of these two relationships between logic and computers.

### Classroom Presentations

In this presentation, various types of machines will be considered, emphasizing their functional use of logic, i.e., weaving machines, farm machinery, wire making machines and computers. These will be contrasted to other machines that actually produce logical calculations, i.e., adding and measuring machines. The presentation will also include directions on how to use available programs for logic calculations.

### Classroom Activities

You will be asked to identify specific machines that use logic as opposed to machines that perform logical calculations. Using categorical syllogisms, you will also have the opportunity to practice logic calculations on a computer.

### Instructional Materials

Logic text section on categorical syllogisms

Categorical syllogisms to be calculated on computers

Software program for logic calculation (Program title: "Sylli")

### Assignments

<u>Logic Exercises</u>

Specific exercises from the text are to be done "manually" and then checked by computer calculation, using "Sylli" program: Exercise 8B, 1-10, from the text, pp. 68.

## Reports

One page report describing how a particular machine of your choosing uses logic.

## Assignment Deadlines

Logic exercises should be completed by the following class meeting.

Reports should be handed in by the third session of this module.

## Session 3

### Brief Summary of Activities

Prior to session three, you will have covered initial fundamentals of symbolic logic, including truth tables. Your instructor will explain the digital and analogue concepts, Boolean and circuit logic, and the relationship between these concepts and deductive logic.

An electric analogue of a word problem will be demonstrated.

### Classroom Presentation

This session will include an explanation of conceptual structures that underlie digital and analogue machines. The explanation will be coupled with a demonstration of an electric analogy of a word problem. You will be asked to identify the relationships of these conceptual structures to formal deductive logic, especially in terms of Boolean logic and truth tables.

### Classroom Activities

Demonstration of an electric analogy of a word problem.

You will join with other members of the class in drawing simple logic circuits representing basic symbolic logic argument forms.

### Instructional Materials

Electric analogue of a word problem

Symbolic logic exercises from the text

Software: Teaching program on circuit logic (Program title: "Logic")

### Assignments

#### Reading

Text: Section on "Logic and Computers," pp. 136-141

#### Exercises

Text exercises on converting symbolic argument forms to electric circuit diagrams (exercise 17D, 1,3,5 from the text, pp. 142)

Computer and Circuit Logic Design

Computer Lab

Run teaching program on circuit logic, using "Logic" program.

**Assignment Deadlines**

Reading assignment and exercises are to be completed prior to next class meeting.

Lab assignment is to be completed within a week.

## Session 4

### Brief Summary of Activities

You will receive instruction concerning what artificial intelligence is and how the combination of logic and previously discussed computer technology make artificial intelligence possible. Using symbolic argument forms, you will also write "expert system" narratives or programs.

### Classroom Presentation

You will be introduced to the principles of logic and technology that underlie the concept of artificial intelligence. This will be done in part through the use of illustrations of expert systems. The use of logic, both deductive and inductive, to construct expert systems will also be explained.

### Classroom Activities

Illustration of computer programs for expert systems.

Class members will experiment (individually or in groups) in adapting symbolic logic argument forms into expert systems.

### Instructional Materials

Text: first two chapters on symbolic logic

Periodical literature on artificial intelligence

Software illustrating expert systems

### Assignments

Reading

Complete your reading of the first two chapters on symbolic logic from the text.

Read periodical articles on artificial intelligence. Specific articles are placed on closed reserve in the library:
"Experts on Call," PC World, Sept. 1985, pp. 192-199.
"Artificial Intelligence," PC Magazine, Apr. 1985, pp. 108-111.

Computer and Circuit Logic Design

## Exercises

Run expert system program in the computer lab (Program title: "Exsys").

Write expert system narrative or program.

## Reporting

Prepare to present an oral description of your expert system narrative or program. Descriptions should include how the system functions as artificial intelligence.

## Assignment Deadline

Assigned readings and exercises are due by the fifth session of this module. You will present your report during the fifth session.

## Session 5

### Brief Summary of Activities

You will present your "expert system" report. Your instructor will discuss natural language programming, its possibilities and limitations.

### Classroom Presentations

You and the other class members will have the opportunity to describe your respective expert system narratives or programs. The descriptions will include an explanation of the artificial intelligence function of the system as well as of the argument forms used. Your instructor's presentation on natural language programming will concentrate on logical means and limitations, as well as on the contruction of logic "trees" made out of natural language.

### Classroom Activities

You and the other class members will present expert system reports. After the instructor explains natural language programming, you will identify the relative expressive power of natural language in contrast with categorical and symbolic logic. The entire class will participate in the construction of a natural language "tree."

### Instructional Materials

Logic text: on the use of truth tables as trees to construct deductive proofs

Computer printout or program exemplifying natural language "trees"

Periodical literature on natural language programming

### Assignments

<u>Reading</u>

Review logic text on using truth tables to construct deductive proofs.

Computer and Circuit Logic Design

Read periodical literature on natural language programming (placed on closed reserve in the library):
"A Mechanics Guide to Grammar," Computer Language, Oct. 1985, pp. 27-35.

Exercises

Construction of logical proofs using natural language "trees."

**Assignment Deadlines**

Readings and exercises are due prior to session six.

## Session 6

### Brief Summary of Activities

The class will discuss the assigned readings and exercises. Your instructor will summarize and review the module material under a general theme of logic programming.

### Classroom Presentations

The class discussion will focus on the kinds of difficulties encountered in the natural language programming readings and exercises and on the possibilities of overcoming these difficulties through future development of computer and circuit logic design. Your instructor's presentation will be a review of module material as preparation for testing.

### Classroom Activities

In the class discussion you will have the opportunity to explain your perception of what natural language programming can do and of the future of logic and computers in general.

You should note the module material highlighted by your instructor as likely test material.

### Instructional Materials

Periodic literature on logic programming

All past module material

### Assignments

#### Reading

Read periodical literature on logic programming (placed on closed reserve in the library).

#### Review for test

Review all module material for test, including module content, computer programs, exercises, illustrations, etc.

## Assignment Deadlines

Reading and review for testing should be completed prior to testing date.

## Evaluation

You will demonstrate your achievement in the module by:

--your performance on assigned exercises,

--your performance on the written report on logical machines and on your oral "expert system" report, and

--your performance on the module test material.

## Weighting of Your Grade

| Activities | Percentage of Grade |
|---|---|
| Exercises | 30% |
| Written Report | 15% |
| Oral Report | 15% |
| Testing Material | 40% |
| TOTAL | 100% |

# Bibliography

## Reading Materials

Course Text:

Baker, Stephen. Elements of Logic, McGraw-Hill Book Co., 1985.

Cavalier, R. J. and Driesbach, C. Study Guide to Accompany Barker's Elements of Logic, McGraw-Hill Book Co., 1985.

Other References:

Blackwell, Richard J. A Bibliography of the Philosophy of Science, 1945-1981, Greenwood Press, Westport, Conn., 1983.

Currie, Gregory. Frege: An Introduction to His Philosophy, Rowman and Allenheld, 1982.

Descartes, Rene. Discourse on Method and Meditations, The Library of Liberal Arts, The Liberal Arts Press, Inc., 1960.

Dreyfuss, Hubert L. What Computers Can't Do: A Critique of Artificial Reason, Harper and Row, 1982.

Hatcher, William S. Foundations of Mathematics, W. B. Saunders Co., 1968.

Heisenberg, Werner. Physics and Philosophy: The Revolution in Modern Science, Harper and Row, 1974.

Nagle, H. Troy. An Introduction to Computer Logic, Prentice Hall, Inc., 1975.

Hutchison, David. Fundamentals of Computer Logic, Halstead Press, 1981.

Sagal, Paul T. Mind, Man and Machine, Hackett Publishing Co., 1982.

Periodicals:

Communications of the ACM, Association of Computer Machines.

Computer Language

High Technology

Computer Software:

"Logic," a teaching program in circuit logic.

"Sandy," a program for teaching predicate logic.

"Sylli," a logic calculating program.

# Contraceptive Technology: The Pill

by

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and

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Student Handbook
for an Instructional Module
in Technology Assessment

Resourceful Exchange: Technology and the Liberal Arts (RETLA)

1986

## Rationale

This module focuses on the development and impact of the contraceptive technology known as The Pill. It emphasizes the interaction between societal needs and the development of new technologies. It also provides a method of assessing the impact of a specific technology upon society.

Specifically, this module will:

--provide you with factual knowledge about the societal context in which the pill was developed,

--introduce you to the bio-chemistry of the pill and its possible side effects, and

--introduce you to a method of technology assessment.

## Learning Objectives

This module should enable you to:

--explain briefly the historical context in which the pill was developed,

--explain the cause-effect relationship between historical events and the development of the technology,

--briefly explain the physiology of human reproduction and how the pill interacts with that system,

--briefly explain some possible side effects of the pill,

--assess the impact the pill has had or could have on society, and

--develop a vocabulary relative to contraceptive technology and technology assessment. Terms such as Technology Delivery System (TDS), inputs, outputs, and many others will be added to your current vocabulary.

Contraceptive Technology: The Pill

## Dimensions of the Module

This module requires two weeks of class time. Seven classroom sessions, each lasting fifty minutes, will be devoted to the module.

## Instructional Formats

Lecture--two hours
Discussion/Seminar--five hours

## Session 1

### Brief Summary of Activities

Your instructor presents a historical overview of the growth in world population which culminates in the demographic explosion of the late 19th century and the 20th century.

### Classroom Presentation

Your instructor presents the major cause of the demographic revolution, focusing on the scientific discoveries that upset the balance between births and deaths. The discoveries of Pasteur and Koch, for example, ushered in immunization and vaccination technologies. Because these technologies engaged human values and were implemented in a socio-economic environment, they led to changes in population growth.

### Classroom Activities

While listening to the lecture, you attempt to develop a sound understanding of the population patterns throughout history. Such an understanding will facilitate your participation in the discussions during Sessions 2 and 3.

### Assignments

Reading

Use **Handout #1: Questions to Guide Your Reading** on p. 14 of this Student Handbook to help you to understand the reading assignments.

Read **Handout #2: A Brief History of Contraceptive Technology** by Maria M. Ricks on pp. 15-18 of this Student Handbook.

Read the following material, which has been placed on reserve in the library:

> Djerassi, Carl. "The Chemical History of the Pill," in The Politics of Contraception. New York: W. W. Norton, 1979, pp. 227-255.

### Assignment Deadline

Complete the reading assignment before the next meeting. Bring notes on these articles to Sessions 2 and 3 so that you can use them as reference material.

## Sessions 2 and 3

### Brief Summary of Activities

Your instructor leads a discussion of the demographic information and societal description presented at the first lecture as well as the material contained in the reading assignment.

### Classroom Activities

You and your classmates are responsible for an in-depth examination of the material presented in Session 1. In sessions 2 and 3, you and your instructor work toward acquiring a better understanding of world population patterns, historical options in contraceptive technology, and the development of the pill. You also explore the impact of institutional issues and value issues on population control.

You participate in discussions of both the lecture and the assigned readings. In Session 2, you work on increasing your awareness of the societal context, contraceptive options and the historical development of the pill. In Session 3, you and your classmates form groups. Each group is responsible for selecting a given option in contraceptive technology.

### Assignments

Reading

Read the following article, which has been placed on reserve in the library:

> Segal, Sheldon J. "The Physiology of Human Reproduction," in Scientific American, Vol. 231, No. 3 (September 1974) pp. 53-62.

Review all assigned reading materials, particularly your notes on Djerassi's article, in preparation for the lecture in Session 4.

### Assignment Deadline

Complete the reading of Segal's article and your review of the previously assigned reading before Session 4.

## Session 4

### Brief Summary of Activities

At a large group lecture, your instructor from the Department of Natural Sciences presents information on the physiology of human reproduction and the biochemistry of the pill.

### Classroom Presentation

Your instructor focuses on the following subjects:

--anatomy and physiology of the male and female reproductive system,

--hormonal control of the female reproductive cycle,

--mechanism by which the pill's action is effected,

--basic biochemistry of estrogen and progesterone,

--evolution of oral contraceptive formulation and dosage, and

--possible side effects.

### Classroom Activities

During the presentation, your instructor refers to transparencies and/or slides of the male and female reproductive systems, the metabolism of estrogen and progesterone, and the landmark events in the development of "sophisticated" contraception. This lecture provides a framework for your assessment of this technology, assigned later in the module. Take notes and develop an understanding of the lecture material.

Refer to **Handout #3: The Human Reproductive System,** on p. 19 of this Student Handbook. Handout #3 depicts the functioning of the male and female reproductive systems as well as the effect of the pill on the female reproductive system.

### Assignment

Review your notes on the physiology of human reproduction and the biochemistry of the pill.

### Assignment Deadline

Complete the review before Session 5.

## Session 5

### Brief Summary of Activities

Your instructor's presentation focuses on the subject of technology assessment. This presentation also includes an introduction to a technology assessment model. Building such a model will enable you to identify, analyze, and evaluate the impacts upon society of the contraceptive technology introduced in this module.

### Classroom Presentation

During this presentation, your instructor defines technology assessment and discusses in some detail the main steps in assessing a technology. These steps are:

1. problem definition
2. technology description
3. technology forecast
4. social description
5. social forecast
6. impact identification
7. impact analysis
8. impact evaluation
9. policy analysis
10. communication of results.

Your instructor then introduces the concept of a Technology Delivery System (TDS), referring you to **Handout #4: Basic Technology Delivery System,** on p. 20 of this student handbook. This basic model represents the integration of information from many sources. It can be modified in many ways, depending on the case under consideration.

Although TDS's are specific to the product to be delivered, they generally include the following:

1. **External Forces** that drive the development of the technology,
2. **System Processes** for development and dissemination, and
3. **Impacts** on the external environment.

Creating a model of a technology delivery system for the pill can help you to discern a pattern of complex relationships among the three items listed above. This model also enables you to integrate the information presented in Sessions 1 - 4. The subjects of these presentations can become components from which you can construct a technology delivery system.

**Contraceptive Technology: The Pill**

To help you understand how to construct a TDS, your instructor presents **Handout #5: Partial Model of a Technology Delivery System for the Pill**, on p. 21 of this student handbook. This partial model is designed specifically for assessment of contraceptive technology. Like a computer programming flowchart, it provides you with a means of visualizing the complex relations between the development of a technology and the components that become the driving forces in that development. This partial model includes the following components:

--Norms and Value Preferences
--Economic, Political, and Social Issues
--Governmental Agencies
--Research and Development
--Manufacturing
--Marketing
--Impacts

A brief review of some examples of these components is useful:

Norms and Value Preferences

--religious/ethical (pro-life, pro-choice)
--cultural (sexual mores, family structure)

Issues: Economic, Political, and Social

--increased population (baby boom, Third World demographic explosion)
--war, famine, and migration
--lower standards of living/GNP per capita
--drain on resources
--demand for birth control
--less demand for new services in area of education and services related to child

Governmental Agencies

--policymakers
--public health policies and procedures
--welfare agencies
--regulatory agencies, such as FDA

Research and Development

--university and non-profit laboratories
--pharmaceutical company laboratories
--search for new formulations
--specialized staff

**Contraceptive Technology: The Pill**

Manufacturing

--pharmaceutical companies
--allocation of capital, manpower, and resources

Marketing

--market research
--advertising
--product distribution

Impacts

--demographic: decreased birth rate
--cultural: sexual revolution
--economic: increased GNP per capita
--economic: standard of living and labor
--medical: side-effects (beneficial and harmful)
--political: balance of power and social and governmental spending

This list of components and examples is not comprehensive. Other examples could be drawn from the session presentations, the readings, or individual research. Take careful notes on the presentation in this session because you will be creating your own model of a technology delivery system in Session 7.

At the end of this presentation, your instructor discusses **Handout #6: Topics for Discussion and Further Application of Technology Assessment Model,** on p. 22 of this student handbook. This handout contains information that will help you to complete the assignment due in Session 6. (See below, Oral Reporting.)

**Classroom Activities**

During the instructor's presentation, you attempt to put in context all the societal, historical and bio-chemical information about contraceptive technology you have gathered. You take notes on technology assessment techniques for later application in Sessions 6 and 7.

The main purpose of this session is to help you become familiar with the technology assessment model that will help you prepare for the application exercises in Sessions 6 and 7.

## Assignments

### Reading

Review all reading material previously presented.

### Oral Reporting

Review **Handout #5: Partial Model of a Technology Delivery System for the Pill** and **Handout #6: Topics for Discussion and Further Application of Technology Assessment Model.** Identify as many **impacts** of contraceptive technology as possible. These impacts may be economic, demographic, psychological, religious, ethical, social or cultural, or they may be related to health or policy.

Your instructor suggests ways in which you may approach this impact-identification oral report, which is due in Session 6.

## Assignment Deadline

Complete your assignments before Session 6.

## Session 6

### Brief Summary of Activities

Your instructor leads a discussion of the technology assessment techniques presented in Session 5. This discussion will be followed by application exercises and oral reporting of the impacts you identified.

### Classroom Presentation

Your instructor briefly summarizes the technology assessment information presented in Session 5. Following this summary, your instructor leads a discussion of applications based on the use of the TDS, represented in Handout #5.

### Classroom Activities

You present an oral report of your findings about areas in which contraceptive technology has an impact on society. Your participation in this session is important because it will help you with your application exercise in Session 7. Your instructor offers suggestions and criticisms.

### Assignment

<u>Reading</u>

Review all reading assignments and lecture notes in preparation for a quiz and an application exercise in Session 7.

### Assignment Deadline

Complete this assignment before Session 7.

## Session 7

### Brief Summary of Activities

Your instructor evaluates your progress in the module.

### Classroom Activities

You take a multiple-choice quiz by which you demonstrate your understanding of basic concepts introduced in the module as well as your knowledge of how to apply technology assessment techniques.

You complete an application exercise which requires completion of a TDS (Technology Delivery System) in which branches and boxes represent a variety of alternatives and their respective effects on society.

## Evaluation

You demonstrate your achievement in this module by:

--taking a quiz in Session 7,

--participating in general discussions in Sessions 2, 3 and 6, and

--completing a technology delivery system in Session 7.

## Weighting of Your Grade

Because this module is part of a larger course, it is not likely that an isolated grade for it can be produced. The figures below are only an approximation.

| Activities | Percentage of Grade |
|---|---|
| Quiz | 30% |
| Completion of TDS | 30% |
| Classroom participation | 40% |
| | 100% |

## Handout #1: Questions to Guide Your Reading

Questions to Guide Your Reading of **A Brief History of Contraceptive Technology**:

--Has man become interested in population control only in more recent times?

--Was the control of conception always the main means of population control?

--Were early contraceptive technologies based on scientific fact (verifiable today) or based on magical or "folk" practices?

--Do the same type of technologies appear in different cultures?

--Is there any relationship between other technological innovations and improvements in contraceptives?

--What effect did industrialization, urbanization and the changing role of the Church have upon contraceptive technology?

Questions to Guide Your Reading of **The Chemical History of the Pill**:

--Why was the program in steroid chemistry an essential ingredient in the development of the pill?

--Is there any relationship between steroid structure and biological activity?

--What is the relationship of steroid chemistry and certain plants found in Mexico and Central America?

--What role, if any, did microbiological fermentation technology play in the industrial synthesis of hormones?

## Handout #2: A Brief History of Contraceptive Technology

by

Maria Ricks

While for many centuries humanity labored under the threat of extinction, it is important to note that as far back as prehistory there is evidence of attempts to artificially control conception; and, although contraception would not for a long time be the chief form of population control - abortion, infanticide and abstinence were far more popular methods. - it has existed for several thousand years. In fact, the records seem to point out that through time and across cultures, man has longed for the ability to have some say in his reproductive patterns.

Many of the earlier methods of contraception can hardly be distinguished from the magical practices of many earlier societies. In many of these however, contraceptive prescriptions are actual forerunners - if crude ones, - of modern contraceptive technology.

In North Africa, for example, the following were all prescribed as contraceptive measures: drinking infusions of gun powder or the foam from a camel's mouth; drinking the water used for the washing of a dead person; eating castor beans, one for each year of desired freedom from pregnancy. This latter type of symbolic magic finds its parallel in folk beliefs of modern Europe, where there is the belief that sitting upon a certain number of fingers will render the woman sterile for an equal number of years.

Among native Americans, it seems that the Shawnee women drank the juice of a certain herb to prevent conception; whereas, Cherokee women chewed and swallowed for four consecutive days the roots of spotted cowbane (Cicuta maculata, also known as musquash root).

Among the Djukas or Bush Men of Surinam we find an okra-like seed pod used as a condom; and, in Guinea and Martinique we find a direct forerunner of the spermicidal agents used today - a douche solution containing lemon juice and a decoction of the husks of the mahogany nut. Both lemon juice and mahogany husks are viable spermicidal agents. We now know that lemon juice is about 5% citric acid, which immobilizes the sperm; and mahogany husks may also have an astringent effect. Along these lines, it is interesting to note that in 18th century France lemons also figured among contraceptive prescriptions; cut in half, the disk was used as a cervical cap after most of the juice was extracted.

The oldest written account of contraceptive techniques is to be found in the Petri papyrus of Egypt (ca. 1850 B.C.) in which three different contraceptives are recommended: a crocodile dung pessary, a solution of honey and sodium carbonate, and a gum-like substance.

Egyptian contraceptive technology, like other Egyptian cultural contributions, found its way to Greece. It is well known that Plato and Aristotle, among others, were concerned with population limitation, favoring a stationary population for the Greek city state. Aristotle, in particular, documents the use of olive oil by his contemporaries as a contraceptive. This may have been a somewhat effective measure, since we now know that oil reduces the motility (ability to move) of the spermatozoa.

In Rome, Pliny the Elder picks up the olive oil method, while Dioscorides, a Greek physician to the Roman armies whose De materia medica was consulted well into the 16th century, gives us a string of contraceptive prescriptions, from pepper to iron rust, to willow leaves.

The most brilliant and original account of contraceptive technique prior to the 19th century is the Gynaecology of Soranos of Ephesus, who practiced medicine during the reigns of Trajan and Hadrian and is considered the greatest gynecologist of antiquity. He reports a variety of methods from sneezing, to the use of a variety of oil and gum-based substances. The following are specific prescriptions: Pine bark mixed with equal parts of rhus coriaria in wine; one part gallnut to one part pulp of fresh granate pulverized with water; dry figs and sodium carbonate; and many others. Soranos is very clinical in his approach and discourages the use of amulets.

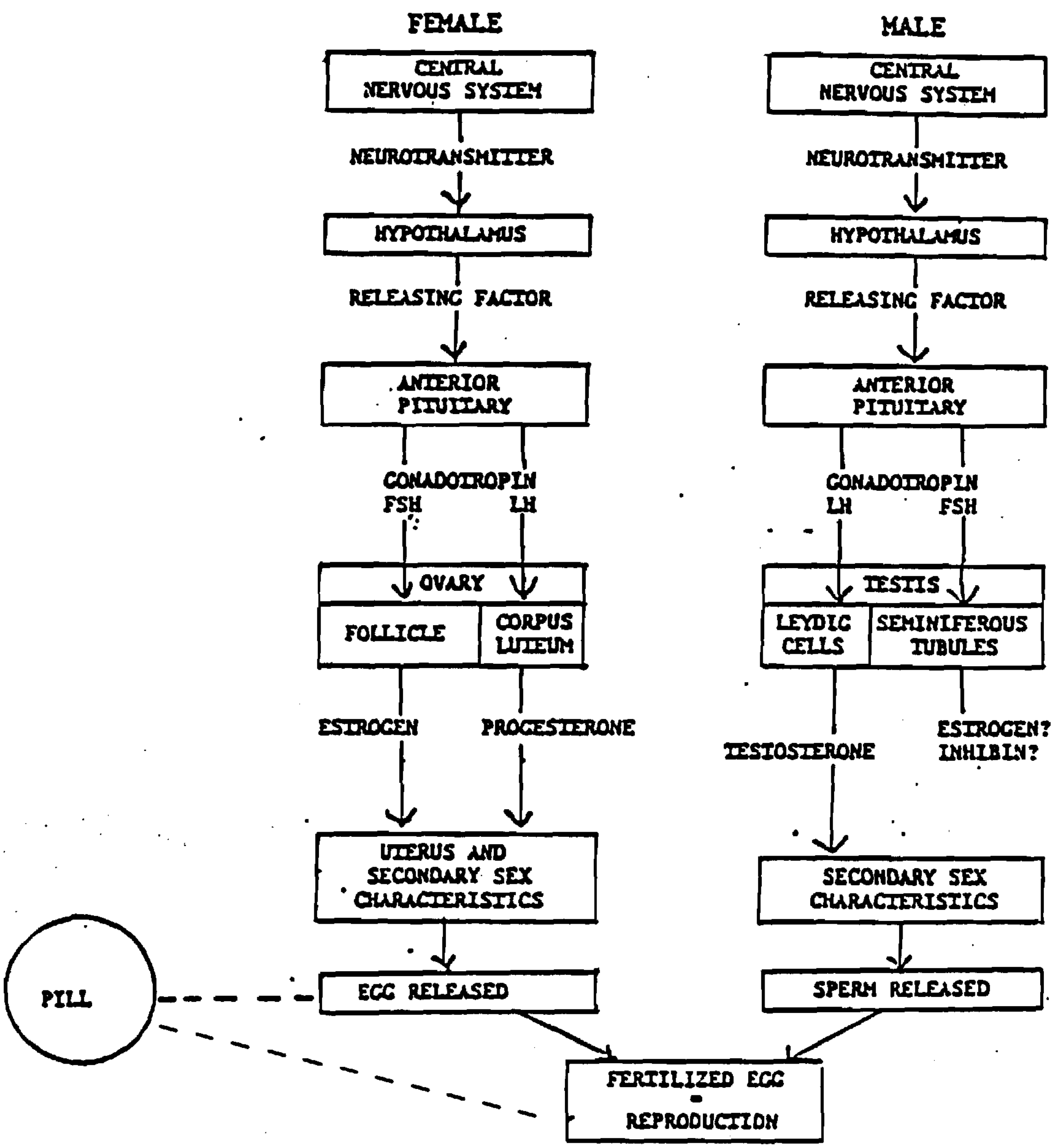
In Europe, during the Middle Ages, many of Sorano's contraceptive methods would be retained along with magic folk medicine and the ingestion of many substances including some that were poisonous. It is not until the 1900's that a sifting of the effective vs. the ineffective, the harmless vs. the harmful in contraceptive technology would begin.

In the 16th century, condoms began to be used in Europe as prophylaxis against venereal infection. Only at about the 18th century were they used as contraceptives according to accounts of the famous Cansanova. The real innovation in this technology, however, only came with another technological breakthrough - the "vulcanization" process in the rubber industry, which occurred around the middle of the 19th century. This made possible the replacement of membranous condoms by the cheaper rubber whose use became widespread. The introduction of the latex condom in the 20th century would represent the second revolution in this contraceptive technology.

It was in 19th century Europe, particularly England, Germany and France, that contraceptive practices would spread most rapidly. This was probably due to the growing industrialization, urbanization, and the lessened influence of the Church. Close to 200 mechanical devices, all based upon a few basic principles and varying only in details, were either developed or considerably improved during that century, with the possible exceptions of the condom, suppositories, and the tampon with or without medication. The diaphragm, for example, in combination with a spermicidal paste or jelly was an invention of the 19th century. Research into the chemistry of contraception was also initiated in this century, as the awareness of the social and economic desireability of contraceptive technology became more evident following the work of Francis Place and the neo-Malthusians.

In early 20th century, Margaret Sanger organized the American birth control movement which, together with developments in steroid chemistry, supplied the impetus for research into the chemical method of contraception which would come to be known as The Pill.

## Handout #3: The Human Reproductive System



## Handout #4: Basic Technology Delivery System

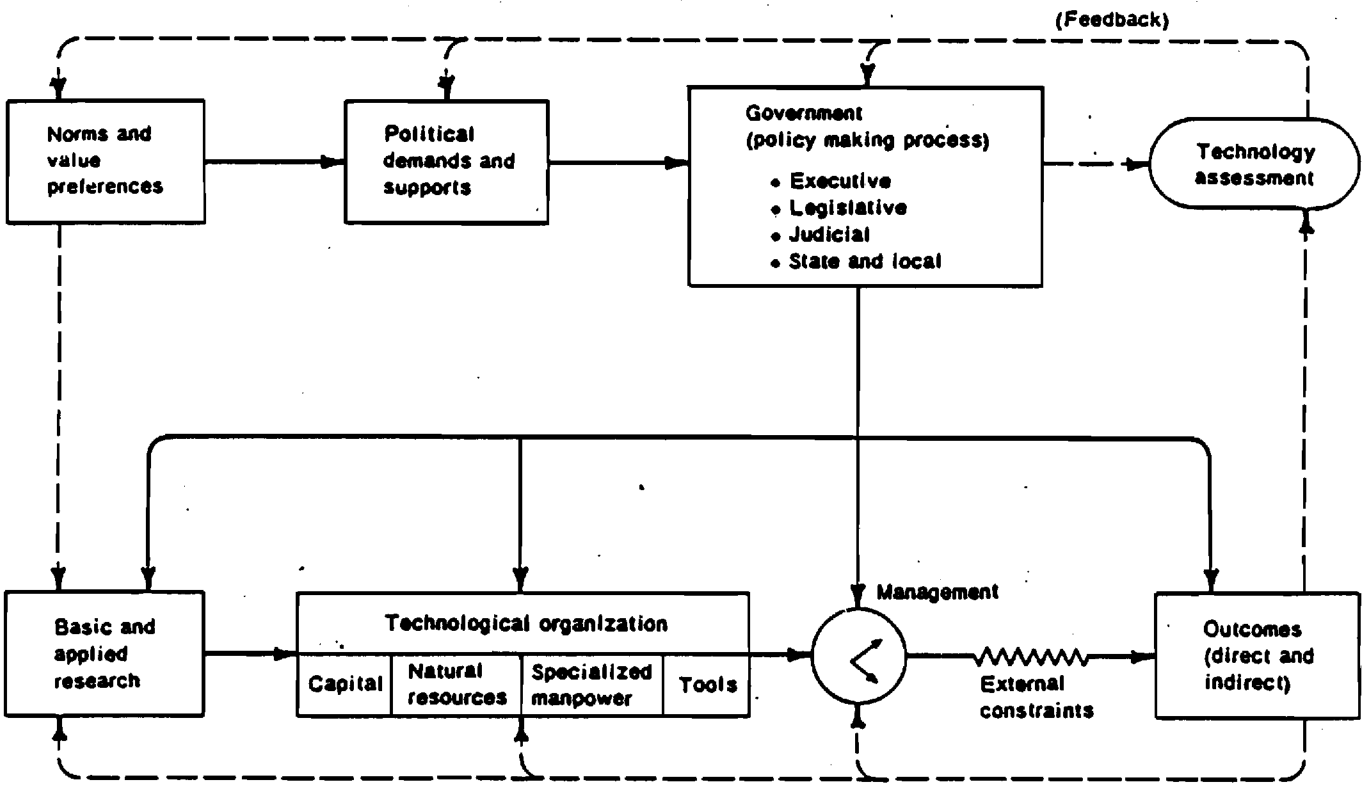
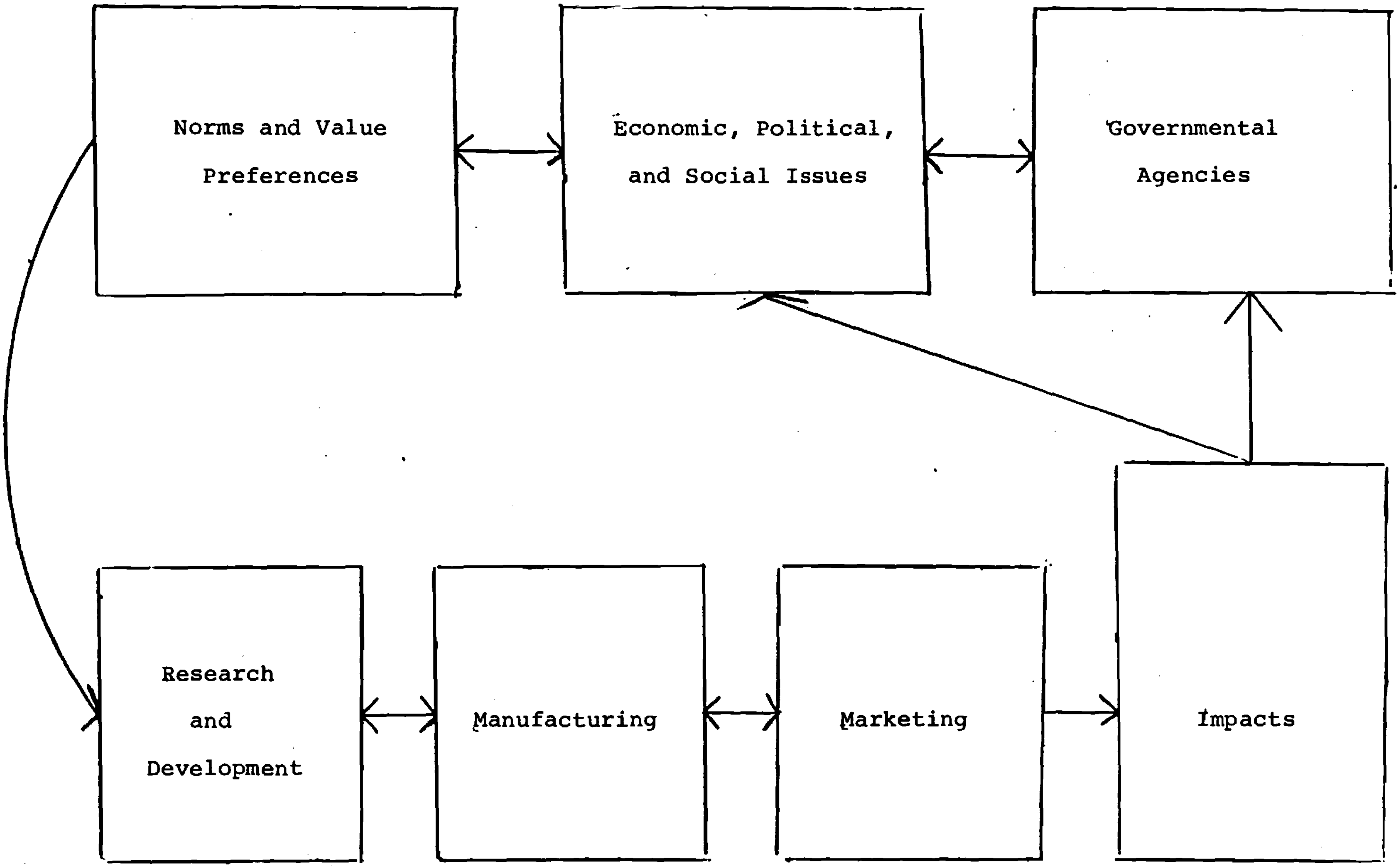



FIGURE 4.1. The technological delivery system.

From: Wenk and Kuehn (1977).

In Porter, Rossini, Carpenter, and Roper. A Guidebook For Technology Assessment and Impact Analysis. New York: Elsevier North Holland, Inc., 1980.

**Handout #5: Partial Model of a TDS for the Pill**



## Handout #6: Topics for Discussion and Further Application of Technology Assessment Model

1. The impact of technological advances in the rubber industry, particularly the vulcanization process, upon contraceptive technology. Changes in the manufacture, pricing and use of the condom. Economic, social and moral impacts.

2. Religion and morals at odds with contraceptive technology: the Catholic Church and the pro-lifers.

3. The birth of a giant: the development of oral contraceptive technology and the Syntex Corporation.

4. "Folk" vs. scientific contraceptive technologies. Popular folk beliefs about contraception in your geographic area.

5. Diosgenin: nature's oral contraceptive.

6. The politics of birth control: genocide vs. famine?

7. The use of the Pill among South Carolina State College students: how safe and effective is it?

8. China's only child: should the state determine the size of your family?

9. The post World War II population explosion in the Third World: has it affected the balance of power? The case of the United Nations.

10. Birth control or revolution: achieving the great leap in the Third World.

11. The rise in venereally-contracted disease and the Pill: The AIDS case.

12. The Pill and mental health: psychological freedom from the fear of pregnancy. Its impact on the job market, the family and other areas of society.

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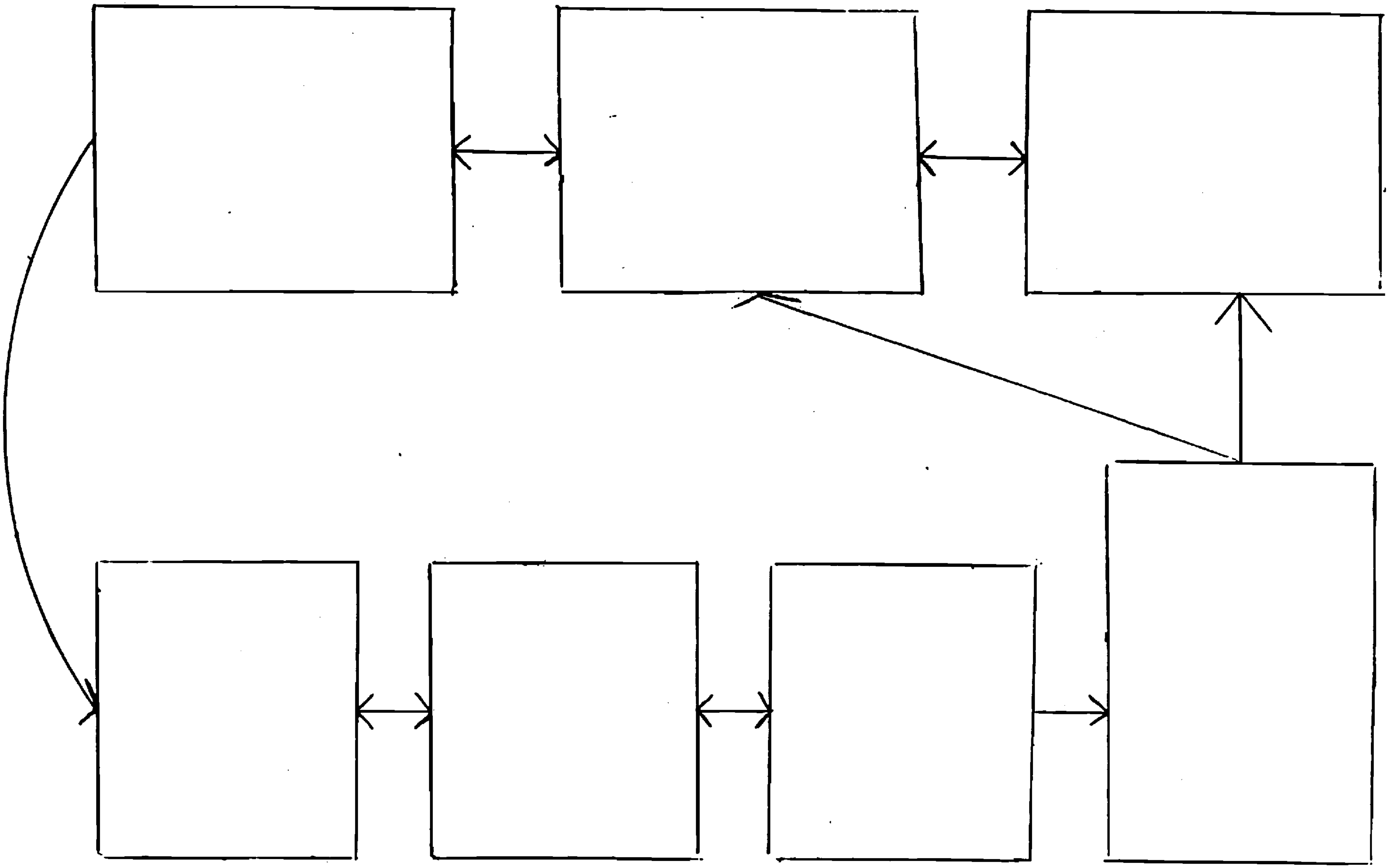
Blank TDS Worksheet for Student to Complete in Session 7

# TDS Worksheet



# Decision Analysis in Ethics

by

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and

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Greensboro, North Carolina

Student Handbook
for an Instructional Module
in Ethics and Technology

Resourceful Exchange: Technology and the Liberal Arts (RETLA)

1986

## Introduction

This module follows presentations that introduce principles of ethics and enable you to compare established beliefs with several value systems. It provides knowledge and skills that will help you solve real world ethical dilemmas. While working through this module, you will:

--engage in decision-making simulations, decision-tree methodology, and elementary decision analysis in order to apply alternative systems of values in the management of moral dilemmas,

--learn how to use quantitative techniques for assessing value and probability that will help you develop mathematical and reasoning skills, and

--learn how to use computer programs as a technological tool that can help you make value judgments based on a sequence of rational processes.

This module should help you to:

--recognize situations in which expected-value decision making and decision-tree analysis are appropriate, and

--apply these methods to elementary scenarios.

## Learning Objectives

After completing this module, you should be able to:

--illustrate the use of a decision tree as a graphic schematic aid to clarify criteria and information needed for decision-making purposes, and

--summarize the main steps involved in decision analysis under risks, confict, or uncertainty, using a decision-tree procedure that entails:

--drawing the decision flow diagram, identifying the points of decision and the alternatives available at each point,

--identifying the points of uncertainty and the type of range of alternative outcomes at each point,

--estimating the values needed to make the analysis, including the probabilities of different events or results of actions,

--analyzing the alternative values and the costs and gains of various events and actions, and

--choosing a course of action.

You should also be able to use computer software for simulation and optimization as a time-saving technological tool.

## Dimensions of the Module

This module is composed of ten sessions, each requiring fifty minutes of class time. Since this module is part of a course in ethics, some of these sessions may not occur consecutively. For example, while you are working on the major assignment on decision trees, your instructor may allocate class time to the course, returning to the module after you have completed these assignments.

## Instructional Formats

Lecture/Discussion--one session
Lecture/Workshop--seven sessions
Workshop--two sessions

## Structure of the Student Handbook

This student handbook should help you to understand the requirements of the module. For each session the handbook includes a detailed description, focusing on **classroom presentation, classroom activities, assignments,** and **assignment deadlines.** See, for example, pp. 7-8.

The handbook also includes a set of handouts that provides important information. See pp. 20-28 for copies of these handouts.

When appropriate, your instructor will pass out three other kinds of documents:

--**activities** (for in-class tasks),
--**assignments** (for out-of-class tasks), and
--**assessment sheets** (for helping you to monitor your progress).

This student handbook indicates when you will receive each of these three kinds of documents.

## Readings for Decision Analysis in Ethics

A packet of readings accompanies this student handbook. These readings are to be completed as part of your work in the course. Deadlines for completion are specified in the student handbook.

## Session 1

### Brief Summary of the Session

Your instructor provides opportunities for you to examine your personal understanding of the term values.

### Classroom Activities

You and your classmates form small groups in order to engage in two activities requiring that you rank values. Your instructor passes out two activity sheets: **Activity #1: Rokeach Instrumental Values** and **Activity #2: Rokeach Terminal Values.** Your task is to rank each of these sets of values in the order of their importance to you.

After you rank these values, your instructor engages in a discussion with your group. Be prepared for this discussion by selecting the values that you rank as #1 and #18 and by listing reasons for your choices.

Place the results of these activities in a folder for future reference.

### Assignment

Your instuctor hands out **Assignment #1: The Auction Game.** You are to pretend that you have been given the sum of $2000, which you must allocate to the items in the Auction Game that you value most. Create a preliminary budget by filling out the column on the form that is entitled Amount You Budgeted.

During Session 2, you and your classmates engage in a simulated auction in which you bid for items on the list. The highest bidder wins.

### Assignment Deadline

Complete your preliminary budget by Session 2.

## Session 2

### Brief Summary of the Session

You participate in a simulated auction demonstrating human behavior as it relates to a series of fifteen values.

### Classroom Activities

Your instructor helps you and your classmates to choose an auctioneer and recorder for the simulated auction. If appropriate, the instructor also serves as arbitrator of any disputes that occur.

You have an opportunity to bid for the items on the auction game form. During this procedure, you fill out the second and third columns on the list: Your Highest Bid and Check Items You Won. Completing this task will enable you to compare your preliminary budget with your responses during the bidding at the auction.

### Assignments

Work on **Assignment #2: Values Grid,** which your instructor passes out at the end of Session 2. If you cannot answer some of the items on the values grid because of lack of information, list those items. Compare your responses on the values grid with your responses during the auction game.

Write a paragraph about your conception of what is meant by the term Human Value. Use either a typewriter or a word processor, double-spacing the lines. The length of your paragraph should not exceed one page.

### Assignment Deadlines

Complete both of these assignments by Session 3.

## Session 3

### Brief Summary of the Session

Your instructor summarizes information about values gathered from the presentations and discussions in Sessions 1 and 2. Axiology, a general theory of values and a branch of philosophy, will be introduced. This branch of philosophy encompasses economic, aesthetic, moral, and ethical values.

### Classroom Presentation

As a background to future problem solving, your instructor briefly assesses the current progress of the class in establishing concepts of values. An approach to the philosophical idea of values, comparing the ways values change with new knowledge, new technologies, or political emphases, is introduced. Cost-benefit relationships in several of these areas are explained.

### Classroom Activities

You and your classmates will form small, "cost-benefit" groups in order to debate the extent of costs in realizing a prescribed value. These costs pertain to energy, time, money, or risks taken. The prescribed values address such practices as assigning donated organs preferentially to wealthy patients or the use of credit cards in terms of the potential confict between personal advantages and bank advantages.

### Assignments

Study the following handouts: **Handout #1: Decision-Making Process Model, Handout #2: Deontological Ethical Method** and **Handout #3: Act-Utilitarian Ethical Method.** (See pp. 20-22 of this student handbook for copies of these handouts.)

Here is a brief summary of the theories that are reflected in Handouts #2 and #3:

<u>Deontological Ethical Theories</u>

Deontological theories maintain that the morality of an action depends on factors other than consequences. It is the <u>kind</u> of action taken that will make it right or wrong. Some of these theories are described as divine command, categorical imperative, prima facie duties, and manimin principle. You may wish to research each of these theories.

## Act-Utilitarian Ethical Theory

Act-utilitarianism theory is usually described as maintaining that the "right act is the one that produces the greatest ratio of good to evil for all concerned." One must think of consequences not only for oneself but for all others. Three basic objections to this theory are that (1) consequences of actions are uncertain, 2) an action can be wrong even if good is produced, and 3) there may be a conflict with justice.

Read the article, **Ethical Decision Making: Three Theories,** by Stan Carpenter. (See the **Readings for Decision Analysis in Ethics,** Reading #1, for a copy of this article.)

**Assignment Deadlines**

Complete these assignments by Session 4, in which you will participate in a discussion of the three handouts and the reading.

## Session 4

### Brief Summary of the Session

This session addresses ethical principles as a basis for forming professional codes and as applicable to areas of human relations, such as politics, education, business, health care, and international relations.

### Classroom Presentation and Activities

Your instructor presents a review of Handouts #1, #2, and #3. Following this review, you participate in a discussion of the decision-making model, the deontological method and the act-utilitarian method.

You also participate in a discussion of the reading, **Ethical Decision Making: Three Theories,** by Stan Carpenter.

### Assignments

Study the following handouts: **Handout #4: Duty-Oriented Process of Making Ethical Decisions** and **Handout #5: Consequence-Oriented Process of Making Ethical Decisions** (See pp. 23 and 24 of this student handbook for copies of these handouts.)

Here is a brief summary of the ideas that are reflected in Handouts #4 and #5:

Duty-Oriented Process of Making Ethical Decisions

According to Kant's "duty ethics," if one follows the "Categorical Imperative," an act is immoral if its authorization (or rule) cannot apply to all persons. He would like for moral rules to be comparable to mathematical truths. These truths should be universal.

Dr. Carol Gould has written a critique of Kant's "abstract universality" that is of especial interest to women. See her article "The Woman Question: The Philosophy of Liberation and the Liberation of Philosophy" in Women and Philosophy, edited by Carol C. Gould and Marx W. Wartofsky, New York: G. P. Putnam's Sons, 1976. According to Gould, Kant's idea of universality excludes women.

## Consequence-Oriented Process of Making Ethical Decisions

The consequence-oriented process reflects teleological morality including ethical egoism and utilitarianism. These theories expect persons to act to bring about "good" consequences. The problem is deciding who will benefit: will self-interest prevail or the interests of all others?

Read the **The Decision Tree Technique** from **Biomedical Ethics: A Guide to Decision Making** by Robert T. Francoeur. (See the **Readings for Decision Analysis in Ethics**, Reading #2, for a copy of this chapter.)

Read General Overview to Decision Trees, Part I: A Decision Tree, Part II: Probabilities in **Decision Analysis** by Ray Treadway. (See the **Readings for Decision Analysis in Ethics**, Reading #3, for a copy of these sections.)

Write down any questions you have about these handouts and readings. Be prepared to ask these questions in class.

**Assignment Deadlines**

Complete these assignments by Session 5, in which you will participate in a discussion of the two handouts and the two readings.

## Session 5

### Brief Summary of the Session

This session addresses the decision tree technique as a means of making informed decisions about ethical problems. It also addresses the concept of a decision tree, probabilities, quantitative values, and expected value.

### Classroom Presentation

Your instructor reviews the main advantages of using decision tree analysis and the basic concepts of probability. Three ways to determine probabilities are discussed. The concepts of outcomes, sample spaces, and events, and the main properties of probability are summarized.

### Classroom Activities

You and your classmates draw simple decision trees and compute some simple probabilities. While engaging in these activities, you refer to the article, **Decision Analysis**, by Ray Treadway, focusing on the General Overview to Decision Trees, Part I: A Decision Tree, and Part II: Probabilities.

### Assignments

Review the Decision Tree Technique from **Ethics: A Guide to Decision Making** by Robert T. Francoeur.

Read Part III: Quantitative Values and Part IV: Expected Value in **Decision Analysis** by Ray Treadway. (See the **Readings for Decision Analysis in Ethics**, Reading #3, for a copy of these sections.)

Your instructor passes out **Assignment #3: Exercises on Probability**. Begin to work on this assignment. You may find it helpful to view supplementary materials on probability in your college's learning center or in a freshman mathematics textbook.

Bring a list of any questions about probability that you may have to Session 6.

**Assignment Deadlines**

Complete the readings by Session 6.

Begin to work on the exercises on probability, which must be completed by Session 7.

## Session 6

### Brief Summary of the Session

This session addresses the concept of expected value.

### Classroom Presentation

Your instructor presents the concept of expected value and the concept of assigning numeric values to outcomes, as specified by a random variable. Means of computing expected value will be discussed, some examples will be discussed, and the properties of expected value will be explored.

### Classroom Activities

You participate in a discussion of any remaining questions that you or your classmates have about probability.

Your instructor presents some questions about expected value that you and your classmates work through. Following this task, you participate in a discussion of these questions.

### Assignments

Review Part III: Quantitative Values and Part IV: Expected Value in **Decision Analysis** by Ray Treadway.

Your instructor passes out **Assignment #4: Exercises on Expected Value.** Begin to work on this assignment.

### Assignment Deadlines

Complete your review of the reading by Session 7.

Complete the exercise on probability by Session 7.

Begin to work on the exercise on expected value, which must be completed by Session 8.

## Session 7

### Brief Summary of the Session

Your instructor presents procedures for using the concepts of probabilities and expected value to analyze a decision tree. The presentation also addresses the method of interpreting the calculated values in each fork in order to make informed decisions.

### Classroom Presentation

Your instructor demonstrates the "roll back" process to analyze a decision tree, using a decision tree similar to the one presented in the readings entitled **Decision Analysis.**

### Classroom Activities

You and your classmates participate in a discussion of any remaining questions that you may have about expected value.

With the help of your instructor, you work through the evaluation of the decision tree in the article on **The Decision Tree Technique.**

### Assignments

Review **Decision Analysis** by Ray Treadway, making sure that you thoroughly understand the material presented in this article.

Your instructor passes out two new assignments: **Assignment #5: Decision Trees** and **Assignment #6: Major Assignment on Decision Trees.**

Begin working on **Assignment #5: Decision Trees.**

Begin working on **Assignment #6: Major Assignment on Decision Trees.** You need to allow sufficient time to determine the appropriate values to be assigned to the final results and to determine the correct probabilities for each branch.

### Assignment Deadlines

Complete the exercises on expected value by Session 8.

**Assignment #5: Decision Trees** is due before Session 9.

**Assignment #6: Major Assignment on Decision Trees** is due before Session 9. You have two weeks to complete this assignment.

## Session 8

### Brief Summary of the Session

This session provides a review of decision tree analysis, presents a new example, and includes time for asking questions about **Assignment #6: Major Assignment on Decision Trees.**

### Classroom Presentation

Your instructor passes out and discusses **Activity #3: The Swine Flu Dilemma.**

### Classroom Activities

Your instructor returns your assignment on probabilities, and you and your classmates take part in a discussion of that assignment.

You participate in setting up and analyzing a tree for the activity on the swine flu dilemma, following the instructions on the activity sheet. You also work through the computations for this in-class assignment.

Note that you and your classmates practice assigning values, rather than being told how to make value judgments.

### Assignment

Read **Handout #6: Decision Analysis Computer Software.**

Continue to work on **Assignment #6: Major Assignment on Decision Trees.**

### Assignment Deadlines

Complete the reading of Handout #6 before Session 9, in which you will participate in the use of computer software.

Complete assignment #5 on decision trees before Session 9.

Complete assignment #6, major assignment on decision trees, before Session 9.

## Session 9

### Brief Summary of the Session

Before this session, your instructor returns your assignments on expected values, decision trees, and your major assignment on decision trees, which will have been graded. Time is provided for a discussion of these assignments.

You participate in a discussion about how changing the values assigned to the branches affects your decision.

Your instructor presents computer software that you can use to perform the calculations pertaining to decision trees. This software enables you to explore alternatives quickly, easily, and accurately.

### Classroom Presentation and Activities

Your instructor presents the calculations for **Assignment #5: Decision Trees.** You participate in a discussion of these calculations.

Your instructor presents the calculations for **Assignment #6: Major Assignment on Decision Trees.** You participate in a discussion of these calculations.

You engage in speculations about changing some of the values. Such changes are appropriate if cost of medical treatment is of no consideration or if personal preferences about medical treatment, alternative therapies, or amount of pain alter the original values you established.

Following this discussion, your instructor introduces computer software and demonstrates the use of this software in performing calculations. Some students may be asked to practice entering and editing probabilities and values.

### Assignment

Your instructor passes out **Assignment #7: Computer Assignment** during Session 9.

### Assignment Deadline

Study this assignment and be prepared to enter revised values, as indicated in Part 1 of the assignment, during Session 10.

## Session 10

### Brief Summary of the Session

You and your classmates use computers and decision tree software to work on Part 1 of your computer assignment. You learn how to use the computer, how to select options that are available in the computer program, how to save your data, and how to print your results.

### Classroom Presentation

Your instructor discusses the process of changing values and reviews the rules for using the computer program.

### Classroom Activities

You and your classmates use the computer program to finish the first part of the computer assignment. Your instructor provides assistance.

### Assignments

Complete Part 2 of the computer assignment, which will require that you work in the computer lab outside of class time. Choosing values for the final results is to be based on your personal judgment. Use the computer and previously stored data to compute revised expected values.

Write a paper about the decision tree analysis. This paper should explain the process you have used to arrive at your values. Indicate in your paper what your revised decision is. Include a computer printout to justify your decision.

### Assignment Deadlines

Complete these assignments in two weeks.

## Evaluation

You demonstrate your achievement in this module by:

--participating in the auction game and filling in the values grid,

--completing the exercises on probability, expected value, and decision trees,

--completing the major assignment on decision trees and the computer assignment, and

--completing two writing assignments.

## Weighting of the Grade

| Activities | Percentage of the Grade |
|---|---|
| Auction Game and Values Grid | 15% |
| Exercises on Probability, Expected Value, and Decision Trees | 30% |
| Major Assignment on Decision Trees and Computer Assignment | 40% |
| Writing Assignments | 15% |
| | 100% |

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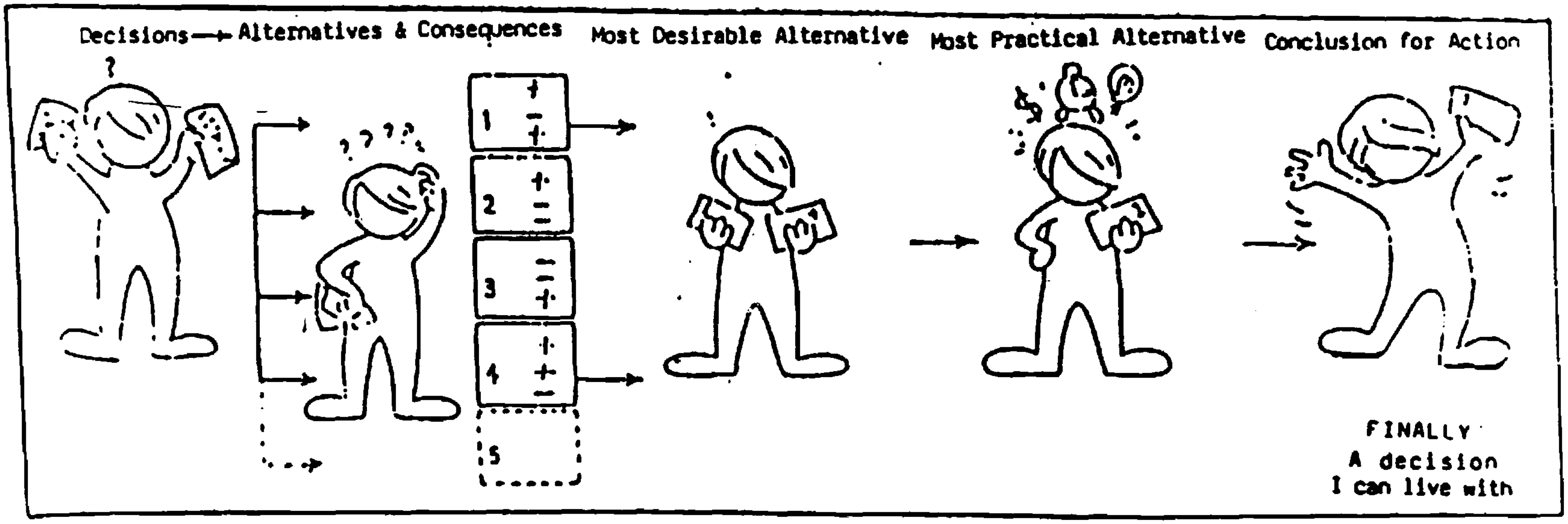
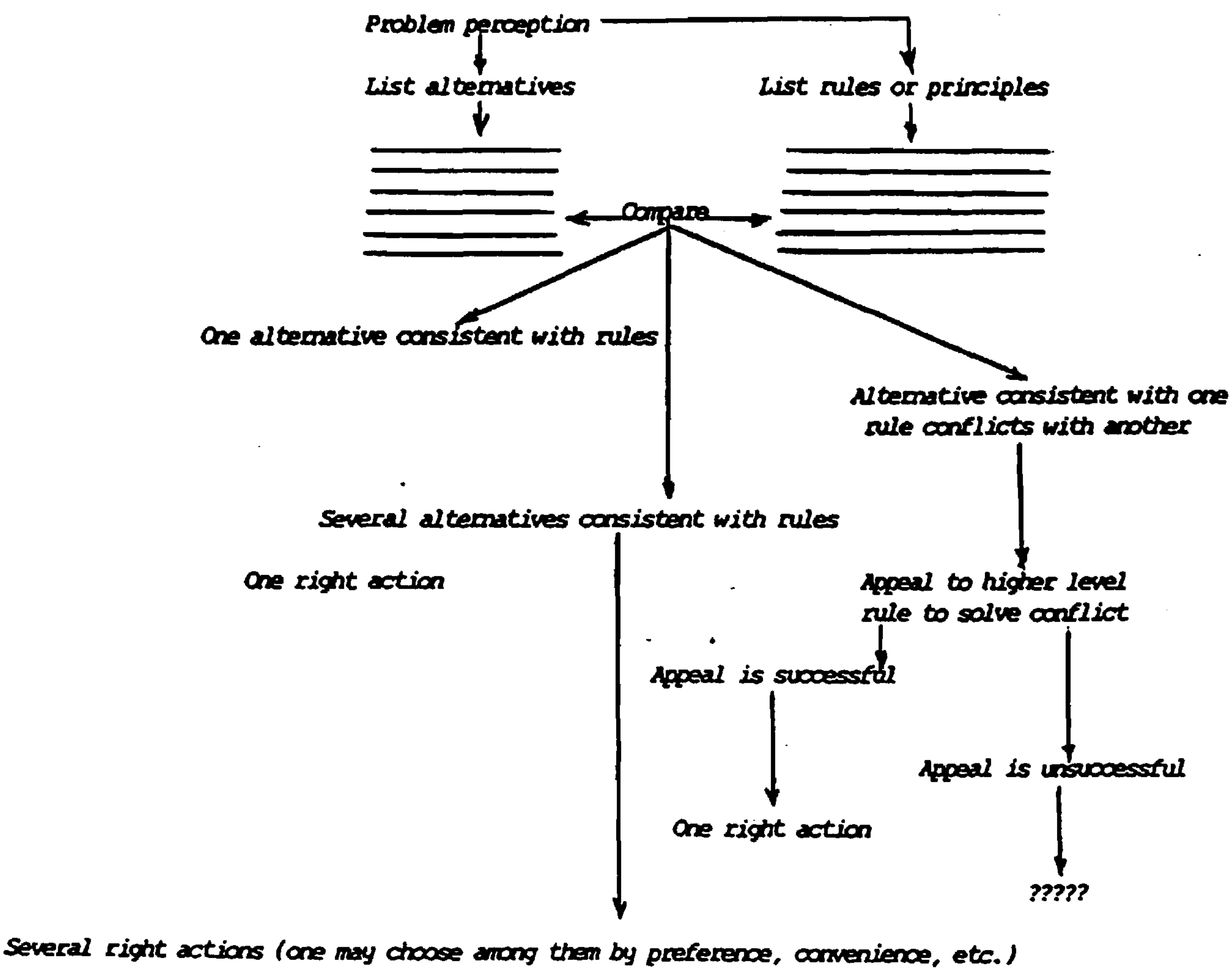
## Handout #1: Decision-Making Process Model






Adapted from Manisha Maskay and Anne Juhasz, p. 115.

## Handout #2: Deontological Ethical Method




Adapted from Brody, Ethical Decisions in Medicine, Appendix I, Figure 8, p. A - 2a.

## Handout #3: Act-Utilitarian Ethical Method

*Problem perception*

↓

*List alternatives*

↓

*For each alternative*

→ *Predict consequences* → *Assign value of happiness produced*

*1 - __________* *1 - + + +*

*2 - __________* *2 - _ _ _*

*3 - __________* *3 - +*

*etc.*

*Select alternative with highest value for happiness*

↓

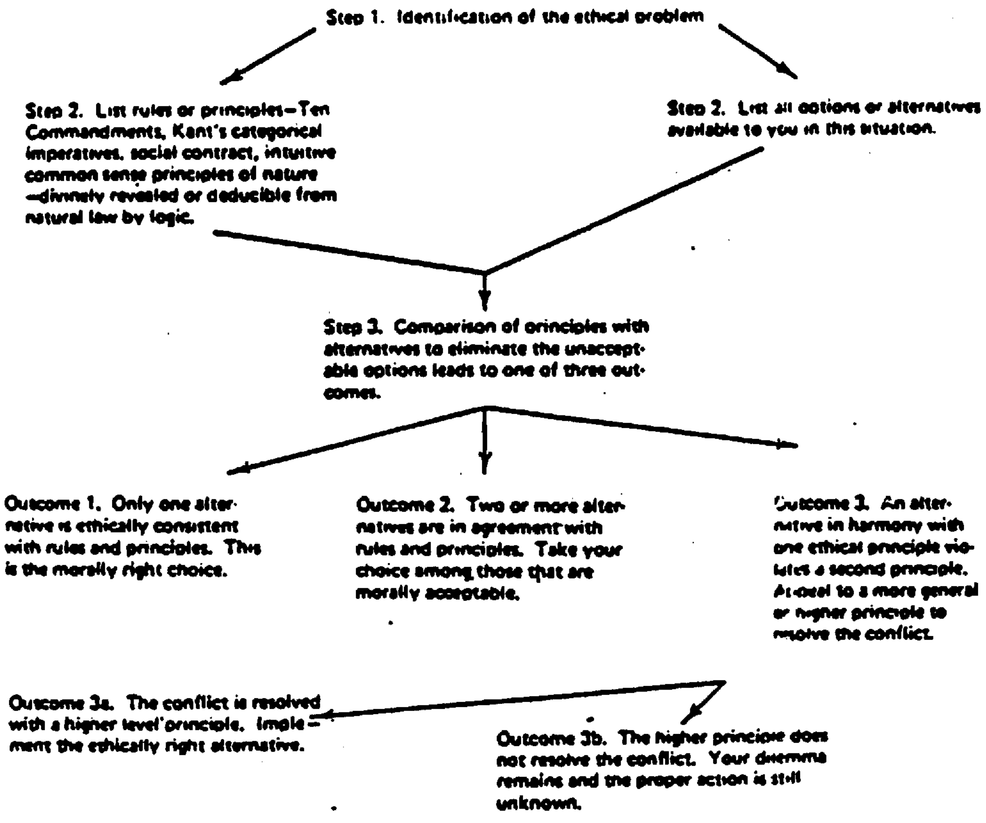
*Ethically correct choice*

<u>*Act-utilitarian Ethical Method*</u>

*This method fails if (1) one is unable to predict consequences accurately, or (2) one is unable to estimate accurate happiness values.*

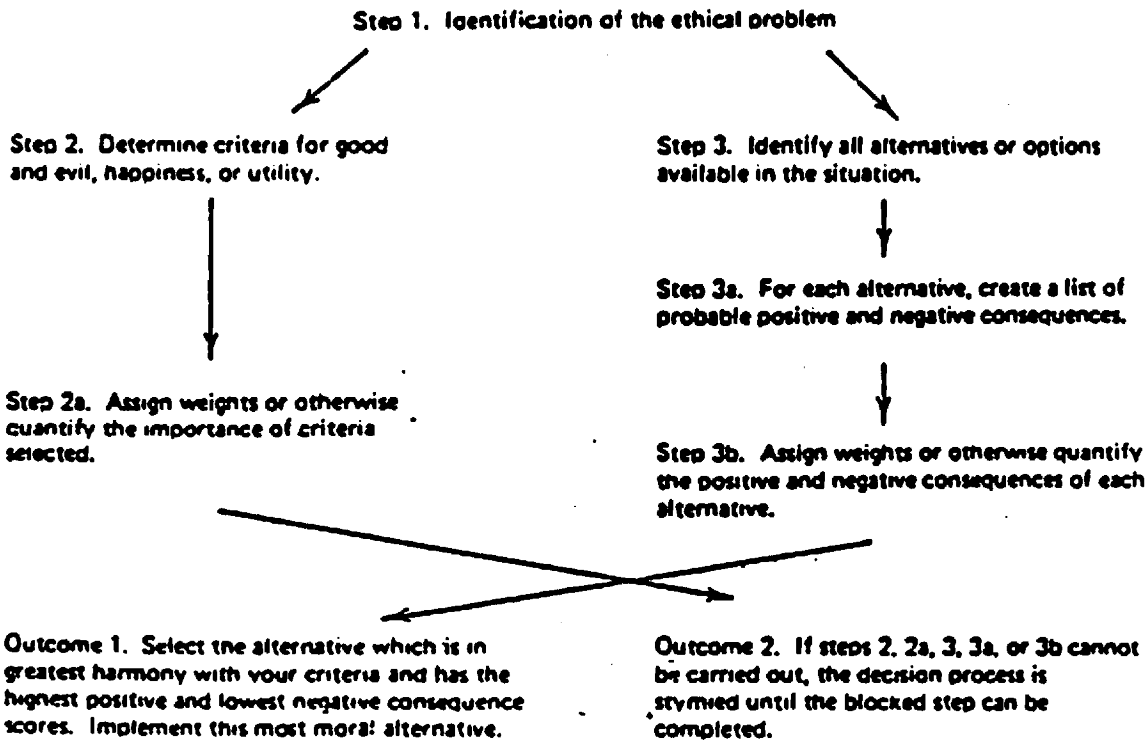
Adapted from Brody, <u>Ethical Decisions in Medicine</u>, Appendix I, Figure 9, p. A - 2b.

## Handout #4: Duty-Oriented Process of Making Ethical Decisions




Adapted from Brody, Ethical Decisions in Medicine, by Francoeur, Biomedical Ethics, p. 9.

## Handout #5: Consequence-Oriented Process of Making Ethical Decisions




Adapted from Brody, <u>Ethical Decisions in Medicine</u>, by Francoeur, <u>Biomedical Ethics</u>, p. 10.

## Handout #6: Decision Analysis Computer Software

### DECIDE: A Decision Tree Model

DECIDE is a computer program, written by Roy Harris and distributed by Decision Sciences Software. It allows for quick manipulation of data when one is computing the expected values and finding the best decisions in a decision tree.

The first step is to draw the decision tree and enter the probabilities and values on the final outcomes.

### Data Control for DECIDE

The basic data structure for the program DECIDE consists of a decision followed by outcomes. Each decision and each outcome is modeled as a branch on the complete decision tree.

### Decision Tree Rules

Each branch (or arc) on the decision tree is specified by a beginning left node and an end right node. The decision tree is specified as a set of branches.

The rules for entering the data in the program DECIDE are as follows:

--Each node number must be unique.

--Decision arcs must have a probability of zero, which signifies that they are decisions.

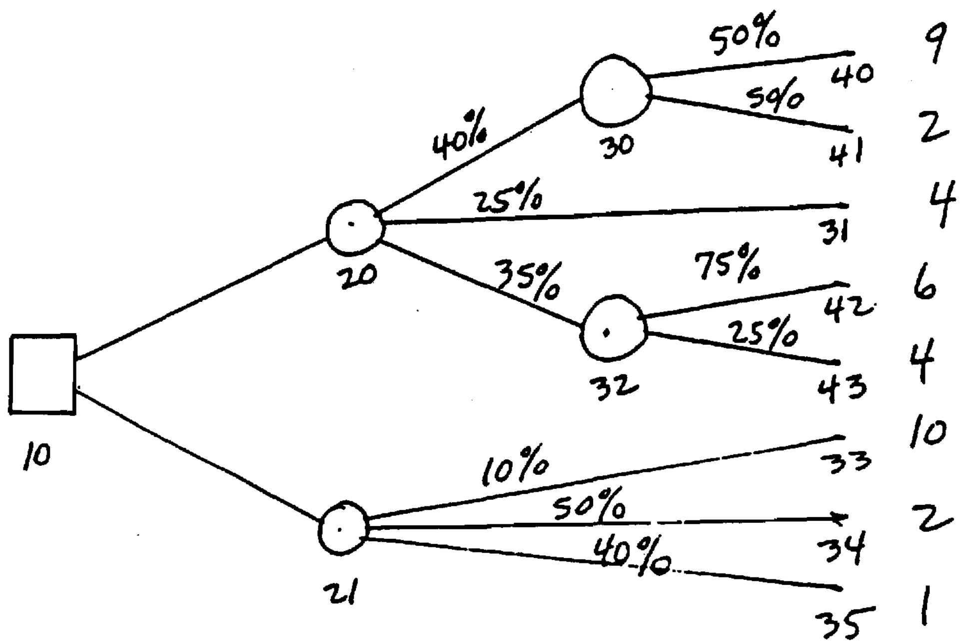
--Each decision must have at least two arcs from a common left node.

--Each chance (or outcome) arc must have a positive probability.

--For each set of chance arcs from a common left node, the probabilities must add to one.

--Node numbers must get larger from left node to right node.

A sample decision tree is presented below with node numbers, probabilities given as percents listed on the chance branches, and values listed on the final outcomes.




Sample Decision Tree

The software is menu driven; that is, you can choose what you wish to do by typing in letters or / followed by a capital letter. The first choice permits you to:

| | |
|---|---|
| --choose a sample data file | (A) |
| --create a new data file | (B) |
| --retrieve a saved data file | (Some Other Letter) |
| --delete a file from the diskette | (X). |

## Edit Rules

When you are working on a new or previously saved data file, the screen looks like this:

```
     DECISION TREE PROCESSOR  ---- (Name)
     /C Catalog   /D Delete   /L List  /H Help
     /I Insert    /P Print    /Q Quit  /S Save
                  /R Run

        FROM      TO  PROB%    $VALUE   YR   I%

  1     10        20   0        0       0    0
  2     10        21   0        0       0    0
  3     20        30   40       0       0    0
  4     20        31   25       4       0    0
  5     20        32   35       0       0    0
                  etc.
                                                  L-R
```

At the beginning, the cursor will be positioned at the upper left value under FROM. To change the value, simply enter the new value and push the RETURN.

To move the cursor left or right in the L-R mode (which is indicated in the lower right portion of the screen), use the left and right arrows ⟵,⟶ on the keyboard.

To move the cursor up or down, you must first change to the U-D mode by pushing the SPACE BAR. This change is indicated in the lower right portion of the screen. Then use the left arrow to go up and the right arrow to come down. Do <u>not</u> use the up and down arrows on the keyboard. If you push the SPACE BAR again, you will return to the L-R mode.

The data for the decision tree may be entered in any order. After you have entered all the data, you can use the following commands:

| | |
|---|---|
| --to list the tree | /L |
| --to print the information on paper | /P |
| --to run the program | /R |
| --to insert a line | /I |
| --to delete a line | /D |
| --to save data on a diskette | /S |
| --to list all the available programs | /C (catalog) |
| --to view a series of rules for using the program. | /H |

To run the program means to compute the expected values and to indicate which is/are the best decision(s).

If you decide to save data, be sure to use another diskette.

# Decision Analysis in Ethics

by

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and

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Greensboro, North Carolina

Faculty Handbook
for an Instructional Module
in Ethics and Technology

Resourceful Exchange: Technology and the Liberal Arts (RETLA)

1986

## Introduction

This module integrates information that is generally not presented in an interdisciplinary manner: philosophical background material relevant to decision making, the structure and methodology of decision trees, and computer software designed to present value alternatives. Its purpose is to help students develop the ability to construct effective methods for devising solutions to:

--case studies or decision scenarios drawn from various fields and

--contemporary problems arising from science and technology.

In the beginning of the module, sessions on values provide two kinds of experiences. Students are encouraged to reflect on their own concepts of values and principles, and they are introduced to philosophical theories and ideas that are relevant to decision making.

Most of the remaining sessions address the structure and methodology of decision trees. These sessions provide relevant information, practical experience with the concepts of probability and expected value, and guided tasks in which students work with quantitative evidence as a means of establishing optimal value judgments.

In the final phase of the module, students use computer software to determine value alternatives and their encoding. Seeing printouts of their final products enables students to monitor their development and to take pride in their accomplishments.

There are four parts to this faculty handbook:

1. a review of the components of the module, featuring the student handbook with its handouts and accompanying readings,

2. a description of the activities, the assignments, and the assessment sheets, which the instructor manages,

3. other features of the module about which the instructor will need to make decisions,

4. the actual activities, assignments, and assessments described in part 2, which the instructor will need to reproduce.

## Components of the Module

This module is composed of a **student handbook**, a set of **readings**, and a **faculty handbook**. A brief description of each of these components should help you to assess how applicable this module is to a course you plan to teach.

## The Student Handbook

The student handbook serves as a guide to the class sessions. For each of the ten sessions, it contains information about the following subjects:

--classroom presentations,

--classroom activities,

--assignments, and

--assignment deadlines.

For an example of these session descriptions, see pp. 7-8 of the student handbook.

This handbook addresses two other subjects: evaluation and resources for the student. It describes the evaluation procedure for the module, indicating what will be assessed and how that assessment will be weighted. A bibliography includes texts about values and decision making.

The student handbook also includes handouts, on pp. 20-28, that provide information about some of the concepts addressed in the module. You should become familiar with these handouts before the classroom discussion begins. Where appropriate, these handouts cite the text from which they were extracted or adapted. You may wish, therefore, to consult the **Bibliograpy** of this faculty handbook for more information about these handouts. (See pp. 12-17.)

The student handbook, under the heading **Assignments**, directs students to read these handouts before the sessions in which they will be discussed. For your information, we list these sessions and the handouts which are designed for them:

<u>Session 3</u>

Handout #1: Decision-Making Process Model

Handout #2: Deontological Ethical Method

Handout #3: Act-Utilitarian Ethical Method

Session 4

Handout #4: Duty-Oriented Process of Making Ethical Decisions

Handout #5: Consequence-Oriented Process of Making Ethical Decisions

Session 8

Handout #6: Decision Analysis Computer Software

The student handbook also provides background information for handouts #2, #3, #4, and #5.

The handbook, including the handouts, should be reproduced and passed out to students early in the module.

**Readings**

A set of readings, entitled **Readings for Decision Analysis in Ethics**, provides background material for the module and reinforces the classroom presentations. Two of these readings, **Ethical Decision Making**, by Stan Carpenter, and **Decision Analysis**, by Ray Treadway, were designed exclusively for this module.

This set should be reproduced and distributed to the students with the student handbook.

Under the heading, **Assignments**, the student handbook directs students to complete these readings before the sessions in which they are discussed. To help you prepare for these discussions, we list these sessions and the designated readings:

Session 3

Reading #1: **Ethical Decision Making: Three Theories**, by Stan Carpenter.

Session 4

Reading #2: **The Decision Tree Technique** from **Biomedical Ethics: A Guide to Decision Making** by Robert T. Francoeur.

Reading #3: **Decision Analysis** by Ray Treadway. Students read the General Overview to Decision Trees; Part I: A Decision Tree; and Part II: Probabilities.

Session 5

Reading #3: **Decision Analysis.** Students read Part III: Quantitative Values and Part IV: Expected Value.

For Session 5, we have found it useful to prepare a transparency depicting a simple tree, similar to the one depicted in **Decision Analysis.** The probabilities and values can be added as the case is discussed in class.

For Session 7, we created a transparency similar to the one depicted in **The Decision Tree Technique** to give students an opportunity to experiment with calculations and to engage the process of constructing a decision tree.

**Faculty Handbook**

This faculty handbook contains material that does not appear in the student handbook or in the readings but that should facilitate your presentation of the module. First, three kinds of material, included in this handbook, are discussed: **activities, assignments,** and **assessment sheets.** Then, this manual focuses on the following topics: **student writing, timeframe of the module, resources for classroom presentations and discussions, computer activities and assignments, evaluation,** and **modifications of the module.**

**Activities, Assignments, and Assessment Sheets**

The activities and the assignments are designed to be passed out to the students during appropriate sessions. The assessment sheets may be used by either the instructor, the students, or both. That is, you may decide to use them exclusively as a guide to your own assessment, or you may use them to guide your own assessment and also pass them out to the students, or you may use them exclusively as guides for the students which help them to evaluate their own responses to the assignments.

Activities

The activity sheets, on pp. 19-21 of this faculty handbook, provide guided practice during class time for the concepts addressed in the presentations. Where appropriate, the activity sheets cite the texts from which the specified activity was extracted or adapted. See the **Bibliography** of this faculty handbook, pp. 12-17, for a listing of these citations.

It is useful, during the classroom activity period, to provide some brief explanation of these activities for the students as well as a rationale for including them.

Should you decide to use any of these activities, you will need to reproduce them before they are needed by the students. To simplify your task, here is a list of the sessions and the designated activities:

Session #1:

Activity #1: Rokeach Instrumental Values
Activity #2: Rokeach Terminal Values

Session #8

Activity #3: The Swine Flu Dilemma

During Session 1, it is useful to indicate that Rokeach claimed that values are determinants of social behavior and that they are internalized standards and critieria for guiding actions, developing and maintaining attitudes, and making moral judgments.

The swine flu dilemma, presented as an activity in Session 8, is extracted from a longer article. You may wish to consult the article by Behn and Vaupel, listed in the **Bibliography** on p. 13 of this faculty handbook, in order to prepare for this activity.

Assignments

The assignments, on pp. 22-31 of this faculty handbook, provide guided practice outside of the classroom for the concepts presented in the presentations. They help you to evaluate each student's understanding of the module.

Like the activities, the assignments need to be reproduced for appropriate sessions. To simplify this task, we list these sessions and the designated assignments below:

Session #1

Assignment #1: The Auction Game

Session 2

Assignment #2: Values Grid

Session 5

Assignment #3: Exercises on Probability

Session 6

Assignment #4: Exercises on Expected Value

Session 7

Assignment #5: Decision Trees
Assignment #6: Major Assignment on Decision Trees

Session 9

Assignment #7: Computer Assignment

During Session 2, the instructor needs to designate an auctioneer and an assistant to keep a record of the proceedings of the auction game. The instructor should also be prepared to alleviate any problems that arise as the auction progresses. For example, students may wish to spend more than $2000 or to spend the total amount on one item.

During Session 3, the instructor sets up small groups, which elect a leader and a recorder, and then circulates to assure that the groups are running smoothly.

During Sessions #5, #6, and #7, we find it useful to work through problems similar to those presented in **Assignment #3: Exercises on Probability, Assignment #4: Exercises on Expected Value** and **Assignment #5: Decision Trees.**

Assessment Sheets

The assessment sheets, on pp. 32-44 of this faculty handbook, can also be passed out in appropriate sessions if you decide to use them to help students understand what they have achieved or what they have not achieved in completing the assignments.

To simplify your reproduction, here is a list of the sessions and the designated assessment sheet.

Session 2

Assessment Sheet #1: Auction Game--Value of Items

Session 7

Assessment Sheet #2: Answers to Excercises on Probability

Session 8

Assessment Sheet #3: Answers To Exercise on Swine Flu

Session 9

Assessment Sheet #4: Answers to Exercises on Expected Value

Assessment Sheet #5: Answers to Assignment on Decision Trees

Assessment Sheet #6: Answers to Major Assignment on Decision Trees: Part I

Session 10

Assessment Sheet #7: Answers to Revised Computer Assignment

**Student Writing**

In addition to the assignments, listed above, the students are given two writing assignments. The first of these assignments, presented in Session 2, requires that students write a paragraph about their conception of what is meant by the term human values. The second assignment, presented in Session 10, requires that they write a paper about the decision tree analysis that they have just completed. This paper should explain the process that they have used to arrive at their values.

We find that it is useful to spend some time in class explaining these two writing assignments. Students often write poorly because they do not understand the writing task, and sufficient explanation often helps students to compose better texts.

**Timeframe of the Module**

This module is composed of ten sessions, each requiring fifty minutes of class time. As the module now stands, these sessions do not always occur consecutively. Two weeks elapse between Sessions #7 and #9. Also, the students have two weeks to complete the computer assignment and the paper assigned in Session 10.

Should you decide to retain this schedule, you should inform the students so that they will not be confused by the assignment deadline in Session #7. Should you decide to change this schedule, you will need to modify the assignments so that they can be completed in time.

## Resources for Classroom Presentations and Discussions

The topics of presentation in each session are described in the student handbook. The bibliography to this faculty handbook contains many sources that you may wish to consult during your preparation of the presentations. (See pp. 12-17.)

We find that the concepts presented in the readings are often not self-evident to the students. It is useful to spend time reviewing these reading assignments in the sessions immediately following them or whenever appropriate.

## Computer Activities and Assignments

### Equipment

For the classroom demonstration in Session 9, you will need a microcomputer, disk drive, and monitor, preferably a large one so that the display can be seen easily by every student. Plan to complete the setup before class begins so that you are sure all parts are operating satisfactorily.

For Session 10 and for the two weeks following the course, you will need either a computer laboratory or a classroom that contains a sufficient number of computers given the class size.

The computer software used in this module is **DECIDE**, a decision tree model, written by Roy Harris for the Apple Computer or the IBM PC. It is distributed by Decision Sciences Software.

This software is only one of the available packages. We have found it useful, but you may wish to consider others.

**Handout #6: Decision Analysis Computer Sofware** provides information that the students will need in order to use this software. Should you decide to use another software package, we recommend that you create a similar handout.

### Instructor Preparation

You will need to be familiar with both the hardware that you are using as well as the software. If you do not already have sufficient experience with both the hardware and software, you should spend time gaining such experience well before Sessions 9

We recommend that you work with the computer software, **DECIDE**, or the software you selected until you can handle all the commands and features of the program, including the menu choices. This hands-on experience will help you to discover the potential pitfalls of the program.

Before Session 9, you should practice entering and running the data for **Assignment #5: Decision Trees.** Because this problem yields a very simple tree, it provides a useful example for the computer demonstration in Session 9.

Before Session 9, you will also need to enter the values and probabilities for **Assignment #6: Major Assignment on Decision Trees** and store this data in a data file. Students will need this data in order to complete **Assignment #7: Computer Assignment.**

Before Session 10, you should work through Part I of **Assignment #7: Computer Assignment** so that you can guide students through the process in Session 10.

Computer Personnel

If lab monitors are available, we recommend that you familiarize them with the computer assignments as well as the decision tree software so that they can adequately assist students.

You may find it useful to recruit a few students in the class who have already worked with similar software packages so that they can assist the beginning students.

**Evaluation**

A detailed description of the grading procedure for this module is included in the student handbook, p. 18. This description lists the assignments that are included in the final grade, and it specifies how these assignments are weighted.

We find that the assessment sheets, listed above, can be used as a means of formative evaluation. Working through these assessment sheets during appropriate sessions helps the students to correct any misunderstandings that they may have. Spending time on this process also encourages students to ask questions which will help them complete the assignments that occur later in the module in a more successful manner because these later assignments require that students understand all the material that has been cumulatively presented.

The assessment sheet designed to accompany the activity about the swine flu dilemma is also useful because it provides immediate feedback about the students' efforts. It can be used during Session 8, as soon as most students have completed the specified activity.

**Modifications of the Module**

Shoud you have more time to dedicate to this module than the ten sessions we have suggested, you might wish to include the following topics: Values and Ethics--Background for Decision Tree Studies, Decision Analysis--Worth Trees, and Decision Analysis--Relevance Trees. The optimal time to include these topics, we believe, is between Session 4 and 5.

We have developed working papers for each of the above three topics as well as student assignments that address them. Should you decide to include these topics, you may wish to get in touch with us at Bennett College.

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(These are only a sample of the kinds of books which are available to present the simple concepts of probability, with examples and exercises.)

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## V. Audio-Visual Materials on Simple Probability, including Conditional Probability

Introduction to Probability and Statistics, from the Center for Humanities, Inc., Communications Park, Box 100, White Plains, NY 10602.

Consists of ten film-strip and cassette modules. Module I--Simple Probability--covers the concepts needed for this project.

## Information on Computer Software

R. D. Harris. DECIDE: A Decision Tree Model. Decision Science Software, P. O. Box 1483, Sugar Land, TX 77487. Copyright 1983.

DESCRIPTION: an interactive computer model which determines the optimal "path" through a decision tree model.

FEATURES:

Input consists of the structure of the decision tree and information about the various branches.
If the tree spans a significant number of time periods, a discount rate may be entered and the "present value" of the optimal solution will be given.
Probabilities may be assigned to each branch which comes from a chance node.

SPECIFIC INPUTS FOR EACH BRANCH:

FROM node
TO node
Probability
Value
Time of start
Discount rate

OUTPUT:

The value of the objective function
The optimal "path" through the tree

CONTENTS OF THE USERS MANUAL:

**Decision Analysis in Ethics**

## Activities, Assignments, and Assessment Sheets

Contents

## Activity #1: Rokeach Instrumental Values

Instructions: Rank the following items from 1 (most important) to 18 (least important).

_____AMBITIOUS (hard-working, aspiring)

_____BROADMINDED (open-minded)

_____CAPABLE (competent, effective)

_____CHEERFUL (lighthearted, joyful)

_____CLEAN (neat, tidy)

_____COURAGEOUS (standing up for your beliefs)

_____FORGIVING (willing to pardon others)

_____HELPFUL (working for the welfare of others)

_____HONEST (sincere, truthful)

_____IMAGINATIVE (daring, creative)

_____INDEPENDENT (self-sufficient, self-reliant)

_____INTELLECTUAL (intelligent, reflective)

_____LOGICAL (consistent, rational)

_____LOVING (affectionate, tender)

_____OBEDIENT (dutiful, respectful)

_____POLITE (courteous, well-mannered)

_____RESPONSIBLE (dependable, reliable)

_____SELF-CONTROLLED (restrained, self-disciplined)

Robinson, John P. and Phillip R. Shaver. Measures of Social Psychological Attitudes. Ann Arbor: University of Michigan, Revised Edition 1973. p. 551. Adapted from "Value Survey (Rokeach 1968)."

## Activity #2: Rokeach Terminal Values

Instructions: Rank the following items from 1 (most important) to 18 (least important).

_____A COMFORTABLE LIFE (a prosperous life)

_____AN EXCITING LIFE (a stimulating, active life)

_____A SENSE OF ACCOMPLISHMENT (lasting contribution)

_____A WORLD AT PEACE (free of war and conflict)

_____A WORLD OF BEAUTY (beauty of nature and the arts)

_____EQUALITY (brotherhood, equal opportunity for all)

_____FAMILY SECURITY (taking care of loved ones)

_____FREEDOM (independence, free choice)

_____HAPPINESS (contentedness)

_____INNER HARMONY (freedom from inner conflict)

_____MATURE LOVE (sexual and spiritual intimacy)

_____NATIONAL SECURITY (protection from attack)

_____PLEASURE (an enjoyable, leisurely life)

_____SALVATION (eternal life, exaltation)

_____SELF-RESPECT (self-esteem)

_____SOCIAL RECOGNITION (respect, admiration)

_____TRUE FRIENDSHIP (close companionship)

_____WISDOM (a mature understanding of life)

Robinson, John P. and Phillip R. Shaver. Measures of Social Psychological Attitudes. Ann Arbor: University of Michigan, Revised Edition 1973. p. 550. Adapted from "Value Survey (Rokeach 1968)."

## Activity #3: The Swine Flu Dilemma

In 1976, a potential epidemic of a possibly severe kind of flu, called "swine" flu, was facing the nation.

A program for nationwide innoculation was developed. The swine flu vaccine was safe and effective, but there was some risk of contracting the flu from the innoculation and there was some possibility that the vaccine would not prevent contracting the flu. On the other hand, getting the flu might result in being uncomfortable, being hospitalized, or dying. Getting the shot was uncomfortable and inconvenient. The decision of whether or not to get the flu shot was complicated by the uncertainty of whether or not an epidemic would occur and, if so, whether a particular individual would catch the swine flu.

A survey of experts in the fields of influenza epidemiology and virology indicated that there was a 10% chance of an epidemic; given an epidemic, the experts predicted a 30% chance of a college student acquiring the flu. There was a 2% chance of an individual having a serious reaction to a swine flu shot and acquiring the flu from the shot. The probability that the vaccine would not protect an individual from getting the flu was listed at 30%. If a person got the flu, she conceivably could suffer ill effects for a few days, be hospitalized or, in rare cases, die. Trial data based on 100,000 persons showed that one died, ten were hospitalized, and the rest suffered discomfort for two to four days.

Draw a tree, assign probabilities, and make a decision. Base your probabilities on the information given above. The decision will be based on using a decision tree analysis and will depend on how you assign "values" to the possible outcomes.

Adapted from Behn, Robert D. and James W. Vaupel. "The Dynamics of Analysis: The Swine Flu Dilemmas." In Quick Analysis for Busy Decision Makers. New York: Basic Books, 1982. pp. 348-401.

## Assignment #1: The Auction Game

Each person is allotted $2,000. It is to be spent on getting what the person wants/values most. After you have worked out a preliminary budget for yourself, an auctioneer will auction off each item. Class members will bid. Items go to the highest bidder. Keep track of how high you bid, noting on which items you were willing to spend more than originally budgeted and which items you were willing to give up.

| ITEMS TO BE AUCTIONED | AMOUNT YOU BUDGETED | YOUR HIGHEST BID | CHECK ITEMS YOU WON |
|---|---|---|---|
| 1. Invitations to the most exciting parties (any place/ with anyone in the whole wide world) every single night. | | | |
| 2. To possess perfect health and a strong, flexible, beautiful, graceful body. | | | |
| 3. A lifetime without "hassling." No one will tell you what to do or how or when. | | | |
| 4. A daily "storm" of new ideas; original poems, songs, book, movies running through your head; visions of paintings to paint, jewelry to make, pots to mold, buildings to design and build, spring into your imagination practically on schedule. | | | |
| 5. To be the richest person in the world. | | | |
| 6. The opportunity to direct the workings of the whole world...to control individuals, businesses, monies, whole nations. | | | |
| 7. No "hang-ups" whatsoever. To possess self-knowledge. To be "self-actualized." | | | |
| 8. A chance to spend a year with the greatest religious figure of your faith--past, present, future. | | | |
| 9. The opportunity to "stick-up-for" and protect the person or thing to which you feel the greatest alliance (like sticking with a friend thru a crisis or fighting for your country,etc.) | | | |
| 10. To have the perfect romance and/or perfect love relationship(s) with the person(s) of your choice. | | | |
| 11. To have a computer-bank of facts and information in your head, to be able to answer any question and solve any problem which presents itself. | | | |
| 12. To have the strength to always do what you believe to be right. To be a person of total integrity. | | | |
| 13. To have the opportunity to spend your life doing only things that bring you real pleasure and enjoyment. | | | |
| 14. To have the skills, know-how, and time to really help others and "serve humanity." | | | |
| 15. To have a real sense of what is fair and to deal with others as honestly and fairly as possible. | | | |

Adapted from Jim Ballard and Tim Timmerman. Strategies in Humanistic Education. Amherst, MA: Mandala, 1976. P. 150-152, V. 2.

## Assignment #2: Values Grid

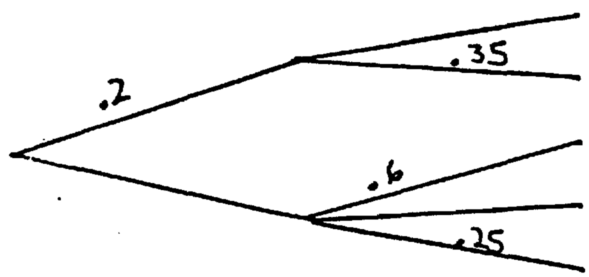
| Contemporary Moral and Religious Issues | Key words that summarize your position | Proud of | | Publicly affirm | | Choosing altern-atives | | Thought-fully consider-ed | | Freely chosen | | Acted on | | Acted on consist-ently | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Birth Control | | | | | | | | | | | | | | | |
| Genetic Engineering | | | | | | | | | | | | | | | |
| Capital Punishment | | | | | | | | | | | | | | | |
| Population Control | | | | | | | | | | | | | | | |
| Euthanasia | | | | | | | | | | | | | | | |
| Pollution | | | | | | | | | | | | | | | |
| War | | | | | | | | | | | | | | | |
| Drugs | | | | | | | | | | | | | | | |
| Interracial Marriage | | | | | | | | | | | | | | | |
| Interreligious Marriage | | | | | | | | | | | | | | | |
| Ordination of Women | | | | | | | | | | | | | | | |
| Abortion | | | | | | | | | | | | | | | |
| Adoption | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |

Adapted from handout given on visit to Alverno College (1979)

## Assignment #3: Exercises on Probability

1. List the sample spaces for the following experiments:
   a. tossing a coin twice
   b. asking a consumer to rank three brands of soda (a, b, c) in order of preference
   c. counting the number of seeds that have sprouted in a test plot of soil, if five seeds were originally planted.

2. a. What is the probability of an impossible event?
   b. What is the probability of an event which is certain to happen?
   c. If a sample space has three outcomes {a, b, c} and if p(a) = .3 and p(c) = .25, what is p(b)?
   d. If the probability of an event A is 3/5, what is the probability of the complementary event A'?
   e. Complete the probabilities on the following tree:




3. Suppose there are three blue balls and seven red balls in a bag.
   a. What is the probability of drawing a red ball?
   b. If a red ball was chosen on the first draw, what is the probability of choosing a blue ball on the second draw if the first ball is not replaced? If the first ball is replaced?
   c. Use conditional probability and the multiplication law: P(A and B) = P(A)P(B|A), what is the probability that two red balls will be picked? Two blue balls? A red ball followed by a blue ball? A blue ball followed by a red ball? A red and a blue ball in either order?

4. a. What are independent events?
   b. What are dependent events?
   c. In the decision tree on p. 7 of Reading #3, Decision Analysis, suppose that the branch from choice #10 to #20 represents "medication has side effects" and the branch from #20 to #31 represents "condition improves even if the medicine causes side effects," what is the probability that "the treatment has side effects and the condition improves?"

## Assignment #4: Exercises on Expected Value

1. In Example #2 on page 14 of Reading #3, Decision Analysis, utility values are assigned to aid in decision making. In the second situation, Tonya hears a weather report indicating that there is a chance that it will rain during the day, and she needs to decide whether or not to carry an umbrella. Tonya has to give a class presentation but does not need to carry any books. It is quite important that she not get wet, but carrying an umbrella will be only a slight inconvenience. Tonya's decision about carrying an umbrella is based on these values:

| Outcomes | Utility Assignments |
|---|---|
| Umbrella & Rain | +5 |
| Umbrella & No Rain | -1 |
| No Umbrella & Rain | -5 |
| No Umbrella & No Rain | +1 |

Assign expected values for the following situations. Use the expected values to make a decision in each situation.

a. probability of rain is 70% -- no umbrella
b. probability of rain is 70% -- take an umbrella

c. probability of rain 40% -- no umbrella
d. probability of rain 40% -- take an umbrella

2. Which would you rather have, a 0.50 probability (a 1/2 chance) of receiving $100, or a 0.10 probability (a 1/10 chance) of receiving $1,000?

3. A roulette wheel has 66 slots--32 red slots, 32 black slots, and 2 white slots. If the ball comes to rest in a white slot, the "house" collects all the money that was bet. A customer can bet $1 on "red;" if the ball comes to rest in a red slot the customer gets back the $1 and receives an additional $1 (red pays 2 for 1), and otherwise the customer loses the $1 bet.

a. What is the probability the customer will win (a net of) $1?
b. What is the probability the customer will lose $1?
c. What is the expected value of a $1 bet to the customer?

4. A contractor has a 1/3 "gather ratio" for bids. That is, for every job for which the contractor submits a bid, there is a 1/3 probability of winning the job. If it costs $2,500 to prepare each bid, and if the net profit on each won job is $12,000 considering all receipts and disbursements other than the cost of bidding, what is the expected net profit on each job for which the contractor submits a bid?

5. A self-insured doctor expects to lose a $1 million malpractice suit for each 10,000 cases that she treats. Ignoring lawyers' fees, costs of defense, suits for other amounts, etc., how much extra would she have to charge each patient to make up for the cost of paying off these suits?

## Assignment #5: Exercise on Decision Trees

A businesswoman is planning to ship a used machine to her plant in Columbus. She would like to use it there for the next four years. She must decide whether or not to overhaul the machine before sending it. The cost of overhaul is $2600. If the machine fails when in operation in Columbus, it will cost her $6000 in lost production and repairs. She estimates the probability that it will fail at .3 if she does not overhaul it and .1 if she does overhaul it.

A. Draw a decision tree showing all possible (compound) outcomes.

B. Put the descriptions, values and probabilities on the tree at the appropriate locations.

C. Compute the expected values for each of the choices.

D. Indicate which strategy should be chosen.

E. Which kind of probability is used in this problem (subjective, empirical, or theoretical)?

## Assignment #6: Major Assignment on Decision Trees

Suppose a person suffers pain in the back and neck due to severe anxiety. She considers three alternative approaches to handling her problem: 1) no treatment, 2) medication, and 3) an alternative approach (such as therapy, meditation, or spiritual healing).

She estimates, based on previous experience, that without any treatment there is a probability of 60% the situation will get worse and she will suffer severe pain. Otherwise she will continue to suffer moderate pain.

Medical authorities tell her that if she takes medication, there is a 20% chance that it will get worse (severe pain), a 30% chance that it will remain the same (moderate pain), and otherwise it will clear up (no pain). The cost of medication is $1,000.

If she decides on alternative methods to reduce the pain and anxiety, her consultants can give the following guidance: 30% of the cases continue to get worse (severe pain), while 40% of the cases exhibit satisfactory results (no pain). The cost of the alternative therapy, including donations, is $1,000.

If, after two months, she finds that her condition gets worse, then she must make a second choice: whether or not to try another approach to solving her problem. To simplify, let us suppose that if she has not been treating the problem, she can decide either to take medication (with the same possible outcomes and probabilities as given in paragraph 3) or continue to get along with no treatment. She has been told that there is a 10% chance that her condition may eventually improve (moderate pain) after a few months without treatment. If, on the other hand, she has been trying medication and the condition gets worse, then she can either increase the dosage (extra $500) or maintain the same dosage. The probability that with extra medication the problem will clear up is 60%; otherwise there will be moderate pain. If she finds that the alternative approach results in a worsened condition, she can decide to try "no treatment" or she can try medication, with the same outcomes and probabilities as listed above in the beginning of this paragraph.

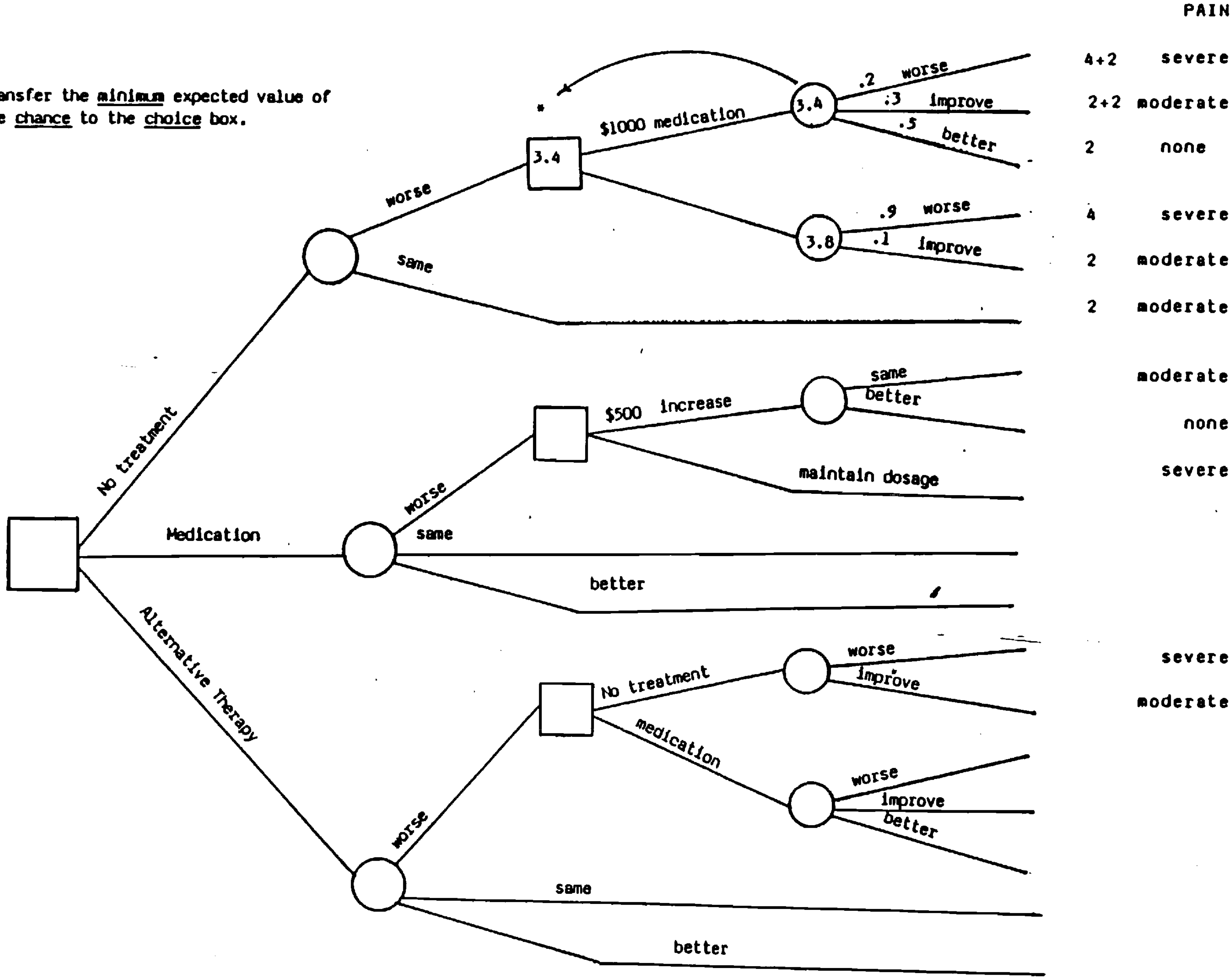
Assign "discomfort values" as follows:

| | |
|---|---|
| payment of $500 | -- 1 point for each $500 payment |
| severe pain | -- 4 points |
| moderate pain | -- 2 points |
| no pain | -- 0 points |

Fill in the decision tree on the next page and compute the expected values at each chance node. The minimum expected value of the chance nodes found immediately to the right of each choice node should be transferred into each choice node.

What decisions should this person make in order to minimize the potential discomfort, including both pain and expenditure? Explain.

* Transfer the minimum expected value of the chance to the choice box.



## Assignment #7: Computer Assignment

Use the computer software **DECIDE** and the work from **Major Assignment on Decision Trees** to reevaluate the decisions which might be made about medical treatment, alternative therapy, and no treatment.

1. Assume that money is not a consideration. Revalue the final outcomes accordingly; that is, compute the values of the final outcomes based on pain and suffering only as indicated on the instructions for **Major Assignment on Decision Trees,** without adding any discomfort values for spending money.

   Prepare the revised decision tree before using the computer program so that you will know how to change your values.

   Use the computer program, and call for the data file MAJOR1. Change only some of the values.

   How would the decision be revised? Which decisions should be made? What are the expected values at each of the decision nodes?

2. Consider the original problem, and use the original data file MAJOR1. Assume that cost is a consideration. Determine other considerations which you personally might make is such a situation; that is, you might place greater value on alternative therapy, on using the the finest medical facilities available, and on avoiding severe pain.

   Using the computer software **DECIDE,** make changes according to your revised evaluations, produce a printout, and turn in your results with your explanation of how you arrived at your changed values.

   What are the expected values at the decision tree nodes? What decisions should be made according to the decision tree analysis? Do you agree with these decisions?

   Write an explanation indicating how and why you arrived at your changed values.

## Assessment Sheet #1: Auction Game--Value of Items

1 - Social Life

2 - Physical Well-being

3 - Freedom

4 - Creativity

5 - Wealth

6 - Power

7 - Emotional Well-being

8 - Religious Faith

9 - Loyalty

10 - Love

11 - Knowledge

12 - Morality

13 - Fun

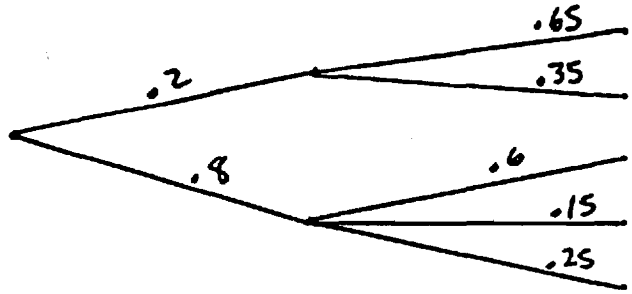
14 - Serving Others

15 - Fairness

## Assessment Sheet #2: Answers to Exercises on Probability

1a. {(H,H), (H,T), (T,H), (T,T)}
1b. {(a,b,c), (a,c,b), (b,a,c), (b,c,a), (c,a,b), (c,b,a)}
1c. {0,1,2,3,4,5}

2a. p(impossible event) = 0
2b. p(certain event) = 1
2c. 1 = p(a) + p(b) + p(c)
   = .3 + p(b) + .25
   = .55 + p(b)
   Hence p(b) = .45
2d. p(A') 1 - p(A) = 1 - 3/5 = 2/5
2e. Probabilities on the branches attached to a common node must add to 1.




3a. p(red) = 7/10
3b. If a red ball is drawn, there are 9 balls left, of which 6 are red. Hence p(red|red) = 6/9 = 2/3
3c. p(red and red) = p(red) x p(red|red) = 7/10 x 2/3 = 7/15

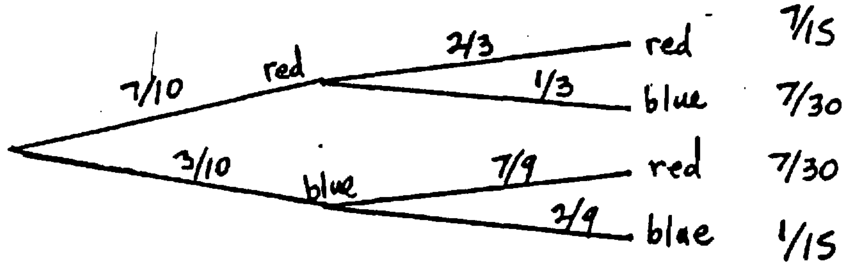
p(blue and blue) = p(blue) x p(blue|blue) = 3/10 x 2/9 = 1/15

p(red) x p(blue|red) = 7/10 x 3/9 = 7/30

p(blue) x p(red|blue) = 3/10 x 7/9 = 7/30

p(red and blue) = p(red followed by blue or blue followed by red) = 7/30 + 7/30 = 7/15

These results are summarized in the following tree:



4a. Two events are independent if the occurrence or nonoccurrence of either of them does not affect the probability of the other. In symbols, $p(A) = p(A|B)$ and $p(B) = p(B|A)$.

4b. Two events are dependent if they are not independent. That is, the occurrence of one of them affects the probability of the occurrence of the other.

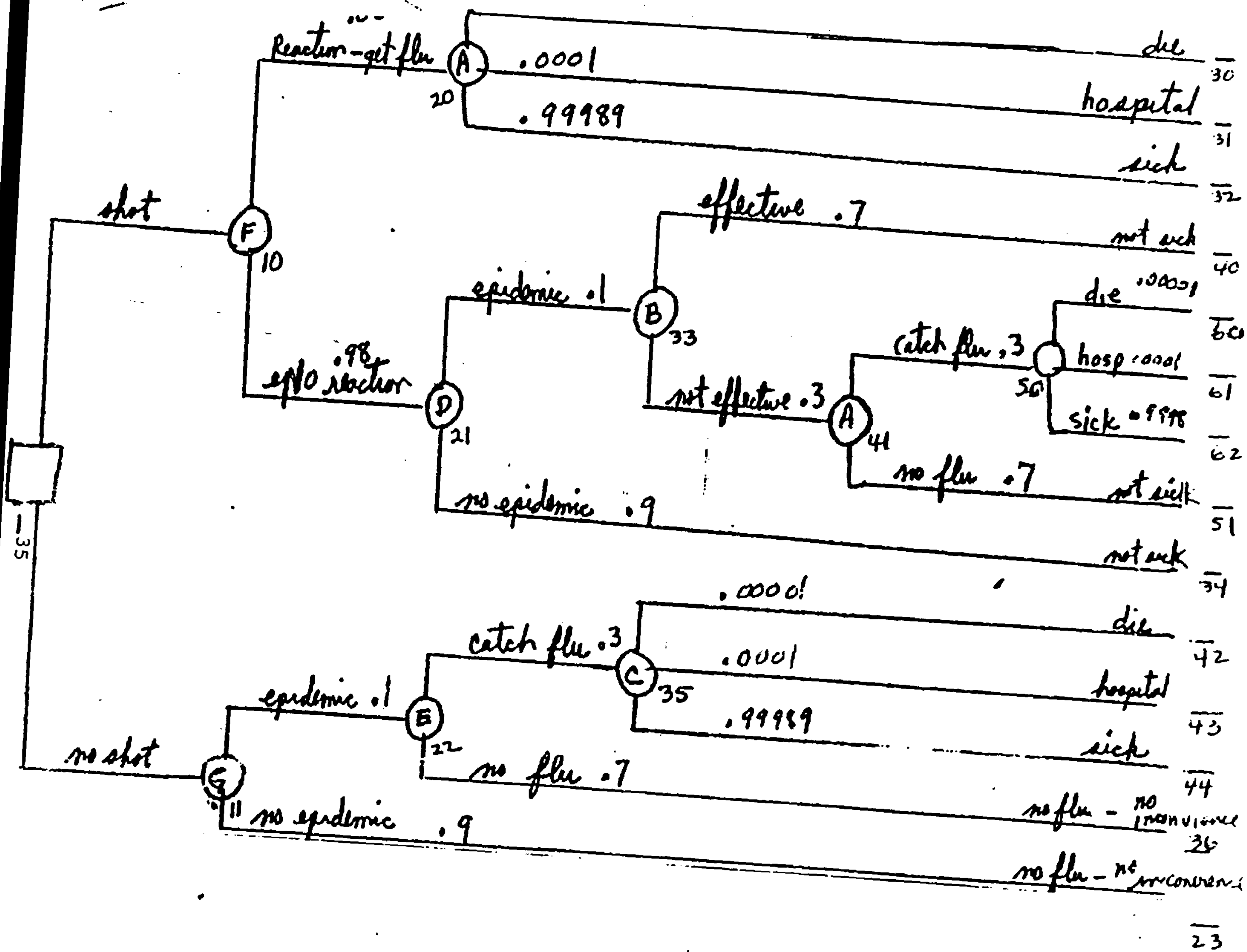
4c.

```
   .4      A    .5      B
0---------0---------0
10        20        30
```

Let A = event that medication has side effects
Let B = event that condition improves
Given facts: $p(A) = .4$ and $p(B|A) = .5$
Hence $p(A \text{ and } B) = p(A) \times p(B|A) = .4 \times .5 = .2$

Decision Analysis in Ethics

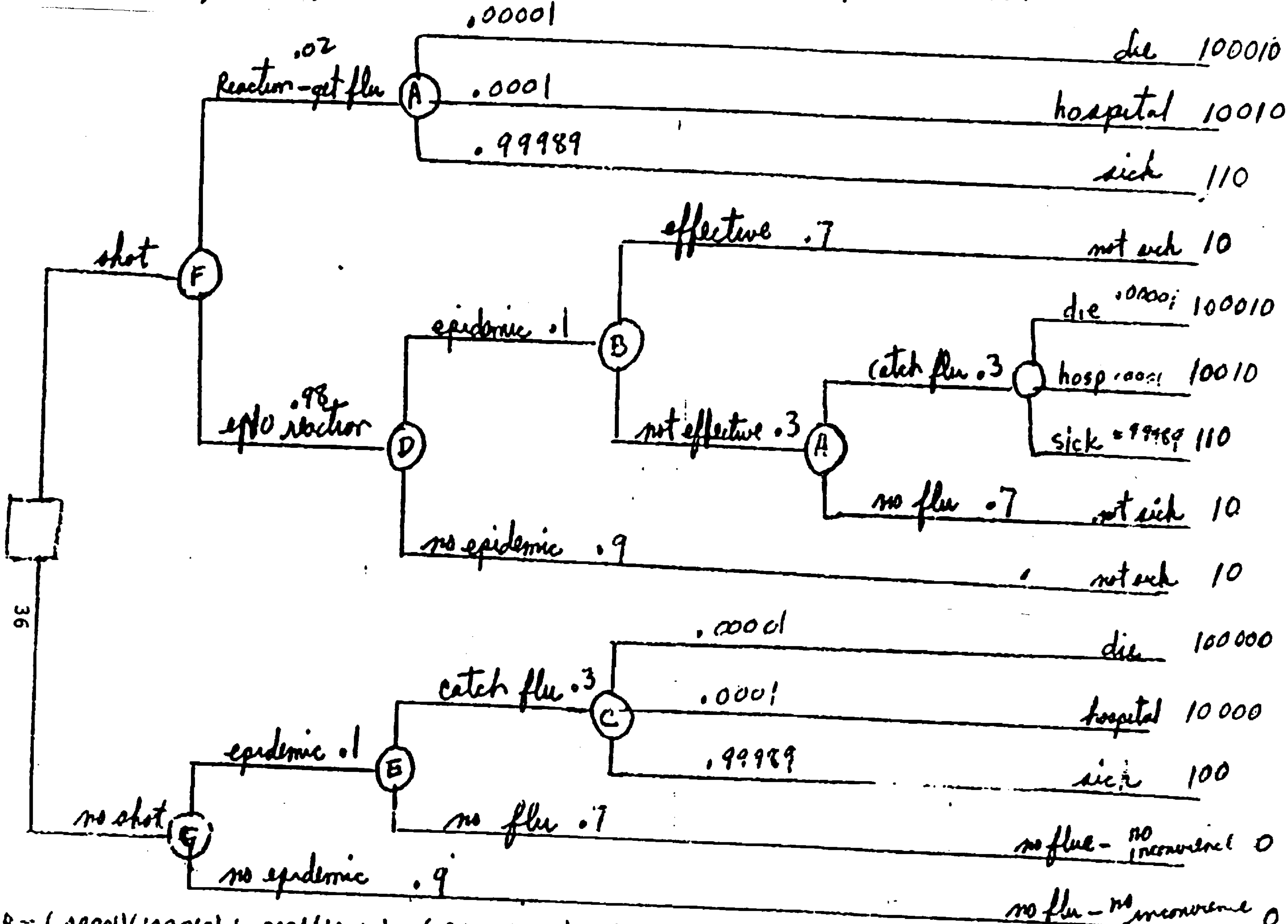
Assessment Sheet #3A: Answers to Exercise on Swine Flu



## Assessment Sheet #3B: Answers to Exercise on Swine Flu

E = .3C + .7(0) = 30.5967

F = .02(A) + .98(D) = 2.23978 + 12.7984 = 15.035  G = .1E + .9(0) = 3.0596 + 0 = 3.0597




A = (.00001)(100010) + .0001(10010) + (.99989)(110) = 1.0001 + 1.001 + 109.9879 = 111.989

B = .7(10) + .3(A) = 7 + 33.5967 = 40.5967

C = .0000(10000) + .0001(10000) + .99989(100)
= 1 + 1 + 999.89 = 101.989

## Assessment Sheet #4: Answers to Exercises on Expected Value

| 1a. | Outcome | Probability | Value | Probability x Value |
|---|---|---|---|---|
| Umbrella | | | | |
| | Rain | .7 | 5 | 3.5 |
| | No Rain | .3 | -1 | -0.3 |
| | Sum | 1.0 | | 3.2 |
| 1b. | | | | |
| No Umbrella | | | | |
| | Rain | .7 | -5 | -3.5 |
| | No Rain | .3 | 1 | 0.3 |
| | Sum | 1.0 | | -3.2 |

With such a high probability of rain and drastic results if Tonya gets wet, it is clearly advantageous to carry an umbrella. The expected value is 3.2 for carrying an umbrella and -3.2 for not carrying an umbrella.

| 1c. | Outcome | Probability | Value | Probability x Value |
|---|---|---|---|---|
| Umbrella | | | | |
| | Rain | .4 | 5 | 2.0 |
| | No Rain | .6 | -1 | -0.6 |
| | Sum | 1.0 | | 1.4 |
| 1d. | | | | |
| No Umbrella | | | | |
| | Rain | .4 | -5 | -2.0 |
| | No Rain | .6 | 1 | .6 |
| | Sum | 1.0 | | -1.4 |

Again Tonya should decide to carry an umbrella, even though the chances of rain are less than 50%. The disaster which would occur if she were to get wet before her class presentation makes it worth the inconvenience of carrying an umbrella.

2. In the first case, the expectation is (0.50) x 100 + (0.50) x 0 = 50 dollars. In the second case, the expectation is (0.10) x 1000 + (0.90) x 0 = 100 dollars. Given a choice between two rewards, one chooses the greater expected value, or $100 (the second alternative).

3a. 32 out of 66 slots correspond to winning, and the probability of every slot is the same; thus the probability of winning is

$32/66 = 0.4\overline{848}$.

3b. $34/66 = 0.5\overline{151}$.

3c. If the outcomes of the sample space are considered to be winning $1 and losing $1, the expected value is

$(0.4\overline{848}) \times 1 = (0.5\overline{151}) \times (-1) = -0.0\overline{303}$. That is, the customer expects to lose about 3 cents per play. If (implicitly using the properties that the expected value of a sum is the sum of the expected values, and that the expected value of a constant is the constant) we consider the customer first to pay $1, then to receive an amount that is either $2 or $0, the expected value calculation is

$-1 + (0.4\overline{848}) \times 1 + (0.5\overline{151}) \times (0)$, giving of course the same result. One can also go from the second calculation to the first to illustrate the property that the expected value of an expected value is the expected value.

4. $-2500 + (1/3)\text{x}12000 + (2/3)\text{x}0 = 1500$ dollars. Here would be a good place to point out that the $2500 and $12000 figures would realistically themselves be expected values, and that this would not change the computation.

5. For each case the doctor treats, the sample space is "lost suit" or "no lost suit" with respective probabilities of 1/10000 and 9999/10000. The expected number of lost suits per case is $(1/10000)\text{x}1 = (9999/10000)\text{x}0 = 1/10000$. Since each lost suit causes a $1 million loss, the expected loss is $(1/10000)\text{x}1{,}000{,}000 = 100$ dollars. Alternatively, for each case the doctor treats, the sample space for monetary outcomes is -$1,000,000 or $0, with the same respective probabilities. (In this problem or in earlier ones, it would be advisable to point out the property that when two events, such as losing a suit and losing $1 million, are equivalent, they have the same probability.) This problem can be used to introduce a discussion of the ethical problems of large malpractice suits. Malpractice insurance, by the way, costs about 1.3 times the "cost of the risk," so if you favor judgments like the ones in this problem, you necessarily also favor the equivalent of having each patient pay an extra $100 to $150 for medical care.

## Assessment Sheet #5: Answers to Assignment on Decision Trees

A businesswoman is planning to ship a used machine to her plant in Columbus. She would like to use it there for the next four years. She must decide whether or not to overhaul the machine before sending it. The cost of overhaul is $2600. If the machine fails when in operation in Columbus, it will cost her $6000 in lost production and repairs. She estimates the probability that it will fail at .3 if she does not overhaul it and .1 if she does overhaul it.

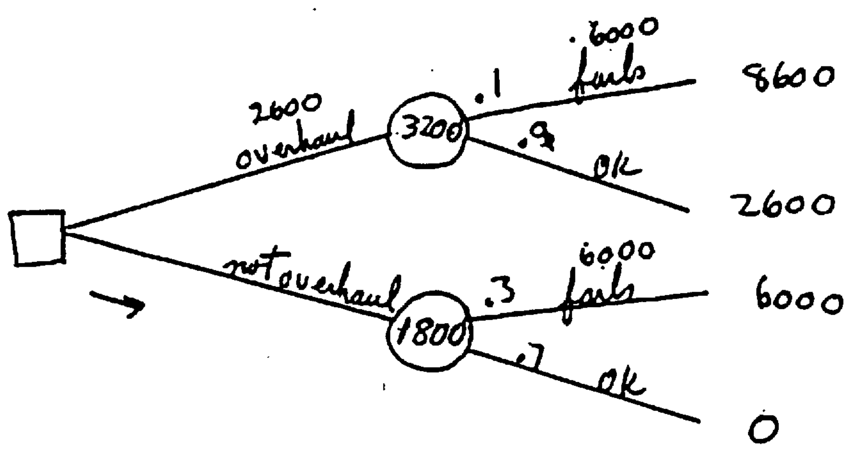
A. Draw a decision tree showing all possible (compound) outcomes.

B. Put the descriptions, values and probabilities on the tree at the appropriate locations.

C. Compute the expected values for each of the choices.

D. Indicate which strategy should be chosen.

E. Which kind of probability is used in this problem (subjective, empirical, or theoretical)?

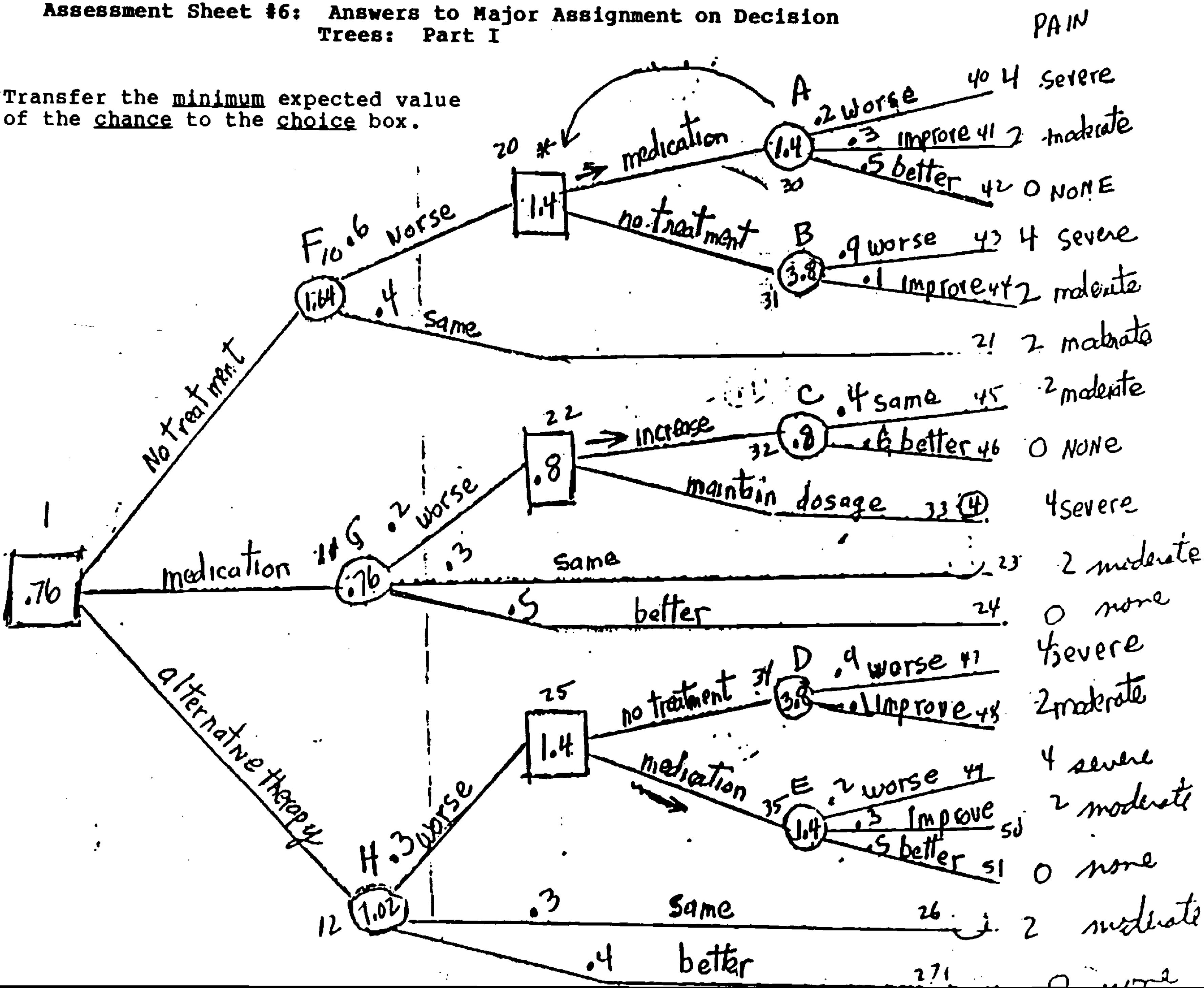



A = .1(8600) + .9(2600) = 860 + 2340 = 3200

B = .3(6000) + .7(0) = 1800

**Assessment Sheet #6: Answers to Major Assignment on Decision Trees: Part I**

*Transfer the <u>minimum</u> expected value of the <u>chance</u> to the <u>choice</u> box.



## Answers to Major Assignment on Decision Trees: Part I

A 6(.2) + 4(.3) + 2(.5) = 3.4

B 4(.9) + 2(.1) = 3.6 + .2 = 3.8

C 5(.4) + 3(.6) = 2.0 + 1.8 = 3.8

D 6(.9) + 4(.1) = 5.4 + .4 = 5.8

E 8(.2) + 6(.3) + 4(.5) = 1.6 + 1.8 + 2.0 = 5.4

F 3.4(.6) +2(.4) = 2.04 + .8 = 2.84

G 3.8(.2) + 4(.3) + 2(.5) = .76 + 1.2 + 1.0 = 2.96

H 5.4(.3) + 4(.3) + 2(.4) = 1.62 + 1.2 + .8 = 3.62

## Answers to Major Assignment on Decision Trees: Part I

DECISION TREE MAJOR1

| FROM | TO | PROB% | $VALUE | YR | I% |
|---|---|---|---|---|---|
| 1 | 10 | 0 | 0 | 0 | 0 |
| | 11 | 0 | 0 | 0 | 0 |
| | 12 | 0 | 0 | 0 | 0 |
| FROM | TO | PROB% | $VALUE | YR | I% |
| 10 | 20 | 60 | 0 | 0 | 0 |
| | 21 | 40 | -2 | 0 | 0 |
| FROM | TO | PROB% | $VALUE | YR | I% |
| 11 | 22 | 20 | 0 | 0 | 0 |
| | 23 | 30 | -4 | 0 | 0 |
| | 24 | 50 | -2 | 0 | 0 |
| FROM | TO | PROB% | $VALUE | YR | I% |
| 12 | 25 | 30 | 0 | 0 | 0 |
| | 26 | 30 | -4 | 0 | 0 |
| | 27 | 40 | -2 | 0 | 0 |
| FROM | TO | PROB% | $VALUE | YR | I% |
| 20 | 30 | 0 | 0 | 0 | 0 |
| | 31 | 0 | 0 | 0 | 0 |
| FROM | TO | PROB% | $VALUE | YR | I% |
| 22 | 32 | 0 | 0 | 0 | 0 |
| | 33 | 0 | -6 | 0 | 0 |
| FROM | TO | PROB% | $VALUE | YR | I% |
| 25 | 34 | 0 | 0 | 0 | 0 |
| | 35 | 0 | 0 | 0 | 0 |
| FROM | TO | PROB% | $VALUE | YR | I% |
| 30 | 40 | 20 | -6 | 0 | 0 |
| | 41 | 30 | -4 | 0 | 0 |
| | 42 | 50 | -2 | 0 | 0 |
| FROM | TO | PROB% | $VALUE | YR | I% |
| 31 | 43 | 90 | -4 | 0 | 0 |
| | 44 | 10 | -2 | 0 | 0 |
| FROM | TO | PROB% | $VALUE | YR | I% |
| 32 | 45 | 40 | -5 | 0 | 0 |
| | 46 | 60 | -3 | 0 | 0 |
| FROM | TO | PROB% | $VALUE | YR | I% |
| 34 | 47 | 90 | -6 | 0 | 0 |
| | 48 | 10 | -4 | 0 | 0 |
| FROM | TO | PROB% | $VALUE | YR | I% |
| 35 | 49 | 20 | -8 | 0 | 0 |
| | 50 | 30 | -6 | 0 | 0 |
| | 51 | 50 | -4 | 0 | 0 |

END OF DECISION TREE

***EXPECTED VALUES ARE***

| FROM | TO | PROB | $$$$.$$ |
|---|---|---|---|
| 1 | 10 | | -2.84*WIN* |
| 1 | 11 | | -2.96 |
| 1 | 12 | | -3.62 |
| 10 | 20 | 60 | -2.04 |
| 10 | 21 | 40 | -.80 |
| 11 | 22 | 20 | -.76 |
| 11 | 23 | 30 | -1.20 |
| 11 | 24 | 50 | -1.00 |
| 12 | 25 | 30 | -1.62 |
| 12 | 26 | 30 | -1.20 |
| 12 | 27 | 40 | -.80 |
| 20 | 30 | | -3.40*WIN* |
| 20 | 31 | | -3.80 |
| 22 | 32 | | -3.80*WIN* |
| 22 | 33 | | -6.00 |
| 25 | 34 | | -5.80 |

<RETURN>

PR#1

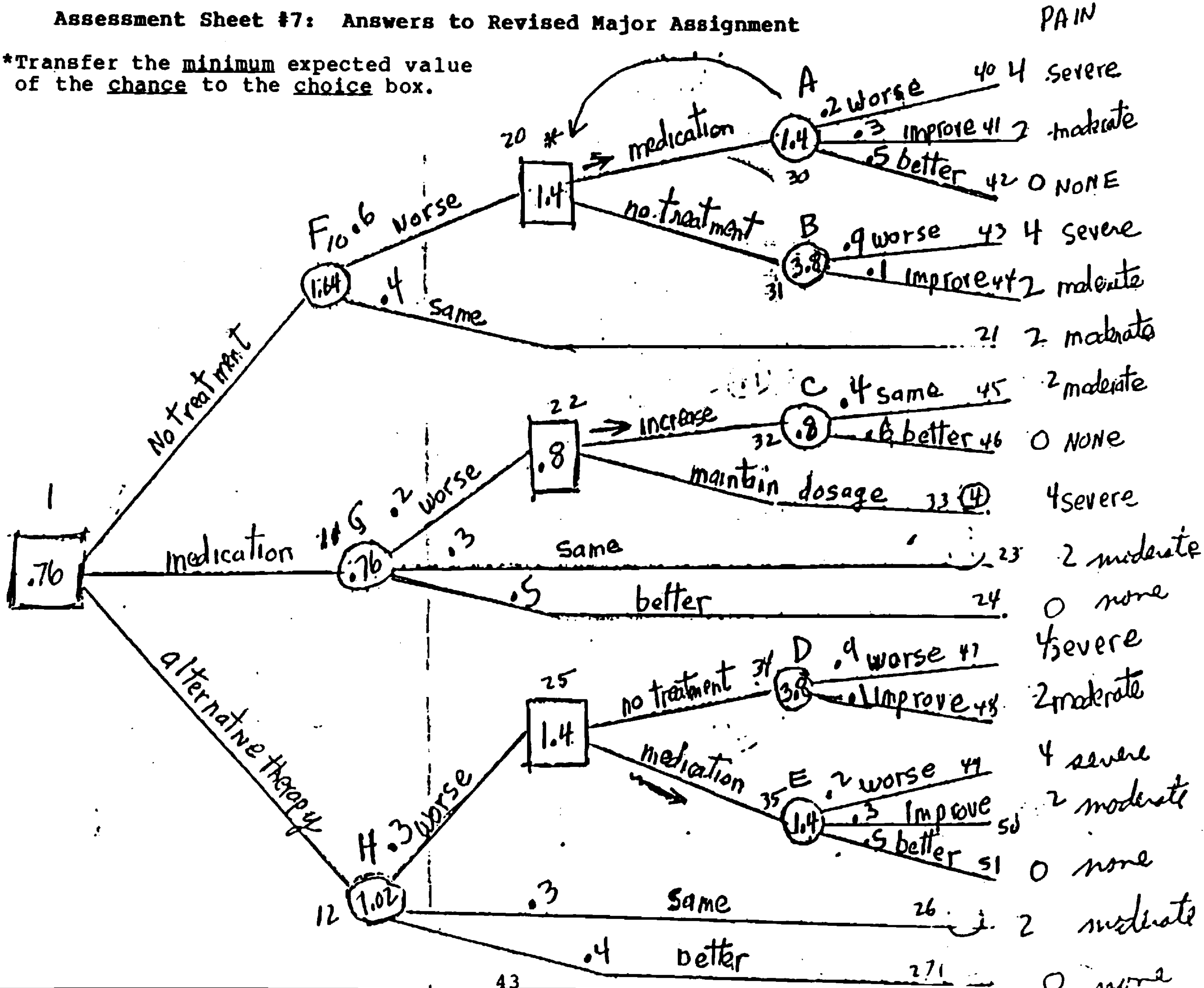
| | | | |
|---|---|---|---|
| 25 | 35 | | -5.40*WIN* |
| 30 | 40 | 20 | -1.20 |
| 30 | 41 | 30 | -1.20 |
| 30 | 42 | 50 | -1.00 |
| 31 | 43 | 90 | -3.60 |
| 31 | 44 | 10 | -.20 |
| 32 | 45 | 40 | -2.00 |
| 32 | 46 | 60 | -1.80 |
| 34 | 47 | 90 | -5.40 |
| 34 | 48 | 10 | -.40 |
| 35 | 49 | 20 | -1.60 |
| 35 | 50 | 30 | -1.80 |
| 35 | 51 | 50 | -2.00 |

END OF EXPECTED VALUES

<RETURN>

**Assessment Sheet #7: Answers to Revised Major Assignment**

*Transfer the <u>minimum</u> expected value of the <u>chance</u> to the <u>choice</u> box.



## Answers to Revised Major Assignment

DECISION TREE MAJOR 2

| FROM | TO | PROB% | $VALUE | YR | I% |
|---|---|---|---|---|---|
| 1 | 10 | 0 | 0 | 0 | 0 |
| | 11 | 0 | 0 | 0 | 0 |
| | 12 | 0 | 0 | 0 | 0 |
| FROM | TO | PROB% | $VALUE | YR | I% |
| 10 | 20 | 60 | 0 | 0 | 0 |
| | 21 | 40 | -2 | 0 | 0 |
| FROM | TO | PROB% | $VALUE | YR | I% |
| 11 | 22 | 20 | 0 | 0 | 0 |
| | 23 | 30 | -2 | 0 | 0 |
| | 24 | 50 | 0 | 0 | 0 |
| FROM | TO | PROB% | $VALUE | YR | I% |
| 12 | 25 | 30 | 0 | 0 | 0 |
| | 26 | 30 | -2 | 0 | 0 |
| | 27 | 40 | 0 | 0 | 0 |
| FROM | TO | PROB% | $VALUE | YR | I% |
| 20 | 30 | 0 | 0 | 0 | 0 |
| | 31 | 0 | 0 | 0 | 0 |
| FROM | TO | PROB% | $VALUE | YR | I% |
| 22 | 32 | 0 | 0 | 0 | 0 |
| | 33 | 0 | -4 | 0 | 0 |
| FROM | TO | PROB% | $VALUE | YR | I% |
| 25 | 34 | 0 | 0 | 0 | 0 |
| | 35 | 0 | 0 | 0 | 0 |
| FROM | TO | PROB% | $VALUE | YR | I% |
| 30 | 40 | 20 | -4 | 0 | 0 |
| | 41 | 30 | -2 | 0 | 0 |
| | 42 | 50 | 0 | 0 | 0 |
| FROM | TO | PROB% | $VALUE | YR | I% |
| 31 | 43 | 90 | -4 | 0 | 0 |
| | 44 | 10 | -2 | 0 | 0 |
| FROM | TO | PROB% | $VALUE | YR | I% |
| 32 | 45 | 40 | -2 | 0 | 0 |
| | 46 | 60 | 0 | 0 | 0 |
| FROM | TO | PROB% | $VALUE | YR | I% |
| 34 | 47 | 90 | -4 | 0 | 0 |
| | 48 | 10 | -2 | 0 | 0 |
| FROM | TO | PROB% | $VALUE | YR | I% |
| 35 | 49 | 20 | -4 | 0 | 0 |
| | 50 | 30 | -2 | 0 | 0 |
| | 51 | 50 | 0 | 0 | 0 |

END OF DECISION TREE

***EXPECTED VALUES ARE***

| FROM | TO | PROB | $$$$.$$ |
|---|---|---|---|
| 1 | 10 | | -1.64 |
| 1 | 11 | | -.76*WIN* |
| 1 | 12 | | -1.02 |
| 10 | 20 | 60 | -.84 |
| 10 | 21 | 40 | -.80 |
| 11 | 22 | 20 | -.16 |
| 11 | 23 | 30 | -.60 |
| 11 | 24 | 50 | 0.00 |
| 12 | 25 | 30 | -.42 |
| 12 | 26 | 30 | -.60 |
| 12 | 27 | 40 | 0.00 |
| 20 | 30 | | -1.40*WIN* |
| 20 | 31 | | -3.80 |
| 22 | 32 | | -.80*WIN* |
| 22 | 33 | | -4.00 |
| 25 | 34 | | -3.80 |
| <RETURN> | | | |
| PR#1 | | | |
| 25 | 35 | | -1.40*WIN* |
| 30 | 40 | 20 | -.80 |
| 30 | 41 | 30 | -.60 |
| 30 | 42 | 50 | 0.00 |
| 31 | 43 | 90 | -3.60 |
| 31 | 44 | 10 | -.20 |
| 32 | 45 | 40 | -.80 |
| 32 | 46 | 60 | 0.00 |
| 34 | 47 | 90 | -3.60 |
| 34 | 48 | 10 | -.20 |
| 35 | 49 | 20 | -.80 |
| 35 | 50 | 30 | -.60 |
| 35 | 51 | 50 | 0.00 |

END OF EXPECTED VALUES
<RETURN>