DESTINATION: MARS!™

Compu-Teach

EDUCATIONAL SOFTWARE™

If anything is missing from this package or you have questions about the program, please call Compu–Teach, Inc. for assistance at 800-44-TEACH.

Please do not return the package to your dealer before calling.

Notes:

Destination: Mars!™

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BEFORE YOU BEGIN

The first thing you should do is make sure your *Destination: MARS!* package is complete. Here's what it should contain:

Program Disks
This manual
Task Card
Registration Card
Mars Space Atlas
Other reference and promotional materials

If anything is missing or damaged, return the entire package to the place where it was purchased.

Please fill out the registration card now and drop it in the mail at your earliest convenience. If we have your registration card, you will receive information about any future enhancements to this program, as well as information on any new educational products from Compu-Teach.

This manual is laid out in four distinct sections: Loading and Installation, Program Overview, Science Backgrounds, and Mars Base Data. You should read through the first two sections before playing. The last two sections will come in handy while you are playing for solving experiments and Mars Base Tasks.

LOADING AND INSTALLATION

For startup and installation instructions read the section below which applies to you:

MS-DOS COMPATIBLES

If you are using an IBM PC or compatible, this is what you will need:
1. Your computer must have at least 384K RAM (If you are using VGA or MCGA, more memory may be required).
2. DOS (disk operating system) 3.1 or higher.
3. Formatted disks to make a backup of your original disks.

MAKING A BACKUP OF THE PROGRAM

You should begin by making a backup copy of *Destination: MARS!* You will need formatted disks for the backup. Use a felt-tipped pen to label each blank, formatted disk to match the original disks.

Destination: MARS! may be copied for your own use. We offer this backup option with the understanding that copies of the program will not be given to or sold to others. Copying software for use on more than one machine or for uses by others is illegal. Please help us to protect our rights.

1. With your DOS disk in drive A: and the drive door closed, turn on the computer.
2. At the A:> prompt, type DISKCOPY A: B: and press Enter.
3. The computer will ask you to insert the source and target disks.
4. Place your original *Destination: MARS!* disk in the A: drive and close the drive door. This is the source disk.
5. Place your blank, formatted disk in the B: drive, and close the drive door. This is the target disk.
6. Press Enter, and follow any on-screen instructions
7. When the copy is complete, remove both disks. Repeat steps 2 through 6 for the remaining disk(s).
8. Put the originals away in a safe place.

INSTALLING ON A HARD DRIVE

If you have a hard drive, we recommend that you use it to store the program. Follow these simple steps for installing on the hard drive of an IBM PC or compatible computer.

1. Turn on your computer.
2. When you reach the C:> prompt, insert *Destination: MARS!* Disk 1 into the disk drive and close the drive door.
3. Type A: and press Enter (where A is the letter of the floppy disk drive in which you have placed the program disk).
4. At the A:> prompt, type INSTALL C and press Enter (where C is the letter of the hard drive onto which you want to install *Destination: MARS!*).
5. The installation program will create a subdirectory called MARS containing the *Destination: MARS!* program. The install program will also instruct you to insert the remaining disks as necessary.
6. When the installation is complete, be sure all original disks are removed from the disk drives, and put them away in a safe place.

LOADING FROM THE HARD DRIVE

On an IBM PC or compatible PC with a hard drive, follow these instructions:

1. Make sure that the DOS prompt is on your screen (C:>).
2. Change to the directory where *Destination: MARS!* is located. If you followed the install routine provided with the program, you will type CD\MARS and press Enter.
3. At the prompt type MARS and press Enter.

4. Depending on your computer, it will take from 10 to 30 seconds for the program to load. You will hear the musical introduction followed by the *Destination: MARS!* logo.
5. *Destination: MARS!* will welcome you to the program and ask you to enter your first and last names.

LOADING FROM A DISK DRIVE

On an IBM PC or compatible with disk drives, follow these instructions:

1. Start your computer with your DOS disk in the drive. When you see the A:> prompt, remove the DOS disk from the drive and insert your backup copy *Destination: MARS!* Disk 1 in the drive and close the drive door.
2. At the A:> prompt, type MARS and press Enter.
3. Depending on your computer, it will take from 10 to 30 seconds for the program to load. You will first hear the musical introduction and then see the *Destination: MARS!* logo.
4. Destination:MARS! will welcome you to the program and ask you to enter your first and last names.

USING A MOUSE

If you wish to use a mouse with *Destination:Mars!*, you must load the mouse driver before entering the program. When using the mouse, the left button is equivalent to the spacebar, and the right button is equivalent to Enter.

APPLE II SERIES

If you are using an Apple II computer, this is what you will need:
1. Your computer must have at least one disk drive.
2. Your computer must have at least 128K RAM.
3. Formatted disks to make a backup copy of the program.

MAKING A BACKUP OF THE PROGRAM

You should begin by making a backup copy of *Destination: MARS!* You will need formatted disks for the backup. Use a felt-tipped pen to label each blank, formatted disk to match the original disks.

***Destination: MARS!* may be copied for your own use. We offer this backup option with the understanding that copies of the program will not be given to or sold to others. Copying software for use on more than one machine or for uses by others is illegal. Please help us to protect our rights.**

If you are using an Apple II or Apple IIGS, use the Apple Disk Utilities that came with your Apple computer to make a backup copy. Refer to your Apple reference manual for more directions on formatting or copying diskettes.

LOADING *Destination: MARS!*

On an Apple II or Apple IIGS computer, follow these instructions:

1. With your computer off, place *Destination: MARS!* Disk 1 in the disk drive and close the drive door.
2. Turn on the computer.
3. Destination:MARS! will welcome you to the program and ask you to enter your first and last names.
4. You will then see the mission screen where you will select your first mission.
5. The program will occasionally ask you for other program disks. Follow the instructions on screen when swapping disks.

MACINTOSH

If you are running the program in Black & White, your Macintosh must have at least 1 Meg of RAM and System 6.0.3. If you will be running the program in color, you must have a hard drive and at least 2 Meg of RAM.

MAKING A BACKUP OF THE PROGRAM

***Destination: MARS!* may be copied for your own use. We offer this backup option with the understanding that copies of the program will not be given to or sold to others. Copying software for use on more than one machine or for uses by others is illegal. Please help us to protect our rights.**

You should begin by making a backup copy of ***Destination: MARS!*** Follow the instructions below:

1. Insert Disk One into your internal disk drive.
2. Press (Command) - E to eject the disk.
3. Insert a blank disk into the second drive.
4. The computer will ask you if you want to initialize the disk. In response to this, click on the button which says **Two-sided**.
5. Type in "Disk One" in the space provided when prompted for the name of the disk, and press **Return**.
6. After the initialization is complete, press (Command)-E to eject the initialized disk.
7. Position the mouse over the picture of the original disk and hold down the mouse button. Drag the image of the original Disk One to the image of the blank disk and release the mouse button. The computer will prompt you to switch disks a number of times, but don't worry, it will not let you do the wrong thing.

8. When the copy is complete, remove both disks, and repeat the process for any additional disks.
9. Store the original disks in a safe place and use the copies for running the program.

INSTALLING ON A HARD DRIVE

If you have a hard drive, we recommend that you use it to store the program. Follow these simple steps for installing on the hard drive of an IBM PC or compatible computer.

1. Insert **Disk One** into a disk drive.
2. Drag the icon of **Disk One** to the icon of your hard drive.
3. The computer will remind you that the program will be placed into a folder on your hard drive. Click **OK**.
4. Remove Disk One and insert **Disk Two**.
5. Drag all of the files from Disk Two to the **MARS** folder on your hard drive.

If you will be running the program in Black & White only, the installation is complete.
If you will be running the program in color, continue with the steps below:

6. Insert **Disk Three** into a disk drive.
7. Double-click on the icon of the disk to open it.
8. Double-click on the file named **Graphics.sit**.
9. The graphics must be installed into the Mars folder on your hard drive.

LOADING FROM THE HARD DRIVE

To start the program:

1. Open the Mars folder on your hard drive.
2. Double-click on the ***Destination:MARS!*** icon to start the program.
3. When you have finished watching the introduction, choose **START** from the File menu.

LOADING FROM A DISK DRIVE (BLACK & WHITE ONLY)

To start the program:

1. Insert Disk One.
2. Double-click on the icon of the disk to open it.
3. Double-click on the ***Destination:MARS!*** icon to start the program.
4. When you have finished watching the introduction, choose **START** from the File menu.

USING THE MOUSE

Destination MARS! uses the standard Macintosh interface. The mouse is used to make selections during experiments and emergencies, as well as for manipulating cargo docking. You may also use the mouse to select items from the pulldown menus.

PROGRAM OVERVIEW

Qualifying for a Mars mission is not easy. You need skill, knowledge, quick reflexes, and good judgment. You must work your way up through the ranks from Mission Specialist to Commander in a series of Low Earth Orbit Shuttle flights, Space Station, and Mars missions.

You must handle fast-action Shuttle Launch, Orbit, Reentry, and Docking tasks, as well as a bewildering variety of emergency situations that call for sound information and good judgment. You must learn to deploy, retrieve, and inspect low orbit payloads and to unload cargo at the Space Station. You must learn to guide other astronauts in Extra-Vehicular Activities (EVAs) or "space walks" to repair satellites and your own spacecraft, to test equipment, and even to rescue stranded crew members. You must apply your scientific knowledge and good judgment in important scientific experiments. And if at any point your performance falls to below 60 percent, your mission aborts, you return immediately to Earth, and you lose an opportunity to move up in rank.

When you walk into the Mars Vehicle Flight Deck and sit down at your control panel. If the mission isn't scrubbed, you launch--the first human mission to Mars! Mars Launch Tasks and emergencies are a whole new challenge. On your long flight through darkness, science experiments help train you for the mission ahead.

As you finally approach Mars, where you must guide the Transportation Vehicle as it enters orbit and rendezvous with the Excursion Vehicle (launched from Earth ahead of time to reduce fuel requirements). You enter the Mars Excursion Vehicle and drift down to the Mars surface, searching for a level landing spot.

Touchdown! Finally, the hatch opens. You gaze in shock at the rusty red landscape, the salmon pink skies of Mars. If it's your first flight--the first human flight to Mars--you explore a bit and record your first impressions before heading off in the Mars Rover for a series of exciting field experiments. If it's a later flight to Mars, you also will work at a variety of Mars Base sites. Emergencies are a constant hazard. All of your major systems--communications, life support, thermal control, and power--are fragile in this new and hostile environment. You're 300 days away from Earth, surrounded by a carbon dioxide atmosphere, temperatures ranging to -200 degrees F., and air pressure that can make your blood boil. Dust storms, lethal radiation, meteorites, and volcanic eruptions can bring your mission to a violent end. The demands of space travel take a frightful toll on the crew. If you make it back, you'll have a lot to talk about.

With graphics and scientific data produced from extensive NASA research material, *Destination: Mars!* provides an accurate recreation of the actual shuttle and planet environment.

OPENING SCREENS

Sign-In

After the program begins, you approach the gate of the Space Center. Mission Control asks you to sign in.

Use the keyboard to enter your first name, then your last name, each followed by ENTER/RETURN.

Once you've signed in, the program welcomes you to the Space Center, gives you your rank, based on experience (Mission Specialist, Pilot, Captain, or Commander), and tells you to report to Mission Center.

Beginning a Mission

Next, you enter the Mission Center building. The Hall of Fame display lists all astronauts who have completed a successful mission to Mars.

The Mission Board displays a description of your mission, including the number of experiments you will be performing.

Before you begin a mission, make sure you have your Task Card handy.

BEGINNING ALL MISSIONS

Shuttle Prelaunch Checkout

You leave Mission Center for the Orbiter launch pad, chatting with other crew members. You enter the Orbiter Flight Deck and sit down at your control panel.

Shuttle Launch

Shuttle Launch begins with a dramatic liftoff amid billowing smoke.

In the Flight Deck, you are busy with Launch Tasks and Launch Emergencies. Use your Shuttle Launch Tasks Mission Card to aid in completing your assigned tasks.

Shuttle Launch Tasks

During Launch Tasks, at the top left of your control panel, the program displays the name of the first major stage of the Shuttle Launch sequence--Ascent phase--followed by Day 1 and mission time in hours, minutes, and seconds. Ascent Phase Launch Tasks display on your cue card, one at a time.

IMPORTANT: FOLLOW THE LIST OF TASKS ON THE TASK CARD SO THAT YOU MAY QUICKLY ENTER THE CORRECT PROGRAM NUMBERS.

Many Launch Tasks display automatically. But be ready. Sometimes the program stops for a specific task. When this happens, a horizontal timer displays and the program gives you this prompt: "Enter the program number."

Look for the four-digit program number for that task on your Task Card. Enter it, then press ENTER/RETURN. You must enter the correct number before the last block in the horizontal timer disappears.

Shuttle Launch progresses through five major stages--Ascent phase, SRB (Solid Rocket Booster) separation, MECO (Main Engine Cutoff), ET (External Tank) separation, and Orbit insertion--each with its specific tasks.

Shuttle Launch Emergencies

If an emergency occurs during Launch, your control panel displays "CAUTION/WARNING" and the emergency alarm begins to sound. You're told what type of emergency you have. On screen, you're also given "Earth", "Crew", and "Database" options and three possible ways to end the emergency.

Use your Earth and Crew options to get more information on the emergency. If you do not know the proper course of action for this emergency, choose Database to access the computer's data files. When you have reviewed the data, you must decide on the best course of action. Use the mouse or arrow keys or space and ENTER/RETURN. The program will tell you whether or not you have selected the right course of action.

After Shuttle Launch is completed, Low Orbit (LO) missions enter low Earth orbit and Space Station (SS) and Mars missions continue their flight to the Space Station. (All Mars vehicles are launched from the Space Station, to cut down on fuel requirements.)

LOW ORBIT MISSIONS

Introduction

Once past Launch tasks and emergencies, Low Orbit missions begin with Mission Control's announcement "You're in orbit!" Glancing at Earth out of your window, you proceed to a low-orbit experiment, a special mission, and whatever emergencies may occur.

Low Orbit Experiments

Experiments play a crucial role in your advancement to higher levels of command. You will perform many of these experiments as you progress through the space program.

When it is time for an experiment, make sure your user's guide is at hand. It contains important information which will allow you to successfully complete each experiment. As an experiment is displayed on your monitor, it will indicate the appropriate section of the user's guide that may be used for reference (You may also want to have a calculator handy for some of the physics experiments). Read through the experiment carefully, using the left and right arrow keys (left and right mouse buttons) to move through the information. At the end of the information is a question which you must answer correctly in order to successfully complete the experiment. Make sure you understand the problem fully before selecting an answer.

Macintosh
Use the mouse to click on Next or Previous to scroll through the experiment text. To record your decision, click on the correct answer.

Low Orbit Special Missions--Remote Manipulations and EVAs (Extra-Vehicular Activities)

Remote Manipulations
Your Low Orbit mission includes a Remote Manipulation, so you'll be deploying a satellite, a special lab, a space observatory, a test vehicle, or another payload. You also could be retrieving or repairing a satellite or other orbiting space hardware. Or you might be inspecting the Shuttle or the payload.

To accomplish your assignment, follow the directions on your cue card. Watch the Remote Manipulator Arm you see in the control panel monitor. Use arrow keys, the mouse, and special key combinations to maneuver your payload where required. Use ENTER/RETURN to seize and release the payload.

Extra-Vehicular Activities (EVAs)
Your Low Orbit mission may also include an EVA--a "space walk".

MS-DOS
The purpose of the EVA is perform construction work on the Space Station. You will be carrying a beam which must be anchored in the correct location on the Space Station. Use the arrow keys to move until the Space Station comes into view. Maneuver yourself into position to place the beam in the correct location.

Watch your gauges carefully. If you run out of oxygen or fuel, you will be unable to complete the assignment.

Apple II
You might be helping the astronaut to test equipment, to repair a satellite, to repair the Shuttle, or to make a crew rescue. Follow on-screen directions to help him/her enter the airlock, open the outer airlock, successfully accomplish the objective, then return safely to the Shuttle. If any gauge gets too high or too low, you must adjust it to the proper levels. Follow on-screen instructions for making adjustments.

Macintosh
The Macintosh version does not include EVAs.

Low Orbit Emergencies

Many emergencies occur in Low Orbit. They can interrupt your mission at any time.

Handle Low Orbit emergencies as you handled Launch emergencies. Watch and listen for the "CAUTION/WARNING" message and the emergency alarm. Then, get more information by using the Earth, Crew, and Database options, then make a decision. Be careful; crew safety depends upon your good judgment.

Low Orbit Mission Completed

When your Low Orbit mission is complete, you head back to Earth. Reentry tasks and emergencies demand your full attention.

Be ready with your Shuttle Reentry Task Card.

Low Orbit Reentry Tasks

With your Shuttle Reentry Task Card in hand, you begin the final phase of your mission, Reentry.

The clock is running. Reentry task phases--Deorbit burn phase, Orbiter entry interface, Blackout, Terminal area energy management, and Autoland--display one at a time on your control panel, with task lists.

Compare these task lists to your Task Card lists. If the program stops and displays the horizontal timer and the prompt to enter the task program number, find the correct number for that task on your Task Card. Type it in, then press ENTER/RETURN before the timer disappears.

Low Orbit Reentry Emergencies

Emergencies can occur at any time during Reentry.

Handle these emergencies as you handled Launch and Orbit emergencies. When you see the "CAUTION/WARNING" message and hear the emergency alarm, use the Earth, Crew, and Database options for more data, then make a decision.

Back to Earth--Touchdown and Welcome

If your mission performance was above 60 percent and you encountered no emergencies that caused you to abort, your Shuttle lands normally. The Space Center ground crew welcomes you back.

You're shown your progress rating compared to the other space agencies. Depending on your mission level, you may be moved up a rank.

You now return to Mission Center to try another mission. If you quit after a mission, your rank and performance information will be waiting when you start the program again.

SPACE STATION (SS) MISSIONS

Launch, Shuttle Flight

If you're on a Space Station mission, or if you're going to Mars, you complete the Launch tasks and emergencies as you did for Low Orbit missions. Then, rather than entering Low Orbit, you continue flying to the Space Station.

As you go, you perform an experiment like your Shuttle Low Orbit experiments. You also might have to deal with emergencies at any time.

Approach Space Station

Soon you see the "Approach Space Station" message on your control panel. Have the Space Station Approach Task Card ready.

Space Station Approach Tasks

With the Space Station Approach Task Card in hand, you see a series of tasks like those you dealt with during Shuttle Launch and Reentry. Watch your approach task list, comparing it with your on-screen display. When you're told to enter a program number, type in the correct four-digit number from your Task Card. Then press ENTER/RETURN.

Space Station Approach Emergencies

Handle your Space Station Approach emergencies as you handled emergencies during Low Orbit flights. Watch for the "CAUTION/WARNING" message and listen for the emergency alarm. Then, use the Earth, Crew, and Database options for vital information. Think carefully, then choose an option.

Space Station Docking

Once you've completed Space Station Approach Tasks and Emergencies, the Space Station itself suddenly comes into view. Now, you must align the Shuttle for docking.

The Space Station disappears from your window as the nose of the Shuttle points out into space during docking. In your control panel monitor are the Space Station docking node, with crosshairs to show your position. Carefully use the arrow keys, or the mouse, to move the crosshairs directly over the central circle of the docking node. Then press ENTER/RETURN, or click on DOCK.

You arrive at the Space Station.

Space Station--Introduction

On a Space Station (SS) mission, you either unload cargo or perform an experiment.

Space Station--Unload Cargo Missions

If you're unloading cargo at the Space Station, you work from the Mission Specialist control panel. Watch the Remote Manipulator Arm in the monitor. Use arrow keys, mouse, special key combinations, and ENTER/RETURN to maneuver your payload into the Space Station cargo area. Follow the directions on your cue card.

When your cargo is delivered, you return to Earth. Your entire flight is automated until you reach the Reentry stage. Then you need your Shuttle Reentry Task card. Handle Reentry Tasks and emergencies as on your earlier Shuttle missions. If you are successful, you touch down. You are welcomed to Earth and invited to begin another mission.

Space Station--Experiment Missions

If your Space Station mission is to perform an experiment, the Shuttle hatch opens and you exit the Shuttle, entering the Space Station through a tunnel. You report to the Space Station Lab Module, where you are given an experiment assignment.

Perform this experiment as you have those in Low Orbit and on your Space Station flight.

Space Station Missions--Return to Earth

When your assignment is finished, you return to Earth in an automated flight, until you reach Reentry. Then use your Shuttle Reentry Task card to help get you and the crew home safely.

MARS MISSIONS

Launch, Shuttle Flight to Space Station

You've done your share of Low Orbit and Space Station missions. This time it's different. You're headed for Mars!

Since Mars missions depart from the Space Station, you begin with a Shuttle flight. After your big Earth sendoff, your Shuttle flight begins, but others are doing the work for you this time. You approach the Space Station and dock. The Shuttle hatch opens and you walk through the Space Station tunnel to the Mission Room.

Apple II and Macintosh

If you're a veteran (on your third or later Mars mission), you stop on the way for a special honor--assembling your own special "stretch" Mars vehicle! Use the arrow keys to separate the segments of the Mars vehicle and insert the "stretch" component.

Mars Launch Tasks/Emergencies

If the launch is a GO, it's an incredible moment. You are quickly plunged into Mars Launch Tasks. You need your Mars Launch Task Card. There are plenty of emergencies during the Launch. Handle these tasks and emergencies as your Low Orbit and Space Station flights have trained you to do.

Mars Flight--Experiments/Emergencies

Once you're out of the Launch stage, you and the crew settle in for a long ride alone through the darkness of space.

For many, many months, you perform important experiments that enlarge your human knowledge and equip you for the great promise and dangers of Mars. Harrowing emergencies punctuate your daily life in the Mars vehicle. Mars flights are the most demanding and dangerous space missions ever attempted.

Enter Mars Orbit--Tasks/Emergencies

Finally, unbelievably, your control panel tells you that you are approaching Mars. You see it glowing in your window, though you're still too far away to see Phobos and Deimos, Mars's tiny moons. Ah, there they are! The red planet looms in your window.

Now you must perform a series of crucial tasks to enter Mars orbit. At this stage emergencies can doom your entire mission. Use the Mars Enter Orbit Tasks card.

Mars Orbit--Dock with Excursion Vehicle

You spot the Excursion Vehicle in your window, orbiting Mars. You position your craft for docking.

The procedure is the same as that used to dock with the Space Station. In your control panel monitor you see the Excursion Vehicle's circular docking node, with crosshairs to show your vehicle's position. Carefully use the arrow keys or mouse to move the crosshairs directly on top of the center of the docking node. Then press ENTER/RETURN.

Descent to Mars Surface

The Mars Transfer Vehicle hatch opens. You float into the Mars Excursion Vehicle.

You begin to aerobrake down to the red planet's surface.

In your Excursion Vehicle monitor appears a scrolling view of the Mars surface below. You need to find a level area for touchdown. Move the crosshairs with the arrow keys. When you find a level spot, press ENTER/RETURN.

Your vehicle touches down. You've landed on Mars!

MARS BASE

Introduction

Here is the moment you've waited for.

You face the Mars Excursion Vehicle hatch. It opens. You look out upon the rust-colored landscape and the salmon-pink skies of Mars.

What happens next depends upon whether this is your first flight or your second flight or later flight.

FIRST MARS FLIGHT

Message Home

If this is your first Mars visit, you walk slowly out onto the Mars landscape. Moving in .38 Gs is awkward after months in zero gravity. You're overwhelmed by the new universe all around you. After months of confinement, freedom and open space is a shock.

Suddenly your Wrist Computer beeps insistently; the MESSAGE bar flashes on and off. It displays a message:

> "What's it like to be on Mars, Specialist [name]?
> "Planet Earth is listening!"

You think carefully. Then you type in a short, personal message, followed by ENTER/RETURN. Earth thanks you for your historic words, then directs you to your Mars Rover.

Mars Rover

You spot the Rover, parked over by the Mars Habitat, the Mars Lab Module, and various cargo modules that were delivered earlier by robotic missions. You move over to the Mars Rover and get in.

Your Wrist Computer gives you directions. You're to drive the Rover to a specific Mars sector.

MS-DOS

Have your Mars Base Locations Card and your Mars Atlas handy, so you can enter the correct coordinates for each location. When you enter coordinates, you must first enter the Latitude, then the Longitude.

For experiments, you will have to locate a geographic feature in the Mars Atlas, then enter its coordinates. First, find the geographic feature on one of the three equatorial views of the planet. Notice the white grid lines running horizontally and vertically near your desired location. The horizontal lines indicate latitude, the vertical indicate longitude.

Latitude is noted as the number of degrees north or south of the equator. For example, find the location: South Spot (Arsia Silva) on the Central Meridian view of the planet. South Spot is located below the equator (the thick white line running horizontally through the center). It runs from 5 to 12 degrees south of the equator. Its center is at about 9 degrees south. We would note this as **9S**. If it were north of the equator we would write **9N**.

Longitude is written as degrees west of the 0 Meridian. Using the above example, we can see that South Spot is centered at about 120 west of the meridian, so we would enter **120**.

Use the above notation for entering any locations on Mars.

Apple II and Macintosh

Type in the coordinates as they are shown on the Wrist Computer, then press ENTER/RETURN. For example, type

26N 3W <ENTER/RETURN>

Your Mars Rover takes you to the right place.

Experiments

Once you've reached your assigned Mars sector, your Wrist Computer guides you. Now, you perform special Mars experiments relying upon the scientific background provided in your user's guide.

Emergencies

In the hostile Mars environment, emergencies constantly occur. Any one of them can bring catastrophe.

Be ready. Keep your Mars Base Emergency Cards at hand at all times. Your Wrist Computer beeps a warning, then displays a description of your emergency and your choice of options. Be very careful. One slip can be fatal.

Mission Completed

Once you've completed your experiments and if you've survived the emergencies, your mission is completed. You may return to Earth.

The speedy automatic return flight is over before you know it. The Mars Transfer Vehicle hatch opens, a Space Center crew person welcomes you, and you're back at Mission Center to greet your friends and begin another mission.

SECOND OR LATER MARS FLIGHTS

Mars Landing

If you've been to Mars before, everybody's already heard your historic words. You get right to work. You bounce out of the Excursion Vehicle and hop into the Mars Rover, parked over by the growing Mars Base.

Once you're in the Rover, your Wrist Computer displays your first assignment. At any time, it also could warn you of a coming emergency.

Mars Base Site Assignments

If you're given a Base Site assignment, enter the coordinates in your Wrist Computer, followed by ENTER/RETURN. You're to drive to one of the Base Site areas and complete an activity. Perhaps it's nearby, at the Launch/Landing Area. Or it could be one of the indoor modules, like the Crew Habitation or the Science Area. Or it might be farther afield, in the Power Production area, in the Resource Management area, or at the Geophysical Station. It could even be a Field Experiment, a real excursion into the astonishing and treacherous Mars landscape.

Mars Base Emergencies

On Mars, emergencies are almost always life-threatening. Correct decisions are vital to your survival.

Mars Resource Control Scenario

When you have completed the Base Tasks and Experiments of your third successful Mars mission, you will enter the phase which will determine the future of the space race. You have reached an agreement with the Director of the WSA which will allow the scenario to be played out without any violence.

Each Space Agency has placed secret resource areas on its side of the planet. The object of the scenario is to discover all of the WSA's secret resource areas before they discover your own hidden resources.

Begin by placing your resource areas on the planetary grid. A resource area must be in a straight line, either horizontal or vertical. The resource areas are different sizes. Each resource area will take up a certain number of squares on the grid as shown below:

Resource Name	Grid Squares
Molybdenum	5
Platinum	4
Zirconium	3
Selenium	3
Beryllium	2

When all of your resource areas have been placed, you will be prompted to begin resource exploration. Select a square on the WSA's side of Mars. If the square contains one of the WSA's secret resource areas, it will be noted by a star (*). If not, another symbol will appear.

After you have selected a square, the WSA will begin its search for your resource areas. Watch your side of the planet to follow the WSA's progress. You will alternate selections until either you or the WSA have discovered all of the other's areas.

MS-DOS

To place a resource area, use the arrow keys to move the cursor to an empty grid square. Press Enter to place a resource in that square. Then, move to an adjacent square to continue placing that resource area. When you have placed all of the squares for that particular resource area, a message will confirm that the resource area has been placed. Continue by placing the next resource area.

Apple II

To place a resource area, use the arrow keys to move the cursor to an empty grid square. Press Return to place a resource in that square. Then, move to an adjacent square to continue placing that resource area. When you have placed all of the squares for that particular resource area, a message will confirm that the resource area has been placed. Continue by placing the next resource area.

Macintosh

To place a resource area, click on an empty grid square. Then, move to an adjacent square to continue placing that resource area. When you placed all of the squares for that particular resource area, a message will confirm that the resource area has been placed. Continue by placing the next resource area.

All Machines

Begin resource exploration by selecting a square on the right board. Move the arrow to a square and press Enter/Return (Macintosh: Click on a square.). If the You have located a WSA resource area, a star (*) will appear (a plus (+) for the Apple II). Continue selecting squares, but keep track of the WSA's progress. If the WSA discovers all of your hidden areas before you find theirs, you'll be out of business.

Mission Completed

When you've finished all of your Mars assignments and surmounted all of the obstacles and emergencies, your space career is complete. Your final progress chart will be displayed, and you will move on to a new career. You will have the options of quitting the game or starting again from the Low Orbit level. Remember, the program is different each time you play, so each player's experience will be unique.

SCIENCE BACKGROUNDS

The science areas addressed in this section of the manual give a basic overview and specific information pertaining to the experiments and emergencies contained in *Destination: Mars!*

ASTRONOMY

Astronomy is the science of the stars, planets, and all other heavenly bodies, and deals with their origin, makeup, motion, relative position, and size.

STRUCTURE OF THE UNIVERSE

The universe consists of everything we know that exists in space. This includes galaxies, solar systems, stars, planets, asteroids, cosmic dust, and about anything else you could imagine. A galaxy is a large system of stars, dust, and gas held together by a common pull called gravity. Gravity is a force created by the common attraction of masses. A star is a huge, glowing mass of gas that generates its own heat and light energy.

GALAXIES AND SOLAR SYSTEMS

Galaxies may contain hundreds of billions of stars and have diameters (widths) of 160,000 light-years or more. (A light-year is the distance that light travels in one year at a velocity of 186,000 miles per second. It would take 160,000 years of traveling constantly at the speed of light to cross a galaxy that is 160,000 light-years in diameter.) Galaxies are separated from each other by great empty space (about 3 million light years). Most galaxies rotate on their own axes. All galaxies travel through space at up to 100 miles per second. There are three different types of galaxies: spiral, elliptical, and irregular.

Spiral galaxies have a swirling shape showing a concentrated center and several spiral arms, like a pinwheel. Cosmic dust is between the stars . Gravity within the mass of stars hold them in place as the mass rotates on its axis.

Elliptical galaxies are oval or ball-shaped, and lack a spiral structure. There is no evidence of a disk or plane. Most elliptical galaxies have a sparse distribution of stars and contain little or no gas and dust.

Irregular galaxies are shapeless, having no organization of stars. Many irregular galaxies contain unstable gas clouds and stars spaced at random.

The Milky Way is a major-sized, disk-shaped galaxy with a diameter of 100,000 light-years. It is flattened, and resembles a record album. The Milky Way is our galaxy. Our solar system is located on the outside edge of the Milky Way, giving us a cigar-shaped view of it when looking directly above us, toward the galaxy's center. Because the amount of stars starts to thicken toward the center, gravity is strong enough to make the center rotate like a solid body. The center of the Milky Way is an almond-shaped bulge, surrounded by the spiral arms of stars.

SATELLITES, ASTEROIDS, AND METEORITES

While a planet develops, smaller hunks of rock often become the property of the individual planets. These are satellites, or moons. The satellites are controlled by the planet's gravity and conditions of the planet's environment. The Earth has one satellite, which we call the moon. Mars has two satellites, called Phobos and Deimos.

Phobos and Deimos are both potato-shaped, black-surfaced, and are carbon- and titanium-rich (two elements). They may be termed C-type, or chondrite. This is a type often associated with asteroids and meteorites. Phobos is about 25 kilometers (16 miles) in diameter, while Deimos is about 12 km in diameter.

In addition to stars, planets, and satellites, asteroids and meteorites were also created during the creation of the solar system. Asteroids are like small planets. Before they could join together to make one big planet, they began to hit one another at great speeds and broke apart into smaller pieces. Their size is usually small, 5 km to 50 km in diameter. Asteroids orbit the sun at a distance ranging from inside the earth's orbit to beyond Saturn's orbit. Asteroids are mainly found in a belt located between Mars and Jupiter.

There are two common types of asteroids, C-type and S-type. C-type asteroids, also called chondrites, are black-surfaced and carbon- and titanium-rich. S-type asteroids, also called achondrite, are red-surfaced and are made up of iron, stony iron, and magnesium minerals. Meteorites are also typed as chondrite and achondrite.

Occasionally a planet will capture an asteroid with its gravity into the planet's orbit. The asteroid will then become a satellite of the planet.

LIFE ON MARS

Human observation of Mars began as soon as the first telescope was invented, hundreds of years ago. In the 1880s, the Italian astronomer Schiaparelli saw a complex pattern of thin dark lines (40+) on the surface of Mars. He included them on his Map of Mars and gave them the names of rivers in ancient history and mythology. He called these lines "caneli," or canals. He declared their existence on Mars, which led to the thought that intelligent life on Mars could have built them. In the late 1800s Percival Lowell, an American astronomer, saw these dark lines through his telescope and recorded hundreds more.

No evidence of canals was found in pictures from the Mariner 4, 5, and 6 probes to Mars during the 1960s. While geological formations on Mars suggested the presence of life, the CO_2 (carbon dioxide) atmosphere and drastic temperature changes on Mars are reasons that life as we know it on Mars would not be possible today.

BIOLOGY

The science of biology is the study of the science of life. This includes the study of all living things from the simplest of plants to the most complex animals, and everything in between. Biology includes many branches of knowledge, including botany, the study of plants; zoology, the study of animals; and physiology, the study of the functions of living things.

Much of what is known about these subjects has been learned through observation and experiment over the course of many years. The study of biology has helped us to understand how and why the world works the way it does. Through biology, doctors have been able to understand how and why people get sick, and how to prevent and treat illness. Biologists who specialize in ecology (the study of the relationship of living things to their surroundings and to one another) have come to better understand the balance of life on the planet.

CELL BASICS

One of the smallest known biological structures is the cell. These small, complex units of organic material were first discovered after the invention of the microscope in the seventeenth century. In 1665, English scientist Robert Hooke was observing a piece of cork under a microscope when he noticed that it seemed to be made up of thousands of tiny chambers. The chambers reminded him of the sleeping rooms of monasteries, called cells, so he called these tiny chambers cells as well.

Cells are the fundamental units of life; they are the smallest entities that may be called living. All organisms are made up of one or more cells. It is cells, working individually or as a group, that perform many of the simple functions of life. For example, cells in many green plants perform a chemical process called photosynthesis that creates some of the oxygen that animals breathe, by using sunlight to convert carbon dioxide. Cells make up food items eaten by animals, and cells digest the food once eaten.

The cells of plants and animals differ greatly. For example, plant cells generally have thick cell walls that provide structure to the plant, while animal cells more commonly have a much thinner cell membrane.

Just as plant and animal cells differ, so do different kinds of plant cells and different kinds of animal cells. Some organisms are made up entirely of one cell. Everything necessary to that organism's life occurs within the boundaries of that single cell. However, many organisms are made up of many cells working together. Cells in multicellular organisms will become highly specialized to specific tasks. For example, the blood cells of an animal, such as a dog, are very different from the nerve cells of the same animal.

PARTS OF THE CELL

All cells have a cell membrane, or a cell wall, depending on whether the cell is an animal or plant cell. The cell membrane separates a cell from other cells and from surrounding fluids.

Plant cells also produce a cell wall, which both provides shape to the cell and contributes to the overall plant structure. The cell walls of a plant may be thought of like the walls of a building. The cell wall is produced by the cell and is made up primarily of cellulose, an organic compound that is strong and fibrous.

Within the cell's membrane is the cytoplasm. The cytoplasm is a mixture of a number of substances that provide and assist in maintaining a stable internal environment for cell activity.

Eukaryotic cells contain a large oval or spherical body within the cytoplasm. This is the nucleus, and it acts as a control center for all the activity within the cell and contains all the genetic information of the cell. The nucleus is surrounded by a nuclear membrane. Everything within the nuclear membrane is known as the nucleoplasm.

Attached to the nuclear membrane and the cell membrane are many thin double-layered membranes lying parallel to one another that aid in the flow of materials in and out of the cell and the nucleus. This is known as the endoplasmic reticulum. The endoplasmic reticulum also provides surface area chemical reactions that result in the production of proteins.

CELLULAR TRANSPORT

To maintain a stable internal environment, a cell must be able to pass certain materials through the cell wall, as needed for activity of the cell or by the organism. Many processes work together to maintain this stable, constant environment.

Some membranes will not allow any substance to pass through them, while other membranes may exclude some substances while allowing others through. Semipermeable membranes allow some materials to pass through, but not others.

The two kinds of active transport are known as diffusion and osmosis. In a system where diffusion occurs, the molecules of liquids and gases often seem to be moving in a random manner. The molecules enter the cell at a certain point, often through a pore in the cell's membrane and are initially higher in concentration around this point of entry. After a while, the molecules are more equally spread throughout the cell.

Osmosis involves the movement of water across a semipermeable membrane. Pressure exerted by dissolved particles in a solution moves across the semipermeable membrane at a slow rate of speed until the pressure is equal on both sides of the membrane. When this equal pressure has been reached, the osmotic action ceases.

A primary form of active transport is called facilitated diffusion. In this type of transport, carrier molecules at the surface of the cell move substances in and out of the cell. This type of movement increases the rate of diffusion across the membrane by allowing substances to enter at multiple points. Molecules are literally picked up at one side of the membrane and released at the other side of the membrane.

CELL REPRODUCTION

Cells reproduce to create more cells and more living organisms. Reproduction usually starts by the division of the cell. However, simply dividing into two will not always accurately reproduce all of the information necessary to the cell's life. Before dividing, a cell will make a copy of all of the necessary genetic information. This preliminary process is called either duplication or replication. Not all cells are identical, and neither are the methods by which the cells reproduce.

Mitosis and meiosis are two examples of cell reproduction by division. Organisms as a whole reproduce in two ways, each related to cellular reproduction. These are asexual and sexual reproduction.

ASEXUAL REPRODUCTION

Asexual reproduction requires only one organism. Amoebas, tiny single-cell organisms, reproduce asexually by dividing into two genetically identical copies of the original by mitosis. Other examples of asexual reproduction include spores, budding, fragmentation, and cloning. All involve the creation of genetically identical cells.

Spores are asexually reproductive cells given off by a parent organism, such as a mushroom. They float in air or water and eventually produce genetic copies of the parent. Budding is a process in which part of the parent sprouts a smaller offspring that eventually separates and becomes a distinct individual. An example of an organism that buds is a hydra. Fragmentation occurs when part of an organism separates from the whole and a new individual organism generates from the fragment. This may occur when an organism is in danger or has been damaged. Some plants have this ability, as do starfish and worms. Cloning, like other forms of asexual reproduction, involves the production of organisms genetically identical to the original. Cloning occurs more often with plant species. For example, one plant may grow from the seed, but many more clones may grow from the roots of the original plant.

BLOOD

Another type of specialized cells are blood cells. Blood makes up about 8% of a human's total body weight. The amount of blood in a human's body is between 4 and 6 liters (over a gallon). Blood is thicker and heavier than water, and is generally saltier than sea water.

The actual liquid portion of blood is called plasma, and this is about 50% to 60% of the volume of blood. Plasma itself is about 90% water and includes the proteins that control the clotting of blood. The remaining 40% to 50%of blood's volume is made up of cells and cell fragments. These cells and cell fragments are divided into three main groups: red blood cells (also called erythrocytes), white blood cells (also called leukocytes), and platelets (also called thrombocytes).

RED BLOOD CELLS

Red blood cells are those involved in the transportation of oxygen through the body. They look like flattened disks with an indentation.

Red blood cells contain hemoglobin, an iron-containing protein that aids oxygen transport. It is the iron that gives blood the red color. Red blood cells are manufactured by the red bone marrow and tend to have a life span of three to four months. Older red blood cells are consumed by the liver at the end of their life span.

Because red blood cells are so important to the transportation of oxygen throughout the body, a significant drop in the concentration of red cells puts the individual in danger of not getting enough oxygen to the other cells in the body. A person with such a condition is called anemic.

BLOOD TYPES

Everybody has very individualized blood. Some of this is attributable to blood types, some types of which are incompatible. There are over 300 blood groups but the most widely known is the ABO group. The ABO group depends on a combination of two alleles (an allele is one of a pair of genes) at the same location on a pair of chromosomes. The combination can be AA, AB, BB, AO, BO, or OO. They are the result of two different antigens, A or B, or their absence, O. AA or AO produce type A blood; BB or BO produce type B blood; AB is type AB blood; and OO is type O blood.

Since antibodies are formed to combat antigens, a person with type A (containing antigen A) blood will form an antibody to combat antigen B. That is, it will have an antibody against antigen B. Similar situations occur in the other blood types. This is best represented by the following chart.

Antigens and Antibodies

Blood Type	Antigens on the Erythrocytes	Antibodies on the Plasma
A	A	anti-B
B	B	anti-A
AB	A and B	None
O	None	anti-A and anti-B

Donor/Receiver Relationship

Blood Type	Can Receive Blood From	Can Act As Donor To
A	A, O	A, AB
B	B, O	B, AB
AB	A, B, AB, O	AB
O	O	A, B, AB, O

When incompatible blood types are mixed, the blood of the patient receiving the wrong type of blood will clump and clot, blocking veins and arteries, clogging organs, and eventually causing a stroke. Type O blood is called the universal donor because it may be well received by any blood type. Likewise, type AB blood may be called the universal recipient, as a person with AB blood can tolerate any type of blood.

BACTERIA

There are about 5,000 different kinds of bacteria and bacteria-like organisms. There are a number of classifications of bacteria, according to cell shape, size, structure of cell walls, movement, how food is obtained, and oxygen need. For example, the class of bacteria called eubacteria is also known as the class of true bacteria. It includes many of the most common and familiar forms of bacteria.

Almost all bacterial cells have a rigid cell wall, and most have another layer over that wall made up of sugars and amino acids called a capsule. Inside the cell wall is a cell membrane, and within the membrane is the cytoplasm. Instead of a nucleus, bacteria have a nuclear area that is not surrounded by a membrane. Like other cells, bacteria hold their genetic material in a chromosome, but the bacterial cell has a single circular chromosome. Some bacterial cells contain an additional separate and small unit of genetic material called a plasmid. Many bacteria move by the use of long, thin whip-like structure protruding from the cell wall called flagellum.

CHEMISTRY

Chemistry is the science dealing with the composition and properties of substances, and with the reactions by which substances are produced from or converted into other substances.

ELEMENTS, ATOMS, AND COMPOUNDS

The study of chemistry is based on elements. Elements are the simplest substances. Elements cannot be broken down by ordinary types of chemical change, and they cannot be created by chemical union. Two examples of elements are oxygen and hydrogen. Neither substance can be broken down into smaller pieces.

However, combining hydrogen and oxygen in specific amounts creates a compound, specifically water (H_2O). Compounds are substances made up of more than one element.

A compound has properties that are different from the properties of its components. The makeup of a compound is definite and is always the same no matter how that compound may have been formed. Water is always H_2O regardless of the chemical reaction that created it.

There are 108 known chemical elements. Fewer than half of these 108 elements make up 99.9% of all substances. Some elements are very rare, while others occur in great quantity. Oxygen, for example, makes up 49.1% of the elemental makeup of the Earth's surface, including the crust, the oceans, and the atmosphere. Carbon makes up .09% of the elemental makeup of the Earth's surface.

Elements can be broadly put into two groups: metals and nonmetals. Metals have a characteristic luster; they are flexible and are usually good conductors of electricity and heat. All metals, except mercury, are solid at room temperature. Nonmetals vary greatly in appearance. More than half of the nonmetals are gases at room temperature, and all others are solid, except for bromine, which is a liquid at room temperature. Nonmetals are poor conductors of electricity, are not malleable, and do not have a characteristic luster.

STATES

All chemical elements exist in three different states at different temperatures: solid, liquid, and gas. The temperatures at which elements attain different states will vary from element to element This is part of the individual physical property of each element. A good example is water. Water is a mixture of hydrogen and oxygen. Both elements exist separately as gases at normal room temperature. When combined, they form H_2O, or water, a liquid at room temperature, a solid (ice) at temperatures below 0°C, and a gas (steam) at temperatures above 100°C.

All chemical elements are assigned a chemical symbol. Chemical symbols are abbreviations used to denote the elements and are usually the first one or two letters of the name of the element. Some symbols are derived from the Latin name for the element. For example, the chemical symbol for aluminum is Al, while the chemical symbol for iron is Fe because the Latin name for iron is *ferrum*.

A few elements exist as diatomic molecules in nature. This means that they exist in nature as two atoms of the element joined together. However, they are still considered single elements because the molecules consist of identical atoms. Hydrogen, oxygen, nitrogen , fluorine, chlorine, bromine, and iodine are all diatomic molecules. They are written as the chemical symbol with a subscript 2. Hydrogen is written as H_2, oxygen as O_2, and so on.

An atom is defined as the smallest part of an element that can enter into a chemical combination. All chemical compounds are formed of atoms. The difference between compounds is due to characteristics, number, and arrangement of the atoms that make up the compound.

A molecule is a unit of two or more atoms joined together. It is also defined as the smallest unit quantity of defined matter that can exist by itself and still have all the properties of the original substance. For example, a molecule of water may exist by itself and retain all properties of any greater amount of water.

ATOMIC THEORY AND THE LAW OF CONSERVATION OF MASS

The key to the understanding of chemistry and chemical reactions is the law of conservation of mass and atomic theory. The law of conservation of mass states that in a chemical reaction, the total mass of the reacting substances is equal to the total mass of products formed. This is just like a mathematical equation where the amounts on both sides of the equal sign are the same, though they may look quite different.

The relative amount of each element in a particular compound is always the same regardless of the source of the compound or how the compound is prepared. A molecule of water (H_2O) will always have two atoms of hydrogen and one atom of oxygen, regardless of how the molecule was formed.

Atomic theory further states the law of constant composition by the following:

1. Matter is composed of small, indivisible particles called atoms.
2. The atoms of a given element all have the same mass and are identical in all respects, including chemical behavior.
3. The atoms of different elements differ in mass and in chemical behavior.
4. Chemical compounds are composed of two or more different atoms joined together. The particle that results when two or more atoms join together is called a molecule. The atoms in a molecule do not necessarily have to be different. If atoms are the same, it is a molecule of an element. If the elements are different it is a molecule of a compound.
5. In a chemical reaction , the atoms involved are rearranged to form different molecules; no atoms are created or destroyed.

ATOMIC AND MOLECULAR MASS

Using atomic theory, relative atomic mass can be determined for atoms of different elements. Atomic mass is defined as the ratio of the mass (weight) of a given atom to the mass (weight) of a particular atom. Hydrogen, the lightest of all atoms, was once arbitrarily given the value of exactly 1. This value of hydrogen was used as the standard by which all other atomic masses were expressed.

Just as atoms have masses, so do molecules. Molecular mass is the sum of the atomic masses of the atoms that make up a molecule. Once molecular mass is determined, so can the mass percentage of an element in a molecule. Once again, a water molecule (H_2O) is an example. Since there are two hydrogen atoms and one oxygen atom in a water molecule, the atomic masses of these atoms are added up.

molecular mass of H_2O=2(atomic mass of H)+(atomic mass of O)

=2(1) + (16)

=2 + 16

=18

The molecular mass of a molecule of water is 18.

THE PERIODIC TABLE OF THE ELEMENTS AND REACTION TYPES

The periodic table of the elements is the basis for understanding chemical reactions. This is because there are patterns in the chemical properties of elements. Chemical reactions can be studied by group. The periodic table gives basic information about chemicals, such as chemical symbol and atomic number and mass. It also groups chemicals according to property.

First, however, there is more that needs to be discussed about the basics of chemical reactions. Many chemical reactions fall into one of four categories: combination reactions, decomposition reactions, single-replacement reactions, and double-replacement reactions. The reactants are the substances that react with each other, and the products are the substances that are formed as a result of the reaction.

The simplest reaction occurs when a metal and nonmetal react to form a new substance. Entirely new substances are then formed in a chemical reaction, and the product(s) of a reaction need bear no resemblance to the reactants.

An example is the reaction of sodium, a very reactive metal, and chlorine, a very reactive nonmetal gas. When sodium metal is dropped into a container of chlorine gas, there is a spontaneous reaction resulting in a white crystalline solid, sodium chloride. Sodium chloride is better known as table salt. The chemical equation for the reaction looks like this:

$Na + Cl_2 \text{-->} NaCl$

1	2											3	4	5	6	7	8
1 H 1.008																	2 He 4.003
3 Li 6.941	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.06	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.90	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.70	29 Cu 63.55	30 Zn 65.38	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.3	71 Lu 175.0	72 Hf 178.5	73 Ta 180.9	74 W 183.9	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	103 Lr (260)	104	105	106	107	108	109									

Atomic Number

Atomic Weight

Lanthanide series

57 La 138.9	58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (145)	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164..9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0

Actimide series

89 Ac (227)	90 Th 232.0	91 Pa (231)	92 U 238.0	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)

CHEMICAL REACTIONS AND EQUATION BALANCING

Chemical equations must be balanced. Individual atoms are neither created nor destroyed in a chemical reaction. The above equation is not balanced. On the the left, there is one atom of sodium and one diatomic molecule of chlorine (containing two atoms). On the right, there is one molecule of sodium chloride, containing one atom each of sodium and chlorine. What happened to the other chlorine atom? It could not exist in nature as a single atom because chlorine exists naturally as a diatomic molecule. The equation must be balanced to efficiently use all reactants. Therefore, another atom of sodium would be added, and the reaction would result in two molecules of sodium chloride. Therefore the equation would be correct as follows:

$$2Na + Cl_2 \dashrightarrow 2NaCl$$

These types of chemical reactions also serve to indicate how other elements will react in certain situations. Patterns can be noticed in the reaction of sodium, lithium and potassium with chlorine. When chlorine was reacted with each of these very reactive metals, a white unreactive crystalline solid resulted. It was also noticed that each of these metals is less dense than water, have very low melting points, and can easily be cut with a knife. As a group, they are considered alkali metals.

Another group of metals, magnesium, calcium, strontium, and barium, all burn brightly when heated in oxygen to form white oxides. These are called alkaline earth metals.

Fluorine, chlorine, bromine, and iodine are nonmetals that are very reactive and react with most metals and nonmetals. As a group, they are called halogens.

As already seen, a combination reaction is the reaction of two substances to form a single product. The example used is:

$$2Na + Cl_2 \dashrightarrow 2NaCl$$

GEOLOGY

Geology is the science that deals with the physical nature and history of the Earth, including the development and structure of its crust, the composition of its interior, individual rock and mineral types, the forms of life found as fossils and other geologic features such as volcanoes and glaciers. Principles of geology may also be applied to the history and structure of other planets.

PLANET STRUCTURE

The interior of the Earth is composed of a crust, a mantle, and an inner and outer core. The crust is the outermost layer of the earth. The thickness of the crust ranges, on average, from 8 km to 32 km (a kilometer, abbreviated km, is equal to about .6 miles).

The mantle lies beneath the crust to a depth of 2,900 km. Rock in the mantle can flow like a liquid due to high pressure and heat. Temperatures range from 870°C to 2,200°C. (Use of the centigrade temperature scale, abbreviated C, is more common in scientific experiments. The formula to convert temperature from centigrade, C, to Fahrenheit, F, is °F=9/5(°C)+32. Therefore, 870°C is equal to 1,598°F)

The liquid outer core begins at 2,900 km beneath the earth's surface. The temperature in the outer liquid core ranges from 2,200°C to 5,000°C at the innermost extent.

The solid inner core is very dense and has temperatures of 5,000°C and up. The enormous pressure at the depth of 5,150 km pushes the particles of iron and nickel so tightly together that they remain solid rather than being in a more normal molten state.

Scientists discovered this information by the use of seismic wave measurements, particularly by the analysis of primary (p-wave) and secondary wave (s-wave) measurements.

Both p- and s-waves move through the crust at the same speed. At the boundary of the crust and mantle, both p- and s-waves slow down, demonstrating the semiliquid nature of the mantle. At the outer liquid core, p-waves continue to slow down, while s-waves disappear (showing an inability to pass through liquid). At the inner solid core, p-waves pick up speed.

Associated with the concepts of the crust and mantle is the idea of plate tectonics. Plate tectonics is the theory of the Earth's crustal structure and the forces that produce changes in it. In part, it is how the Earth's crust floats and moves across the mantle.

Many scientists believe that, millions of years ago, one big continent named Pangea existed, surrounded by a vast ocean. The continent began to break apart into large fragments that became smaller land masses that we know as the seven continents, surrounded by water. The continental and oceanic plates of the Earth's crust now move across the Earth's semiliquid mantle. Scientists have found evidence that shows how all the continental and oceanic plates fit together in a sort of puzzle, similar to a broken china plate that has been glued back together.

These continental and oceanic plates are still moving, often against one another, thus creating certain types of geologic phenomenon such as earthquakes and volcanoes.

EARTHQUAKES

Earthquakes are rapid movements inside the Earth's crust. They occur in the outer 40 miles of the Earth's crust, often where one or more continental or oceanic plates join together. As these plates push against each other, they create intense pressure. Somehow this pressure must be relieved.

Earthquakes have a focus that is the spot inside the crust where the actual crust movement takes place. The spot on the surface of the crust directly above the focus is called the epicenter. The most intense surface vibrations are often experienced here. Earthquakes are measured with a seismograph. Vibrations are then translated into a measurement called the Richter Scale that gives an idea of the strength of an earthquake.

Earthquakes tend to occur in localized areas where they have the same or similar focus and epicenter. They sometimes create visible scars called faults. A fault is a crack or fracture on the surface of the Earth's crust that reflects the stress on the rock below.

GLACIERS

Glaciers are an interesting geological phenomenon. In very cold areas of the Earth, the only form of precipitation is snow. When layers of snow build up on themselves, they eventually turn into thick layers of ice. The weight of the ice makes itself creep forward. A giant sheet of ice is called a glacier. Glaciers can scar and reshape the Earth's surface.

Glaciers pick up rocks and sediment as they move across the land. When the air temperatures become warmer, the ice melts and the glacier drops off loads of sediment in many different shapes on the Earth's surface. There are some specific glacial features associated with this dropping of sediment: drumlins, and moraines.

Drumlins are teardrop-shaped mounds. Moraines are long hill shaped deposits of random sediment.

Terminal moraines are long hill-shaped deposits found at the end of the farthest advanced sign of glaciers, perpendicular to the glacier's direction.

Lateral moraines are long hill-shaped deposits that are parallel to the directional flow of the glacier and are often found along the sides of glaciers.

Over the past million years, glaciers have moved south across Canada and the upper United States from the North Pole. They have since melted, but have left their scars across the continent's surface.

VOLCANOES

Volcanoes are vents in the Earth's crust through which magma, gases, and ash can escape. Volcanoes often occur near the boundaries of continental and oceanic plates. This is also a way new land mass is created.

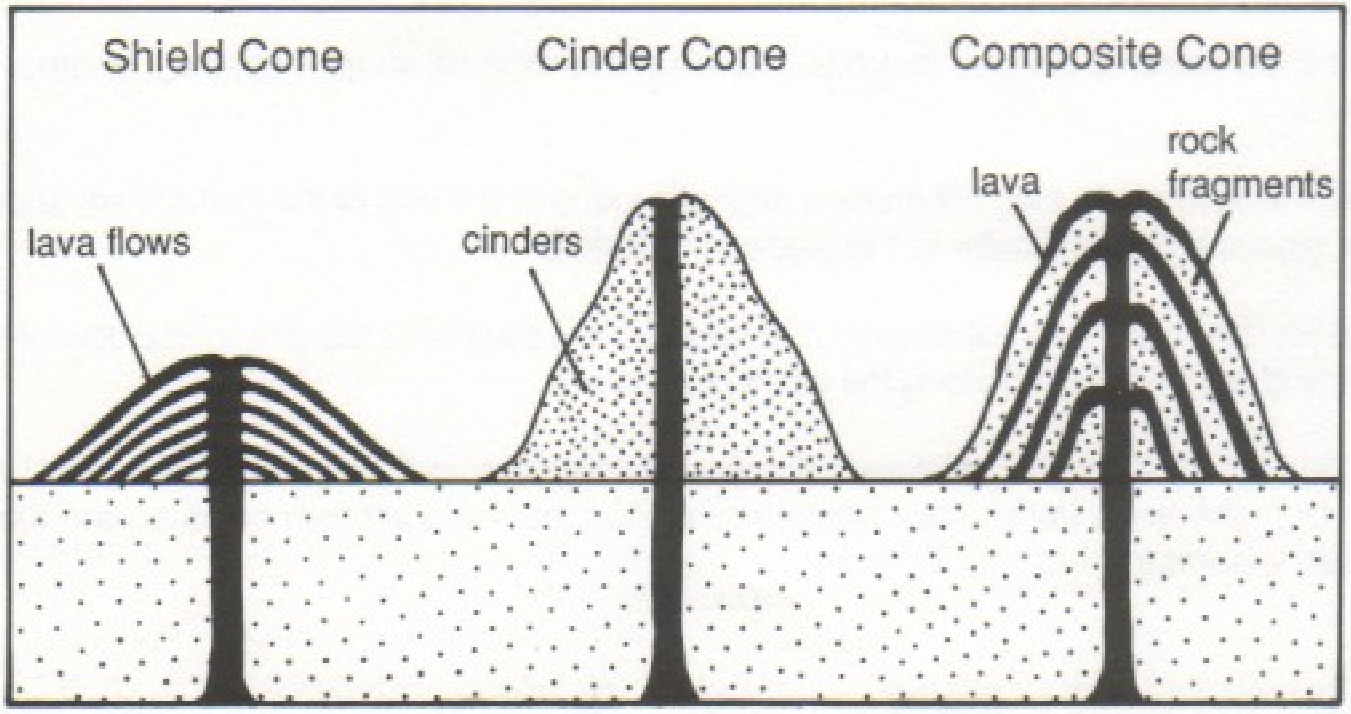
Magma is liquid rock that is trapped in the mantle. As the magma finds an escape route, through a fracture in the Earth's crust, it travels upward under pressure and temporarily collects in a pocket, called a magma chamber, before continuing up the vents to the Earth's surface. The size and the shape of a volcano depend on the size of the magma chamber, which is like a deep underground cave. The magma chamber also consists of a neck, or pip, through which the magma will eventually reach the surface.

There are three kinds of volcanoes: shield, composite cone, and cinder cone. There are also two kinds of eruptions: quiet and explosive.

Shield volcanoes are low in elevation and wide in horizontal extent. The lava is honey-like and spreads out as it oozes from its opening. Shield volcanoes often grow from the ocean floor through the ocean crust.

Composite cone volcanoes can become large in height and width. The lava is of two types: honey-like fluid lava and ash (pyroclastic sediment) that explodes into billowing clouds and settles on the ground as dust and pebbles. Composite cones often grow through the continental crust.

Cinder cone volcanoes have the steepest shape of the three types of volcanoes. Their lava is ash (pyroclastic sediment) that piles up on top of itself in a funnel shape. Cinder cones usually grow along the edges of oceanic islands and plate boundaries.

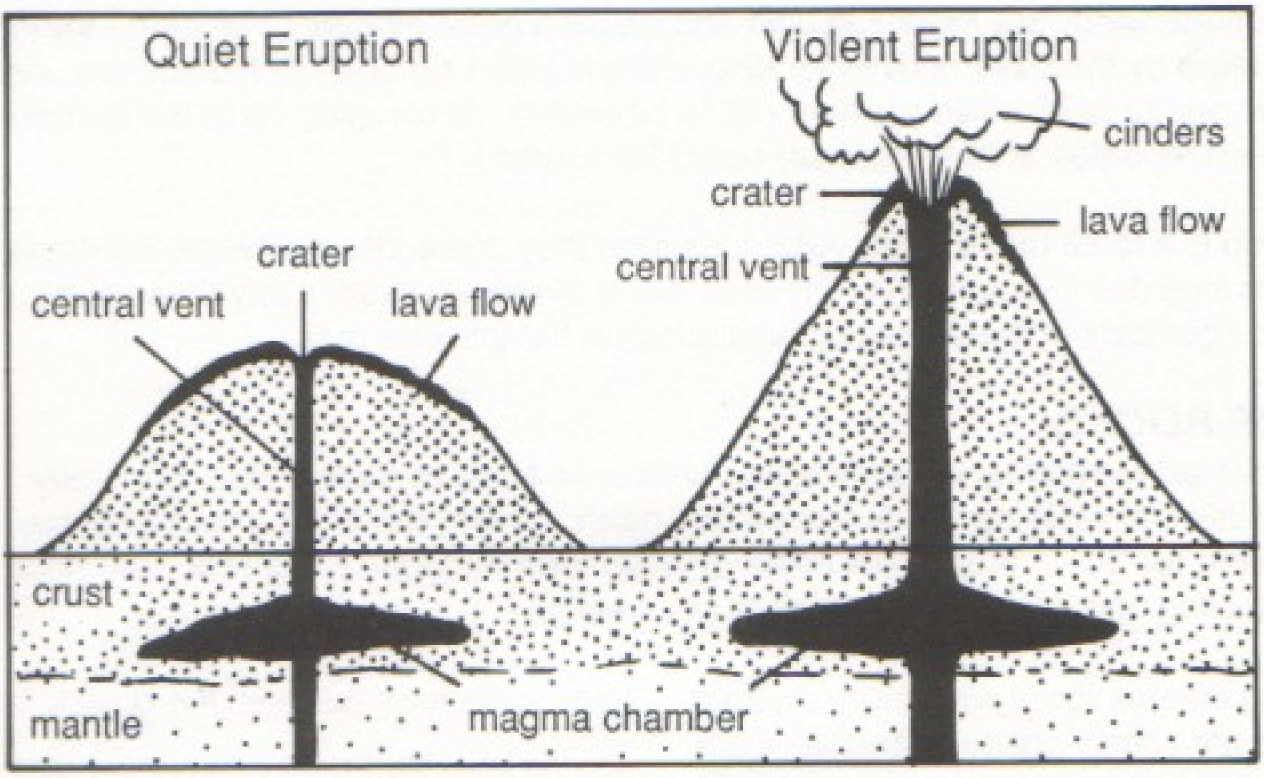


ERUPTIONS

When a volcano erupts, the rock, as lava and ash, builds up on the ground. The volcanoes cannot hold as much lava and sediment because the sides become steeper in angle due to the gravitational pull of the earth's surface. This is less of a factor on Mars because the gravitational force on Mars is one-ninth that of the gravitational force on Earth.

Quiet eruptions occur when the magma oozes out of the vent. It spreads over the Earth's surface without violent eruptions. The shape of the volcano that produces quiet eruptions is generally broad and flat.

Explosive eruptions occur when the magma is released after pressure has built up underground to an extremely high level. When the pressure reaches a certain point, the magma blasts to the surface. With it come rocks, ash, dust, steam and often poisonous gases. The shape of the volcano that would produce an explosive eruption usually resembles a steep sandpile.



MAGMA CHAMBERS

There are also two types of magma chambers, simple and complex. Smaller, more symmetric volcanoes have magma chambers with one pocket and one neck. The largest volcanoes have more complex chambers, with branches of lava tubes (multiple necks) that carry the lava to the surface of the side of the volcano.

Calderas are a geologic feature associated with volcanoes. Calderas are large, basin shaped volcanic depressions, generally caused by a weakness and collapse of a magma chamber's roof. Such a collapse can be due to an explosive eruption of half the volcano or by a vacuum created by the return of the magma into deeper portions of the magma chamber. During a caldera collapse in an oceanic volcano, water is often sucked in and fills the caldera basin.

While a crater is fairly small, about 1 km in diameter, and occurs in the early stages of a volcano's growth, the rim and the outside slopes of a crater tend to appear undisturbed. In contrast, a caldera's walls my have fractures pointing inward toward its center.

There are two kinds of craters: volcanic and impact. A volcanic crater is the opening or mouth at the top of a volcano from which lava spews forth. An impact crater is a depression created by a meteorite when it makes contact with the ground at great speeds. The meteorite pushes out existing soil with its impact.

EROSION

Erosion and surface wind are also factors in the appearance of volcanoes. Erosion and surface wind are even more important factors concerning volcanoes on Mars. Erosion is the gradual wearing away of surface either by wind or water. On Earth, erosion occurs by both wind and water. Wind blows away loose sediment on the surface of the Earth , thus eventually altering the appearance of a surface. The same occurs with water.

On Mars, surface winds are much stronger and cause a great amount of erosion. Wind is created on Mars by the sun's uneven heating of the Martian surface. At the surface, average wind speeds are 22 to 43 miles per hour (36 to 70 km/hr). At six miles up in the atmosphere, wind has been recorded at 224 miles per hour (600 km/hr).

While erosion is a force that shapes volcanoes after they come into existence, the creation of volcanoes includes the creation of the rock that is eventually worn away by erosion. A type of rock significant in the creation of volcanoes is the igneous rock.

TYPES OF ROCKS

Igneous rocks are formed by volcanic action or intense heat, as molten rock, generally magma, solidifies at or below the surface of the earth. In fact, the word *igneous* comes from the Greek word for "fire." When rock cools, crystals form throughout the rock. Different lengths of cooling time create different sizes of crystals.

Slow cooling creates rocks with larger crystals. These rocks form beneath the crust's surface and are called igneous-intrusive rocks.

Rapid cooling forms rocks with smaller crystals. These rocks form at the crust's surface and are called igneous-extrusive rocks, or sometimes, more simply, volcanic rocks. Volcanic rocks can be solid (dense) and dark-colored, or spongy, as a result of escaped gas, and light-colored. There are normally tiny glassy fragments seen with other crystals. Minerals include augite, plagioclase, hematite, olivene, and megenite.

Another kind of rock is sedimentary rock. Nature forces the breakup of rocks into smaller fragments. These broken fragments can be pebbles, gravel, sand, or clay. On Earth, fragments are moved around by water, wind, and ice (glaciers). As the particles settle on the ground, they pile up in small pieces called sediment. Sediment is always laid down in flat layers. Sediment turns into sedimentary rock by the pressure of its own weight or by the cementing of minerals in the sediment when they react to water. The thickest sediment is found where rivers empty into shallow oceans. When a river empties into a lake or ocean, it drops the sediment it has been carrying. The heaviest sediment settles first, followed by the lighter varieties.

Rivers carry much sediment and display the relationship between erosion and the creation of new land mass. At the same time that rivers erode some areas, they are carrying sediment to new areas. In the process of erosion and creation by water, grooves are cut into the Earth that eventually become gullies, then gorges. An example of such erosion is the Grand Canyon in northern Arizona. The Colorado River, an immature river, has become the base of the valley floor as it has cut a V-shaped valley. The walls of the valley display layer upon layer of sedimentary rock. The rock of the Grand Canyon was not only created by the dumping and compression of sediment eroded from another areas but is now being eroded itself, its sediment creating new rock later in the cycle.

Strata are sedimentary rock layers. Sedimentary rock layers are deposited one on top of the other. The oldest rock layer is the layer that was laid down first. By applying this, one can figure out which rocks are the youngest and oldest in relation to the rocks above and below. Different layers of sediment also have different colors due to the different minerals contained in the sediment.

MINERALS

Color is a simple but inaccurate way to identify a mineral. Many minerals can be more than one color, depending on their chemical makeup. Mineral identification cannot be based on color alone. Some but not all minerals always have a characteristic color. Two examples are malachite, which is green, and sulfur, which is yellow.

Luster is the way in which minerals reflect light from their surfaces. Certain minerals have a metallic luster, one that shines like polished metal. Two examples are gold and silver. Other nonmetallic minerals that do not reflect as much light may appear glassy, pearly, greasy, or dull. These adjectives describe the kind of shiny quality that a mineral has. Two examples of a glassy-looking mineral are quartz and diamonds. Two examples of minerals with a greasy look are talc and topaz. Two examples of a pearly look are the minerals muscovite and halite.

The color of a powder left by a mineral when it is rubbed against a hard surface is the mineral's streak. This test can be especially useful when two minerals have the same body color and luster. Each mineral has its own characteristic streak color. Examples of white streaks are halite, topaz, and calcite. Examples of clear streaks are quartz and celestite. Examples of minerals that leave colored streaks are galena and gold.

Cleavage is the way in which a mineral breaks across its surface. Upon impact, some minerals duplicate the original shape of the parent crystal. A cubic crystal will break into several smaller cubes because it has three planes of weakness. A plane is an imaginary sheet that passes through a crystal. There are three sets of parallel places, or sides, in a cube. These are the weakest planes of the crystal where separating can occur. Some minerals have only one direction of cleavage instead of two or three. Sheets of these crystals peel across the mineral face, which happens to be the plane of weakness. For example:

One direction of cleavage: galena, calcite, halite
Two directions of cleavage: calcite, topaz
Three directions of cleavage: galena, calcite, halite.

Fracture is the way a mineral breaks other than by cleavage. Some fractures appear shell-like or concoidal. An example is quartz.

Most minerals form crystals or solids that have a geometric shape. The crystal's shape results from the way in which atoms or molecules of a mineral come together as the mineral is forming. Since each mineral has its own pattern of molecules, each mineral has its own special shape. There are six basic shapes of crystals. Each shape has a number of faces or flat surfaces that meet at angles to form sharp edges and corners. The six shapes, with examples, are as follows:

Cubic: halite, fluorite, galena
Hexagonal: corundum, quartz, calcite
Orthorhombic: sulfur, topaz
Monoclinic: talc, biotite, muscovite
Triclinic: plagioclase, feldspar
Tetragonal: zircon, rutile.

HARDNESS

Friedrich Mohs, the German mineralogist, created a hardness scale for mineral identification. He used ten common minerals and arranged them in order of increasing hardness.

To find out how hard a mineral is, test it against other minerals. The softest mineral has a hardness of 1 and can be scratched with a fingernail. Talc has a hardness of 1.

A diamond, the hardest mineral, has a hardness of 10 and cannot be scratched by any other known mineral.

Mineral Hardness Scale

	Hardness	Mineral
Softest	1	talc
	2	gypsum
	3	calcite
	4	fluorite
	5	apatite
	6	feldspar
	7	quartz
	8	topaz
	9	corundum
Hardest	10	diamond

In the process of weathering, the sedimentary rock can break down and become brittle. Common minerals in sedimentary rock are quartz, feldspar, mica, calcite, and traces of magnetite. Mineral grains are usually somewhat rounded.

WEATHER

Understanding the sky above us just as important as the ground beneath us. By understanding clouds, we can begin to predict the coming weather.

CLOUDS

Clouds are masses of condensed water vapor which consist of water droplets or ice crystals. They are classified into a number of categories.

Cumulus clouds are very puffy and have flat bottoms. They form at altitudes of 2.4 to 13.5 kilometers. They usually indicate fair weather.

Cumulonimbus clouds are cumulus clouds that have grown larger and produce thunderstorms.

Stratus clouds are gray, smooth clouds that cover the whole sky and block out the sun. they form at altitudes of about 2.5 kilometers. Light rain and drizzle are usually associated with stratus clouds.

Cirrus clouds are feathery or fibrous. They form at very high altitudes and are made of ice crystals. They often indicate that weather is fair, but that rain or snow is possible within hours.

STORMS

When a cold front moves in and meets a warm front, cumulonimbus clouds will produce a thunderstorm. Rapidly rising air causes electrical charges to build up inside the clouds. The charges can jump from cloud to cloud. They can also jump between the cloud and the Earth. Lightning is the result of these jumps. After a lightning flash, the air cools and contracts. The expansion and contraction of the air cause the vibrations heard as thunder.

A tornado is a whirling, funnel-shaped cloud. It develops in low, heavy cumulonimbus clouds. The area at the bottom of this funnel of swirling air is extremely low in air pressure. When this low-pressure part touches the ground, it acts like a giant vacuum cleaner. The diameter of an average tornado is only about 0.4 kilometers. The width of a tornado's path averages about 6 kilometers. Wind speed can reach more than 350 kilometers per hour.

A cyclone is an area of low pressure containing rising warm air. Cooler air moves in to take the place of the rising warm air. The air currents begin to spin. Winds spiral around and into the center of the cyclone. They move in a counterclockwise direction in the Northern Hemisphere.

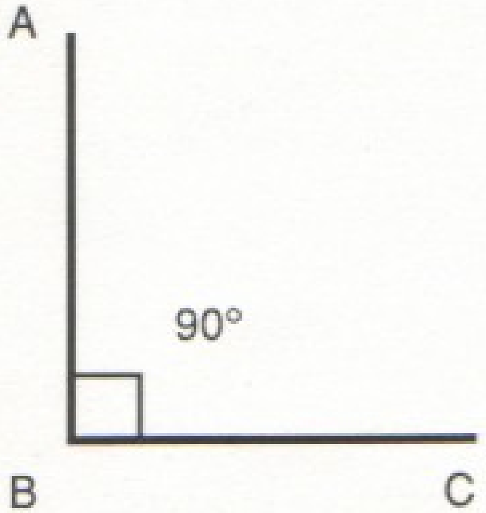
A hurricane is a very powerful cyclone. The rising air forms a cylindrical wall of winds, clouds, and rainfall. Inside the wall, the air is calm. This is called the eye. Winds may reach speeds between 120 and 320 kilometers per hour outside the eye.

PHYSICS

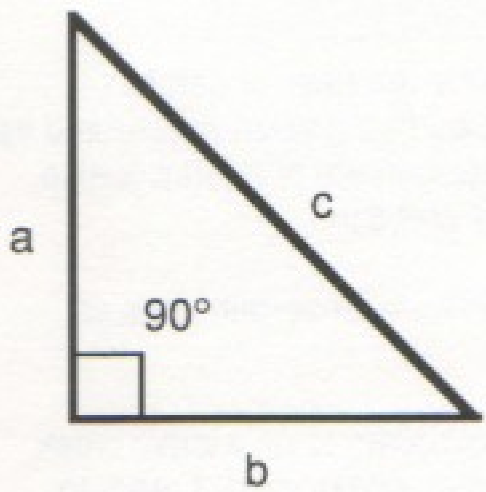
TRIANGLES

The Pythagorean Theorem gives us a method of determining the measurements of right triangles.

The angle diagramed below is a right angle. The angle measures 90° (degrees) where the lines (AB and BC) meet. Lines AB and BC are perpendicular to one another. The square at the intersection of lines AB and BC denotes that the angle created measures 90° and is a right angle.



If another line were to join points A and C, a right triangle would be created.



When points A and C are joined, two more angles are created. For all triangles, the sum of the measures of the angles will equal 180°.

Using the Pythagorean Theorem, you can find out the length of the line that joins points A and C. The line joining points A and B is called *a*, the line joining B and C is called *b*, and the line joining points A and C is called *c*. For all right triangles, the lengths *a* and *b* are both multiplied by themselves (squared) and then added together. The result is the length *c* multiplied by itself (squared). Or, mathematically stated,

$$a^2 + b^2 = c^2$$

For example, a right triangle has two sides of length 3 inches and 4 inches. For this right triangle,

$a=3 \qquad b=4$

$a^2 + b^2 = c^2$

$3^2 + 4^2 = c^2$

$9 + 16 = c^2$

$25 = c^2$

$\sqrt{25} = c$

The square root of 25 is 5 (because 5 * 5 = 25). So,

$5 = c$

UNITS

One of the major goals of science has been to discover and define the laws of nature. Physics is the branch of science that studies the fundamental laws that govern nature and its behavior. This includes the study of properties, changes, and interactions of matter. It also includes the study of energy, from heat and optics to mechanics and light.

Scientists work as precisely as possible by agreeing on the definitions of certain units of time, length, weight, and so on.

The basic unit of time is the second, and it is abbreviated "s". According to an atomic clock, one second is the time required for 9,192,631,770 vibrations within a cesium-133 atom to occur.

The basic unit of length is the meter, abbreviated "m". In 1983, the meter was redefined according to the speed of light. A meter is the distance light travels through a vacuum in 1/299,792,458 of a second.

Mass is a quantity that is related to weight, although they are actually different. The weight of an object is the force with which gravity pulls on it. While massive objects are often heavy, heavy objects are not necessarily massive. By experiment, the relationship between mass and weight was found to be:

$$W = Mg$$

where W stands for weight, m for mass, and g for gravity. When you look at this relationship, you begin to understand why an object may weigh more on Earth than it would on the moon. The gravity on Earth is about 9.8 m/s^2 while the gravity on the moon is about 1.5 m/s^2. The units for weight are either pounds or Newtons. When an object is said to weigh 50 Newtons (about 11 pounds), it means that gravity pulls the object downward with a force of 50 Newtons.

The unit that measure mass is the kilogram, abbreviated "kg". A certain platinum iridium cylinder kept near Paris, France is defined as having the mass of one kilogram. Other masses are determined by comparison to this metal cylinder.

The two other basic units are Kelvin (K) for temperature, and the Ampere (A) for electric current.

Basic Units

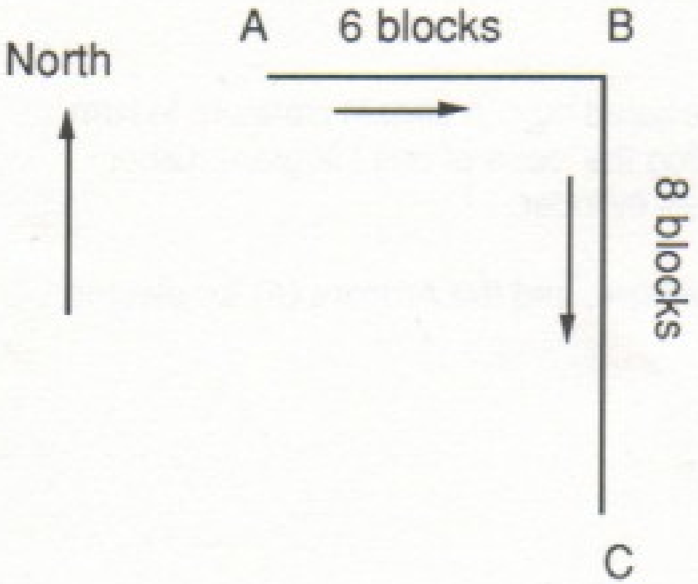
Quantity	Unit	Abbreviation
Length	Meter	m
Time	Second	s
Mass	Kilogram	kg
Temperature	Kelvin	K
Electric Current	Ampere	A

SCALAR AND VECTOR QUANTITIES

In addition to units, some quantities also have directions associated with them. Most quantities do not have a direction, such as a dozen eggs, or a number of books. These quantities, which have a number only, are called scalar quantities, or just scalars.

In instances where a quantity has a direction as well as a number, the direction is just as important as the number. For example, when moving objects from one point to another, knowing the direction in which the objects were moved is just as important as the distance they were moved. Vector quantities, often just called vectors, are quantities that have direction as well as magnitude (a number). Think of a moving automobile. It is not enough to know that the car is moving at a rate of 100 km/hr. The direction of the travel, 100 km/hr north is just as important. Other examples of vector quantities are acceleration and velocity.

When solving problems which include vector quantities, it is often helpful to draw a diagram. The following diagram illustrates the statement, "He walked six blocks east, then eight blocks south."



BODIES AT REST

Statics is a portion of physics that studies objects at rest. Just because an object is at rest does not mean there is nothing happening to it. Even for objects at rest, there are forces acting on it, such as its weight. Newton, perhaps the most famous physicist, discovered a law: For every action, there is an equal and opposite reaction. What does that mean?

We know that the force of gravity pulls us downward. That's what we call our weight. But, if gravity is pulling us downward, why don't we just sink through the floor and drop into the Earth? The answer is that the floor stops us. The floor pushes us up and counteracts the force of gravity. The two forces are balanced so we don't sink into the Earth or rise up into the air. That means the forces are equal.

So, if we call our weight *W*, and the push of the floor *P*, we know that they must be equal, but in opposite directions. We write that as:

$$W = -P$$

But we know:

$$W = mg$$

So,

$$mg = -P$$

As an example, let's say a person has a mass of 60 kg (132 pounds). Acceleration due to gravity is about 10 m/s^2. What would P be in this case?

$$-P = mg$$

$$-P = (60 \text{ kg})\ (10 \text{ m/s}^2)$$

$$-P = 600 \text{ kgm/s}^2 = 600 \text{ Newtons}$$

$$P = -600 \text{ Newtons}$$

That means the floor pushes up on the person with a force of 600 Newtons.

FORCES

Another of Newton's laws deals with finding the acceleration of an object in relationship to its mass and the forces acting on it. If we call the force *F*, the mass *m*, and the acceleration *a*, then the law shows:

$$F = ma$$

So, if we push an object with a mass of 2 kg using a force of 2 Newtons, what would its acceleration be?

$$a = \frac{F}{m} = \frac{2N}{2 \text{ kg}} = 1 \text{ m/s}^2$$

AVERAGE AND CONSTANT VELOCITY

Just as forces act on objects at rest, they also act on objects in motion. A person who is walking still has the force of gravity pulling down on her. Velocity is a measure of the distance an object will travel over a period of time. Many people think velocity is the same as speed, but they are different. Speed is the rate at which something travels, but it doesn't take into account the direction. Velocity is the rate of travel, but the direction must be known. The speed of a car may be 90 km/hour, but its velocity would be 90 km/hour *north*.

Average velocity is determined by measuring the distance an object moves, divided by the time it takes to travel that distance. For example, a ball roll to the right. It takes the ball 10 seconds to travel 20 meters. Let's look at that mathematically, where v is the velocity.

$$v = \frac{\text{distance}}{\text{time}} = \frac{20\text{ m}}{10\text{ s}} = 2\text{ m/s}$$

So, the velocity would be 2 m/s to the right.

If we rearrange the above equation, we can find the distance an object will travel as long as we know the velocity, and the amount of time it traveled.

$d = v * t$

Let's say a car is traveling west at 300 meters per minute. It travels for ten minutes. How far does it travel?

$d = v * t = (300\text{ m/min}) * (10\text{ min}) = 3000\text{ m}$

So, the car traveled 3000 meters to the west.

Let's try a more difficult problem. Your friend just called from 1000 meters away. He is leaving his house in Car A and traveling at a velocity of 50 meters per second to the south. He wants you to leave your house at the same time and catch up to him. How fast do you have to drive to catch him in 100 seconds?

Because you and your friend are leaving at the same time, you'll both be traveling for the same amount of time. However, you'll be going at different velocities, and you have to travel an extra 1000 meters.

His equation would look like this:

$d = v * t = 50\text{ m/s} * 100\text{ s} = 5000$ meters

Since you travel an extra 1000 meters, your equation would be:

$d + 1000\text{ m} = v * t = v * 100\text{ s}$

or:

$5000\text{ m} + 1000\text{ m} = v * 100\text{ s}$

which simplifies to:

$6000m = v * 100 s$

If we solve for your velocity, we get

$v = 60$ m/s

This means you would have to travel south at 60 meters per second in order to catch your friend in 100 seconds.

UNIFORM ACCELERATION

We've already seen acceleration a few times, but what is acceleration? It is the rate at which velocity changes. When a car changes its velocity from 40 miles per hour to 50 miles per hour, we say it is accelerating. True acceleration is the measure of how long it took the car to make that change in speeds. Let's say it took the car 2 hours to change its velocity.

$$a = \frac{50 \text{ m/h} - 40 \text{ m/h}}{2 \text{ h}} = \frac{10 \text{ m/h}}{2 \text{ h}} = 5 \text{ m/h}^2$$

If an object starts from rest, the equation which shows the distance it will travel based on acceleration is shown as follows:

$d = 1/2\ at^2$

If we drop an object from the top of a building, gravity will cause it to accelerate downward. We know the acceleration due to gravity is 10 m/s^2. How far would the object drop after 2 seconds?

$d = 1/2at^2 = 1/2\ (10 \text{ m/s}^2)\ 2^2 \text{ s} = 1/2(10 \text{ m/s}^2)\ 4s^2 = 20 \text{ m}$

So, the object would fall 20 meters.

Often, we use the above equation to find the amount of time an object must be accelerated to travel a certain distance, or the amount of acceleration needed to get an object to travel a distance in a given period of time.

MOMENTUM

Momentum of an object is equal to the object's mass times its velocity. So, if we represent momentum with *M*, mass with *m*, and velocity with *v*, the equation for momentum would be:

$M = mv$

Momentum is especially useful when you are trying to stop a moving object. Let's say a rock is traveling directly towards you, and you need to stop it. The rock has a mass of 4 kg, and a velocity of 3 m/s. You want to stop it by throwing another rock at it. The rock you are going to throw weighs 1 kg. At what minimum velocity must you throw your rock to stop the other rock?

Let's look at the rock coming towards us. We can calculate its momentum:

$M = mv = (4\ kg)\ (3\ m/s) = 12\ kgm/s$

In order to stop that rock, the one you throw must have at least the same momentum, going in the opposite direction. That means the rock you throw must have a momentum of 12 kgm/s. From this, we can calculate its velocity:

$12\ kgm/s = mv = (1\ kg)\ v$

If we rearrange the equation:

$$v = \frac{12\ kgm/s}{1\ kg} = 12\ m/s$$

Therefore, you need to throw the rock with a velocity of 12 m/s.

ELECTRICITY AND CIRCUITS

Electricity is another area included in the study of physics.

Electric current is the flow of an electric charge between two points. Current flows in circuits, which are simply paths that encourage the electricity to flow. A lamp and the plug which goes from it into the wall would be part of a circuit. The electric current flows through the circuit to the lamp, then lights up the bulb. We represent the magnitude of the electric current by the letter I. The unit for electric current is the ampere.

In order for electricity to flow through a circuit, there must be a power source providing the electricity. A power source could be a battery or a generator. Also, any electricity that flows through the circuit MUST be used up in the circuit. This electricity that gets used up is called the voltage. We represent it with the letter V, and the units are called Volts.

Inside the circuit are devices which use up the electricity. In our example, the light bulb in the lamp would be one of those devices. These devices that use up electricity are called resistors. Each resistor may have a different ability to use up electricity, and we call this ability resistance. The unit for resistance is the Ohm, and we use the letter R.

George Ohm found a relationship between current, voltage, and resistance. It is called Ohm's Law and is written:

$$V = IR$$

Almost every problem involving circuits involves the use of Ohm's Law.

Let's try an example. In a certain circuit, you need to find out what voltage is required to send 4 Amperes of current through the circuit when the circuit has 1.5 ohms of resistance.

$$V = IR$$

$$V = 4 \text{ A} * 1.5 \text{ Ohms}$$

$$V = 6 \text{ volts}$$

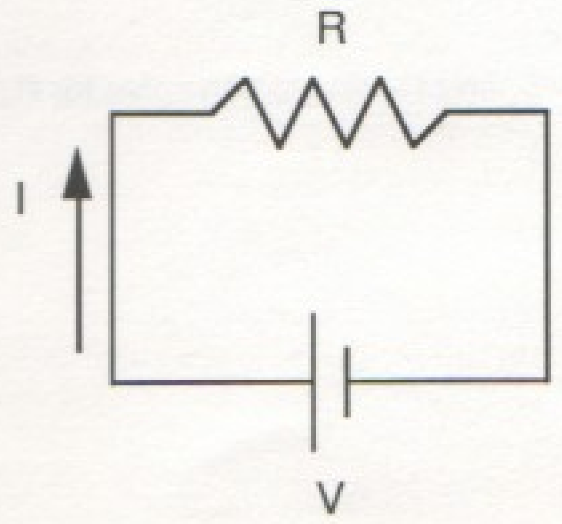
Therefore, 6 volts of electricity are required to send the 4 amperes of current through that circuit.

Remember, as long as you know two parts of the equation, you can find the third.

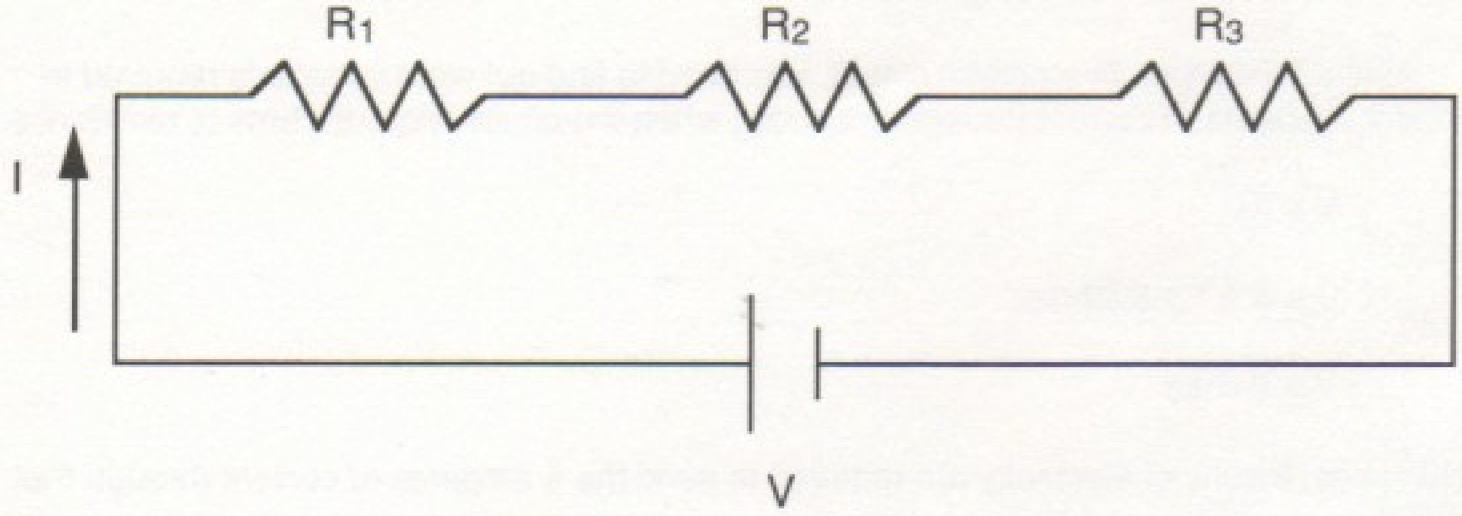
SERIES CIRCUITS

One of the simplest circuits is made up of a singles power source and a single resistor. A light bulb connected directly to a battery would be a good example. The current in this circuit flows from the battery, through that curly wire in the bulb, then back into the battery. This is a simple, definite path. When a circuit has such a definite path, it is called a series circuit.

The diagram below demonstrates how circuits are commonly represented. The diagram could even represent the battery and light bulb. The battery symbol is at the bottom, with the longer side of the symbol representing the positive terminal of the battery. The symbol used to represent a resistor looks like a zigzagged line. The arrow show the direction the current will flow.



The next diagram shows another series circuit that is a bit more complex. Notice that the current still flows in a simple path, but it flows through more resistors. The same current flows through each resistor. In the case of series circuits, we can simplify the drawing by replacing the three resistors with one that will do the same job. Let's use Ohm's Law to do that.



Let's find the voltage for the whole circuit:

$$V = IR_1 + IR_2 + IR_3$$

We can rewrite that as:

$$V = I(R_1 + R_2 + R_3)$$

So, if we wanted to replace the three resistors with just one called R_{eq}, we could say:

$$R_{eq} = R_1 + R_2 + R_3$$

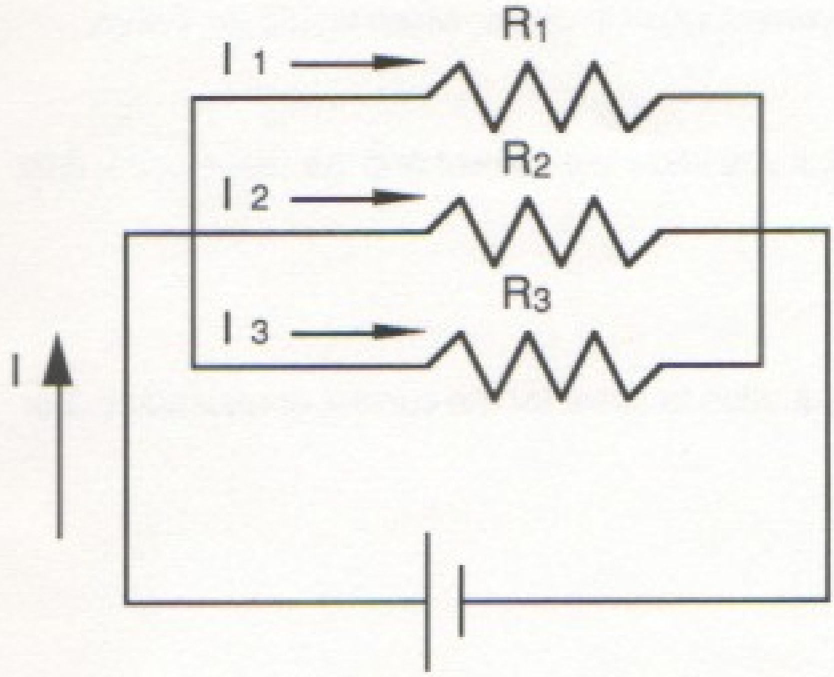
In summary, when you are looking at a series circuit, you can simplify it by adding up the value of all the resistors.

As an example, using the diagram above, and $R_1=3$, $R_2=5$, and $R_3=4$, we can solve for R_{eq}.

$R_{eq} = R_1 + R_2 + R_3 = 3 + 5 + 4 = 12$ ohms

PARALLEL CIRCUITS

Parallel circuits are ones where the current doesn't follow such a simple path. Notice, in the diagram below, how the current has to split up to reach the three resistors.



We can still simplify this circuit, but the value of R_{eq} will be different than in the series circuits. In parallel circuits, the voltage used up by each resistor is the same. So, we can write the following equations:

$$V = I_1R_1 \qquad V = I_2R_2 \qquad V = I_3R_3$$

If we rearrange those to solve for I and add them up we get:

$$\frac{V}{R_{eq}} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

And, if we divide by V, we end up with:

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

This is the equation we use to simplify the circuit. Let's try an example.

Using the diagram above, we can look at a circuit where R_1=3, R_2=6, and R_3=2.

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} = \frac{1}{3} + \frac{1}{6} + \frac{1}{2} = 1 \text{ ohms}^{-1}$$

We the invert the 1 ohms^{-1} to obtain the correct value in ohms, which would be 1 ohm.

POWER AND CIRCUITS

The power of a circuit is easily calculated, if you know the current and the Resistance. Just use the equation:

$$P = I^2 \cdot R$$

Or, if the power is known, rearrange the equation to solve for the current or resistance. For example,

$$R = \frac{P}{I^2}$$

OPTICS

Another area of physics is optics. This is the branch of physics dealing with the nature and properties of light and vision. The most common everyday applications of the study of physics are eyeglasses. When the eyes cannot focus properly, placing a lens of a particular size and shape in front of the eye helps the eye to focus correctly.

The two primary types of lenses that serve this purpose are convex lenses and concave lenses. Convex lenses curve outward and make objects seen through them look larger. People who are far-sighted have convex lenses in their eyeglasses.

Concave lenses curve inward and make things seen through them look smaller. People who are near-sighted have concave lenses in their eyeglasses.

MARS BASE DATA

MARS BASE -- LAUNCH/LANDING AREA

The Mars Base Launch and Landing Area is located 500 meters from the Crew Habitation Area. It provides service and communications facilities to vehicles before, after, and during launches and landings.

The 100 meter-diameter Launch/Landing Area is set up some distance from the Crew Habitation Area to prevent debris lofted by rocket exhaust from reaching the living area. It consists of circular landing pads, navigational beacons, tracking equipment, pad markers, Mars Excursion Vehicle (MEV) Servicers, and related power supply. A Payload Unloader, Mars Rovers, and other support equipment are also kept in the area.

MEV Servicer

After any reusable vehicle lands on Mars, a MEV Servicer is placed next to it to supply power, provide thermal rejection and protection, reliquify the vehicle's propellants, and monitor its major subsystems. MEV vehicles also need this support during quiescent periods and pre-launch operations. The MEV Servicer's thermal/micrometeoroid tent, a deployable structural support frame with an insulation blanket, protects the vehicle from micrometeoroids and from Mars' extreme temperatures.

Payload Unloader

The Payload Unloader is a gantry crane, a versatile machine with a high lift capability per unit of its own mass. The Payload Unloader has three supporting struts or legs that can be telescoped to vary its overall height or to level its overhead load platform. Each leg has large powered wheels for traversing various kinds of terrain.

The Payload Unloader's most important function is to unload cargo from Mars vehicles. But since the Payload Unloader has 6 degrees of freedom of adjustment, it can align one movable component--such as an airlock--with a stationary component such as a habitat module, thus aiding in structural assembly. Fitted with interchangeable implements, the Payload Unloader also is used for construction tasks. One set of implements outfits it to evacuate, relocate, and smooth Martian soil (regolith). Regolith is bagged and placed on structures to provide thermal and radiation protection. Another set of implements enables it to grasp and lift small objects such as boulders and structural components. The Payload Unloader is teleoperated, with on-site supervision by a robot or crew member.

Mars Unpressurized Rover

This general purpose vehicle transports the crew around the Mars Base, between the Launch/Landing Area and the Crew Habitation Area and out to the Resource Management and Power Production areas for inspection and maintenance missions. It can carry two crew members--four in an emergency--as well as up to 300 kg of scientific payloads for scientific missions beyond the Mars Base. Beyond a 50 kilometer range, it can be teleoperated up to 100 kilometers from the Mars Base for one to two year missions.

The Mars Unpressurized Rover shares its Dynamic Isotope Power Supply (DIPS) with the Payload Unloader. Every day, before both machines begin their 12-hour machine workdays, the Rover charges the Payload Unloader with the DIPS. The Rover also assists the Payload Unloader when tasks require another view of the work site or help in steadying an element for placement.

MARS BASE--CREW HABITATION AREA

The Crew Habitation Area consists of habitat and laboratory modules, airlocks, a constructible habitat, and various logistics modules. The center of all Mars Base activity, it contains quarters for the crew; pressurized, "shirt-sleeves" laboratories; a communications center; an EVA and telerobotic activity control center; and the life support system for the outpost. Its thermal system is emplaced nearby.

Hab/Lab Airlock Modules

The first human Mars flight carried habitat, laboratory, and airlock modules and associated power and thermal systems, along with a Payload Unloader that helped emplace the structures. The Payload Unloader also bagged regolith and placed it over the structures to protect the crew from micrometeoroids and radiation. Within 24 hours, these structures were usable. They continue in use on the established Mars Base.

The horizontally cylindrical habitat module, 4.5 meters in diameter and 8.2 meters long, can house a crew of four. This module docks with a laboratory module and an airlock. The laboratory module--identical to the habitat module in terms of size, structure, and essential systems--contains experiments and research equipment. The airlock, which allows crew members to go in and out without depressurizing, consists of a crew lock, an equipment lock, and a deployable dust-off porch.

Constructible Habitat

During the Consolidation Phase of the Mars Base, the crew built the constructible habitat, a spherical, inflated structure, 11 meters in diameter, placed in a crater that is 5.5 meters deep. This structure, originally tested on the Lunar Base, was erected mechanically: its self-deploying central column telescoped upward as its exterior membrane inflated, creating room for three floors. The constructible habitat's structural cage supports the floors, walls, and equipment as well as the external membrane in case pressure is lost. Covered by regolith for protection against radiation, micrometeoroids, and thermal extremes, the constructible habitat houses a crew of eight while also accommodating research, experimentation, and other base operations.

Life Support

Life support systems on Mars include air revitalization, water purification/reclamation, waste management/processing, air/water quality control, and sensors/processors for reliable environmental monitoring and autonomous operations.

Water
The transportation weight of water makes recycling on Mars very important. The recycling system retrieves 97% of the used water by recycling humidity, condensates, hygiene water, and urine. However, even with 97% recycling, each person on the Mars Base uses 560 pounds of water per year.

Thermal Control System
This system provides passive protection, acquisition, transportation, and rejection of latent and sensible heat. Inside habitat areas, major heat sources are metabolism and equipment. The regolith covering the habitats provides good insulation. Drastic temperature variations are handled through a cascaded vapor cycle system.

Work/Rest Cycle
The Mars Base crew's general work/rest cycle consists of a 10-hour duty shift, 3 hours of pre-sleep, 8 hours of sleep, and 3 hours of post-sleep. Pre- and post-sleep periods both include 1 hour of exercise and sometimes 1 hour of mission operations. Crew tasks vary. All participate in housekeeping tasks, science experiments, construction projects, and maintenance of equipment and existing systems.

Health
The health of the Mars Base crew members is monitored carefully. In the established Mars Base, the Health Maintenance Facility supplies routine exercise and therapeutic devices. It contains health monitoring equipment, diagnostic research, surgical, and other special facilities. Meals are almost all consumables that need to be resupplied from Earth, supplemented by the plants grown on the base. Self-sufficiency in food production is an important long-range goal for the Mars Base, since resupply cycles can be up to 600 days apart.

EVAs and Life Support
Many crew activities require extra-vehicular activity (EVA) or time on the planet's surface. EVA tasks employ two crew members in extra-vehicular mobility units (EMUs), assisted by a crew member inside the habitat or logistics module, who plays a support or monitoring role. The EMU has two parts--a suit and a portable life-support system (LSS). The back-entry suit, set to 6 psi pressure, is made up of modular hard and fabric components, designed for mobility, modularity, and easy maintenance. The portable life support system is a four-hour closed loop, to minimize resupply. A four-hour replaceable or rechargeable heat pump is used to control temperature.

Automation and Telerobotics
Because of limited crew members and the many hazards of the Mars surface, many Mars Base surface activities are automated, robot-operated, or telerobotically controlled from the habitat or logistics modules. Examples of automated surface activities include: construction tasks, repair, mining, hauling, digging, loading, and routine maintenance.

Surface Vehicles
Surface vehicles are available to assist in transporting cargo, construction (grading, trenching, excavating, hauling, and piling regolith), surface mining, and equipment hauling.

Rovers are charged by the main power system or by power system emplaced onboard individual vehicles. These require only nominal power levels--2 KW to 20 KW -- for outpost operations. In situations where rovers need continuous high power, a Dynamic Isotope Power System (DIPS) is placed onboard to assure reliable power output during long periods away from the outpost.

Local and construction/mining rovers use rechargeable batteries and regenerative fuel cells (RFCs).

Rovers
The crew in EMUs can travel up to 50 kilometers in a Mars Unpressurized Rover for outpost duties and scientific experiments. This vehicle has an onboard extended life support capability for up to 18 hours of EVA. For long-distance travels, a Mars Pressurized rover is available, with a life support system that provides a shirt-sleeve environment for several days. Most long-duration expeditions beyond 50 kilometers are handled telerobotically in the Mars Unpressurized Rover, controlled by a crew member at the base.

Mars Base Communications
The Mars Base communications system ties into the enhanced Deep Space Network (DSN)which is an Earth-based general spacecraft tracking facility with several large tracking antennae around the world. The DSN can send and receive signals at a number of frequency bands. Mars communications links are enhanced by two telecommunications relay satellites in stationary Mars orbit and by many landers deployed over large areas of the Mars surface. These systems provide backup and emergency communications links.

Personnel on Earth and/or at the Space Station can monitor and reconfigure the Mars Base communications system, analyze performance, and telerobotically perform operations. But since round-trip Mars-Earth and Earth-Mars communication requires 40 minutes, the established Mars Base is granted virtual autonomy. Earth provides built-in guidance and support through expert software systems, telerobotics, and automation. A system designed and tested on the Lunar Base allows unattended signal acquisition, data transfer,and remote mission operations support.

MARS BASE -- POWER PRODUCTION AREA

The Mars Base Power Production and Distribution Area is located one kilometer from the other base areas. Its power units supply energy to the entire Mars Base; its location ensures crew safety.

All major functions of the Mars Base -- gathering scientific data, emplacing equipment, vehicle servicing, communications, information management and control, habitation, EVA, robotic and transportation rovers, thermal control and resource utilization -- call for reliable, long-lived power systems. As surface operations expand, power needs grow as well.

The Power Production Area includes a solar power system with photovoltaic arrays and regenerative fuel cells (PVA/RFC), a self-contained 100 KW power module, and a 550 KW nuclear power plant. These were remotely deployed and installed during the Mars Base's Emplacement phase.

PVA/RFC

This static power system meets power demands from 10s to 100s of KWs. As demand for power grows, its modular pieces can be emplaced just ahead of demand. Solar-based power system operations, added in 25 KW units, are used for daytime power generation and energy storage at night. These units are larger and require more frequent system maintenance than nuclear power systems.

SP-100 Reactor

SP-100 nuclear reactors produce about 100 KW power with a system lifetime of 7-10 years. With Stirling-cycle heat engines, the thermal-to-electric conversion is greatly increased, with power levels up to 1,000 watts with multiple dynamic conversion units. These systems are the most cost-effective, long-lived, and reliable power source.

MARS BASE -- RESOURCE MANAGEMENT AREA

Because Mars is 35 million miles from Earth, on-site materials production is vital to the survival of the Mars Base. Loss of a resupply mission might mean up to 1200 days between supply deliveries from Earth.

The purpose of the Resource Management Area--also called the In Situ Resource Utilization (ISRU) Area-- is to produce and store materials made from Mars resources. This area is located 750 meters from the Mars Base's Crew Habitation Area and 1 kilometer from the Power and Production Area. Another busy Resource Management Area is found on Phobos, the nearer of Mars' two moons. Resource management technology was pioneered on the Lunar Base, which was established on Earth's Moon in 2001.

ISRU Plants on the Mars Base and on Phobos produce oxygen for use in life support and fuel. They also produce water for life support; metals and ceramics for building. Agricultural experiments are under way to create an indigenous food supply, using genetically engineered plants that can produce food and fiber in Mars' low gravity, carbon-dioxide atmosphere, and cold environment.

Lunar Base Resource Management Area
The Lunar Base utilizes lunar soil, which is 42% oxygen, to produce liquid oxygen. The Lunar Liquid Oxygen (LLOX) production plant produces up to 60 metric tons of liquid oxygen per year for use a propellant. This means that Lunar Excursion Vehicles (LEVs) can be entirely refueled on the Moon for their frequent docking flights within lunar orbit.

On-site production of liquid oxygen has helped make the Lunar Base autonomous, since 85% of the propellant mass required by the Earth-Moon transportation system is oxygen. Production of 50-60 tons of liquid oxygen per year, powered by a 550KW nuclear power plant and a second SP-100 reactor, reduces Lunar Base fuel resupply requirements by about 3,000 metric tons in a 10-year period. It also cuts down Lunar Base operations costs.

The LLOX plant produces oxygen from lunar soil by means of a hydrogen reduction of ilmenite process. The ore is mined by automated excavator vehicles, then carried to and deposited in a conveyor. After one hour at 1,000 degrees C., the process removes about 70% of the oxygen. The conveyor takes the ore to an area where ilmenite particles are removed with high-intensity magnetic fields. The ilmenite then is processed by feeding it through low and high pressure hoppers into a three-stage reactor. Wastes are discarded. Then a solid-state electrolytic cell dissociates water into oxygen and hydrogen. The oxygen is liquefied for use as rocket propellant, then stored in underground tanks for cooling. The hydrogen is recycled.

Mars Base
As on the Moon, oxygen production is a top priority at the Mars Base. On-site production facilities also produce hydrogen, water, other minerals, and construction materials. The Mars Base relies on teleoperation, automation, and robotics to maximize outpost productivity without increasing the number of crew members.

Mars Oxygen Production
The Mars Base Oxygen Production plant uses the Martian atmosphere. The atmosphere consists of 95% carbon dioxide, 2% nitrogen, 1.5% argon, and 0.1% oxygen, with traces of water vapor, carbon monoxide, neon, krypton, and xenon (to produce oxygen for life support and propellants).

The robot-operated Mars Base Oxygen Production propellant plant produces 330 tons of oxygen per year, powered by a 740 KWE power plant. Oxygen is produced from carbon dioxide by an electrolytic process. First, a blower forces Martian air through a filter to remove particulates. The gas is compressed and preheated to 950K., then enters an electrolytic unit that operates at .1273 K. Here carbon dioxide dissociates into oxygen and carbon monoxide. Membranes isolate the oxygen. Unused exhaust gas preheats the inlet gas before it is vented.

Carbon monoxide and oxygen are used as engine fuel for rockets, Mars Rovers, and other machinery. Much of the oxygen also is stored in balloon tanks, providing a breathable atmosphere to Mars Base crew.

Mars Water Production
Water is found on Mars in polar ice caps and in permafrost. The Martian Atmosphere also contains trace amounts of water vapor. These are extracted by the same process to supplement the water supply that is recycled.

Phobos Oxygen and Water Production
On Mars' nearer moon, Phobos, ISRU plants produce oxygen and water for use in life support and as propellants. Phobos serves as a valuable refueling stop for Phobos-Mars and Phobos-Earth flights.

Phobos is a major source of water for the Mars Base. Research proved Phobos and Deimos, Mars' two moons, to be similar in composition to carbonaceous chondritic asteroids, which consist of 5-20% water. Using a 1067 KWE power plant, the Phobos Water Production Plant obtains 600 tons of water per year from Phobos' rock and soil.

The Phobos Water Production Plant uses a rock-penetration device in which a rock melter is configured as a coring device. As the coring device penetrates the soil, an impermeable glasslike lining forms around the borehole. This seals in the released volatiles so they will not leak into surrounding porous rock. The process produces impurities such as carbon monoxide, carbon dioxide, and hydrogen sulfide. Cross-separation occurs when condensing water from gases is emitted from the borehole. Absorption filters purify the water, which then is dissociated by electrolysis. Oxygen and hydrogen are then liquefied and stored.

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