CHAPTER 2

Mystery Artifact Challenge

INTRODUCTION

Past mystery artifacts have taken a number of forms: a complete, working device; a sub-component of a system; or a prototype of some leading-edge technology. An artifact is chosen to illustrate an engineering principle or to represent an engineered object. The challenge, using all resources available, is to develop, test and defend hypotheses for the functioning of selected artifacts. Only the artifact donors, and perhaps one other coordinating professor, know the identity and function of the objects.

This exercise is used as an introduction to the design process and reverse engineering. It provides an initial opportunity for team members to work together to solve an open-ended problem.

MYSTERY ARTIFACT LEARNING GOALS

The learning objectives of the mystery artifact challenge include the following:

- Solidify team dynamics in a short-term exercise.
- Help students learn to work effectively in a team activity.
- Provide an introduction to reverse engineering.
- Disperse teams throughout the community to meet and talk with a variety of faculty members and be introduced to available resources.
- Cultivate investigative skills.
- Increase resourcefulness in seeking out information.
- Encourage the habit of making detailed observations correlating aspects to functions.
- Introduce the formulation and testing of hypotheses, drawing and supporting conclusions.
- Provide practice of communication skills.
- Ease entrance into engineering.

THE ORIGINS OF ARTIFACTS

An artifact is never used more than once. This is to insure that the exercise remains an engineering exercise and does not degrade into an effort of searching for students in prior classes or old assignments for answers. In other words, the goal is to create engineers not historians. In the past, artifacts have come from a variety of sources, including:

- Professors
- Alumnae
- Technological pack rats
- Local commercial and government laboratories
- Other universities
- Antique stores and museums
- New materials or prototype devices
- Surrounding engineered objects

EXAMPLES OF PAST ARTIFACTS

Examples of past mystery artifacts indicate the broad range of devices and materials presented for analysis. Past artifacts include:

- Muscle wire
- Section of a floor mat from an engineering building
- A plastic that changes color when exposed to ultraviolet light
- An optical coupler for transferring movie film to video
- Components of a pressure sensor for detecting nuclear explosions
- A device used by scientists for capturing insects
- Wind noise reducer for a microphone
- Replica of an ancient Chinese seismometer
- Staple dispenser from a copy machine
- Thermostat from a refrigerator
- Adjustable pressure switch
- Radio beacon
- Helmholtz resonator

This is only a small sample of the artifacts used to date. Teams can expect to encounter practically anything. The mystery artifacts have represented all disciplines and included complete devices, materials and sub-components. Quantitative testing and analysis of data obtained to determine function was possible for many students. One example, emphasizing the importance of paying attention to small clues, is the student who was investigating the radio beacon. While holding the artifact, which looked like a bomb (a sealed, small plastic case with a fuse-like appendage), he noticed strange interference on a nearby television. Following up on this clue the team was able to determine most of the beacon properties.

THE MYSTERY ARTIFACT EXERCISE

During one class meeting, the instructor reviews the background and learning goals, presents examples of past artifacts and runs through the exercise in capsule form. The original information for the example devices is provided for each artifact. After each team has inspected the example devices, students are asked to make quick guesses concerning their function. After this "guessing game," the solutions to the example are presented.

Next, students are introduced to a selection of unknown artifacts to be investigated. An information sheet taped to the table in front of each artifact provides a modest amount of background information. Also at each table there is a sheet for written questions and answers. Student teams choose three artifacts on which to report. For one of these three, each team prepares a detailed report and presentation; the team produces short summaries for the other two artifacts. There is a sign-out sheet if a team wishes to take an artifact from the classroom *during their class period* for testing or consultation. Teams should be aware that other students also require access, and the artifacts must be returned on time.

EXAMPLES OF ARTIFACT INFORMATION PROVIDED

Four samples of past artifacts appear below. The information that was originally provided to students appears with each artifact. Without actually physically inspecting and testing, deducing functions and purpose is close to impossible. The purpose here, however, is to capture the sequence of events involved in the process. Solutions to these artifacts appear at the end of this chapter.

Artifact A: Clear Box with Red Balls

Information provided:

- This was sold by a company in quantity.
- This is not a toy.
- This is complete as is and not intended to be used with any other devices.
- This is in working order.

Artifact B: The Rubber Thing

Information provided:

- This is made out of rubber.

Artifact C: Gears & Levers

Information provided:

- The back of this was removed so that the mechanism can be inspected. The knobs can be moved freely to see how the various parts are linked together. Do not mess with the linkages in the back. As an exercise, try using the Working Model software program to represent a portion of the system.
- There is important information on the front. The stand is not a part of the device and was added so that the mechanism could be inspected easily. There is no important information underneath the device.
- It was purchased in a parts store for three dollars.
- Can the function be determined?
- Why was it needed?
- From what period of time does it come?
- How was it designed? By a single person? By a team?

F

B

Artifact D: The Blue Box

Information provided:

- This is a “one of a kind” object. It was built to illustrate a concept and resulted in the Federal Aviation Administration funding a multi-year program at well over a million dollars.
- An Italian TV personality (in-depth news show) brought a crew to Boulder, Colorado, and video was taken of him carrying this device out of an elevator.
- This is in full working order.
- Feel free to take it out of the case. Do not disconnect any wires or tubes. There seem to be two circuits: one electrical and one pneumatic. Trace these out if desired.
- What is it? How does it work?

WRITTEN QUESTION / ANSWER FORMAT

In most cases, only one or two people associated with this course know the functions of the mystery artifacts. This places everyone (students, TAs, professors and other faculty) on an even playing field. Professors and TAs are free to make suggestions and answer questions. To provide everyone with the same information, once a day, someone “in the know” visits the question/answer sheets and provides answers. This way, everyone receives the same feedback. Although this process would work over the Internet, taping the sheets to the tables in front of the artifacts permits efficient information updates. The written question/answer format has proven fair and efficient.

WHAT QUESTIONS CAN BE ASKED AND HOW?

Any questions can be asked. However, keep in mind that the spirit of the exercise is to apply analytical skills; it is not intended to be a “hot or cold” guessing game. Thus, there is a two-column sheet for questions and answers.

Some questions will not be answered. For others, the response will be “Zen like,” in the sense that the answer will probably be profound, but not supply anything very helpful. Feel free to write any question on the sheet. Do not be disappointed by the reply, and remember that other students will also read the Q/As.

Examples of questions that are valuable to ask (and will probably be answered) are those dealing with the following areas:

- Limits of testing: *Can it be put underwater? Can it be set on fire?*
- Historical background: *How many were made?*
- Context of use: *Was it part of a system? Is another component or device necessary for functionality?*
- Resources: *Can a pressure gauge be made available?*

For the four example artifacts listed above, the following are some typical Q/As:

Questions	Possible Answers
Artifact A: We put this underwater and now the balls are all stuck together. Can you fix it?	Will work on it. Low heat overnight solved the problem.
Artifact A: Can we test this in a microwave oven?	Please don't. There is metallic paint on one portion that will probably vaporize.
Artifact B: Were these used in large numbers with a long rope through the center?	Could be, or on the other hand, perhaps not.
Artifact C: Was this used in aircraft?	Not telling.
Artifact D: Why was the Italian TV personality in the elevator?	Good question.

INVESTIGATIVE CONTEXT AND CONDUCT

The process of solving a mystery artifact replicates the steps of a major reverse-engineering project, but on a short time scale. The exercise is intended to develop keen perception skills and sensitivity to subtle design features. The habit of curious questioning is a valuable trait for engineers to nurture, and solving and exploring an interesting mystery can be a satisfying experience. The following suggestions for solving mystery artifacts emphasize the need to be organized, analytical and open minded. Rarely, a team member may have special knowledge concerning an artifact. Should this happen, please keep this knowledge within the team, and be aware that there is still a requirement to follow through with a complete analysis and reporting.

Suggestions for Solving Artifacts

Suggested approaches for solving mystery artifacts include:

- *Inspect the artifact* with notebook in hand. Record all first impressions.
- *Record the details* of the device or material (color, shape, weight, dimensions, etc.) in journal entries. Make sketches as part of this process.
- *Summarize all information* provided including Q/A information. Pose questions that arise.
- *Meet as a team and brainstorm* the function of each object. Remember to include guidance from team dynamics experiences and record non-judgmental suggestions for future discussion.

- *Develop a plan* for further investigation, quantitative testing and analysis. Some artifacts are especially suited to exploration by measurement. At this point, an artifact may particularly intrigue one team member; it may be effective for that person to explore the artifact and then report back to the team.
- *Start the testing and analysis*. Through this period, it is wise to remain open-minded to new clues and information. Any resource developed or thought of can be applied (e.g., Internet and patent searches, visiting various faculty, visiting local laboratories). Resourcefulness and persistence are also valuable traits for engineers. Many people in the scientific and business community have assisted teams with advice and information.
- At some point, it is effective to *make a priority list of hypotheses*, and start to work on the presentation and report. The time to start collecting information with a report and presentation in mind is from the very beginning. Factual sections can be written early in the process, while sections on deductions are developed later when tests and analyses are complete.
- Teams should meet to decide how best to do this. In the past, some teams have divided the various artifact sub-tasks between members, while other teams have elected to do all the work as a group. Everyone should be involved in the process and do their fair share of work. Teamwork is important because the effectiveness of a team as a whole is a model for the rest of the semester. It is imperative to address potential problems within the team as early as possible and solve these issues before the team "falls apart."
- *Plan the presentation* and report so that everyone has an opportunity and is contributing.
- After the mystery artifact exercise is over, meet as a team and *discuss the overall team's efforts*. Should the approach and methodology change in the future? Provide feedback comments to faculty and TAs.

PROJECT CLOSURE

Project solutions are only provided when all sections of the course have completed their presentations. This means that some classes will have to wait several days before the solutions are disclosed. Often, faculty members who have been contacted concerning a particular artifact will come to a class to find out the artifact's function. For some artifacts, a simple demonstration of use will be possible. If time permits, a summary of suggested solutions from various sections will be provided. The variety of reasonable hypotheses advanced is amazing.

Solutions to the mystery artifacts presented earlier appear below in the same format usually followed. Some artifact solutions are accompanied by additional detail:

- manufacturer's specifications/manuals
- technical properties
- advertisements
- historical background
- analytical calculations

Solutions

Artifact A: Clear Box with Red Balls

The transparent plastic container with the little red balls floating in air was sold briefly in large quantities during the cold war. The device is a nuclear radiation detector. When radiation is present, it ionizes the air inside the container, allowing the static charges to leak off and the balls to fall.

Artifact B: The Rubber Thing

This artifact is a part of a large bus suspension system. The main rear suspension for large buses, such as those used on main bus routes, uses large air springs to provide “springiness” under normal driving conditions; but the rubber things (of which there are two) come into play if a large bump in the road is encountered. They stiffen the spring rate of the suspension and prevent metal-to-metal contact between the suspension and the frame of the bus. Some teams tested this in a civil engineering lab under compression loads of up to 10,000 pounds.

Artifact C: Gears & Levers

This is an analog computer that was used during the Second World War for setting the timing on the fuses of anti-aircraft shells. The complex set of interacting parameters, and the need for speed and accuracy, made this device a valuable resource in the absence of electronic computers.

Artifact D: The Blue Box

This is a prototype of a pressure jump detector designed to respond to the pressure increase that occurs at the leading edge of thunderstorm outflow boundaries and other sources of wind shear causing aircraft flight hazards. When a pressure increase occurs fast enough, the switch will close, setting off an alarm. Teams tested this by taking it down in an elevator until the alarm went off, using the pressure change with altitude to investigate the response.