

DRAFT PRELIMINARY ONE

**SERIES 200 MODEL 16
SELF-PACED LEARNING GUIDE**

PRELIMINARY JULY 1983



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Before You Begin This Course

Materials Needed to Complete This Course

Following is a list of equipment and materials needed to complete this course. Contact your local HP Sales Office immediately if you do not have any of the items listed.

The Series 200, Model 16 Self-Paced Learning Package (P/N 35142-90002) which includes:

1. The *Series 200, Model 16 Self-Paced Learning Guide* (P/N 35142-90001)
2. Manuals:
 - 9816 *CE Handbook* (P/N 09816-90039)
 - 92171 *V/W/Y Installation Note* (P/N 92171-90000)
 - HP 9816 Service Manual* (P/N 09816-90030)
 - HP Series 200 Computer Pricing Information Configuration Guide HP Series 200 Computers* (P/N 5953-4659)
3. Tools:
 - Antistatic pouch (P/N xxxx-xxxx)
 - Micro-jumper cable (P/N 8120-4302)
4. Final Review Envelope (P/N 35142-90003) to be given to the course coordinator before the course begins.

Model 16 System Hardware

1. Series 200 Model 16S or Model 16A with a 98256A 256K RAM board and BASIC 2.0 (RAM)
2. 9121S/D or other available HP-IB 5¼" or 3½" flexible disc drive including its operating/installation manual

Required Special Tools:

1. Processor board extender cable (P/N 09816-67006)
2. Serial DataComm loopback connector (P/N 98626-67950)
3. Series 200 System Test Disc, 3½" (P/N 09800-10330) or Series 200 System Test Disc, 5¼" (P/N 09800-10530) as appropriate
4. *Series 200 System Tests Manual* (P/N 09800-10031)

Note: All items in this list are found in the Dealer Support Kit (P/N 09816-83401).

Standard Tools:

1. Needle nose pliers (P/N 8710-0004)
2. Flat-blade screwdriver (P/N 8730-0001)
3. Antistatic service kit (P/N 9300-0794)
4. Alignment tool (P/N 8710-1388)
5. #2 Pozidriv screwdriver (P/N 8710-0900)

Other Useful Items (not required for completion of the course)

PASCAL 2.0 (RAM based)

BASIC 2.0 (ROM based)

HPL 2.0 (ROM based)

92171 V/W/Y

82905B option 002 or other suitable HP-IB printer

7470A option 002 or other suitable HP-IB plotter

Course Completion Checklist

HP Series 200 Model 16 Self-Paced Learning Package

Lesson Title	Date Completed	Time Required	Supervisor's Initials
1. General Information	_____	_____	_____
2. Get to Know the Model 16	_____	_____	_____
3. Block Structure	_____	_____	_____
4. Take It Apart	_____	_____	_____
5. Model 16 Self-Checks and Peripheral Tests	_____	_____	_____
6. Fix It	_____	_____	_____

Program Completion Date _____

Student's Signature _____

Company Name _____

Address _____

Final Review Administered By: _____ Date: _____

How to Take This Course

1. Give the sealed Final Review Envelope to your supervisor or administrator.
2. Read each lesson in sequence.
3. Observe all warning notes before attempting the defined procedures!
4. Follow the instructions given before or after each lesson, i.e., Do Quiz 1 Now, Start Lab Project 2 Now, etc. If you correctly answer 8 out of 10 quiz questions (quiz answers are located in Appendix B), continue with the course. If you miss 3 or more of 10 questions, go back and review the lesson and retake the quiz.

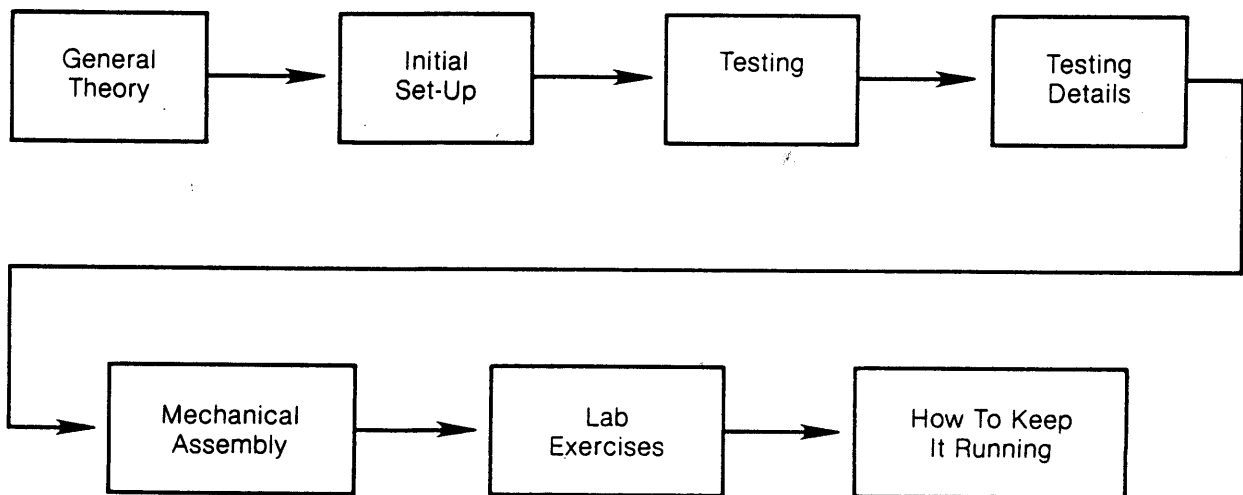
After completing the course, complete the Final Review Package at the end of the guide. If you score less than 80%, review the areas you had trouble with and retake the Final Review.

Course Structure

The sequence below explains the plan of this self-paced guide. The elements of the flowchart are the major points to be covered to repair the products to the modular (board) level. This guide does not intend to develop good electronics technicians. It is designed to teach good technicians to repair the products covered to the modular level only.

WARNING!

Always remove AC power before opening any electrical device. If the service requires that power be on while protective covers are removed, proceed with extreme caution. Be careful not to touch any exposed areas. Failure to do so can result in serious injury. Heed all WARNING—HAZARDOUS VOLTAGE labels.



Course Description

This course will prepare you to repair a malfunctioning Model 16 using the service procedures described in the *9816 Service Manual* and the *9816 CE Handbook*.

Achieving the major objectives of this course will enable you to meet the mission of the course. These are the major objectives:

- List the functions associated with each circuit board or assembly using the terms used in the *Service Manual*.
- Identify functional blocks on the block diagram which are and are not tested by the Model 16 self-test.
- Disassemble, assemble, align, and adjust a Model 16 to the standards provided in the *Service Manual*.
- Troubleshoot from the outside of the unit at least one problem in each functional area of the Model 16.
- Identify the available documentation for the Model 16.
- Demonstrate knowledge of the Model 16 service policy.

This course deals with troubleshooting and replacement to the assembly level. Component level repair is beyond the scope of the course.

Course Objectives

- The primary goal of this self-paced guide is to train an individual to repair the products covered in the most direct and efficient manner through logical troubleshooting to the modular level.
- To teach efficient troubleshooting techniques.
- To enhance the technical knowledge on the products covered.
- To train engineers or technicians to service the products through hands-on testing and experimenting.
- This guide will enhance the repair person's technical knowledge and enable the individual to reap greater benefits from Product Training and/or Service Training classes. These classes are designed for more complex hands-on classroom instruction.

NOTICE!

This guide is intended for use by qualified service personnel only. Normal safety precautions must be observed at all times while servicing electronic equipment.

Many Hewlett-Packard products are designed to be easily repaired to the modular level. Hewlett-Packard has used this approach in designing all Series 200 products.

This self-paced learning guide supplies the basic information for modular repair. Operator errors, installation configuration problems, program coding procedures, and data communications problems are areas not covered in detail and are part of other training programs available from HP through Customer Training. Consult your local training catalog for more information.

All the material and information needed to repair the standard product are included in this guide.

A reference list to supplemental information such as Owner's Manuals, Service Manuals, etc., is included at the end of this guide in the Bibliography.

General Information

Lesson 1

This section will supply you with some basic information about the Model 16. You will also become familiar with the course format and documentation.

Objectives:

When you have completed this lesson, you should be able to:

- List and demonstrate knowledge of any of the features advertised for the Model 16.
- Determine, referring to the Model 16 documentation, if a specific configuration is allowed or supported.
- Determine if a specific environment is supportable for the Model 16.
- List the part numbers, general contents, source and key information contained in the following documents:
 - Service Manual
 - CE Handbook
 - Configuration Guide
 - Service Notes
- Using the service manual and pricing information sheet, demonstrate knowledge of the service policy and support strategy, including warranty and typical service contracts.

Instructions

On the following page is a list of topics to be covered in this lesson. Each topic has one or more things to do listed in the column to the right.

Each item in the right-hand column should be completed in the listed order. If you are asked to read, you should read that reference and any others that you see pertaining to the subject. You may find that you prefer one manual over another; however, since you may be asked questions pertaining to a specific document, you should read them all.

When you have finished reading each of the learning activities, cross it off the list and go on to the next. Continue crossing off topics until you have finished the list under Lesson 1.

Lab projects immediately follow the topics list.

When you have completed all the "Learning Activities," take the quiz at the end of the lesson. You may use any appropriate reference to answer the quiz questions.

If you miss any quiz questions, review the appropriate references until you are comfortable with the material, then go on to the next lesson.

Topics to be Covered

Documentation Familiarity

Documentation Availability

Model 16 Description

Product Description

With the Model 16, HP gets personal about technical computing!

- Small footprint.
- Detachable keyboard with rotary control knob and 5 softkeys (10 with [SHIFT]).
- 9" CRT with 25 lines of 80 alpha characters.
- 300 Vertical × 400 Horizontal graphics.
- 2 backplane slots.
- Built-in HP-IB up to 60K bytes/sec, over 300K bytes/sec with DMA.
- Built-in serial interface, up to 19.2K Baud.
- Complete Series 200 architecture. Same performance as Model 26/36.
- New Series 200 Boot ROMs. Boot up from 3½" or 5¼" flexible disc drives on the Model 16A with Boot ROM 3.0L, or from any supported mass storage device on the Model 16S with Boot ROM 3.0, including SRM.
- System clock and programmable beeper. The same as on the Model 26/36; nothing was left out.

Learning Activity

- Review all documents listed on the required materials list (page iii) and any available marketing literature
- Read: *9816 Service Manual*, Section "9816 Documentation"
- Read the following product description
 - 128K or 256K bytes RAM on the processor board. Expandable to 640K or 768K bytes using the two backplane slots. With the backplane expander, up to 4.6M bytes!
 - Runs all Series 200 2.0 language systems and extensions. Series 200 software compatibility means software investment protection.
 - Building-block mass storage. Only pay for the mass storage desired. With SRM, local mass storage may not always be necessary.
 - Passes VDE Level B and FCC Class B! Another example of HP's continuing commitment to quality and performance.
 - MC 68000 16/32-bit microprocessor.
 - 2382A terminal case parts.
 - 7 levels of prioritized interrupt.
 - 50/60Hz refresh rate, jumper or software selectable.
 - Complete self-tests upon power-up to 90% confidence.

Hardware Support

Warranty: The Model 16 has a 90-day Return-to-HP Warranty. Although not common for Desktop Computers, it is expected to become the low-cost warranty strategy for HP's personal computation products and peripherals. For the traditional desktop user, on-site service is also available. If a customer purchases a one-year on-site service contract within two weeks of purchasing a Model 16, the warranty is upgraded to the terms of the service contract. The customer receives 15 months of on-site service.

Service Contracts: FMMC and PMMC service contracts are available for the Model 16, as they are for the Model 26 and Model 36.

Service without Contracts: If the customer does not choose service under contract, the following service is also available:

- **On-site Repair (Time and Materials):** HP will travel to the customer site and repair the unit. The customer is billed for CE travel and repair time and all materials used in the repair.
- **Return to HP:** The customer pays to ship the unit to the closest HP Field Repair Center where HP repairs the unit and returns it to the customer. HP bills a Standard Repair Charge in most cases.

Service Notes: Service Notes for the Model 16 are distributed in the *Support Update Supplement* which is part of the *Support Update* magazine provided with dealer and customer cooperative support agreements. In order to support the Model 16, the repair person must have a copy of all the Service Notes to date and either a *CE Handbook* or *Service Manual*.

Dealer Service

Dealer Repair Center (DRC): The customer who buys a Dealer Repair Center contract can deliver his failed unit to the dealer, who verifies the failure. An HP CE actually goes to the dealer's site weekly to repair units on contract.

Dealer Cooperative Support: The customer takes his unit to a qualified and trained HP dealer, who will repair the unit to the assembly level and charge a competitive price.

Customer Repair

If a customer chooses to perform his own repair, the following program is provided.

Customer Cooperative Support Program: The customer buys a self-study hardware repair training course from HP. HP also provides a Hardware Subscription Service (HSS) and a Technical Assistance Service (TAS). After being qualified by HP, the customer is able to carry out assembly-level-exchange repairs on his own equipment.

Software Support

The Model 16 is a member of the Series 200 family and thus uses the same language systems, application software, and software support services as other Series 200 products.

Software Information Service (SIS): Includes the *Software Status Bulletin (SSB)*, *Communicator* magazine, Phone-in Consulting Service (PICS), manual updates, and bug reporting by telephone.

Software Notification Service (SNS): includes the *SSB* and *Communicator* magazine.

SIS with Updates: The existing SIS available on the Series 200 language systems plus all updates to the existing operating system.

SSS (Software Subscription Service): includes *SSB*, *Communicator* magazine, manual and software updates, and bug reporting by mail.

Customer Courses: Series 200 customer programming courses are applicable to the Model 16.

Now, continue on with the list.

Topics to be Covered

Model 16 Configurations

Environmental Limitations

Service Policy

Learning Activity

- Read: *Configuration Guide, HP Series 200 Computers*
- Read: *9816 CE Handbook*, Chapters 1 and 2
- Read: *9816 Service Manual*, Chapter 6, "Replacement Parts," for service strategy in replacing or exchanging parts

Read: *9816 Service Manual*, "Environment" section

Quiz Introduction

The quiz will serve three main functions:

1. Provide feedback to you on your understanding of the material covered in this section.
2. Help you become familiar with the reference documentation you will be using to repair Model 16 computers.
3. Help you quickly build confidence in your knowledge of the Model 16.

Since you have studied the material suggested on the preceding pages, you will probably do well on the quiz. The answers to the quiz are in Appendix B. You can use any available materials to assist in answering these questions.

Quiz 1

General Information

1. List the primary features of the Model 16 including processor, clock rate, price, CRT diagonal size, and built-in interfaces.

2. How much RAM is built into the Model 16A, and what board is it on? How about the Model 16S?

3. Are there any differences between the Boot-ROM capabilities of the Model 16A and 16S? If any, what are they?

4. Which Model 16's do not have graphics, and how can you tell if a unit does have graphics capabilities?

5. Is the 9134 supported on the Model 16A? Are there any limitations?

6. How many HP 98628A cards can be installed in the Model 16A? Model 16S?

7. What is the maximum data rate for the Model 16 built-in 98626 serial interface in bits/second?

8. What is the alpha screen size (in characters/line and lines/screen) and graphics dot size for the Series 200, Model 16, Model 26, and Model 36?

9. Which of the following systems is not supported? Each system contains a Model 16S.

Operating System		Mass Storage	Printer	Plotter
a. BASIC	2.0	9133	82905	none
b. PASCAL	2.0	9135	82905	none
c. PASCAL	2.0	82901M	2601A OPT 826	9872C
d. HPL	2.0	9121D	2673G	none
e. HPL	2.0	9134A OPT 010	2631G	none

10. What is the maximum temperature to which a Model 16 should be subjected during storage?
During operation?

11. What is the general operating environment for the Model 16?

12. What is the part number of the 9816 *Service Manual*?

13. How does the information contained in the *CE Handbook* chapter compare to that available in the *Service Manual*?

14. Are Service Notes required in order to repair a product?

15. If a Model 16 were to fail 2½ months after shipment from HP, would it be in Warranty?

16. If a Model 16 were to fail in Warranty, what would the customer do to get it fixed?

17. What is a PMMC, and what is the PMMC for the Model 16?

18. What two service programs are available for dealers who wish to service Model 16's?

19. What is the difference between the 09816-66561 board and the 09816-69561 board?

Get to Know the Model 16

Lesson 2

In this lesson you will familiarize yourself with the Model 16: installation, reading the power-up self-test, configuring a system, and loading an operating system.

Objectives

- Describe the functions and operations of all connectors and any switches built into the Model 16.
- Configure and install a representative Model 16 System.
- Describe the meaning of the self-test message and Boot list which appear on the CRT at power-up.
- Select and load an operating system in a given Model 16 System.

Topics to be Covered

Model 16 Configuration

Mass Storage Configuration

Optional Peripheral Configuration

Model 16 Boot List

Self-Test CRT Messages

Instructions

Before starting this lesson make sure you have all the equipment listed in the "Before You Begin This Course" section (page iii).

Listed below are the topics to be covered in Lesson 2 and learning activities. When you have finished reading about each topic, cross it off your list and go on to the next. You will find labs at the end of the topics list.

When you have completed the "Lab" section, take the quiz which follows. You may use any appropriate reference to help you answer the quiz questions. If you miss any quiz questions, review the appropriate references until you are comfortable with the material, then go on to the next lesson.

Learning Activity

- Read: *Installation Manual*, Chapter 1
- Read: *Installation Manual* for mass storage device and 92171 V/W/Y
- Read: *Installation Manual* for all optional peripherals
- Read: *Installation Manual*, Chapter 2
- Read: *Installation Manual*, Chapter 3

Lab Projects Introduction

This will be your first opportunity to get your hands on a Model 16. You will be working on the following tasks:

- Configure and install a minimum Model 16 System.
- Describe the meaning of the self-test message and Boot list which appear on the CRT at power-up.
- Select and load an operating system in a given Model 16 system.

Feel free to use your *9816 Service Manual*, *Installation Manual*, and *CE Handbook* during the labs. This documentation is provided to make the repair of the Model 16 as simple and straightforward as possible.

Lab Project 1

Model 16 Installation

Introduction

In this lab you will install your Model 16 system. Although you will find the task of setting up the Model 16 very simple, pay special attention to the "Setting the RAM Address" and "Setting the Datacomm Line Control Switches" sections. These are the sections most commonly misunderstood.

Instructions

Follow the instructions in the *Installation Manual*, Chapter 1, "Unpacking and Set-Up" to install your Model 16 system. Configure the machine with 512K bytes of memory (or 384K bytes if using a Model 16A), a mass storage device with either a 3½" or 5¼" flexible disc drive disc, and optionally, a 92171 V/W/Y tilt-and-swivel device, a printer and plotter—on either the HP-IB or serial interface. If available, also install a ROM operating system board.

When your Model 16 system installation is complete and the self-test indicates that everything including the full 512K or 384K bytes of RAM has passed, go on to Lab 2.

Lab Project 2

Self-Test Introduction

Introduction

In this lab you will be introduced to the Self-Test LEDs of the Model 16.

Instructions

- Turn off the Model 16.
- Turn the Model 16 so that the back of the unit is facing you.
- Remove the I/O backplane cover or I/O card.
- Remove any card that is in the lower accessory slot and reinstall it in the upper accessory card slot if the slot is not already taken.
- Observe the LEDs which are visible through the I/O backplane hole.
- Configure the Model 16 for Continuous Self-Test.
- Turn the Model 16 on.
- Watch the LEDs light up in different patterns as the self-test progresses.
- Compare the light patterns with the Self-Test Status Codes in Appendix B of the *Installation Manual*.
- Restore your Model 16 to its original configuration.

Lab Project 3

Loading an Operating System

Introduction

In this lab you will select and boot an operating system into the Model 16. You will also become familiar with the concepts of the Default Boot Selection and how to override it.

Instructions

Follow the instructions in the *Installation Manual*, Chapter 2, "Loading an Operating System," to load RAM-based BASIC, HPL, or the Pascal operating systems if more than one operating system is installed. Select each available operating system by both manipulating the default boot selection and overriding the default. Also, if a ROM-based operating system is installed, select either a RAM-based operating system in the mass storage device or the ROM-based system.

Quiz 2

Get to Know the Model 16

1. Imagine a Model 16S with 768K bytes RAM made up of the internal RAM and two 98256A 256K RAM boards. What are the switch settings on the two RAM boards and the RAM address of the internal RAM if the system is configured as recommended in the *Installation Manual* for the Model 16?

	SW2	SW6
1 RAM	-----	
2 RAM	-----	
	SW1	SW8
Internal	-----	

Use a 0 to represent an open switch and a 1 to represent a closed switch.

2. What switch is used to set the Internal HP-IB System Controller status? Which position is "NOT SYSTEM CONTROLLER"?

3. What are the two ways to select the CRT refresh rate?

4. What is the large connector on the left side of the rear panel of the Model 16? Is this a serial or parallel interface? What standards does the interface comply with?

5. Where is the 115/220VAC line-select switch for the Model 16?

6. What is the select code of the built-in HP-IB interface?

7. Imagine a Model 16S system with a dual flexible disc drive (9121D or 82901M) and a ROM-based HPL 2.0 System. The dual flexible disc drive has BASIC 2.0 in the left drive (drive #0) and a PASCAL BOOT disc in the right drive (drive #1).

If the dual flexible disc drive is at address 0, what will be the default boot-up selection?

What if the flexible disc drive is at address 1?

If the flexible disc drive is at address 1, how would you boot in PASCAL?

8. If the self-test writes "KEYBOARD MISSING" on the CRT, does this mean the Keyboard is not installed?
-

9. When the self-test writes "HP98626 AT 10 FAILED", what is the select code of the suspect I/O card?
-

10. If the Model 16 self-test writes "RAM GONE ABOVE FFC0000" at the top of the screen and fails to continue, what is the most probable cause of the problem?
-

11. Name a simple user-accessible adjustment which could cause the screen of the Model 16 to stay dark when the Model 16 is turned on.
-

Block Structure

Lesson 3

In this lesson you will learn how the basic functioning blocks of the Model 16 act and interact. This information will be useful in understanding the self-tests and choosing which board to replace if the self-test indicates a failure.

Objectives

Describe any of the blocks represented on the Block Diagram in the *9816 Service Manual*, including the following major blocks:

- PROCESSOR
- ALPHA
- GRAPHICS
- DISPLAY
- KEYBOARD
- POWER SUPPLY

Locate the Basic Block Diagram and Expanded Block Diagrams of the Model 16 in the *Service Manual* and *CE Handbook*.

Topics to be Covered

Expanded Block Diagram

Instructions

The topics to be covered in this lesson are presented below in the usual format. Do the reading for the topic and cross it off when you have finished. As you read the material, follow the explanations on the 9816 Expanded Block Diagram. This will help you see the entire picture. You will probably be surprised to find that the Model 16 is a straightforward, easy-to-understand computer from the assembly-level point of view.

When you have finished the reading, take the quiz at the end of this lesson. Remember, use any appropriate reference in answering the quiz questions.

Answers to the quiz questions can be found in Appendix B. If you miss any questions, you should review the appropriate references until you are comfortable with the material, then go on to the next lesson.

Learning Activity

- Read: *9816 Service Manual*, Chapter 3
- Study: 9816 Block Diagram and Expanded Block Diagrams in the *9816 Service Manual*
- Read: "Block Structure Introduction," included in this lesson.

Block Structure Introduction

As shown in the 9816 Basic Block Diagram in Chapter 3 of the *Service Manual*, the Model 16 CPU interfaces with the video display and keyboard and other connections to the outside world through separate blocks. There is no direct connection from the 68000 to the outside of the computer. These separate blocks are referred to as "peripherals" (i.e., they are peripheral to the 68000). Since these peripherals are internal to the computer, they are called "internal peripherals."

The internal peripherals of the Model 16 have three functions:

1. communicating with the 68000
2. communicating with the outside connection—keyboard, video display, etc.
3. translating between the 68000 and the outside connection.

The third function is usually a large task and is frequently performed by a processor of its own—often called a "peripheral processor."

The operation of the Model 16 includes many data transfers between the 68000 and the internal peripherals of the system. The 68000 initiates a communication by putting the address of the appropriate internal peripheral on the address bus. The address bus decoders turn that address into a single line chip select which points to and enables the desired peripheral. The 68000 determines whether it wants to write to or read from the peripheral with the R/W line.

So, how many address lines are required to access all the different internal peripherals?

When you have answered this, continue.

The lower order address lines are often used to select registers or RAM within the selected peripheral. The peripheral acknowledges that a communication has taken place by toggling DTACK (Data Transfer ACKnowledge). This DTACK line is very important in knowing what internal peripherals are installed and operational. Now, DTACK for the 8250, 8041 and TMS 9914 is generated by the chip select address decoder on the processor board.

Where is DTACK for the alpha and graphics board generated? When you have answered this, continue.

If the 68000 is trying to talk to the 8250 and the 8250 has failed, a DTACK will be returned since the circuit that generates it is still working, but the communication will have been lost. If the communication was a write from the 68000, it will never know the difference. If the communication was a read in to the 68000, it will read incorrect data.

If the 68000 was trying to write to and read from the alpha board memory and the alpha board timing and control logic were malfunctioning, what might the symptoms be? Note: Approach this problem as in the preceding paragraph.

Quiz 3

Block Structure

1. On which board is the chip select address decoder for internal peripherals?

2. On which board are the Boot ROMs?

3. Which address lines are used to designate the appropriate internal RAM byte to access?

4. What model processor is used to interface the 68000 to the keyboard?

HP-IB? _____
Serial datacomm interface? _____
5. Which 68000 address lines go to the alpha and graphics board?

6. Through which boards does the 68000 data bus pass to get from the 68000 to the graphics board?

7. Which block arbitrates whether alpha or graphics information will be displayed at a given dot?

And what board is the block on?

8. On which assembly are the display characters generated?

What is the maximum number of characters which can be displayed?

9. What are the main functions performed by the display board?

10. Could a stuck data line on the 8250 prevent the self-test from executing?

What if the data line were held high on the alpha board connector to the display board?

11. In which block are the real time clocks actually performing the counting?

12. Could a stuck data line on the 6845 CRT controller prevent the 68000 from writing information into graphics RAM without errors?

Take it Apart

Lesson 4

In this lesson you will learn to take your Model 16 apart and put it back together safely and efficiently. Learning the techniques and procedures in this lesson will help you avoid causing problems while you are working on your computer.

Objectives

- Describe and use correct handling and packaging procedures for static-susceptible parts.
- Identify and list all field-replaceable units (FRUs), identified in the *Service Manual*, by:
 - Visual inspection
 - Assembly numbers (e.g., A11, A91)
 - Part numbersand
 - Identify any board revisions
 - Identify whether any assembly is for replacement or exchange
- Remove and replace all FRUs according to the procedures presented in the *9816 Service Manual*.
- Set all the adjustments on the display board and set all the switches on the alpha board as specified in the *Service Manual*.
- Correlate the blocks on the 9816 expanded block diagram with the boards mentioned above.
- List and order any special tools described in the *Service Manual*.
- Clean the product according to the procedures provided in the *9816 Service Manual*.

Topics to be Covered

Handling and Packaging Procedures

Block Diagram Identification

Board Identification

FRU Removal and Identification

Cleaning

Instructions

Listed below in the usual format are the topics to be covered in this lesson. Complete the items indicated for each of the topics and cross them off as you finish.

At the end of the list you will find additional reading material on handling guidelines and special tools. Study this material before going on.

When you have finished the required reading for this lesson, you will have a chance to practice what you have learned.

When you have finished the entire lesson, take the quiz that follows. Remember, use any appropriate reference in answering the quiz questions.

Answers to the quiz questions can be found in Appendix B. If you miss any questions, you should review the appropriate references until you are comfortable with the material, then go on to the next lesson.

Learning Activity

- Read: *Service Manual*, Chapter 4, Inset
- Review: *Service Manual*, Chapter 3
- Review: *9816 Service Manual*, Chapter 6
- Read: *9816 Service Manual*, Chapter 4
- Read: *9816 Service Manual*, Chapter 4, "Clean the Computer" section

Hewlett-Packard Static Handling Guidelines

Typical Electrostatic Voltages

All nonconductive materials are capable of storing a static charge. The charge is generated whenever two nonconductive materials are separated from each other. Whenever a charged nonconductive material and a conductive material come in contact with each other, a discharge occurs.

Desktop computers, like most modern electronic equipment, are susceptible to damage from electrostatic discharge (ESD), especially when the case has been removed. To prevent further damage to the unit while it is being serviced, the engineer must follow approved antistatic procedures, and be aware of the following misconceptions:

"If I don't feel a static zap, then it didn't happen." No. You cannot feel a static discharge of less than about 400 volts, but most modern integrated circuits (and some passive components) can be damaged by discharges of 400 volts or less.

"Static is only a problem in low-humidity areas." No. Static is more of a problem in low-humidity areas because the charge can build much higher before it leaks off the surface, but it is also very much a problem in high-humidity areas. You just *feel* the discharges less often. The following table shows the electrostatic voltages that can build up during normal activities, in both humid and dry environments.

Electrostatic Voltages

Means of Static Generation	10% to 20% Relative Humidity	65% to 90% Relative Humidity
Walking across carpet	35,000	1,500
Walking over vinyl floor	12,000	250
Worker at bench	6,000	100
Vinyl envelopes	7,000	600
Common poly bag picked up from bench	20,000	1,200
Work chair padded with polyurethane foam	18,000	1,500
Sliding plastic box on carpeted bench	18,000	1,500
Pulling tape from PC board	12,000	1,500
Skin packing PC board	16,000	3,000
Triggering standard solder remover	8,000	1,000
Cleaning circuit with eraser	12,000	1,000
Freon circuit spray	15,000	5,000

"Static-sensitive parts are safe when they are mounted in their assemblies." No. A static-sensitive part is never safe. The assembly may minimize the risk to the part through external connections, but it may increase the risk to the part by providing a channel for the charge into the chip from elsewhere on the assembly. Also, it does nothing to protect the part from induced charges, perhaps through the metal lid on the part.

"Only MOS parts are static-sensitive." No. Most common parts (MOS, LS-TTL, S-TTL, LINEAR) can be damaged by the discharge levels common in normal repair operations.

"Static damage will be apparent—the machine will fail." Not necessarily. Many times, a static discharge will degrade a chip to a point where it still works, but will fail much sooner than normal.

Remember, ESD can cause two types of failure: immediate catastrophic failure and intermittent failures. The intermittent failure is, of course, the greatest concern, as it can make troubleshooting very difficult.

Static damage can, and should, be prevented during the course of repair. Following these suggestions will help you prevent further failure of the product you are repairing:

1. Use a static-safe workstation. At a repair bench, this can consist of a grounded conductive work surface, a grounded wrist or heel strap, a grounded soldering iron, and an ionized air blower directed over the workstation. Keep all insulators (coffee cups, paperwork, packing material, etc.) far away from static-sensitive devices; they are notorious static generators.
2. Keep all assemblies and components in their conductive packages until needed. This will bleed off any static charge before it causes damage. When the part is needed, unpack it only at a static-safe workstation, and only while you are grounded. If you must set the part somewhere, place it only on the conductive mat.

3. Handle PC boards by the edges or the ejectors. DO NOT TOUCH any component, trace, or connector.
4. Keep your clothing away from static-sensitive parts, even when using heel and wrist straps, as charge on clothing is often not bled away.
5. DO NOT USE ERASERS to clean contacts. (They generate lots of static, and also tend to rub off the gold.)
6. Connect the chassis of the instrument you are working on to the grounded mat, so that it will remain grounded even when you remove the power cord for service. (The ground jumper should have a 1 megohm resistor built in to protect you in case of a ground fault in the instrument.)

The key to preventing ESD damage is, therefore, not preventing ESD, but conducting static discharge away from static-sensitive parts, and preventing the buildup of static in the first place. Both of these are accomplished through use of wrist and heel straps, as well as conductive mats.

If you follow these precautions, you, the machine, and the parts you are using will all be at the same voltage potential, and there will be no static discharge — hence, no damage.

Description of Special Tools

Look up the contents of the Dealer Support Kit at the end of Chapter 6 in the *9816 Service Manual*. These are the special tools required for servicing the Model 16. As you can see, the system test disc is available in two different sized media. Both sizes will be needed for most repair environments. You should already have the Expense Tool Package.

Lab Projects Introduction

This lab is provided to give you practical experience with the most efficient techniques for disassembling and reassembling a Model 16. These techniques, developed at Hewlett-Packard, will reduce the potential of static damage, case part damage, and reduce the time required for the operation.

Lab Project 4 Field Replacement Unit Removal

Using the *Service Manual*, perform the following operations. Check off each item as it is completed.

1. Remove the top cover of the Model 16.
2. Identify all the major assemblies of the Model 16, referring to the *Service Manual*, Figure 4-1, "Computer Assembly Locations."
3. You should have enough antistatic pouches to package every board in the Model 16. Get out one of the pouches. First, review the CAUTION at the beginning of the *9816 Service Manual*, Chapter 4, and the Hewlett-Packard Static Handling Procedures, then remove the processor board using the instructions in the *Service manual*.
4. Using the same procedure as in 3 above, remove the alpha and graphics boards.
5. Remove the display board. Remember not to force any parts. Also, the single screw which holds the display board is toward the back left side of the Model 16. Now, remove the display board.
6. Using this same procedure, remove the backplane connector board.
7. Following the instructions in the *Service Manual*, remove the power supply. Notice that the power supply basket should not be removed from the chassis.
8. Finally, remove the bezel and side covers. The assembly that remains, including the power supply basket and cover, is the chassis assembly (09816-67008).

Quiz 4

Take It Apart

1. True ___ or False ___ Grounded conductive mats should be used only during dry weather.
2. True ___ or False ___ Grounded wrist straps should be used when packing or unpacking static-susceptible assemblies.
3. True ___ or False ___ TTL parts are not static-susceptible.
4. Turn to Figure 4-5 in the *Service Manual*. What is the assembly number of the board shown in the photo?

5. What is the part number of the A71 assembly? _____
6. What revision of the A81/82 board is in your Model 16? _____
7. Name two boards in the Model 16 which are replacement assemblies. _____

8. How many connectors have to be removed before the display board can be removed? _____
What else, if anything, has to be removed before the display board can be removed? _____
9. How many screws have to be taken out to remove the power supply board? _____
10. What special precaution should be taken when reinstalling the power supply? _____
Top cover? _____
11. On what board is the 6845? _____
12. List by name and part number the special tools required for assembly-level repair of the Model 16.

13. What type of cleanser is used to clean the Model 16 case parts? _____

Lab Project 5

Assembly Identification

- ___ 1. Now go back to the *Service Manual*, Figure 4-1. Lay out all the assemblies you have removed and correlate those assemblies with the A numbers in the figure.
- ___ 2. Turn to Table 6-1 in the *Service Manual* and associate the assemblies laid out in front of you with the A number, HP part number, description and repair status.
- ___ 3. Also notice that the HP part number for each of the major assemblies is also marked on the assembly itself. Read the HP part number on each assembly and compare it to Table 6-1.
- ___ 4. The revision level of an assembly is also marked somewhere on that assembly; it's the mark that looks like "Rev A" (or B, etc.). Find the revision levels of each of the assemblies that you have removed.
- ___ 5. Get out the Expanded Block Diagram from the back of the *Service Manual* and the Basic Block Diagram at the beginning of Chapter 3 of the *Service Manual*. Looking at the major assemblies that you have removed, correlate the block diagram major blocks with the major assemblies.

6. Finally, find the following parts on both the major assemblies and the 9816 Expanded Block Diagrams. The parts can be located on the boards using either the model number of the part or the HP part number (whichever is marked on the part).
- 68000 CPU (P/N 1820-2505)
 - 8041 Peripheral Processor (P/N 09816-80003)
 - 8250 UART (P/N 1820-2443)
 - TMS 9914 HP-IB Chip
 - 64K RAM Chips (P/N 1818-3005)
 - Socketed Boot ROMs (P/N 09816-80011,12)
 - HP-IB Connector
 - Serial DataComm Connector
 - Self-Test LEDs
 - Control Switches
 - CPU Crystal 16 MHz
 - Keyboard Connector
 - Keyboard ESD Protection (small toroid near keyboard connector)
 - Crystal for Serial Interface 2.4575 MHz
 - Crystal for HP-IB and Keyboard Interface 10 MHz
 - Flyback Transformer
 - CRT Yoke
 - +12V and -12V Regulators
 - Vertical Size Adjuster
 - Vertical Position Adjuster
 - Brightness Adjuster
 - Focus Adjuster
 - Width Adjuster
 - Speaker
 - Power Switch
 - Line Voltage Select switch
 - 6845 CRT Controller
 - Alpha RAM Chip labeled —6116—
 - Alpha Character ROM (P/N 1818-3042)
 - Alpha Configuration Switches
 - Alpha Crystal 19.968 MHz
 - Graphics RAM 2118s

Lab Project 6

Field Replacement Unit Reassembly

Using the *Service Manual*, perform the following operations. Check each off when completed.

CAUTION: When reassembling the Case parts, DO NOT FORCE the items together. THE CASE PARTS SNAP TOGETHER EASILY. Be careful to LINE UP the parts correctly BEFORE SNAPPING.

- ___ 1. First, reassemble the chassis assembly, side covers, and front bezel using the procedures outlined in the *Service Manual*. Make sure each of the parts is correctly lined up before trying to set the snaps holding the part on.
- ___ 2. Reinstall the power supply assembly into the power supply bucket using the directions specified in the *Service Manual*. Be very sure that the lower edge of the power supply is actually resting in the two card guides mounted in the bottom of the power supply bucket AFTER bolting the card into place. Finally, replace the power supply cover.
- ___ 3. Reinstall the backplane connector board, display board, alpha and graphics boards and finally the processor board using the instructions specified in the *Service Manual*. Remember to take all necessary precautions regarding static electricity.

Lab Project 7

Field Replacement Unit Adjustments

- ___ 1. First, misadjust and then readjust each of the following adjustments on the display board using the techniques in the *Service Manual* and *CE Handbook*:
 - Display Width
 - Focus
 - Grid 1 Voltage
 - Intensity
 - Height
 - Vertical Position
- ___ 2. Turn each of the alpha board switches. Observe what happens and compare this to what is shown in the *Service Manual*.
- ___ 3. Reinstall the top cover using the technique described in the *Service Manual*. Two special precautions are required. First, make sure the ground jumper to the processor board is wedged neatly between the power supply bucket and the chassis assembly. Second, make sure that the keyboard connector (the one mounted on the processor board) is fitted into the hole in the top cover before snapping the top cover into place.

Model 16 Self-Checks and Peripheral Tests

Lesson 5

In this section you will learn what the Model 16 turn-on self-test does and how it reflects which board to replace. This lesson alone provides all the information needed to fix most hardware problems in the Model 16.

Objectives

- Given the name of a test, list what is and is not tested.
- Interpret any documented beeper, LED failure, or test status indication using the *Service Manual* or *CE Handbook*.
- Using the *Service Manual* or *CE Handbook* and given a hypothetical failure indication, either in LED patterns or beeper patterns, determine which board to replace.
- Exercise the entire Model 16 system using the Series 200 system test disc.

Topics to be Covered

Using the turn on self-test for diagnosis

Exercising Peripherals using the Series 200 system test disc

Instructions

Listed below in the usual format are the topics to be covered in this lesson. Complete the steps indicated for each of the topics and cross them off as you finish.

When you have finished the required reading, do the lab at the end of the lesson. There you will have a chance to practice what you have learned.

After you have completed the lab, take the quiz at the end of the lesson. Remember, use any appropriate reference to answering quiz questions.

Answers to the quiz questions can be found in Appendix B. If you miss any questions, you should review the appropriate references until you are comfortable with the material, then go on to the next lesson.

Learning Activity

- Read: *Service Manual*, Chapter 5, "Diagnosis Turn-on Self-Test," and *CE Handbook*, Chapter 5, "Running the Self-Test"
- Read: Series 200 System Test Disc Operating Note

Some Gotchas with the Self-Test

Notice the difference between the failure message "GRAPHICS MISSING" and "GRAPHICS FAILED." This difference applies to all the internal peripherals. The difference is elaborated in the following paragraphs.

In the case of graphics, the Boot ROM does a marching 1's RAM test on the graphics RAM. If the byte read is not the same as the byte that was written, a Graphics Failure has occurred.

On the other hand, if the processor attempts to write or read from graphics memory and the processor does not receive a DTACK at the end of the proposed transfer, a Graphics Missing failure has occurred. The Graphics Missing failure can be caused by a short or open in an address line, a failure in the chip-select address decoder, an open GCS (Graphics Chip Select) line, or a failure in the state machine of the graphics board.

Therefore, "GRAPHICS FAILURE" indicates that a failure actually occurred on the graphics board; whereas, a "GRAPHICS MISSING" message indicates that the CPU cannot talk to the graphics board and the failure could be in anything from the processor board to the graphics board.

To further complicate the issue, the graphics board test only tests the graphics RAM. It does not test the graphics display circuitry (i.e., the interface between the graphics board and the outside world).

These rules can be generalized for any internal peripheral test. They are true with the alpha board, HP-IB interface, serial interface, and keyboard interface.

Finally then, we've seen a general rule for internal peripheral tests that are performed by the Boot ROM:

- "Peripheral Missing" means that the central processor could not communicate with the specified peripheral and any board could be the suspect, although the board containing the peripheral is likely.

- "Peripheral Failed" means that a specific test of the peripheral has failed and the board containing the peripheral is highly suspect.
- "Peripheral Passed" means that only the specific test of the peripheral has passed. No tests have been performed on that peripheral's interface to the outside world.

Some questions to ask yourself:

- If the RS-232-C test passes, is everything in the RS-232-C circuit okay?
- To which internal peripherals do the above rules apply?
- For which interfaces does this rule indicate that there is a potential problem?

These rules indicate that there are some specific problems to look for.

Since the interface to the outside world is not tested whenever an interface is tested, the serial interface drivers, HP-IB interface drivers, keyboard drivers, graphics drivers, and alpha drivers are untested.

The alpha output circuits, however, are implicitly tested when the boot-up self-test results are displayed. This leaves the HP-IB, keyboard, serial interface, and graphics output circuits untested. The HP-IB can be tested by booting in an operating system. The keyboard can be tested by turning on the Model 16 without an available mass storage device and typing. (The depressed key will be printed in the lower right corner of the screen.)

This leaves the serial interface and graphics output circuits untested. These two functional blocks must be tested with the system test disc if it is imperative that the system be completely checked out. The graphics output circuits can be tested using the Mainframe Diagnostic, and the serial interface can be tested like a 98626 card at Select Code 9.

Lab Projects Introduction

This lab gives you a chance to see failures in the self-test. You will introduce failures into the Model 16 and observe how the self-test behaves. The failures that you introduce will improve your understanding of what is and is not tested, as well as help you gain proficiency in reading the self-test results.

Lab Project 8

CAUTION CAUTION!!

In this lab you will power up the Model 16 with the top cover removed. Do not touch anything inside the Model 16 when it is plugged in. Remove the power cord before making any modifications to the inside of the Model 16!

1. Remove peripherals connected to the Model 16 and anything in the accessory backplane. Remove the top cover of the Model 16.
 2. After this step, **You will no longer be protected from the potential of high voltage shock. Do not touch anything** inside the Model 16 when the power cord is plugged in. Now, install the power cord into the rear of the Model 16 and plug it in an approved receptacle. Notice that the self-test progresses to completion through the status codes that you have read about.
 3. Turn off and unplug the Model 16. **Remember not to touch anything in the Model 16 when the power cord is plugged in!** Remove the graphics board. Now, plug in and turn the Model 16 on. You will see the self-test progress to completion and, since there is no graphics board, report "GRAPHICS MISSING."
 4. Read the Graphics Missing indication on the CRT.
 5. Read the self-test LEDs. The LEDs should read "off on off on" for the left set and "on on on on" for the right set. Since an "on" LED translates to a 1 and an "off" LED translates to a 0, the code on the LEDs is 0101 1111. Using the *Service Manual* or *CE Handbook*, translate the error code to "No Graphics Board DTACK," which means the graphics board does not respond.
 6. **Please note: This step applies only to a Model 16S.** Now, turn the unit back off and on again. This time listen for the beeper tone. The sequence you hear should be "HI LO HI HI HI HI HI". Because a HI tone is a 1 and a low tone is a 0 and the first bit is not beeped, this translates to X101 1111. Since the chart in the documentation has no 1101 1111, the code must be 0101 1111, which is the same failure indication the LEDs gave — of course.
 7. Reinstall the graphics board. Power up the Model 16 with the top cover still removed and notice that the self-test passes again.
 8. Perform the same steps above (steps 3 - 7) with the following failure mechanisms:
 - Set the internal memory to some location other than FF. This means there will be no RAM available for the self-test, and the self-test will stop midway.
 - Remove the keyboard. You have probably already done this and noticed that the self-test does not report Keyboard Missing.
- Unplug the display board from the accessory backplane. This prevents the 68000 from communicating with the alpha or graphics boards, thus the error will be Alpha Board Missing.
9. Replace the top cover of the Model 16. Reconfigure the Model 16 into the system described in Lesson 2. Exercise each peripheral in the system using the system test disc as described in the Series 200 System Test Disc Operating Note.

Quiz 5

Model 16 Self-Checks and Peripheral Tests

1. What does the Alpha RAM test actually test? _____
What is not tested? _____
Is there an implicit test for the portions not tested? _____
2. What does an indication "1010 1000" on the LEDs indicate? _____
3. What does the beeper indication "LO LO HI HI LO LO LO" indicate? _____
What does "HI LO HI LO LO HI LO" indicate? _____
4. In the general rule described in the text, what is not tested if the self-test indicates Peripheral Passed?

5. Given the following Boot ROM failure codes, decide which board should be replaced first. Also, give an indication of whether or not it is likely that the failure could be on a different board.

Failure Code	First Replacement	Likely to be Another Board?
0000 0100		
1111 1111		
1010 1001		
HI LO HI LO LO HI LO		
LO LO HI LO HI LO LO		
KEYBOARD FAILED		
HP98626 at 9 Missing		
Hex 81		
1001 1110		
HI LO HI HI HI HI HI		
0000 0000		
Hex A7		

Fix It

Lesson 6

In this lesson, you will actually observe a variety of failure symptoms in a Model 16. You will be amazed at how helpful the turn-on self-test really is when you diagnose the malfunctioning units with the COVER IN PLACE and then open the cover, fix the unit, and find that your diagnosis was correct!

Objectives

- Experience relating failure modes to failure symptoms of a Model 16 with the following types of failures:
 - Dead units
 - Display failures
 - Units with a stuck address or data bus
 - Units with failures from each of the major failure types available in the turn-on self-test
- List the six failure types for the Model 16.
- Given a hypothetical LED indication, indicate the steps required to repair the unit as described in the *Service Manual* or *CE Handbook*.
- Given a hypothetical block failure, indicate which test will find the failure, and what the test failure will indicate to repair.

Topics to be Covered

Diagnosing dead units

Diagnosing units with a Stuck Address or Data Bus

Diagnosing turn-on self-test failures

Instructions

Listed below in the usual format are the topics to be covered in this lesson. Complete the items indicated for each of the topics and cross them off as you finish.

When you have finished the required reading, do the lab at the end of the lesson. There you will get a chance to practice what you have learned.

After you have completed the lab, take the quiz at the end of the lesson. Remember, use any appropriate reference to answer the quiz questions.

Answers to the quiz questions are in Appendix B. If you miss any questions, you should review the appropriate references until you are comfortable with the material, then go on to the Final Review Package.

Learning Activity

- Read: *9816 Service Manual*, Chapter 5, "Dead Unit Procedures" section and *9816 CE Handbook*, Chapter 4 "Dead Unit Troubleshooting Flow Chart" section
- Read: *9816 Service Manual*, Chapter 5, "Live Unit Procedure" section and *9816 CE Handbook*, Chapter 4, "Live Unit Flow Chart" section
- Review: *9816 Service Manual*, Chapter 5, "Turn-on Self-Test" section and *9816 CE Handbook*, Chapter 5

Lab Projects Introduction

Instructions

In this lab you will get a chance to repair several units in which a failure has been forced. If a qualified mentor is available, have the cause the failures. If no mentor is available, cause the failures yourself. The failures are forced with a micro-jumper cable.

The text will describe two pins to short using the cable. Always connect the jumper clips to the component leads on the component side of the board.

The description of the pins will be given as "A81 U4 pin 7 and 8." This means the A81 alpha board should have a jumper between pins 7 and 8 on U4. The U numbers for the ICs are printed on either or both the front and back of the PC board. Be careful to put the jumpers on the correct IC.

If you hold the board so that the U numbers are printed right side up, then the ICs are numbered from left to right, top to bottom (just as you read a book). So, count the ICs if there is any doubt about the U number of an IC.

To find the pin number, look for a notch at one end of the chip. Counterclockwise from that notch is pin 1. Pin numbers increase from that point in a counterclockwise direction.

After installing the failure, put the top cover back on the Model 16. This way you will diagnose the unit without seeing the failure jumper, which is the way you will see it when doing a repair.

Turn on the unit, read the self-test, and write down in the table what the self-test and your knowledge indicate the failed board is. Decide and note how probable it is that another board could cause the failure. Finally, repair the unit, ignoring where the failure jumper is, and note the board the failure was on.

Since you will be opening up the Model 16 to do this work, please review the "Static Handling Procedures" and "Open Unit Cautions" you have already learned.

The list of failure installations is at the end of Appendix B, "Quiz Answers." Fill out the following table for each failure.

Lab Project 1

Results

Failure Number	First Replacement	Possibly Other Board?	What Board Failure Was On
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			

Planning for Success

Preventive maintenance is also an important element of any support program, but how much is necessary? What type? When should it be scheduled? When should it be performed on an "as needed" basis? How much can the user do? These questions you must consider for your particular application and needs if you are to be successful in applying your new skills.

Up to this point in the training program you have focused on understanding and repairing the Disc Drive family. Your progress through this program has been measured on your ability to understand the material presented and on your troubleshooting expertise. While these are important aspects of product repair, they are only a single link in the overall repair and support process. Your true success can be measured only in the overall results of how well you keep the equipment running, not how well you understand the product or how fast you find the problem. Take, for example, the case of a defective fuse—isolating the problem quickly is of little value if you do not have a spare fuse. Having a large quantity of the wrong fuse neither increases the utilization of the equipment, nor helps you fix it faster. What then is a support program and how do you use it for your success?

Elements of a Support Program

A successful support program involves four (4) major elements:

1. Definition of the needs/requirements and expectations of the user.
2. Evaluation of the support resources available to meet the needs of the user.
3. Effective allocation of resources.
4. A mutually agreeable measurement system to record results.

The first element, "Definition of the needs," establishes the goals of the user. None of the key points can be addressed properly until the product application and need of the user is defined.

For instance, is the application one of monitoring on-line manufacturing processes, as in a production line system, or a less critical application in an engineering or research environment? These applications can require very different levels of support and resources. Further, the expectations of the users can vary dramatically.

1. Determining Need

To identify needs you should find answers to the following questions for each site or user you will support.

- What is the application of the product? Know how it is currently used and any new applications planned. These sometimes change the support requirements.
- What type of equipment is being used? Different products require more maintenance or interaction with other areas.
- How many hours/day is the equipment expected to be used? Will the system be expected to function 24 hours/day or something less? What about after hours?
- Are some times more critical than others? Most operations have critical times either daily, weekly, or monthly when the operation must run. Find out!
- How long can the users or process be inoperable? It is important to establish alternate plans for critical times. Suggest alternatives for the user. Backup procedures, etc.

The User Requirements Worksheet on page will help answer some of these questions and should be completed for each site and product that you will support.

For this program select one site you will support and answer the questions the way you feel the user would answer. (If you wish to use the worksheet for other sites you should make several copies before you complete the form.)

STOP!

Complete steps 1 through 6 of the User Requirements Worksheet located on

2. Evaluating Resources

With steps 1 through 6 completed in the User Requirements Worksheet, you can begin to identify the resources required to meet the user's needs in the areas of Response Time, Repair Time, and Planned Maintenance. These three key areas impact the overall system utilization. You should have a good understanding of each of these areas for your organization for normal working hours, after hours, weekends and holidays.

A. Response Time

Response time is a measure of the efficiency of the dispatching process. It is an issue that varies with each organization and location. Consider the effect of the following areas on response time for your organization.

Communication

Communication is important in any interaction with people. In response time it can mean long delays in responding to service requests or worse, missed service requests.

- How are requests for service received?
- Who receives them?
- How are service personnel notified?
- What about after hours, weekends or holidays?

Manpower Availability

Manpower is a difficult issue in any organization, and it is not the intent of this program to suggest a simple solution. You must, however, understand what procedures are in place in your organization for available manpower. For example:

- How are service requests assigned?
- Can you leave immediately?
- Do you have a backup plan?
- What happens after hours?
- Weekends and holidays?

Parts/Tools Availability

This area is the most overlooked area of response time, but perhaps the most critical. If you don't have the proper parts and tools you must get them from somewhere before you can respond. Will they be carried by service personnel, stored in a central location, or will they be available once you arrive? What about access during normal working hours? After hours? Weekends/holidays? This can waste valuable time if parts are stored miles away from your current location.

User's Location

The user's location can definitely affect your ability to respond.

- Distance from support personnel.
- Geographic territory (mountains, etc.).

- Travel time consideration (traffic, etc.).
- Travel method (airplanes, etc.).
- Security issues.

Check your situations! How does your organization handle each of these? What is your estimate of the time required for you to receive a service request? What do you feel your response time will be?

STOP!

Complete Section I of the Resource Analysis Worksheet on page

B. Repair Time

Repair time is mainly a function of your ability to locate and solve the problem once you have arrived at the user's site. Other areas that impact your ability to repair the product are:

Product availability — Can you begin work on the system immediately once you arrive on site?

Parts availability — How do you get the part you need when you find the failing assembly?

Consulting assistance — What about the times you can't isolate the problem? Who is your technical backup?

STOP!

Complete Section II of the Resource Analysis Worksheet on page

C. Planned Maintenance

The first portion of this lesson described the preventive maintenance (PM) procedures for the HP Series 200 Model 16. You should understand that planned maintenance is a means to an end. Performing PMs 100% of the time would result in the equipment being utilized 0%. No PMs may cause unnecessary failures during critical operations. This raises several questions concerning preventive maintenance. What is a proper PM? How often should they be performed? The answer is dependent on three major factors:

- Product design.
- Environment.
- Equipment usage.

Any successful maintenance program must constantly evaluate each of these major areas to establish a Planned Maintenance program to fit the user's needs.

Product Design

The Hewlett-Packard disc drives have been designed as a high-reliability, minimum-maintenance product. Under normal conditions it requires no scheduled maintenance. Still, you should evaluate the user's particular environment and usage situation to determine preventive measures for optimum product usage.

User Environment

What type of environment is the equipment subjected to? Is it a manufacturing facility? Computer room environment or office area? Is it subjected to high/low temperature extremes? Power fluctuation? Dirt? Caustic atmosphere, etc.? All of these affect the equipment utilization and should be monitored on a continuing basis.

Equipment Usage

Equipment usage involves the amount of time the specified product is used, i.e., 2 hrs/day, 10 hrs/day or 24 hrs/day, etc. Generally, the more the equipment is used, the higher the probability that mechanical components may wear.

STOP!

Complete Section III of the Resource Analysis Worksheet on page

With the Resource Analysis Worksheet completed, compare your capabilities to those identified in the User Requirements Worksheet. What do you feel the measurement criteria should be?

Establishing a Measurement Program

One of the easiest and most comprehensive methods of measuring your results is equipment utilization or uptime. The uptime measurement allows an easy way to set user expectations and graphically identify potential problems or reduced performance.

Uptime Calculations

Many definitions and calculations exist for uptime. It is not important that only one definition or formula is correct. It is, however, important that once the criteria have been established, they not be changed.

The general formula for Uptime calculations is:

$$\text{Uptime \%} = \frac{\text{PPM-Downtime}}{\text{PPM}} \times 100$$

PPM = Principal Period of Maintenance per month determined by the number of hours service is provided.

Downtime = the amount of downtime during the covered period.

Table 6-1 shows PPM for typical applications.

Hours of Service Coverage/day	# of days covered/week		
	5	6	7
8	174	208	242
12	261	312	363
16	348	416	484
24	522	624	728

Example:

Assume you provide support for a particular system or product for 8 hours/day, 5 days/week. (8:00 a.m. to 4:00 p.m. Monday through Friday.) Downtime is 6 hours total for the month of January.

$$\text{Monthly Uptime \%} = \frac{\text{PPM-Downtime}}{\text{PPM}} \times 100$$

$$\text{Monthly Uptime \%} = \frac{174-6}{174} \times 100$$

$$\text{Monthly Uptime \%} = 96.6$$

The uptime graph provided on pages 6-15 and 6-16 can be used to record graphically the uptime results for both the site and service person.

STOP!

Complete steps 7 through 11 of the User Requirements Worksheet on page

User Requirements Worksheet

Date _____

Prepared by _____

1. a) User's description of application (name, purpose, etc): _____

Site Name _____ Installation Location _____

Contact Name _____ Telephone Number _____

b) Used in production of process control? Yes No

c) As part of Network System? Yes No

2. HP System Configuration: System Model _____ Memory Size _____

of Discs _____ Model _____

of Mag Tapes _____ Model _____

of Line Printers _____ Model _____

of CRTs _____ Model _____

Other Equipment _____

Types of modems: Manufacturer SYNC ASYNC Model _____

3. Software used: HP O.E.M. Other _____

4. System Usage:

Hours:

5 days/week: 8 to 5 12 hours/day 16 hours/day 24 hours/day

7 days/week Other _____

5. Critical Periods: Days: (Circle appropriate days M T W TH F S S)

Hours from: _____ to: _____ Days of Month

_____ Months of the year: _____ Other: _____

6. Maximum Downtime/Day:

Less than 1 hour 4 hours 10 hours 12 hours Other _____

7. What service coverage is required to meet the System usage?

5 days/week 7 days/week Other _____

8 hrs/day 12 hrs/day 24 hrs/day Other _____

8. What response time is required to meet the users requirements?

4 hours 10 hours 12 hours 24 hours Other _____

9. Do you have a service contract with HP? No Yes

Contract Number _____

Type Contract(s):

Hardware Software Cooperative

10. Service Information:

Location providing _____ HP location providing _____

Service Telephone # _____ HP Service# _____

After Hrs Phone # _____ HP After Hrs Phone # _____

Site Manager _____ HP District CE Manager _____

Trained Service Personnel _____ HP Account CE _____

11. Special Considerations:

Resource Analysis Worksheet

Section I Response Time Analysis

Communication System

A. Normal Working Hours

1. How are service requests received/recorded?
 Central location Other _____
2. Requests are recorded by: Secretary Dispatcher
 Service Personnel Other _____
3. How are service personnel notified? Pager Phone Message
 Wait for call in Other _____
4. Estimated average amount of time required to notify service personnel of a pending service request: _____ hours

B. After Hours

1. How are service requests received/recorded?
 Central location Other _____
2. Requests are recorded by: Secretary Dispatcher
 Service Personnel Other _____
3. How are service personnel notified? Pager Phone Message
 Wait for call in Other _____
4. Estimated average amount of time required to notify service personnel of a pending service request: _____ hours

C. Weekends/Holidays

1. How are service requests received/recorded?
 Central location Other _____
2. Requests are recorded by: Secretary Dispatcher
 Service Personnel Other _____
3. How are service personnel notified? Pager Phone Message
 Wait for call in Other _____
4. Estimated average amount of time required to notify service personnel of a pending service request: _____ hours

Manpower Availability

A. Normal Working Hours

1. How are service requests assigned? Designated Service Personnel
 Next Available Service Person Other _____

2. Can you respond immediately? Yes No

If no, what happens? _____

3. Do you have a backup plan? No Yes: What is it?

_____ hours

4. Estimated average amount of time before service person is available: _____ hours

B. After Hours

1. How are service requests assigned? Designated Service Personnel

Next Available Service Person Other _____

2. Can you respond immediately? Yes No

If no, what happens? _____

3. Do you have a backup plan? No Yes: What is it?

4. Estimated average amount of time before service person is available: _____ hours

C. Weekends/Holidays

1. How are service requests assigned? Designated Service Personnel

Next Available Service Person Other _____

2. Can you respond immediately? Yes No

If no, what happens? _____

3. Do you have a backup plan? No Yes: What is it?

4. Estimated average amount of time before service person is available: _____ hours

Parts/Tools Availability

A. Normal Hours

Parts Availability

Parts Available: On-Site Carried by Service Personnel

Other _____

Tool Availability

Standard Tools: On-Site Carried by Service Personnel

Other _____

Estimated average amount of time required to pick up parts and tools per call: _____ hours

B. After Hours

Parts Availability

Parts Available: On-Site Carried by Service Personnel

Other _____

Tool Availability

Standard Tools: On-Site Carried by Service Personnel

Other _____

Estimated average amount of time required to pick up parts and tools per call: _____ hours

C. Weekends/Holidays

Parts Availability

Parts Available: On-Site Carried by Service Personnel

Other _____

Tool Availability

Standard Tools: On-Site Carried by Service Personnel

Other _____

Estimated average amount of time required to pick up parts and tools per call: _____ hours

User's Location

A. General

1. Estimated distance to user's site: _____ miles

2. Geographic territory: City Mountainous Rural Other _____

B. Normal Working Hours

1. Travel method used: Car Walk Airplane Van Other _____

2. Estimated travel time: _____ hours

3. What type of security clearance is necessary? None Pass

Special Other _____

4. Estimated time delay for acquiring security access to site: _____ hours

C. After Hours

1. Travel method used: Car Walk Airplane Van Other _____

2. Estimated travel time: _____ hours

3. What type of security clearance is necessary? None Pass

Special Other _____

4. Estimated time delay for acquiring security access to site: _____ hours

D. Weekends/Holidays

1. Travel method used: Car Walk Airplane Van Other _____

2. Estimated travel time: _____ hours

3. What type of security clearance is necessary? None Pass

Special Other _____

4. Estimated time delay for acquiring security access to site: _____ hours

Response Time Analysis Summary

A. Normal Working Hours

Estimated average amount of time required to notify service personnel: _____ hours
Estimated amount of time before service person is available: _____ hours
Estimated amount of time to pick up parts and tools: _____ hours
Estimated travel time: _____ hours
Estimated time delay for security access to site: _____ hours
Total Response Hours: _____ hours

B. After Hours

Estimated average amount of time required to notify service personnel: _____ hours
Estimated amount of time before service person is available: _____ hours
Estimated amount of time to pick up parts and tools: _____ hours
Estimated travel time: _____ hours
Estimated time delay for security access to site: _____ hours
Total Response Hours: _____ hours

C. Weekends/Holidays

Estimated average amount of time required to notify service personnel: _____ hours
Estimated amount of time before service person is available: _____ hours
Estimated amount of time to pick up parts and tools: _____ hours
Estimated travel time: _____ hours
Estimated time delay for security access to site: _____ hours
Total Response Hours: _____ hours

Resource Analysis Worksheet

Section II Repair Time Analysis

A. Normal Working Hours

1. Product Availability

- a. Is the product or system available to use when you arrive on-site? Yes No
- b. How long must you normally wait? _____ hours
- c. What can you do while you wait? _____

- d. What can the user do before you arrive? _____

2. Parts Availability

- a. What are the procedures for obtaining a part? _____

- b. Estimated average time to receive part: _____ hours

3. Consulting Assistance

- a. Is technical assistance available? Yes No
- Name _____
- Location _____
- Phone No. _____
- b. Estimated amount of time to contact technical backup: _____ hours
- c. Is management assistance available? Yes No
- Name _____
- Location _____
- Phone No. _____

B. After Hours

1. Product Availability

- a. Is the product or system available to use when you arrive on-site? Yes No
- b. How long must you normally wait? _____ hours
- c. What can you do while you wait? _____

- d. What can the user do before you arrive? _____

2. Parts Availability

- a. What are the procedures for obtaining a part? _____

- b. Estimated average time to receive part: _____ hours

3. Consulting Assistance

a. Is technical assistance available? Yes No

Name _____

Location _____

Phone No. _____

b. Estimated amount of time to contact technical backup: _____ hours

c. Is management assistance available? Yes No

Name _____

Location _____

Phone No. _____

C. Weekends/Holidays

1. Product Availability

a. Is the product or system available to use when you arrive on-site? Yes No

b. How long must you normally wait? _____ hours

c. What can you do while you wait? _____

d. What can the user do before you arrive? _____

2. Parts Availability

a. What are the procedures for obtaining a part? _____

b. Estimated average time to receive part: _____ hours

3. Consulting Assistance

a. Is technical assistance available? Yes No

Name _____

Location _____

Phone No. _____

b. Estimated amount of time to contact technical backup: _____ hours

c. Is management assistance available? Yes No

Name _____

Location _____

Phone No. _____

Resource Analysis Worksheet

Section III Planned Maintenance

A. Product Design

1. What is the recommended interval for preventive maintenance? _____ months
2. Who can best perform the maintenance procedures? Service Personnel
 User Other _____

B. User Environment

1. To what type of environment is the equipment subjected? Industrial Manufacturing
 Office Area Computer Room Other _____
2. In what temperatures will equipment operate? High Low
 Moderate Other _____
3. What types of humidity? High Low
 Moderate Other _____
4. What type of atmosphere? Caustic Dirt Laden
 Other (please describe) _____
5. What power setup is available? Line Conditioned
 Line Filtered Other _____
6. What is the voltage range? _____ Volts to _____ Volts

C. Equipment Usage

1. The equipment is in constant use for approximately: 2 hours/day 4 hours/day
 8 hours/day 16 hours/day Other _____

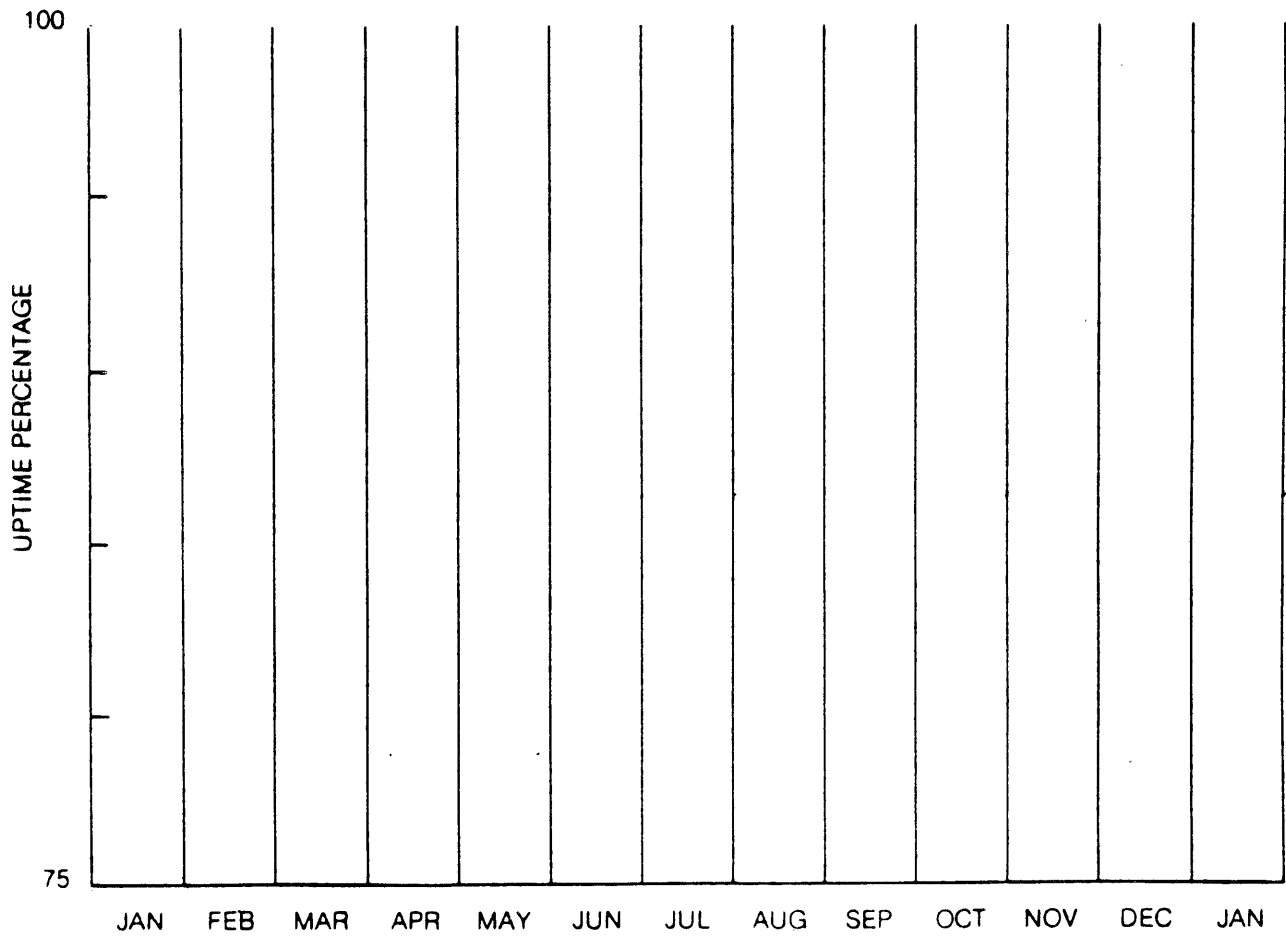
Uptime Graph

User Name _____

Product Type _____

Serial # _____

Service Person: _____



Quiz 6

Fix It

1. Given the following symptoms, describe the steps required to effect a repair.

a) Nothing works and the power line fuse is okay. _____

b) No LEDs, nothing works but the fan runs. _____

c) Everything works except that it won't load an operating system. _____

d) Self-test passes but the screen is dark. _____

e) Self-test writes "Memory Failed at FAE344 W:EFFEFF R:EFFEFE". _____

f) Self-test writes "BOOTROM 3.0L Failed". _____

g) Self-test writes "Graphics Missing". _____

h) Self-test writes 1001 1110 on LEDs. _____

i) Self-test beeps out "HI HI LO HI LO LO HI". _____

2. Given the following block description and failure mechanism, describe what the symptoms of the unit will be.

a) Processor board chip select address decoder output labeled CS Graphics is open. _____

b) Power supply does not put out +12 volts, but all other supplies are up. _____

c) Processor board ESD protection circuit shorts KEYDATA to ground. _____

- d) Processor board 2.4576 MHz clock output is ground. _____

- e) Processor board refresh state machine is stuck in the state of holding off refresh. _____

- f) Processor board BD (Bus Data) 3 and 5 are shorted on peripheral side of data buffer near TMS 9914.

- g) Display board video amp output stuck to low. _____

- h) Alpha Board data bus isolation buffer -4 always has a 3-state output. _____

- i) Graphics board data buffer and latch short BD 1 and 2 on alpha board side. _____

- j) Alpha board parallel to serial converter output is stuck low. _____

- k) Alpha board HPOS delay CKT switch output is stuck low. _____

Extra Information

Appendix

Following is a list of other documents that Hewlett-Packard provides for you to "Read More About It!"

Marketing Literature

HP 9845 and Series 200 Computer Software Price Information (P/N 5953-4636D)

HP Series 200, Model 16 BASIC 2.0, BASIC Extensions 2.0 and Pascal Language Systems (P/N 5953-4629)

HP Series 200, Model 16 Personal Technical Computer (P/N 5953-4631)

HP Series 200, Models 16, 26, and 36 HPL 2.0 Language System (P/N 5953-4634)

HP Series 200, Models 16, 26, and 36 BASIC 2.0 Language System and BASIC Extensions 2.0 (P/N 5953-4633)

HP Series 200, Models 16, 26, and 36 Pascal 2.0 Language System (P/N 5953-4640)

Choosing the Right Tool for the Job (P/N 5953-7836)

Service Literature

9816 IOSM (available from the division or CSD)

CSD's Packaging and Handling Procedures

The Operating System and Interface card manuals are listed as part of the course materials.

Quiz Answers

Appendix B

Quiz 1

1. 68000 16/32-bit CPU, 8-MHz clock, 9816A-\$3985, 9816S-\$5550 (anything close is sufficient), 9" CRT, built-in HP-IB, built-in serial interface, graphics dot size 300V × 400H. (Note: You do not need to know all these.)
2. The Model 16A has 128K bytes built-in RAM; the Model 16S has 256K; both are on the processor board.
3. The Model 16A has BOOTROM 3.0L and can only boot an operating system off of a 3½" or 5¼" flexible disc drive. The Model 16S has BOOTROM 3.0 and can boot off any mass storage device that is supported on the Series 200 products.
4. The Model 16A Option -10 is the only Model 16 without graphics.
5. The 9134A is supported, but another mass storage device of either a 3½" or 5¼" supported flexible disc drive also needs to be on the system to provide a boot source.
6. One in either.
7. 19,200
8.

Computer	Alpha Size	Graphics Size
Model 16	25 lines, 80 characters	300Vert x 400Horiz
Model 26	25 lines, 50 characters	300Vert x 400Horiz
Model 36	25 lines, 80 characters	390Vert x 512Horiz
9. c and e
10. Maximum operating temperature 55C. Maximum storage temperature 75C.
11. Office or home use.
12. 09816-90030
13. An abbreviated form of the *Service Manual* with emphasis on details and away from generalities.
14. Yes
15. Yes
16. Packs up the unit in the original shipping container and mails it to the local Field Repair Center with a description of what went wrong and, if purchased from a dealer, a copy of the purchase receipt including date sold, dealer's name, and price paid. The location of the local Field Repair Center can be found by calling the local HP Sales Office.
17. Product Monthly Maintenance Contract. Approximately \$20 a month.
18. Dealer Repair Center and Dealer Cooperative Support.
19. The 09816-66516 board is new and the 09816-69561 board has been repaired.

Quiz 2

1.	SW1	SW6
1 RAM	0 0 0 0 0 1	
2 RAM	0 0 0 0 1 0	
	SW1	SW8
INTERNAL	0 0 0 0 0 0 0 0	

Note: 0 is open, 1 is closed.

2. On the switch set closest to the back panel, switch -7, turned on.
3. Set switch -8 in the switch set closest to the back panel. On is 50 Hz. Or, select Control-C instead of a mass storage device during boot up, then press 5 for 50 Hz.
4. Serial Interface, Serial, EIA-RS 232C.
5. Above the serial interface connector.
6. 7
7. BASIC 2.0; HPL 2.0; select 1P
8. The keyboard is not the problem. The keyboard processor on the CPU board has failed to DTACK.
9. 10
10. No RAM including any 98256A boards or the internal RAM is set to FF.
11. Brightness all the way off.

Quiz 3

Text questions: There are 7 internal peripherals: alpha, graphics, HP-IB, serial, RAM, BootROM, keyboard; alpha and graphics board timing and control logic block: There are three different failure modes:

- 1) The board should have but did not DTACK.
- 2) The board should not have but did DTACK.
- 3) The board should not have and did not DTACK.

If the CPU were writing, an error will be generated only if the board does not DTACK.

If the CPU were reading and the board failed to DTACK, an error will occur. If the board returned a DTACK, garbage will be read.

1. Processor board.
2. Processor board.
3. BA1-16
4. Keyboard: 8041 or 8042
HP-IB: TMS 9914
Serial DataComm Interface: 8250 UART
5. Alpha: BA 1-11 and BA 13
Graphics: BA 1-11 and BA 15
6. Processor board, I/O backplane, display board, alpha board, graphics board.
7. Attribute logic and video mixer; alpha board.
8. Alpha; 80 characters on 25 lines.
9. Taking in serial data and displaying it on the CRT; post regulating $\pm 14V$ to $\pm 12V$; bringing AC line voltage from the power cord to the power supply board.
10. No, the Data Buffer would prevent that: Yes, these lines are connected directly to the 68000.
11. The 8041 keyboard processor.
12. Yes; the data bus is connected to both the 6845 and the RAM.

Quiz 4

1. F
2. T
3. F
4. Display board.
5. 09816-66571 or 09816-69571 (exchange board).
6. You may have a Rev. B alpha board board or an A82 board Rev. A or later.
7. Power supply 0950-1637; and accessory backplane 09816-66561.
8. 6; the screw in the left rear corner.
9. 4 cover screws and 2 screws holding in the board.
10. Remember to seat the bottom edge of the power supply in the card guides; check that the keyboard connector fits in the hole made for it in the top cover before snaps are set.
11. Alpha board.
12. Processor board test cable 09816-67006.
13. A mild detergent.

Quiz 5

1. A test through the RAM that stores characters; the capability to transfer the characters from the RAM storage to the CRT is not tested; during boot up, the fact that the CRT displays any characters indicates that this section is working.
2. I/O card at select code 8 failed.
3. DMA card failed; no keyboard DTACK.
4. The interface between the internal peripheral and the outside world.
- 5.

Failure Code	First Replacement	Likely to be Another Board?
0000 0100	Check RAM Addressing Processor Board	Yes
1111 1111	Processor Board	Yes
1010 1001	Processor Board	No
HI LO HI LO LO HI LO	Processor Board	No
LO LO HI LO HI LO LO	Processor Board	No
KEYBOARD FAILED	Processor Board	No
HP98626 AT 9 MISSING	Processor Board	No
Hex 81	Processor Board	No
1001 1110	Alpha Board	No
HI LO HI HI HI HI HI	Graphics Board	Yes
0000 0000	Power Supply or No Failure	Yes
Hex A7	Processor Board	No

Quiz 6

1. Answers are a list, separated into sections. If the items in the list is a board name, replace that board. If there is a check involved other than "Does it work?", it will be specified.
 - a) Check that unit is plugged into live outlet; measure AC line voltage leaving display board; if okay, replace power supply; if still a problem, replace cabling; if AC is not okay, replace display board.
 - b) Check +5 volts coming into display board; if okay, replace display board, I/O backplane, processor board until fixed; if +5 not okay, replace power supply.
 - c) Processor board.
 - d) Alpha board; graphics board; display board.
 - e) Check RAM addressing, replace 98256 or processor board set to FC.
 - f) Processor board.
 - g) Graphics board; processor board; alpha board; display board; I/O backplane.
 - h) Alpha board; graphics board; display board; I/O backplane; processor board.
 - i) Processor Board.
2.
 - a) Graphics Missing.
 - b) Self-test passes, fan runs slowly, no display.
 - c) Self-test passes; can't type on keyboard.
 - d) HP98626 at 9 failed.
 - e) Memory failed at (any numbers could be here—probably near FFFFFFFF").
 - f) Keyboard failure.
 - g) Self-test passes, no display.
 - h) Alpha board failed.
 - i) Alpha board failed.
 - j) Self-test passes, no display.
 - k) Self-test passes, no display, no high voltage.

Lab 1 Exercises

Read the instructions to Lesson 6, Lab 1 before installing any of these failures.

Failure Number	Failure Jumper	Description of Failure
1	Remove power line fuse.	Dead unit.
2	Remove red wire at power supply connector. (See Note 1 for instructions.)	Dead unit.
3	Move internal RAM to start at 000000.	No RAM.
4	Set switch 1-3 on the A81 board off (this lab not available for A82).	Disables alpha board.
5	A81 U32 pin 3 and 4 or A82 (N/A).	Alpha board RAM failure.
6	A91 U25 pin 5 and 6.	Graphics RAM failure.
7	Turn brightness all the way off.	
8	A11-2 U59 pin 4 and 40.	HP-IB write disabled makes BootROM think it's in a 9826 and it initialized CRT to a 9826.
9	A81 U9 pin 5 and 14 or A82 (N/A).	Shorts address bus (live unit).
10	A11 U33 pin 19 and 35.	Serial interface missing.
11	Remove the graphics board.	
12	A11 U44 pin 11 and 16.	Chip select short.
13	A91 U8 pin 5 and 6.	Graphics RAM short.
14	A91 U27 pin 3 and 4.	Linked graphics RAM failure; diagonal lines are dashed.
15	A81 U26 pin 3 and 14 or A82 (N/A).	Disabled alpha board.

Note 1: Remove the connector to the power supply; turn the connector around; use a small screwdriver to push in the latch on the metal part of the connector; pull connector out.