大学生数学模型竞赛

优秀案例汇编

（上）

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Mathematical Contest in Modeling

MCM 1992

Dear Department Head/Past MCM Participant:

The Mathematical Contest in Modeling (MCM), a national contest for college undergraduates, will hold its eighth competition in late February. The MCM is designed to stimulate and improve problem-solving and writing skills in a team setting.

Last year, over 350 teams submitted solution papers, representing 190 schools. Outstanding solution papers were published in September in a special issue of *The UMAP Journal*. The MCM has had increased participation each year since its inception.

You can be part of the MCM effort by encouraging a member of your department to serve as a faculty advisor. The advisor will help organize the team, distribute exam materials, and return solution papers to COMAP.

Please take a few minutes to read the enclosed materials, and to fill in and return the reply form. Complimentary copies of sample solutions papers from 1991 will be sent to the first 150 requestees. Please submit the name of your faculty advisor(s) on the enclosed form by January 10, 1992.

Best Wishes,

Frank R. Giordano

Frank R. Giordano, Contest Director

The Ground Rules

MCM 1992

The Advisor

The advisor is the key to success of MCM. The advisor alerts students to the competition and encourages the organization of teams of three undergraduates. It is both legitimate and desirable to coach or otherwise prepare the teams.

Contest Date and Time

The contest will be held the weekend of February 21st. It begins at 12:01 AM local time, Friday, February 21, 1992.

Registration of Teams

Teams must be registered in advance. Each department may sign up either one team of three members, or two teams of three members each. No more than two teams may be registered from any one department. Team members may be changed at the last minute without notifying COMAP. If a department only preregisters one team, a second team may be added, but a control number *must* be obtained from COMAP before a second team paper can be entered. Please see the card attached to this announcement at right. It must be sent to COMAP to register.

The Two Problems

Each team will be presented with two problems and will choose one. The sample problems on the next page give an idea of what they will be like. Once a problem is chosen and work begins, the team may not discuss any aspect of the problem with the advisor or anyone else. The team may use computers, software packages, libraries, or any other *inanimate* sources. An MCM packet will provide the requirements and suggested procedures. Problems will tend to be open-ended and are unlikely to have a unique solution. Attention must be paid to the clarity, analysis, and design in attempting a solution. The narrative part of solution papers must be typed and in English. Partial solutions are acceptable. Two copies of each paper must be submitted. Papers must be postmarked no later than Monday, February 24, 1992. English translations must be received at COMAP by Wednesday, March 4, 1992.

Judging

Judging will take place three weeks after the contest. Some of the solutions will be recognized as Honorable Mention, Meritorious, or Outstanding.

MCM Results

The advisors and teams will be notified of the results in April. News releases will be prepared and there will be announcements in college and professional publications.

Recognition

All successful participants will receive a certificate. Outstanding teams will receive bronze plaques and their solution papers will be published in *The UMAP Journal*.

Prizes

The Operations Research Society of America (ORSA) will designate one Outstanding team from each problem as an ORSA winner. The two teams will be awarded an all-expenses-paid trip to the 1992 ORSA national meeting in Orlando, FL. In addition, ORSA will give free student memberships to all Meritorious teams.

The Society for Industrial Mathematics (SIAM) will designate one Outstanding team from each problem as a SIAM winner. Each SIAM winning team will receive a certificate, a cash prize, and partial expenses for a trip to the SIAM annual meeting in Los Angeles, CA.

Mathematical Contest in Modeling

February 3, 1992

Dear MCM 1992 Team Advisor:

Enclosed is your 1992 MCM Control Packet, and a separate envelope with your problems inside. Please read every sheet of this packet *very carefully* and comply with the instructions and requirements. There are several changes from the past year. It is always best for you to understand all the requirements fully so that you can answer your team's questions.

REMEMBER: DO NOT OPEN THE PROBLEM ENVELOPE PRIOR TO 12:01 AM LOCAL TIME ON FRIDAY, FEBRUARY 21, 1992! Only then may either you or your team members look at the problems for the contest.

Good luck, and happy modeling!

Frank R Giordano

Frank Giordano
Contest Director

Encl.

COMAP, Inc.
Suite 210, 57 Bedford Street, Lexington, MA 02173
(617) 862-7878
FAX: (617) 863-1202

MCM 1992

The Rules

- DO NOT OPEN PROBLEM ENVELOPE BEFORE FRIDAY, FEBRUARY 21 (12:01 A.M. LOCAL TIME)
- Each department may sponsor up to two teams of no more than three members each.
- No team may assign itself a control number. Only COMAP assigns control numbers.
- Signed Control Sheet must be returned with the two copies of the solution paper.
- Each team will receive two problems and will choose one.
- Neither the school name nor team members' names may appear anywhere in the paper. School name/team members' names may only appear on the control sheet.
- All papers must be typed.
- Typed English translations must be received at COMAP by Wednesday, March 4, 1992.
- Two copies of each paper must be submitted, including two copies of any and all support materials (i.e., posters, graphs, videos, charts, etc.).
- Names on certificates will be printed exactly as they appear on the control sheet.
- If your team would like verification of receipt at COMAP, include a self-addressed, stamped postcard with your solution paper and it will be sent to you upon its receipt at COMAP.
- Papers must be postmarked no later than Monday, February 24, 1992.
- Any rule infraction will be grounds for disqualification.

Judging the Solutions, MCM Results, Recognition, Prizes

- Judging will take place three weeks after the contest. Some of the solutions will be recognized as Honorable Mention, Meritorious, or Outstanding.
- The advisors and teams will be notified of the results in April. News releases will be prepared and there will be announcements in college and professional publications.
- All successful participants will received a certificate. Outstanding teams will receive bronze plaques and their solution papers will be published in *The UMAP Journal MCM Issue* in the fall of 1992.
- The Operations Research Society of America (ORSA) will designate one Outstanding team from each problem as an ORSA winner. The two teams will be awarded an all-expenses-paid trip to the 1992 ORSA national meeting in Orlando, FL. In addition, ORSA will give free student memberships to all Meritorious teams.
- The Society for Industrial Mathematics (SIAM) will designate one Outstanding team from each problem as a SIAM winner. Each SIAM winning team will receive a certificate, a cash prize, and partial expenses for a trip to the SIAM annual meeting in Los Angeles, CA.

What to Send to COMAP

1. Your original solution paper plus a copy of it with:
   - your typed summary page on top of each paper;
   - 2 copies of all support material (disks, charts, graphs, posters, videos, etc.);
   - your control number on every page of both copies and on all support material;
   - your signed control sheet (original only--no copy necessary);
   - your school name or team members' names appearing nowhere in the paper.
2. (If desired) A self-addressed, stamped postcard for acknowledgment of receipt of your solution at COMAP.

All solution papers must be postmarked no later than Monday, February 24, 1992.
English translations must be received at COMAP no later than Wednesday, March 4, 1992.

Mail entire packet to:
MCM 1992
COMAP, Inc.
Suite 210, 57 Bedford Street
Lexington, MA 02173

Mathematical Contest in Modeling – 1992
Solution Paper Guidelines/Checklist

Identification

- ☐ At the top of every page of your solution paper and on all support materials, include your team's ID (control) number.
- ☐ Neither the school name nor team members' names may appear anywhere in the paper. Please do not include a title page with your paper.

Sources

- ☐ You may use any *inanimate* source of data or materials – computers, software packages, reference works, handbooks, etc. Be sure to credit all sources used.
- ☐ You may not seek help in obtaining an answer from your team advisor or anyone else.

General Guidelines

- ☐ Partial solutions are acceptable. There is no passing or failing cut score, nor will numerical scores be assigned. The MCM judges are primarily interested in your approach and methods. Every team that submits a properly outlined solution paper will be awarded a Certificate of Participation. A number of papers will receive Honorable Mention; some will be classified as Meritorious. Selected Outstanding papers will be published in *The UMAP Journal MCM Issue*. ORSA and SIAM will offer special awards or prizes from some Outstanding papers.
- ☐ Conciseness and organization are extremely important. Key statements should present major ideas and results.
- ☐ The paper must be typed, except for diagrams, graphs, computer programs, etc., in English. (Foreign solutions may be sent in a native language, but English translations must follow.)
- ☐ Each solution paper must include a one-page, typed summary. (See item 7, below.) ***It is unlikely that MCM judges will read beyond a poorly constructed summary.***

Outline for Required Topics

1. A clarification or restatement of the problem, as appropriate.
2. A clear exposition of all assumptions and hypotheses.
3. An analysis of the problem justifying or motivating the modeling to be used.
4. The design of the model.
5. A discussion of how the model can be tested, including error analysis and stability (conditioning, sensitivity, etc.).
6. A discussion of the strengths and weaknesses of the model.
7. A one-page summary of the results, typed on the Summary Sheet, and attached to the front of each copy of the paper.

Final Product

- ☐ Your original solution paper and a copy, including 2 copies of all support materials (disks, charts, graphs, posters, videos, etc.), must be mailed to COMAP by your team advisor, postmarked *no later than* Monday, February 24. (Foreign solutions must also be postmarked February 24, with English translations received at COMAP *no later than* Wednesday, March 4, 1992.)

Acknowledgment of Receipt

- ☐ If you wish to receive acknowledgement of receipt at COMAP, please also enclose a stamped, self-addressed postcard, or send via "Return Receipt Requested" through the postal service.

For office use only

T1	
T2	
S	
F1	

MCM 1992 Summary Sheet

Team Control #:

Problem: A B (Circle one)

For office use only

	F2
	F3
	F4
	F5

Type Summary Here

<u>Do not</u> include name of school or team members on this sheet

MCM 1992 Control Sheet

You may not photocopy this control sheet to give to a new team, nor may you assign any team a control number.
Only COMAP may issue a control number to a team entered in MCM.

YOUR TEAM'S
CONTROL NUMBER IS:

98

(Place this control number on all pages of solution paper and on all support material.)

Your team's advisor is: (Please correct if necessary)

Yan-ping Zhao
Dept. of Applied Mathematics
Beijing Institute of Technology
PO Box 327
Beijing 100081
CHINA

Advisor's Telephone: Office ( ) ____________ Home ( ) ____________
Print or type Print or type

Problem Chosen By Team (circle one): A B

NAMES OF TEAM MEMBERS IN ALPHABETICAL ORDER
(Names will appear on certificates *exactly* as shown here: please check spelling accuracy):

1. ________________________
Print or type name

2. ________________________
Print or type name

3. ________________________
Print or type name

ALL TEAM MEMBERS MUST SIGN THE STATEMENT BELOW:

Each of us hereby certifies that our team abided by all of the contest's rules and did not consult with anyone who was not on this team in developing the enclosed solution paper.

____________ ____________ ____________
Signature Signature Signature

This form must be attached to one of the two copies of your solution paper.
Two copies of it are not necessary.

Problem A: Power Problem for an Air Traffic Control Radar

You are to determine the power to be radiated by an air traffic control radar at a major metropolitan airport. The airport authority wants to minimize the power of the radar consistent with safety and cost.

The authority is constrained to operate with its existing antennae and receiver circuitry. The only option that they are considering is upgrading the transmitter circuits to make the radar more powerful.

The question that you are to answer is what power (in watts) must be released by the radar to ensure detection of standard passenger aircraft at a distance of 100 kilometers.

Technical specifications:

a. The radar antenna is a section of a paraboloid of revolution with focal length of 1 meter. Its projection onto a plane tangent to its vertex is an ellipse with a major axis of 6 meters and a minor axis of 2 meters. The main lobe energy beam pattern, located at the focus, is an elliptical cone that has a major axis of one radian and a minor axis of 50 milliradians. The antenna and beam are sketched in the figures provided *below*.

b. The nominal class of aircraft is one that has an effective radar reflection cross-section of 75 square meters. For the purposes of this problem, this means that in your initial model, the aircraft is equivalent to a 100% reflective circular disc of 75 square meters, which is centered on the axis of the antennae and is perpendicular to it. You may want to consider alternatives or refinements to this initial model.

c. The receiver circuits are sufficiently sensitive to process a return signal of 10 micro watts at the feed horn of the radar (which is located at the focus of the radar antenna).

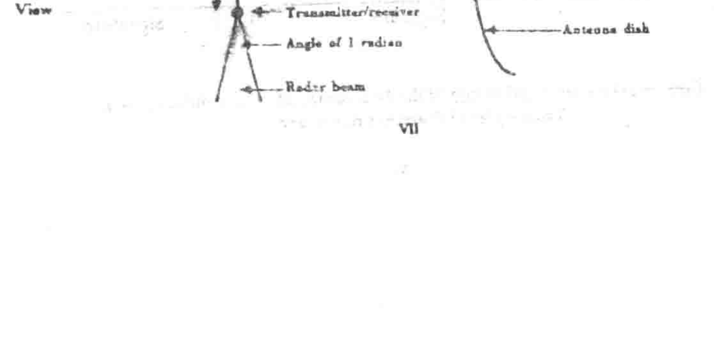

Table 1. Storm Restoration Requirements

Time (a.m.)	Location	Type	#Affected	Estimated Repair Time (Hours for crew)
4:20	(–10, 30)	Business (cable TV)	?	6
5:30	(3, 3)	Residential	20	7
5:35	(20, 5)	Business (hospital)	240	8
5:55	(–10, 5)	Business (railroad sys.)	25 workers; 75,000 commuters	5
6:00	All clear given; storm leaves area; crews can be dispatched			
6:05	(3, 30)	Residential	45	2
6:06	(5, 20)	Area *	2000	7
6:08	(60, 45)	Residential	?	9
6:09	(1, 10)	Government (city hall)	?	7
6:15	(5, 20)	Business (shopping mall)	200 workers	5
6:20	(5, –25)	Gov't (fire dept.)	15 workers	3
6:20	(12, 18)	Residential	350	6
6:22	(7, 10)	Area *	400	12
6:25	(–1, 19)	Industry (newspaper co.)	190	10
6:40	(–20, –19)	Industry (factory)	395	7
6:55	(–1, 30)	Area *	?	6
7:00	(–20, 30)	Gov't (high school)	1200 students	[illegible]
7:00	(40, 20)	Gov't (elementary school)	1700	?
7:00	(7, –20)	Business (restaurant)	25	12
7:00	(8, –23)	Gov't (police station & jail)	125	7
7:05	(25, 15)	Gov't (elementary school)	1900	5
7:10	(–10, –10)	Residential	?	9
7:10	(–1, 2)	Gov't (college)	3000	8
7:10	(8, –25)	Industry (computer manuf.)	450 workers	5
7:10	(18, 55)	Residential	350	10
7:20	(7, 35)	Area *	400	9
7:45	(20, 0)	Residential	800	5
7:50	(–6, 30)	Business (hospital)	300	5
8:15	(10, 40)	Business (several stores)	50	6
8:20	(15, –25)	Gov't (traffic lights)	?	3
8:35	(–20, –35)	Business (bank)	20	5
8:50	(47, 30)	Residential	40	?
9:50	(55, 50)	Residential	?	12
10:30	(–18, –35)	Residential	10	10
10:30	(–1, 50)	Business (civic center)	150	5
10:35	(–7, –8)	Business (airport)	350 workers	4
10:50	(5, –25)	Gov't (fire dept.)	15	5
11:30	(8, 20)	Area *	300	12

* Area signifies a combination of two or more of the other classification types.

Table 2. Crew Descriptions

- Dispatch locations at (0, 0) and (40, 40).
- Crews consist of three trained workpersons.
- Crews report to the dispatch location only at the beginning and end of their shifts.
- One crew is scheduled for duty at all times on jobs assigned to each dispatch location. These crews would normally be performing routine assignments. Until the "storm leaves the area," they can be dispatched for "emergencies" only.
- Crews work eight-(8)hour shifts.
- There are six crew teams available at each location.
- Crews can work only one overtime shift in a work day and receive time and-a-half for overtime.

Problem B: An Emergency Power Restoration System

Power companies serving coastal regions must have emergency response systems for power outages due to storms. Such systems require the input of data that allow the time and cost required for restoration to be estimated and the "value" of the outage judged by objective criteria. In the past, Hypothetical Electric Company (HECO) has been criticized in the media for its lack of a prioritization scheme.

You are a consultant to HECO power company. HECO possesses a computerized database with real time access to service calls that currently require the following information:

Time of report;
Type of requestor;
Estimated number of people affected;
Location (x, y).

Crew sites are located at coordinates (0, 0) and (40, 40), where x and y are in miles. The region serviced by HECO is within $-65 < x < 65$ and $-50 < y < 50$. The region is largely metropolitan with an excellent road network. Crews must return to dispatch site only at beginning and end of shift. Company policy requires that no work be initiated until the storm leaves the area, unless the facility is a commuter railroad or hospital, which may be processed immediately if crews are available.

HECO has hired you to develop the objective criteria and schedule the work for the storm restoration requirements listed in Table 1 using the work force described in Table 2. Note that the first call was received at 4:20 a.m. and that the storm left the area at 6:00 a.m. Also note that many outages were not reported until much later in the day.

HECO has asked for a technical report for their purposes and an "executive summary" in laymen's terms that can be presented to the media. Further, they would like recommendations for the future. To determine your prioritized scheduling system, you will have to make additional assumptions. Detail those assumptions. In the future, you may desire additional data. If so, detail the information desired.

(See back of page for Tables 1 and 2.)

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MATHEMATICAL COMPETITION IN MODELING

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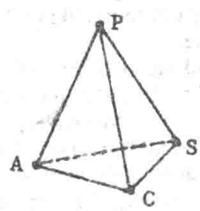
1. INTRODUCTION

The concept of a national applied math contest for undergraduates occurred to me in October 1983. It surfaced because of difficulties we were having in getting our students to prepare for the Putnam. Salisbury State College has a high percentage of first-generation students, and they tend to view facing such a formidable exam alone as an ordeal. The practice of reporting very low scores adds to the chilling effect. Finally, the small applied content of the Putnam problems did not generate much enthusiasm in practical-minded students. However, there was more to this notion of an applied math contest than modifying a exam.

The concept was based on a substrate that had developed over a dozen years. I had chafed at the overemphasis in established mathematics of the pure, formalistic approach, almost devoid of content. Many campuses lacked any appreciable applied or constructive presence. In my mind, (classical) applied math, computational math, and statistics were as important a part of mathematical activities and curricula as pure math. The model I had in mind represented each of these four as a vertex of a tetrahedron. The edges, faces, and interiors represented such "interdisciplinary" activities as applied linear algebra, numerical analysis, or operations research.



The Putnam, reflecting post-1945 Bourbaki bias, dealt with a small neighborhood of the lofty apex. . . . It would be difficult to tell from the exam that the computer existed.

These thoughts merged and then popped up in verbal form as "Applied Putnam." I tested the notion on a colleague, Bob Tardiff. His response was: "Why don't you do it?" Most of my other colleagues also liked the idea, but it seemed prudent to check with some off-campus mathematicians who had long involvements in applied math. Calls to M. S. Klamkin, H. O. Pollak, and E. Y. Rodin elicited favorable responses and encouragement to proceed. I then called A. P. Hillman, who has had many years of experience with the Putnam competition. Hillman urged me to start with a *small* pilot project and warned that I might be underestimating the difficulty of running a national contest. (He was right.)

Being chairman of the Education Committee of the Society for Industrial and Applied Mathematics (SIAM) gave me a natural forum for this project. An outline of a proposal for a pilot contest was sent to members of this SIAM committee on 5 November 1983. The gist of the proposal:

	Pure Putnam	"Applied Putnam"
Sessions	Two (each 3 hours long)	Two (each 3 hours long)
Number of Problems	Twelve	Two
Type of Problems	Structural, pure	Contextual, applied
Format	Individual students	Teams of three students Microcomputers allowed
Time	December	March

The committee responded very favorably to the proposal, but with strong reservations on the time allotted per problem. The feeling was that an applied math problem could not be done in half a day—estimates ran from a day to a week. One experienced SIAM officer said that a realistic problem needed a whole semester! These observations, coupled with my fairly unshakable view that a contest for undergraduate should not occupy more than a weekend, doomed one of my favorite schemes: Teams should be required to do one *continuous* and one *discrete* problem.

Although the education committee looked on the applied Putnam with favor, SIAM's leadership felt that the committee already had enough projects and that it should continue to concentrate on the K-12 level. However, so many people had judged the idea to be good and workable that I decided to seek another forum.

2. FUNDING THE CONTEST

Warren Page, editor of the *College Mathematics Journal*, gave an invited lecture to the Maryland, Washington, D.C. and Virginia Mathematical Association of America section on 18 November. His lively presentation included many applied examples, so I approached him with the idea after his talk. Page listened attentively but guardedly—the term "Applied Putnam" was definitely not to his liking. His initial reaction was that the concept was interesting but not feasible.

About three weeks later, Page called me at home to say he had given this concept of an applied contest quite a bit of thought. He had come around to the position that it was a valuable idea and that it ought to be done. Moreover, he had broached the subject to S. A. Garfunkel, executive director of COMAP. The Consortium for Mathematics and its Applications had been supporting applicable math in a variety of ways since 1972. Garfunkel was very enthusiastic, and Page urged me to get in touch with him. Although I was a member of COMAP and had used its materials, I had never had any interaction with Garfunkel. After one phone conversation, it was clear that we had similar goals. In fact, "increasing the applied presence" on campus might be one way to describe what COMAP had been doing over the years. He suggested that a proposal for a three-year grant be sent to the Fund for the Improvement of Post-Secondary Education (FIPSE), Department of Education, with COMAP the administering body and me as project director. FIPSE had a reputation for backing novel ideas that might have far-reaching effects. The offending term *Applied Putnam* was transformed into the *Mathematical Competition in Modeling* (MCM), and the preliminary proposal squeaked by FIPSE's 12 January 1984 deadline. It was soon approved, and the final three-year proposal was approved in June 1984.

3. GOALS OF THE MCM

The goals and purposes of the MCM are best described by two paragraphs from the abstract of the final proposal to FIPSE.

The purpose of this competition is to involve students and faculty in clarifying, analyzing, and proposing solutions to open-ended problems. We propose a structure which will encourage widespread participation and emphasize the entire modeling process. Major features include:

- The selection of realistic open-ended problems chosen with the advice of working mathematicians in industry and government.
- An extended period for teams to prepare solution papers within clearly defined format.
- The ability of participants to draw on outside resources including computers and texts.
- An emphasis on clarity of exposition in determining final awards with the best papers published in professional mathematics journals.

As the contest becomes established in the mathematics community, new courses, workshops, and seminars will be developed to help students and faculty gain increased experience with mathematical modeling.

4. ORGANIZING THE MCM

An advisory board was formed of applied mathematical scientists who had been early backers of an applied math contest:

B. A. Fusaro, Salisbury State College, Salisbury, MD
A. P. Hillman, University of New Mexico, Albuquerque, NM
M. S. Keener, Oklahoma State University, Stillwater, OK
H. O. Pollak, Bell Communications & Research, Inc., Morristown, NJ
F. J. Roberts, Rutgers University, New Brunswick, NJ
E. Y. Rodin, Washington University, Saint Louis, MO
L. H. Seitelman, Pratt & Whitney, East Hartford, CT
Maynard Thompson, University of Indiana, Bloomington, IN

Hillman, who for many years directed grading for the Putnam, agreed to be chief grader. This eliminated one of the two swords that hung over our heads: finding suitable problems and grading.

The first advisory board meeting was scheduled for August, which left just enough time to prepare for a contest in February 1985. Budget problems in Washington delayed our funding. COMAP took the risk of spending unreceived money for our first meeting, held in Chicago on 30 September 1984.

The board made all decisions by consensus. We selected two types of problems, approved ground rules, set up a Putnam-like system of faculty advisors, and established grading classifications. (We all agreed it was unrealistic to linearly order problems of this nature.) The inaugural contest was set for the weekend of 15 February 1985. The meeting was very productive, but we departed with a note of concern over the short amount of time for publicity, registration, and final write-up of contest materials. We wondered whether we could get our predicted 55 colleges to enter the first Mathematical Competition in Modeling.

It turned out that 158 teams registered, representing 104 colleges, a response that overwhelmed us. Anything above 100 solution papers was unmanageable—there was not enough manpower to allow multiple readers for each paper. There were actually 90 papers submitted, representing 70 colleges, a large but tractable number.

5. THE TWO MCM PROBLEMS

Managing an animal population

Naturally-occurring animal populations are found in environments where there are resource constraints, that is, limited food, space, water, etc. Select a fish or mammal (Chincoteague ponies, deer, rabbits, salmon, striped bass, for instance) and an environment for which you can find appropriate data, and formulate an optimal policy for harvesting members of the population.

Managing a strategic reserve

Cobalt, which is not produced in the U.S., is essential to a number of industries (Defense accounted for 17 percent of the cobalt production in 1979). Most cobalt comes from central Africa, a politically unstable region. The Strategic and Critical Materials Stockpiling Act of 1946 requires a cobalt reserve that will carry the U.S. through a three-year war. The government built up a stockpile in the 1950s, sold most of it off in the early 1970s, and then decided to build it up again in the late 1970s, with a stockpile goal of 85.4 million pounds. About half of this stockpile had been acquired by 1982.

Build a mathematical model for managing a stockpile of the strategic metal cobalt. You will need to consider such questions as: How big should the stockpile be? At what rate should it be acquired? What is a reasonable price to pay for the metal? You will also want to consider such questions as: At what point should the stockpile be drawn down? At what rate should it be drawn down? What is a reasonable price to sell the metal? How should it be allocated? (Accompanied by a sheet with more information on the sources, cost, demand, and recycling aspects of cobalt. See Appendix A.)

The faculty advisor was to open the envelope Friday morning and instruct the team to choose a problem by noon (else the advisor was to assign the team one of the problems).

The ground rules allowed the team to use any *inanimate* source. It was emphasized that partial solutions were acceptable, and that there was no passing score. Except for diagrams, graphs, etc., the solution paper had to be typed.

The open-ended nature of the problems required guidance, so the following outline was provided:

1. A clarification or restatement of the problem as appropriate.
2. A clear exposition of all assumptions and hypotheses.
3. An analysis of the problem, justifying or motivating the modeling to be used.
4. The design of the model.
5. A discussion of how the model can be tested.
6. A discussion of the strengths, weaknesses of the model, including error analysis and such things as stability (e.g. conditioning sensitivity).
7. A one-page summary of results.

6. RESULTS OF THE CONTEST

Awaiting the onslaught of these 90 problem-solving teams were 13 graders. (See Appendix B.) They were headed by A. P. Hillman, of long-time Putnam experience. The graders met at the University of New Mexico, Albuquerque, the first weekend in March. Each of the papers was read by at least three graders. After an effort that can only be described as *character-building*, 12 of the student papers were classified as Honorable Mention, and 18 were classified as Meritorious.

The MCM advisory board unanimously designated six of the meritorious papers as outstanding:

Animal Population problem (60 solution papers)

1. Population Dynamics of Deer
   Harvey Mudd College — Dana Hobson
   Claremont, CA 91711 — Scott Bailey
   (Prof. S. N. Busenburg) — David Ho
2. Grizzly Bears in Yellowstone National Park
   Mount St. Mary's College — Michael Caulfield
   Emmitsburg, MD 21727 — Daniel McCaffery
   (Prof. C. O. Harris) — John Kent
3. An Effective Strategy for Harvesting Salmon
   Southern Methodist University — Julian Anthony
   Dallas, TX 75275 — Mike Frohme
   (Prof. Richard Haberman) — Joe Ramey
4. Mathematical Modeling of the Peruvian Anchovy Population Dynamics
   Washington University — Jonathan Caulkins
   St. Louis, MO 63130 — Andrew Yates
   (Prof. D. A. Elliott) — Rob Barrett

Strategic Reserve Problem (30 solution papers)

1. The Problem of Managing a Strategic Reserve
   Calvin College — Jack Snoevink
   Grand Rapids, MI 49506 — Loren Haarsma
   (Prof. G. A. Klaasen) — David Cole
2. Managing a Cobalt Stockpile
   New Mexico State University — Sunit Bhalla
   Las Cruces, NM 88003 — David Thomas
   (Prof. J. D. Thomas) — Lance Waller

These solution papers have been edited slightly for inclusion in this special issue.

The excellent geographical and college-university distributions might suggest to the reader that there was some sort of quota system, but there was none. The solution papers had all been coded. The twelve other meritorious teams are:

Animal Population Problem

California Polytechnic State University, San Luis Obispo, CA (Prof. Thomas O'Neil)
California State University, Northridge, CA (Prof. T. F. Lin)
Cooper Union (two teams), NYC, NY (Prof. E. Kondopirakis)
Harvey Mudd College, Claremont, CA (Prof. S. N. Busenberg)
Oklahoma State University, Stillwater, OK (Prof. J. R. Choike)
University of California (two teams), Berkeley, CA (Prof. F. R. Grunbaum)

Strategic Reserve Problem

Beloit College, Beloit, WI (Prof. P. D. Straffin)
Central Washington University, Ellensburg, WA (Prof. Ken Gamon)
Harvard University, Boston, MA (Prof. Andrew Gleason)
Trinity University, San Antonio, TX (Prof. J. E. Gayek)