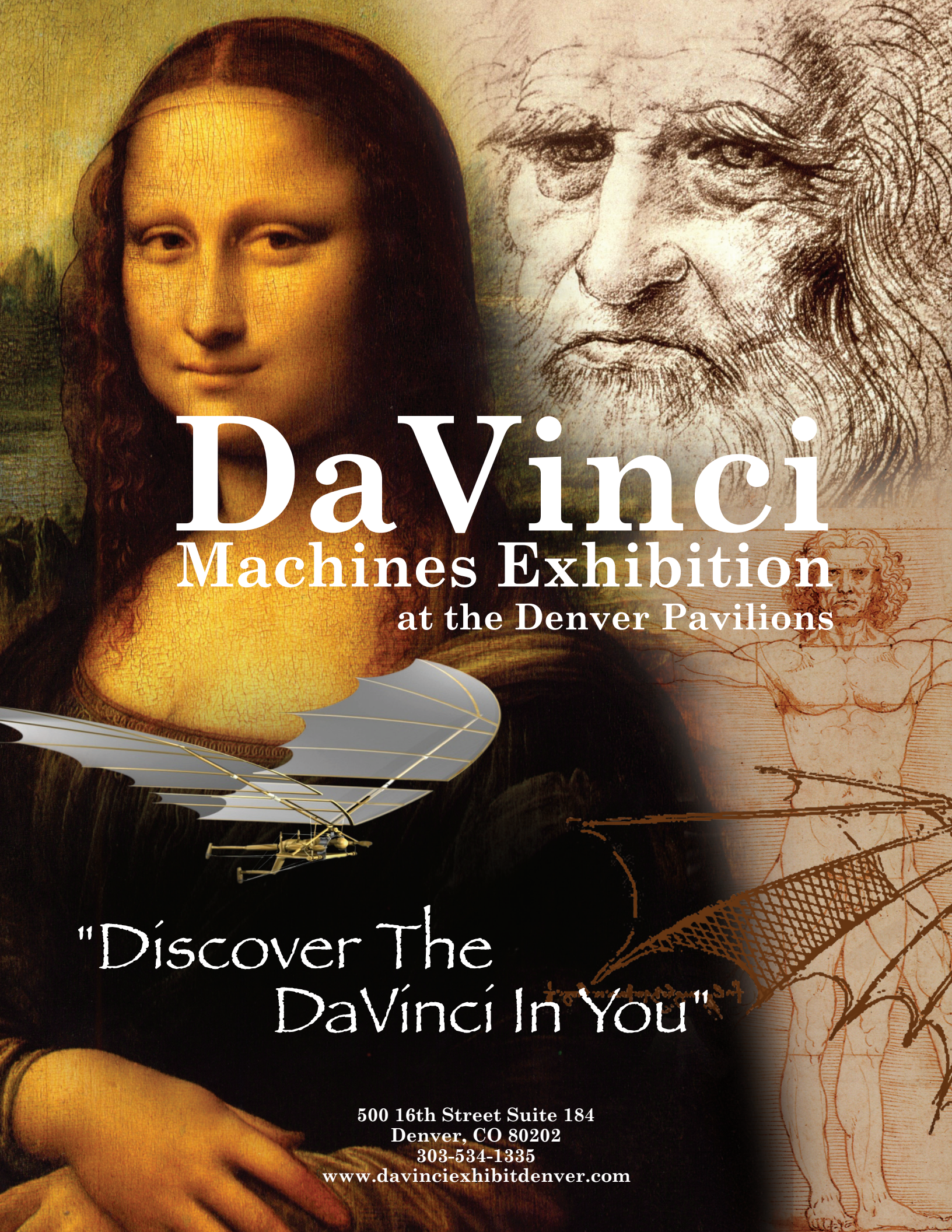

DaVinci
Machines Exhibition
at the Denver Pavilions
"Discover The DaVinci In You"
500 16th Street Suite 184
Denver, CO 80202
303-534-1335
www.davinciexhibitdenver.com

Table of Contents

Introduction

This guide is designed to help teachers and their students understand the life and times of Leonardo da Vinci as well as machines that have been replicated for the Da Vinci Exhibit Denver. This guide contains information, activities and ideas that can be copied and used with students from kindergarten through twelfth grade.

The DaVinci Exhibition

More than 60-full sized and interactive machines described, designed, and developed by Leonardo da Vinci are displayed in gallery spaces devoted to his:

- TRANSPORTATION DEVICES

- MILITARY DEVICES

- MECHANICAL DEVICES

- ENTERTAINMENT DEVICES

with explanatory signage, animated films, and mechanical drawings that connect Da Vinci's ideas to modern applications. In addition, the exhibit features high quality reproductions of his most famous artistic contributions with detailed discussions about them.

Leonardo da Vinci has become the definition of a Renaissance Man — at once an artist, architect, designer, engineer, philosopher, and scientist. He learned to use art, anatomy, botany, geology, mathematics, and physics to improve on what was known in his day and to develop new ideas. Leonardo's artistic contributions can be studied at close range, including special detailed displays of the Mona Lisa and the Last Supper, and a wide array of the fascinating machines he created can be seen and tested at the Da Vinci Exhibit Denver.

Overview of Exhibit

Dates: April 1, 2012 – September 30, 2012

Place: DaVinci Machines Exhibition
At the Denver Pavilions
500 16th Street, Suite 184
Denver, CO 80202

Phone: (303) 534-1335

Website: www.davinciexhibitdenver.com

Hours: Tuesday - Wednesday - Thursday 10am to 6 pm
Friday and Saturday - 10am to 7pm
Sunday - 12 Noon to 6pm
Monday - Closed for Groups and Private Functions

Ticket Prices:

Adults:	$14.00
Seniors:	$11.00 (55 years and older)
Students:	$11.00
Military:	$11.00
Teacher:	$11.00
Family Pack:	$40.00 (2 adults, 3 children)
Children:	$9.00 (5 to 10 Years)
Children:	Free Under age of 5

Groups of 25 ore more: $7 (per person)

Brief Biography

Dates:

April 15, 1452 — Born in the hamlet of Anciano, outside of the village of Vinci, near the city of Florence

1468 — Apprenticed to Andrea del Verrocchio, craftsman, sculptor and painter

1473 — Elected to the painters' guild

1478 — Opened his own art studio

1482 — Became court artist to the Duke of Milan

1503 — Returned to Florence

1513 — Went to Rome at the invitation of the Vatican

1516 — Invited by the King of France to be the official painter, engineer and architect to the king

May 2, 1519—Died in France

THE STORY OF LEONARDO DA VINCI

Godfrey Harris
Curator of the DaVinci Exhibit

Leonardo da Vinci is one of the most intriguing men in history – an ordinary person who did extraordinary things. He was, at once, an accomplished artist, designer, engineer, philosopher and scientist. In short, Leonardo da Vinci was the very embodiment of what we now think of as a Renaissance Man.

But how did this one individual come to accomplish so many things in so many fields? Why this person at this time in the 15th Century?

No one, of course, is quite sure, but Leonardo's overwhelming desire to succeed seems to have been driven by forces greater than his insatiable curiosity and enormous imagination. One theory holds that his childhood was filled with such personal doubts and family uncertainties that he did everything in his power throughout his life to ensure that he was not forgotten or ignored, that his work and effort would receive the respect and attention he sought and thought they deserved.

Leonardo may well have done wondrous things because of the type of life he was forced to lead given the difficult circumstances of his early years. Leonardo, after all, had to face the fact that he was the illegitimate son of a prominent Florentine notary and a household servant. At an early age he was taken from his mother to grow up in his father's house in Vinci. When Ser Pierro's third wife bore Leonardo's father a second, but legitimate, son, Leonardo was automatically disinherited from any claim on the family fortune and was on his own.

As a child born out of wedlock, Leonardo was denied the right to enter a profession, obtain a position at the university, or gain social access to the royal courts. On top of this, Leonardo was determinedly left-handed in an era when people were taught that such activity was literally sinister – a tool of the devil and something to be avoided. Leonardo dealt with this by perversely writing from right to left, and backwards. Was this to avoid smudging the writing or to keep prying eyes from readily reading his words? Or was it merely Leonardo's way to draw attention to his ideas, his sketches and himself? And if these two challenges were not enough to cope with, Leonardo had to confront a third factor in the years to come: He was almost certainly homosexual at a time when such behavior was extremely risky and subject to severe penalties and public ostracism.

Given his status and prospects in society, his father hoped that the boy's great interest and obvious talent for drawing might qualify him for an apprenticeship. It did. Popular artisan Andrea del Verrocchio headed one of Florence's leading craft studios where everything from furniture to religious objects, from paintings to statues – were designed and built for the city's aristocracy and wealthy merchants. His apprenticeship to one of Florence's leading artists would give him the training and experience that would serve him well in the future – as well as help him rise above the circumstances of his birth.

Leonardo served as Verrocchio's apprentice for nearly nine years and during this time learned a dozen different crafts. He was given the honor of providing an angel in the corner of a painting that became known as the Baptism of Christ. Legend has it that Leonardo's contribution to that painting was so extraordinary that Verrocchio himself pledged never to paint anything else ever again.
In the atmosphere of Verrocchio's all-male studio, his left-handedness may well have been embraced for the distinctiveness it gave his brush strokes and his physical beauty may well have been welcomed by some of the artisans employed there. Because of his acceptance in the studio and its relative safety from the harsher attitudes of the outside world, Leonardo did not hesitate to take chances in his work and his thinking. These intellectual, artistic, and personal risks clearly provided satisfying rewards that may well have been the stimulus for the great advances that he would later make and that we marvel at today.

For example, in the field of art he was one of the first to experiment with oilbased paints because of their flexibility and luminosity. Leonardo quickly mastered the crucial skill of perspective to create detailed backgroundscenes and he experimented with blending light and dark areas seamlesslyt o give his paintings a more realistic look. He invented a surface for frescoes that permitted him to work at his own pace rather than within a time frame that traditional methods dictated.

In his desire for attention and recognition, he also showed an unbridled willingness to do whatever was asked of him to gain the approval of his patrons and their friends. We never think of him as such, but in modern terms his desire to please helped Leonardo to become a superb event planner, a skilled costume designer, a brilliant lighting technician, a resourceful impresario, and an accomplished musician. A number of the machines that Leonardo developed were not for some practical engineering purpose, but simply to entertain and dazzle the royal guests at various social functions.

For example, his designs for a:

- Robot
- Spotlight, and
- Chamber of Mirrors

When Milan was faced with the threat of invasion by the French in the late 1490s, Leonardo volunteered to develop machines and engineering strategies to assist Duke Ludovico Sforza in repelling the foe. Many of the machines Da Vinci sketched and described -- for war or for engineering purposes -- were probably never built because they required too much money, too many scarce materials, or too many experiments to perfect their use or performance. But a number of these projects embodied ideas and concepts we know and enjoy today, such as:

- The energy transfer in a chain
- The repetitive accuracy of a cam gear
- The safety features of a worm screw
- The weight capacity of a central crane
- The equalizing role of a differential gear
- The capability of a water-powered saw and drill

Perhaps because he could never seem to harness his mind to concentrate on one topic until he completely mastered it, perhaps because of his overpowering desire for perfection in his effort to gain recognition or perhaps because of his need for personal security, he seemed incapable of finishing anything he started. But he also saw ways to improve objects in common use.

- The employment of multiple pulleys to lift great weights with the same motive force, but at the sacrifice of distance and speed.

- The use of a candle of a specific diameter and a chart precisely carved into a backdrop to calculate the passage of time as the candle melted on dark nights.

The patience and persistence he exhibited to accurately tell time at night revealed a pattern that would mark all of Leonardo's efforts as a designer and engineer: If it wasn't perfect it wasn't finished. To perfect ideas he experimented relentlessly, welcoming failure as a way to make progress.

In fact, a younger Michelangelo criticized Da Vinci for his procrastination. Was this seeming indolence triggered by his perfectionism or by his constant inquisitiveness? Anything that he observed in nature could trigger a flood of questions in his mind about how it functioned, how it accomplished particular tasks, and the purpose each of its attributes served. None of this was more evident than his fasc nation with birds to unlock the secrets of flight.

His desire to be free from the confines of earth suggests the confidence he had that there was nothing he couldn't accomplish if he put his mind to finding a solution. Evidence of that confidence and his desire for perfection can be found in his constant sketching and voluminous notes to portray his subjects and operate devices as accurately and as efficiently as possible. In fact, we think that only 25% of his original notes and sketches have been found to date.

For Leonardo, nature was the perfect machine that had to be understood completely in order to be emulated as closely as possible in man-made efforts. That is why he became skilled as an anatomist to learn how the muscles, tendons, and skeletal structure worked together to make a smile or raise an arm, why he theorized on how the fossils he found high in the Alps might have gotten there, and why the relatively few paintings he completed – only some 14 are known to have survived to the modern era – were renowned then as now for the subtly, accuracy, and secrets they embodied.

The best way to form your own impression of this remarkable man and what he accomplished is to remember what he once proclaimed…

The natural desire of good men is knowledge.

and to contemplate what others have said about him. This, in the words of author E. L. Kongsburg:

[Leonardo] could not look at things made by God without wondering how He had made them, and he could not look at things made by man without thinking of some way to make them better.

Airscrew

Writing Backwards

Leonardo wrote all his notes and observations backwards from right to left. This is also known as mirror writing. With paper, pencils and mirrors students can try to write like Da Vinci.

First show the students a sample of backwards writing. Using a blank transparency, hand write a message. Put it on an overhead projector upside down and see if the students can read what you wrote. When they have tried to read it, flip it over to reveal what you did, in fact,write.

Now encourage the students to try to write their names, words and sentences. If students have trouble forming letters in reverse, they should try holding a pencil in each hand and write backwards with the usual writing hand while writing forwards with the opposite hand. Having the one hand mirror the other hand's action seems to help the brain coordinate the movements.

Distribute mirrors and have the students try to write forwards while looking into the mirror. Also have the students use the mirrors to check the backward writing they tried without the mirrors.

Codes

While writing backwards was one way for Da Vinci to keep his ideas from being stolen or read by others, using codes was another. A code can be as simple as switching each letter with a number as the example below demonstrates. For example, the word “up” can be coded as: 21 16. Tables like the below are called ciphers, and can be used to code or decode – they work both ways.

A	B	C	D	E	F	G	H	I
01	02	03	04	05	06	07	08	09
J	K	L	M	N	O	P	Q	R
10	11	12	13	14	15	16	17	18
S	T	U	V	W	X	Y	Z	
19	20	21	22	23	24	25	26	

Here is an example of a message written using the above code.

12	05	15	14	01	18	04	15		04	01		22	09	14	3	9

Another Number Cipher

Using the following grid, write two numbers for each letter with the first number coming from the top of the grid and the second number coming from the left side. For example: 32 equals H.

Code Numbers	1	2	3	4	5
1	A	B	C	D	E
2	F	G	H	I/J	K
3	L	M	N	O	P
4	Q	R	S	T	U
5	V	W	X	Y	Z

Here is an example of a message written using the above code.

31	43	41	51	34		11	24	51		12	54	33

Scrambled Letter Code

This code substitutes one letter for another letter. Using a code reader, the code can be written and read.

ABCDEFGHIJKLMNOPQRSTUVWXYZ

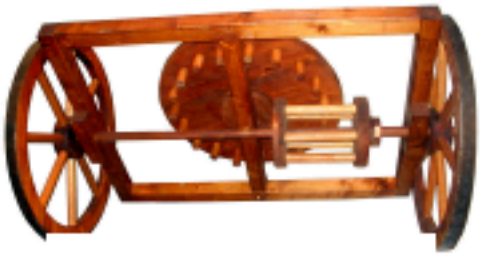
ZYXWVUTSRQPONMLKJIHGFEDCBAZYXWVUTSRQPONMLKJIHGFEDCBA

Cut out the box with the alphabet and cut two slots on the vertical lines. Then cut out the thin strip with the alphabet displayed from Z to A twice.

Slide the thin strip into the two vertical slots.

Choose a key letter and position it beneath the A. Use letters on the strip to spell out the message. For example if you choose the key letter D, then the word "up" is coded JO.

Once you have created your code then only someone who knows the key letter should be able to read the message easily. (Of course, a properly programmed computer might get the sequence in a few nanoseconds.)



Differential

DaVinci Trivia

Copy the game board to an overhead and use it to guide the students. Give the individual students or teams of students the answers and ask them to give the questions in order to earn points. Students can find the answers by doing research on Leonardo by reading reproduced parts of this guide, at the exhibit, on the Internet or in the library.

Bio	***Science***	***Art***	***Machines***	***More Machines***	***Misc.***
100	**100**	**100**	**100**	**100**	**100**
200	**200**	**200**	**200**	**200**	**200**
300	**300**	**300**	**300**	**300**	**300**
400	**400**	**400**	**400**	**400**	**400**
500	**500**	**500**	**500**	**500**	**500**

Answers

Ask these answers first for a "Jeopardy" – like trivia game.

Bio

100: April 15, 1452
200: Vinci
300: Backwards
400: Meat
500: France

Science

100: The Human Body
200: Dissection
300: The Scientific Method
400: An Anemometer
500: A Night Clock

Art

100: Mona Lisa
200: Eggs
300: Pigments
400: A Wall
500: 1512

Machines

100: The Air Screw
200: Bird Flight
300: Perpetual Motion
400: The Archimedes Screw
500: The Military

More Machines

100: 8
200: Water
300: Pulley
400: Bridges
500: The Bicycle

Misc.

100: The Renaissance
200: A Robot
300: Michelangelo
400: A Horse
500: Andrea del Verrochio

Questions

Ask these questions first if you are playing a regular trivia game

Bio

100: When was Leonardo da Vinci born?
200: Where did Leonardo live with his grandfather and father?
300: How did Da Vinci write in his notebooks?
400: What was something Da Vinci didn't eat for humanitarian reasons?
500: Where did Leonard da Vinci die on May 2, 1519?

Science

100: What subject did Da Vinci sketch a lot?
200: What did Da Vinci do in order to learn about the human body?
300: What method did Da Vinci use to study nature and the world around him?
400: What was one of the devices Da Vinci invented to measure wind?
500: What did Da Vinci make using a candle and a graph behind it?

Art

100: What is the name of Da Vinci's most famous portrait?
200: From what were Da Vinci's paints made?
300: What are the colors Da Vinci had to make called?
400: On what was The Last Supper painted?
500: When did Da Vinci paint his well known self-portrait?

Machines

100: What was an early design for a helicopter?
200: What did Da Vinci try to imitate with many of his flying machine designs?
300: What did Da Vinci prove was impossible?
400: What device was improved by Da Vinci to lift water?
500: Who was intended to use many of Da Vinci's devices?

More Machines

100: What was the number of men needed to operate the tank?
200: What did Da Vinci use to power many of his machines?
300: What machine makes it easier to lift heavy weights?
400: What did Da Vinci make more portable and easier to construct?
500: Which design was discovered stuck between two pages?

Misc.

100: What was the era in which Da Vinci lived called?
200: What did Da Vinci invent for the amusement of others?
300: Who was a rival of Da Vinci?
400: What animal did Da Vinci unsuccessfully sculpt in bronze?
500: For whom was Da Vinci an apprentice?

Art

1476 — Annunciation

1478 — Portrait of Ginevra de' Benci

1486 — Virgin of the Rocks

1492 — Vitruvian Man

1493 — Young Girl with Ermine

1498 — The Last Supper

1503 — Mona Lisa

1512 — Self Portrait

Mix & Match

Can you draw a line to match up these famous Da Vinci works of art?

1478 — Portrait of Ginevra de' Benci

1512 — Self Portrait

1486 — Virgin of the Rocks

1498 — The Last Supper

1503 — Mona Lisa

1492 — Vitruvian Man

1476 — Annunciation

1493 — Young Girl with Ermine

Mixing Pigments

Da Vinci had to make his own paint using natural pigments and a kind of paint that was based on eggs. It was called tempera. Pigments are colored substances that occur naturally in animals, plants and minerals. The Aborigines painted and printed with whatever pigments they found locally. If you did not have any paints in school, what could you find around you to use to create your artwork?

Try some of the following: Clay. You might have some red (terracotta) or grey (buff) clay around school. Dig up a small amount of soil from outside. Different soils from different areas will give different colors. Blackberries, raspberries, elderberries and blueberries make good paint. Crush them to release the juice. There may be lots of other safe plants and foods that would make good paints. Try tea, coffee, crushed mushrooms, turmeric and henna powder. Try rubbing grass cuttings or crushed leaves directly on to paper or canvas. Some stones and rocks, such as yellowish sandstone and very soft red rock, can be crushed and mix with a little water to produce a paint.

Cartooning

Da Vinci used an exact drawing of a scene – called a cartoon – to transfer his designs to a wall, wood panel or canvas. Once he completed his drawing he would then punch tiny holes along the lines of the drawing onto the surface being used for the painting. He would then rub charcoal over the holes to complete the outline. He was then ready to add the paints to complete the final picture in color.

Essays

(1) Write about the benefits and dangers of taking risks.

(2) Choose something that you use every day and describe precisely how it functions – the retractor button on a ball point pen, the clasp on a necklace, a staple gun, the wheels on a desk chair, etc.

(3) If you had the time and money, what everyday item you regularly see or use would you want to have improved – and how?

Machines

The exhibit consists of over 60 machines recreated by Italian artisans using Da Vinci's drawings and designs as well as employing the same materials available in Leonardo's time. The machines are divided into four galleries for Transportation, Military, Mechanical and Entertainment devices. Each device has a detailed description that explains its function and unique characteristics. Some of the machines are interactive, allowing students to operate the machine to see how they were intended to work.

Transportation Devices
Examples of the 19 Machines on Display

Double Hull Boat:
The double-walled structure was supposed to reduce the likelihood of a boat sinking if it were rammed by an enemy vessel.

Paddle-wheel Boat:
The outer paddle wheels were turned by inside cranks operated by a person's hands or feet. It was one of Leonardo's most ingenious labor-saving devices and allowed the crew to face forward when moving.

Airscrew:
This is an early design of a vertical-lift flying machine, and presaged the modern helicopter. The airscrew is covered with cloth and has space for a spring that was intended to lift the machine into the air to start its flight.

Glider:
The wings of the glider are based on the wings of a bird and were used in a variety of Da Vinci machines. One machine included wings that could be flapped by human power in order to imitate the motion of a bird in flight.

Water Shoes:
While Da Vinci didn't invent the concept, he designed his own version that used poles and pontoons to allow a person to walk on water.

Bicycle:
The design for this machine was found stuck between two sheets of paper. It has a chain drive, foot pedals and a handlebar.

Bicycle

Military Devices
Examples of the 18 Machines on Display

Catapult:
This device was improved upon so that it worked more reliably and could be loaded and fired more rapidly.

Bridges:
These mobile and arched bridges were designed to be easy to construct from readily available materials allowing a military unit to surprise its enemy by crossing a river or moat unexpectedly.

Tank:
Eight men worked together to not only maneuver the tank but also fire its weapons from inside.

Wall Defense:
A bar was attached to the wall and pushed out by a hand gear. The movement of the bar would overthrow a ladder being used to scale the wall by an enemy.

Tank

Wall Defense

Mechanical Devices
Examples of the 24 Machines on Display

Hydraulic Saw:
A water wheel moves a vertical saw blade up and down.

Chamber of Mirrors: ***Interactive***
The field of optics fascinated da Vinci and he used this reflection chamber for royal entertainment as well as 360° observation of objects.

Anemometer:
This device measured wind speed.

Archimedes Screw: ***Interactive***
This device for lifting water continuously from one level to another was improved from earlier versions by reducing the amount of friction and water seepage.

Ball-bearing: ***Interactive***
The principles used in this device to reduce friction are still used today in applications that utilize ball-bearings.

Pulley: ***Interactive***
This device shows how heavy objects can be lifted with reduced effort.

Perpetual Motion: ***Interactive***
Using unfixed weights, da Vinci was eventually able to prove that the concept of perpetual motion was impossible.

Pulley

Engaging Activities

Will It Float

Have student design and construct a floating platform that can hold a designated amount of weight. Allow students to be creative in their use of materials or restrict them to a finite set of materials that each person or team of people must use. Some examples of material might include aluminum foil, Styrofoam, cardboard, straws, and plastic bags.

Let Her Go

Have students build simple catapult devices and see how far they can launch balled up pieces of paper. Using cardboard, tape, pencil, pink eraser and a paper cup the students construct their devices. The eraser is taped to the middle of the cardboard. One end of the pencil is taped to the cardboard about an inch from the eraser. The walls of the paper cup are trimmed and then the cup is taped to the other end of the pencil. A piece of paper is placed in the cup, the pencil is pulled down against the eraser and then released in order to launch the paper. Students may need to hold the pencil down if the tape isn't strong enough. Have the students experiment with different distances from the eraser and different amounts of tension on the pencil in order to obtain the maximum distance. Consider using different classroomsafe materials (rulers, etc.) to let the students improve their catapult designs.

Wing It

Have students use letter-size pieces of paper to construct various paper airplanes to see which design works the best. Accuracy, distance or both can be used as criteria for success. Encourage students to experiment with the shape and size of the wings they create. Small weights and slits are two other ways to make changes to the function of the plane.

SIMPLE MACHINES

Leonardo envisioned many different types of machines to apply to all kinds of tasks. All of his machines were based on mechanical principles that had been known for a long time.

GEAR
Gears are wheels with teeth that mesh with other toothed objects to transmit motion from one place to another or to change the speed or direction of the motion.

INCLINED PLANE
An inclined plane is a flat surface that is higher on one end than the other. Inclined plane machines are used to move an object to a lower or higher place. It provides a mechanism to use less energy or force, making moving things easier.

LEVER
A lever is a board or bar that moves up or down against a turning point called a fulcrum. The closer an object is to the fulcrum, the easier it is to move in the desired direction.

PULLEY
Pulleys are wheels that work together with ropes. The rope is threaded around a groove cut into the bottom of a wheel and is tied to the object to be moved. By pulling around a free turning wheel, the object is easier to move up, down or even sideways.

SCREW
Screws are simple machines made from another simple machine—an inclined plane that winds around itself. Screws are used to hold objects together, whether a bracket to a wall or a lid on a jar.

WEDGE
This simple machine is used to force two objects apart and is also created from the principle of two inclined planes put together at their lower or thinnest edge. Think of a knife.

WHEEL and AXLE
Wheels and axles also make moving objects easier by overcoming friction when rolling. The axle is a rod that connects two wheels to allow them to work in tandem.

Mechanical Principles

All the devices developed by Da Vinci are based on the fundamental principles of mechanics. Each machine is labeled with one of the seven “simple machines” symbols shown below. Younger students can make a tally mark next to each symbol every time they see one during their visit and then graph their data. They could also compare and contrast two machines using the same principles or write down modern day applications of these.

Scavenger Hunt

Here are some questions that will get you exploring all aspects of the Exhibit. Answers can be recorded in each box below the question either in words or with drawings.

How does a person fly on Da Vinci's glider?
How many pieces are needed to make the Da Vinci's portable bridge?
How many pulleys can you test?
How does a worm screw work?
How many guns are on the tank?
How is the spotlight illuminated?
Which of the two angels appears to be by Da Vinci in the painting THE BAPTISM OF CHRIST?

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Paddle

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The Great Idea Finder:
http://www.ideafinder.com/history/inventors/davinci.htm

Museum of Science Boston:
http://www.mos.org/leonardo/index.html

About.com:
http://inventors.about.com/library/inventors/blda-vinci.htm

The My Hero Project:
http://myhero.com/myhero/hero.asp?hero=Leonardo_da_Vinci

Leonardo's Machines:
http://www.museoscienza.org/english/leonardo/

Da Vinci Links:
http://www.artcyclopedia.com/artists/leonardo_da_vinci.html

Ball Bearings

Notes / Reflections