

# PLATO® Technology Fundamentals Phase II (draft 1)

## 1. Product Overview

The Technology Fundamentals (TF) curriculum will give the learner a broad overview of the concepts and principles underlying modern technology systems. It will focus primarily on principles of operation and qualitative understanding rather than quantitative computation. However, some math will be required in order to properly convey the concepts.

TF will be designed to align closely to Work Keys Applied Technology (see Appendix). It will NOT replace our current MPAS-and-paper Technology Skills courses.

To that end, TF will rely heavily on simple system simulations that permit the learner to manipulate different aspects of systems and their components. It will not teach troubleshooting and problem-solving *per se*, but troubleshooting failed systems will be an integral part of the instruction.

## 2. Assumptions

### 2.1. Target market

#### 2.1.1. Academic

The primary market for this course is academic work-preparation programs (school to work, vocational preparation, tech prep or alternative programs), community colleges (in either vocational programs or contract training departments, where they train local employers' people), or employment preparation (JTPA-type programs, community-based non-profits, etc.).

Conversations with community-college clients indicate that Work Keys is used or will be used extensively in these settings. TF will be useful in preparing learners to find employment, or to be successful in keeping themselves employed.

#### 2.1.2. Workplace

A secondary market for this course is corporations. The buyers are training managers, human resources managers, or occasionally line managers of specific operations within the company (such as production manager, operations manager, etc.) at either a corporate, division, or plant level.

The learners are entry level employees through first level supervisors in either clerical / administration or production environments. Even in a workplace environment, this product may be delivered as part of a community college program.

## 2.2. Audience

### 2.2.1. Geographic Distribution

US, Canada, possible international English-speaking

### 2.2.2. Age / Educational Background

The primary audience for this course will be students in school-to-work and vo-tech programs, technical schools and community colleges. At least 16 years old. High school, junior college, adult learner. Some may be middle-aged females entering the work force for the first time, or re-entering it after an absence of many years.

### 2.2.3. General math and reading abilities

Reading level 6th-8th grade. See Prerequisites for discussion of expected math abilities. Because this audience may have poor reading fluency, especially with technical subject matter, Read-The-Screen audio will be incorporated into the product architecture.

### 2.2.4. Relevant prior experience (job title)

Learners may have had some blue-collar job experience, but it is not assumed as a prerequisite. Learners are expected to have at least a beginning familiarity with the operation of an automobile and basic household appliances, such as a toaster, clothes iron, oven, vacuum cleaner, etc. (These items will be drawn on as concept exemplars in the instructional sequences.)

### 2.2.5. Variation in ability, experience and goals

The age and experience range of this target population will be a development challenge. Some learners may have undiagnosed learning disabilities. Some may have difficulty with basic math skills.

Neither population is likely to have experience using Windows-based software, so information management and screen real estate will be an issue.

### 2.2.6. Attitude and motivation issues

Preferred learning style is experiential and hands-on. These learners are motivated by making things and by making things work. They are put off by theoretical, stuffy, academic presentations.

Some may have low confidence in their own ability to understand mechanical concepts, so WIIFM and YCDI are important.

## 2.3. Prerequisite skills

Learners should have completed the equivalent of Math Fundamentals, Advanced Math, Geometry and Measurement 1 and 2, and Beginning and Intermediate Algebra.

Work Skills and Data Skills.

### 3. Course outline

Each module will contain two activities, a tutorial and a test. The tutorial will provide instruction and practice on the concepts and principles of a particular type of system. The Mastery Test will present Work Keys-like multiple-choice questions, with only "Correct" and "Incorrect" feedback.

Course 1: Simple Systems (2-5 components)

- Module A: Overview of Systems
- Module B: Simple Mechanical Systems
- Module C: Simple Fluid Systems
- Module D: Simple Heat Systems
- Module E: Simple Electrical Systems

Course 2: Complex Systems (up to 10 components)

- Module A: Complex Mechanical Systems
- Module B: Complex Fluid Systems
- Module C: Complex Heat Systems
- Module D: Complex Electrical Systems
- Module E: Complex Combined Systems  
(systems that combine simpler systems such as numerically-controlled manufacturing machines)

### 4. Treatment

Use these items as concept exemplars: Basic automobile systems (brakes, headlights, etc.), basic household appliances (toaster, clothes iron, oven, etc.).

#### 4.1. *Instructional Sequence*

The Work Keys Applied Technology Targets for Instruction recommend a sensible instructional sequence for teaching Applied Technology. We will follow that strategy in this course. Each main concept will be addressed as follows:

##### 1. *Concept exploration*

This lets the learner discover a system's behavior in a hands-on, experiential, experimental way rather than by having it presented as a set of abstract, theoretical ideas.

In the courseware, concept exploration will be done through a "mini-sim." A mini-sim is a representation of a system that allows the learner to manipulate one or more components and view the effect of the change on the operation of the system.

Example: "Here's a simple electrical circuit. Click here to try different ways of connecting the batteries and see what happens. Which arrangement makes the bulb burn brightest? Which makes it burn the longest?"

## 2. *Concept introduction*

This is a more formal explanation of concepts and principles. The learner should already have an intuitive understanding of the system's behavior (though he may not be able to explain it) from the earlier experimentation, so he has a place to put the labels (voltage, amperage, series, parallel) that are introduced here.

In the courseware, concept introduction may be done with text feedback built into the mini-sim, or via a mini-tutorial linked to the mini-sim.

Example: "When the batteries are connected *in series* (nose-to-tail), the bulb burns brighter. When the batteries are *in parallel* (side-by-side), the bulb burns longer. Putting batteries in series increases the *voltage* (electrical 'pressure'). Putting batteries in parallel increases the *ampere-hours* (electrical power)."

## 3. *Concept application*

The learner is asked to explain and predict the behavior of the system under different conditions.

In the courseware, concept application will be done with additional mini-sims and with multiple-choice questions.

Example: "In this circuit, what will happen to the bulb if one battery is dead? Why?"

## 4.2. *Media*

### 4.2.1. Audio

There will be two kinds of audio in the course: Read-the-Screen (RTS) and Sound Effects (SFX). Both will be accomplished via the Audio Text widget (see separate documentation).

The purpose of RTS is to provide support to learners with poor reading comprehension. It will be learner-controllable as described in the Audio Text Widget specification.

The purpose of SFX is to let the learner hear what certain systems or components sound like, where that information is instructionally important. For sound effects, the text of the Audio Text widget will be "Hear [description of sound effect]."

### 4.2.2. Video

The purpose of video is to show the learner a real-world system or component in operation, where that is instructionally needed.

## 5. Content analysis

### 5.1. Content outline

#### 5.1.1. Overview of Systems - Components

##### **Basic systems model**

- Input
- Components (“black boxes”)
- Output

##### **Work Keys system model**

- Power Source
- Flow
- Pressure
- Resistance

#### 5.1.2. Overview of Systems - Concepts

##### **Basic concepts**

- Process
- Feedback
- Control
- Normal operation
- Abnormal operation
- Failure modes
- GIGO
- Cause / effect

##### **States of matter**

- Solid - molecules are moving just a little
- Liquid - molecules are moving fast
- Gas - molecules are moving very fast

##### **Measurement units and methods**

- Distance, Area, Volume
- Mass
- Force
- Oscillation (vibration)
- Work
- Power

##### **Kinds of energy**

- Kinetic energy (energy of motion)
- Thermal energy (heat energy)
- Potential energy (stored energy)

### 5.1.3. Overview of Systems - Principles

- Conservation of energy: Energy can be converted from one form to another, but it cannot be created or destroyed.
- Inertia (1): An object at rest will remain at rest unless acted upon by some outside force.
- Inertia (2): An object in motion will remain moving in a straight-line at a constant speed unless acted upon by some outside force.
- Linear velocity = distance / time
- Rotational velocity = angular distance (revolutions) / time
- Acceleration = velocity / time
- Force = mass times acceleration
- Torque (moment) = force x distance
- Momentum (kinetic energy) = mass times velocity-squared

### 5.1.4. Mechanical Systems - Components

#### **Lever**

Three classes of levers (we won't get into this formally): Has to do with the relative position of load, effort, and fulcrum

Wheel

Cam

Crank

Shaft

Flywheel

#### **Gear**

Planet / sun gears

Rack & pinion

Spur gear

Worm gear

Crown gear

Ring gear

#### **Springs**

Torsion spring (like a watch mainspring)

Flat spring (like on a car suspension)

Coil spring (Like on a MacPherson strut)

#### **Pulley**

Wheel & belt

Sprocket & chain

Sheave & belt

Pulley and cable

### 5.1.5. Mechanical Systems - Concepts

Friction  
Gear ratio / Pulley ratio  
Load  
Mechanical advantage

### 5.1.6. Mechanical Systems - Principles

- Mechanical systems have friction.
- Friction causes energy loss through heat.
- Friction causes components to wear
- A system of gears or pulleys can change the direction of motion.
- A lever can convert a small force applied over a large distance to a large force applied over a small distance and vice versa.
- A system of gears or pulleys can convert a small force at a high speed to a large force at a low speed and vice versa.
- A crank converts rotary motion to linear motion or vice versa

### 5.1.7. Heat Systems - Components

Heat exchangers  
Coolant  
Radiator fins  
Thermocouple (temperature sensor)  
Thermostat (adjustable temperature sensor + control device)  
Thermal insulation  
Combustion chamber  
Exhaust  
Cooling fins

### 5.1.8. Heat Systems - Concepts

#### **Heat**

BTU \ Calorie

#### **Temperature**

Fahrenheit \ Celsius (don't get into Kelvin)

#### **Laws of thermodynamics**

You can't win: Energy cannot be created - only converted

You can't break even: All systems lose energy (entropy)

You can't quit the game: It's impossible to remove 100% of the energy from a system

#### **Heat transfer**

Convection

Radiation

Conduction

Heat of vaporization

Heat of solidification

### 5.1.9. Heat Systems - Principles

- Heat flows from warmer to cooler
- Heat is radiated as infrared light, so it can be reflected by mirrors (also explains how the radiators on the Space Shuttle work in the vacuum of space)
- Different materials have different abilities to absorb heat (water and metal absorb heat readily, chalk does not.)
- Different materials have different abilities to hold heat (stone and water can hold a great deal of heat, milk-jug plastic cannot)
- Different materials have different abilities to conduct heat (e.g., aluminum conducts heat extremely well, wood very poorly.)
- Power = heat flow rate
- Heat must be applied to a material at its melting point to get it to convert to liquid
- Heat must be applied to a material at its boiling point to get it to convert to vapor

### 5.1.10. Fluid Systems - Components

Pump

Filter

Dehumidifier

**Valve**

Bleed valve

Check valve

Release valve

Ball valve

### 5.1.11. Fluid Systems - Concepts

Compressible

Incompressible

Volume

Area

Density

Pressure

Cavitation

### 5.1.12. Fluid Systems - Principles

- Power = volume change / time
- Power = pressure change / time
- Boyle's Law: Pressure, temperature, and volume are related:  
Hold volume constant and increase pressure, temperature increases.  
Hold volume constant and increase temperature, pressure increases  
Hold temperature constant and increase pressure, volume decreases
- Bernoulli's principle: pressure of a moving fluid is inversely proportional to its speed.

### 5.1.13. Electrical Systems - Components

- Transmitter
- Receiver
- Battery
- Alternator
- Magneto
- Generator
- Circuit**
  - Short
  - Closed
  - Open
- Switch**
  - SPST
  - SPDT
  - DPST
  - DPDT
- Fuse
- Circuit breaker
- Laser
- Fiberoptic cable
- Coaxial cable
- Resistor
- Capacitor
- Transistor
- Diode

### 5.1.14. Electrical Systems - Concepts

- Electrons
- Electromagnetic spectrum**
  - Wave
  - Frequency
  - Amplitude
  - Wavelength
- Volt - measure of electrical potential or “pressure”
- Watt - measure of power
- Ampere - measure of work(?)
- DC
- AC
- Polarity
- Ohm
- Ground
- Radio / television / cellular / pager services

### 5.1.15. Electrical Systems - Principles

- Power = ampere hour
- 1 ampere = 1 coulomb per second
- Ohm's Law: Voltage (E) = Current (I) times Resistance (R)
- If a switch is closed, the circuit is complete
- Frequency is inversely proportional to wavelength

### 5.2. *Concept map*

See the attached ABC Flowcharter diagram.

### 5.3. *Work Keys concepts*

This table shows how the concepts and system components for each of the different technology areas fit into the Applied Technology structure.

|                      | <b>Power Source</b>   | <b>Flow</b>   | <b>Pressure</b>   |
|----------------------|---|---|---|
| <b>Mechanical</b>    | Engine, force or torque applied to one end of the system, flywheel, horsepower, watts, elastic, springs | Gear train, pulley system, levers, cranks, cams   | Force, pressure   |
| <b>Fluid</b>         | Pump, spark plug (gas engine), mechanical system such as brake lever, horsepower, watts                 | Incompressible fluid - force transmitted, fluid flows<br>Compressible fluid - fluid flows, volume changes               | Force, pressure   |
| <b>Thermodynamic</b> | Heat transfer rate  | Heat transfer   | Temperature difference between adjacent objects / regions |
| <b>Electrical</b>    | Battery, generator, alternator, municipal power battery, transmitter, laser, watt, ampere-hours         | Electrical current<br>Circuit, Fuse, Switch, Circuit breaker<br>Fiberoptic cable<br>Coaxial cable<br>Capacitor<br>Diode | Voltage, transmitter power                                |

## 6. Risk Factors

### 6.1. *Market Risks*

We must clearly communicate the scope and content of this curriculum to the market. It should be clear that this product is not designed to replace Industrial Electronics, Hydraulic Power Fundamentals, Pneumatic Power Fundamentals, and Mastering Programmable Controllers.

There is a risk that the market wants a micro level training course in the technologies - which could mean 200 or more hours of content. However, conversations with community-college clients indicate a strong need for a Work Keys Applied Technology course along the lines of this product.

Another risk is that the market really wants a technology-troubleshooting course. Discussions with clients indicate that if the scope of this course is clearly communicated (i.e., system knowledge is a part of troubleshooting, and this course focuses on that) then this course is acceptable.

Additional risks are related to the delivery of the courseware. This curriculum will require a high-end (by 1996 standards) multimedia workstation running Windows 95. Some potential clients may reject the requirement to have a CD-ROM drive on each workstation or other development tools or technologies may appear in the near term that reduce the predicted life of the product.

Finally, the product definition and the sales documentation must make clear that this product will only operate under PLATO Pathways, not DOS CMI.

### 6.2. *Content stability*

The electronics portion of the course is subject to change. Technologies that are on the horizon today, such as GPS, HDTV and PCS may be either a major part of the landscape or moot. This will be addressed (and probably re-addressed) during design and development.

Conversations with clients indicate that the decision NOT to include an in-depth discussion of computer technology is a safe and prudent one. There are many options for "Computer 101" training, and most of those options involve a great deal of instructor-led activities and one-on-one coaching.

### 6.3. *Technology Risk*

Advanced programming such as simulations, and media elements such as digital video and audio, can present development risks.

The highly technical nature of the content will make expert proofing and checking a requirement. Even with that, it is possible that some typographical errors will slip through either in instruction, answer-judging, or feedback. In addition, the desired open-endedness of learner responses in simulations will make exhaustive unit testing and T&M extremely difficult. For those reasons, a thorough beta test program is strongly recommended.

#### *6.4. Budget Risk*

The scope of the content, new activity structure, and media-intensiveness all pose risks to the budget and schedule.

#### *6.5. Schedule Risk*

The scope of the content, new activity structure, and media-intensiveness all pose risks to the budget and schedule.

## **7. Issues**

### *7.1. Design*

Later modules may rely on concepts and terms introduced earlier.

SCANS and Work Keys Applied Technology have very different approaches to the way content is structured. We will target Level 4 of Work Keys.

Work Keys Applied Technology does not address feedback and control, nor does it address the fundamental concept that most systems are designed to convert energy from one form to another. These concepts are rolled into the Work Keys concept of “Flow.”

### *7.2. Synergy with Problem Solving curriculum*

The designs for ITS and Problem-Solving must be complementary. This will require coordination between the design teams.

### *7.3. Content*

Will need input from tactical SMEs re real-world technology problems and who solves them.

### *7.4. Simulations / new interaction widgets*

New widgets will have to be developed for simulations and other interactions (e.g., allowing the learner to assemble system components into a working system). Simulations are a key component of a systems technology course. They allow a learner to manipulate the components of a system and observe their behavior and interaction. Risk associated with hand-crafting simulations can be minimized by adopting an object-based approach to the simulation.

## *7.5. Multimedia*

Audio and video would be used to show real-world systems in operation. Small files and high production values are very nearly mutually exclusive.

### *7.5.1. Video*

TRO has no significant experience with digital video in courseware.

### *7.5.2. Audio*

Audio will take two forms: Read-the-Screen and Sound Effects. Production of sound effects poses risks to budget and schedule.

## *7.6. Assessment & Prescription*

The interaction between ETS and whatever A&P scheme we use needs to be carefully thought out, as it greatly affects the module structure.

## *7.7. Pathways*

Pathways should be able to run the courseware locally and still report scores and student records up to the Internet. If one CD-ROM is not adequate to store the courseware, Pathways should direct the user to load the correct CD-ROM. This should be transparent to the courseware.

## *7.8. Windows 95*

This PRD specifies Windows 95. Supporting 3.x will give us difficulties with maintenance and support, and may limit the tools we can use, such as speech synthesis

## Appendix A: Work Keys Applied Technology

The ACT Work Keys Applied Technology test looks at the basic principles of mechanics, electricity, fluid dynamics and thermodynamics as they apply to machines and equipment found in the workplace. Because the Applied Technology skill scale is oriented toward reasoning rather than mathematics, the emphasis is on problem solving and troubleshooting. Technology is divided into four systems; mechanical, electrical, thermodynamic, and fluid dynamic. For each of these systems, Work Keys Applied Technology emphasizes:

- What information is important to the problem
- What is the best method for analyzing and solving the problem
- understanding the principles that guide the technology - what the principle is, and when, why, and how it is used.

According to Work Keys Applied Technology , all systems have four components: a power source, flow, pressure, resistance.

Note - Work Keys Applied Technology leaves out two important characteristics of systems: That the primary purpose of most systems is to convert energy from one form to another, and that most systems incorporate sensing, feedback and controls. Work Keys apparently rolls them into the four concepts listed above. According to the Advisory Panel, these are critical items that should be called out separately. This issue will be addressed in the Phase II and III designs.

Work Keys Applied Technology also involves knowing how to use tools and measuring equipment, from basic hand tools to voltage testers, vacuum and pressure gauges, flow meters, and multimeters.

### Level 3 Skills

- Apply the elementary principles underlying the operation of technical systems to solve problems within those systems.
- Understand the operation of basic hand tools and simple electrical tools, subsystems of basic machines, and uncomplicated tools.
- Recognize obvious symptoms when diagnosing a problem.
- Determine, with efficiency and logic, what to check first when faced with a malfunctioning system or machine usually containing 2 to 5 components that are potential sources of the problem.
- Solve problems that involve a one-step solution path.

### Level 3 Systems

- Sprinkler
- Component stereo system
- Boiling water

**Level 4 Skills**

- Apply elementary principles underlying the operation of physical systems, such as the effect of resistance on flow, to solve a problem.
- Comprehend physical principles that are more abstract, less intuitive, and less observable than those at Level 3.
- Understand the operation of moderately complex tools, machines, or systems such as home appliances, pulley-driven equipment, or piping systems that carry more than one fluid.
- Recognize and identify information relevant to solving the problem while disregarding extraneous information.
- Determine, as efficiently as possible, what to check first when inspecting a malfunctioning system or machine usually containing up to 10 components that are potential sources of the problem.

**Level 4 Systems**

- Electrical circuits that include switches, series and parallel connections, batteries and/or outlets, lights.
- Block and tackle
- Cooling fins

According to the MRD, most jobs which involve Level 5 or 6 skills are technical jobs where the worker would need in-depth knowledge such as that provided in the Technical Skills curricula or in a Vo-Tech program. For that reason, the MRD suggests that we only teach to Level 4. However, it is instructive to look at the Level 5 and 6 skills and systems to see what we would be leaving out.

**Level 5 Skills**

- Use the basic principles of mechanics, electricity, fluid dynamics, and thermodynamics in moderate and advanced applications.
- Understand complex machines and systems, such as the operation of gasoline engines, complex appliances, or an electrical system in a building.
- Solve problems that include a larger problem space, more extraneous information, and more technical terms than those at Level 4.
- Manipulate two or three variables within a system to solve a problem.
- Reduce the problem space to the point of knowing what to check first when inspecting a malfunctioning system or machine usually containing more than 10 components that are potential sources of the problem.

**Level 5 Systems**

- A string of decorative miniature lights (series or parallel)
- Electrical circuits that include fuses or dimmer switches
- Lawn mower engine
- Belt-driven record player

**Level 6 Skills**

- Use principles of mechanics, electricity, fluid dynamics, and thermodynamics interacting in advanced applications.
- Use subtle, less visible cues to determine the source of the problem with a machine or a tool.
- Troubleshoot complex systems in which a variety of mechanical, electrical, thermal, or flow faults are potential sources of the problem.
- Choose the appropriate tool or piece of diagnostic equipment to accomplish a certain task. (Note that this is Task 3 of SCANS.)

**Level 6 Systems / Problems:**

- Using circuit diagrams to build electrical circuits that include components such as fuses, motors or thermostats.
- Reconfiguring kitchen wiring including calculating loads on different parts of the circuits.
- Automobile hydraulic lift
- Bicycle with sprockets and chain drive
- Compressor of an air-conditioning system (or heat pump or refrigerator)

Note: though Work Keys focuses on problem solving and troubleshooting technology, we've decided to separate the problem solving skills from the system knowledge. This course should focus on the basics of the technology - the principles of mechanics, electricity, fluid dynamics and thermodynamics.

## Appendix B: SCANS

The Technology section of the SCANS report focuses on selecting equipment and tools, applying technology to specific tasks, and maintaining and troubleshooting technologies. Specific tasks within each of these areas are ranked from Lower to Higher. Examples from the SCANS report are given below.

### **Selects Technology**

Judges which set of procedures, tools or machines, including computers and their programs, will produce the desired results. Includes determining desired outcomes and applicable constraints; visualizing the necessary methods and applicable technology; evaluating specifications; and judging which machine or tool will produce the desired results.

Lower: Molding operator removes part from mold, selects tools to trim it.

Higher: Supervisor selects a new machine by preparing performance requirements and evaluating vendor presentations and literature.

### **Applies Technology to Task**

Understands the overall intent and the proper procedures for setting up and operating machines, including computers and their programming systems. Includes understanding how different parts of machines interact and how machines interact with broader production systems; on occasion installing machines including computers; setting up machines or systems efficiently to get desired results; accurately interpreting machine output; and detecting errors from program output.

Lower: Purchasing agent runs year-end computer reports.

Higher: Manufacturing inspector determines whether a process is in compliance with regulations and determines what changes need to be made to bring it into compliance (i.e., add a guard to a foot pedal).

### **Maintains and Troubleshoots Technology**

Prevents, identifies, or solves problems in machines, computers, and other technologies. Includes identifying, understanding, and performing routine preventative maintenance and service on technology; detecting more serious problems; generating workable solutions to correct deviations; and recognizing when to get additional help.

Lower: Machine operator fixes a jam in the machine.

Higher: Programming technician draws up requirements and testing plans to test the release of a new information management system.