

IISME SUMMER FELLOWSHIP 2005

EDUCATION TRANSFER PLAN

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Marina Middle School

SFUSD

A Career in Math and Science

Starting with a comparison of salaries earned according to the length of stay in school, this unit aims to introduce students to different career choices and to help students learn various aspects of math and science including statistics, geometry and measurement, density, and quantum mechanics using the context of computer chips production.

Day1

Students will receive a table comparing salaries earned according to the number of years at school (Appendix 1). They will use EXCEL to create a bar graph showing the information. Students will also start a journal; the first entry would be on how much education they intend to pursue.

Day 2

Students will receive a list of career options (Appendices 2 & 3). They will then work in groups of four on a computer and use information from the website: <http://www.careers.org/career-reference/occupations/cref-index.html> to find out the median salaries and requirements of the jobs listed. Students will write into their journal what possible career they would like to go into.

Day 3

The teacher will use the list of career options to conduct a class survey to find out students' interest in those careers. Students will organize the data (Appendix 4) and use Excel to create a bar graph to show the information. Students will write into their journal what area and what level of education they might want to get before they can start the career of their choice.

Day 4

The teacher will show a web video on “**Atoms: The Space Between**” available online <http://www.teachersdomain.org/6-8/sci/phys/matter/atoms/index.html> and use the printout from the same website to conduct a class discussion on atoms.

Day 5

The teacher will show a web flash interactive on “**Periodic Table of Elements**” available online <http://www.teachersdomain.org/6-8/sci/phys/matter/ptable/index.html>.

Students will use a copy of the ‘Periodic Table of Elements’ to do a scavenger hunt activity, available online http://www.teachersdomain.org/9-12/sci/phys/matter/lp_pertable/ to get themselves familiar with names and properties of elements. Students will do a research on the element ‘Silicon’ for homework.

Day 6

The teacher will show a web video on “**Quantum Mechanics**” to help students understand the idea of electrons, available online <http://www.teachersdomain.org/9-12/sci/phys/matter/quantum/index.html>, and use the printout from the same website to conduct a class discussion on electrons.

Day 7

The teacher will show a Power Point presentation on the history and development of semi-conductors (Appendix 5). Students will write into their journals on what they think about all those scientists who contributed in the development of the IC industry.

Day 8

The teacher will show a Power Point presentation on the manufacturing process of silicon chips (Appendix 6). Students will write into their journals on how technology changes the way people live.

Day 9

The teacher will introduce the use of a clean room in the IC industry and have students set up proportions to find out the amount of dust particles in clean rooms of different dimensions (Appendix 7).

Day 10

The teacher will introduce 'meter' as the metric measure for length and use the video "**Powers of Ten**" available online <http://www.micro.magnet.fsu.edu/primer/java/scienceopticsu/powersof10/index.html>, to deliver the idea of significant numbers and very large/small numbers.

Day 11

The teacher will explain the definition and applications of significant numbers and scientific notation. Students will practice on problems involving significant numbers and scientific notation.

Day 12

The teacher will introduce some specifications of wafers (Appendix 8) and will have students calculate the area based on a given diameter. Students will also calculate different volumes and compute the density of silicon.

Day 13

Using the results from previous lesson, students will explore how the areas and volumes change with the diameters. Students will use the data and EXCEL to plot graphs showing diameter vs. area. Students will discuss how area changes with diameter.

Day 14

The teacher will use the ten career options identified earlier and conduct a class survey to find out students' current interest in those careers. Students will organize the data and use Excel to create a bar graph to show the information. Students will write into their journal how the new graph differs from the one that they created earlier.

Homework. Students will go online and do a search on requirements leading to a career in the IC industry.

FINAL ASSESSMENT

Students will prepare a portfolio on what they have learned over the course of this unit (Appendix 9). The portfolio will be assessed using a rubric (Appendix 10).

Appendix 1

EARNING VS EDUCATION

Use the data in the following table to create a bar graph.

EDUCATION	MEAN ANNUAL EARNING (\$)
High School Dropout	18978
High School Graduate	27915
Associate Degree	35958
Bachelor Degree	51207
Master's Degree	62512
Doctorate Degree	88471
Professional Degree	115212

Appendix 2

CAREER CHOICES

DIRECTIONS: Fill in Columns 4 and 5 by using information from the website: <http://www.careers.org/career-reference/occupations/cref-index.html>.

	OCCUPATION	JOB	MEDIAN SALARY	REQUIREMENTS
1	Management	Sales Manager		
		Marketing Manager		
2	Financial	Accountant		
		Insurance Underwriter		
3	Engineering	Electrical Engineer		
		Computer Hardware Engineer		
4	Mathematics	Computer Programmer		
		Computer Systems Analyst		
5	Science	Physicist		
		Medical Scientist		
6	Social Service	Mental Health Counselor		

7	Legal	Lawyer		
8	Teaching	Middle School Teacher		
9	Media	Fashion Designer		
10	Health	Surgeon		
11	Protective Service	Police Patrol Officer		
12	Food Preparation	Waiter/Waitress		
13	Personal Care	Child Care Worker		
14	Sales	Retail Salesperson		
15	Communications	Teller		
16	Agricultural	General Farmworker		
17	Construction	Construction Laborer		
18	Maintenance & Repair	Home Appliance Repairer		
19	Assembling	Butcher/Meat Cutter		
20	Transportation	Bus Driver, School		
		Bus Driver, Transit and Intercity		
21	Military	Soldier (Search with www.goarmy.com)		

Appendix 3

CAREER CHOICES

(Teacher's Version)

DIRECTIONS: Fill in Columns 4 and 5 by using information from the website: <http://www.careers.org/career-reference/occupations/cref-index.html>.

	OCCUPATION	JOB	MEDIAN SALARY	REQUIREMENTS
1	Management	Sales Manager	92 900	
		Marketing Manager	98 200	
2	Financial	Accountant	54 100	
		Insurance Underwriter	51 800	
3	Engineering	Electrical Engineer	78 900	
		Computer Hardware Engineer	89 600	
4	Mathematics	Computer Programmer	71 700	
		Computer Systems Analyst	68 200	
5	Science	Physicist	84 000	
		Medical Scientist	64 500	
6	Social Service	Mental Health Counselor	38 400	

7	Legal	Lawyer	117 800	
8	Teaching	Middle School Teacher	52 400	
9	Media	Fashion Designer	55 200	
10	Health	Surgeon	145 600	
11	Protective Service	Police Patrol Officer	61 900	
12	Food Preparation	Waiter/Waitress	16 000	
13	Personal Care	Child Care Worker	19 100	
14	Sales	Retail Salesperson	19 700	
15	Communications	Teller	21 700	
16	Agricultural	General Farmworker	16 000	
17	Construction	Construction Laborer	30 500	
18	Maintenance & Repair	Home Appliance Repairer	34 200	
19	Assembling	Butcher/Meat Cutter	28 600	
20	Transportation	Bus Driver, School	27 000	
		Bus Driver, Transit and Intercity	36 600	
21	Military	Soldier (Search with www.goarmy.com)	19 000	

Appendix 4

CAREER CHOICES SURVEY

DIRECTIONS: Fill in Columns 4 and 5 by using information from the website: <http://www.careers.org/career-reference/occupations/cref-index.html>.

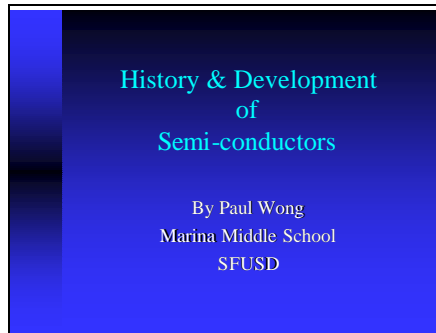
	OCCUPATION	JOB	TALLY	NUMBER OF PEOPLE CHOOSING THIS JOB
1	Management	Sales Manager		
		Marketing Manager		
2	Financial	Accountant		
		Insurance Underwriter		
3	Engineering	Electrical Engineer		
		Computer Hardware Engineer		
4	Mathematics	Computer Programmer		
		Computer Systems Analyst		
5	Science	Physicist		
		Medical Scientist		
6	Social Service	Mental Health Counselor		

7	Legal	Lawyer		
8	Teaching	Middle School Teacher		
9	Media	Fashion Designer		
10	Health	Surgeon		
11	Protective Service	Police Patrol Officer		
12	Food Preparation	Waiter/Waitress		
13	Personal Care	Child Care Worker		
14	Sales	Retail Salesperson		
15	Communications	Teller		
16	Agricultural	General Farmworker		
17	Construction	Construction Laborer		
18	Maintenance & Repair	Home Appliance Repairer		
19	Assembling	Butcher/Meat Cutter		
20	Transportation	Bus Driver, School		
		Bus Driver, Transit and Intercity		
21	Military	Soldier (Search with www.goarmy.com)		

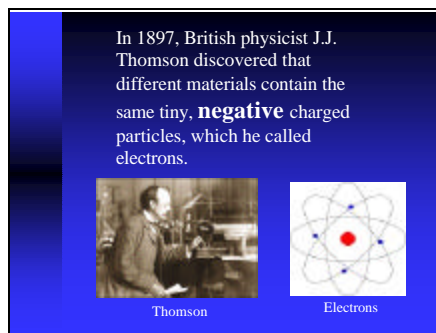
Appendix 5

Power Point Presentation: History and Development of Semiconductors

Slide 1





Slide 2



Slide 3

In certain materials, such as metals, some of the electrons could have enough energy for them to move freely inside the material, hence transferring electricity. These materials are called **CONDUCTORS**.



GOLD ALUMINUM



Slide 4

Electrical Conductors:
Silver, copper, gold, aluminum, iron, steel, brass, bronze, mercury, graphite, dirty water, wet concrete

Electrical Insulators:
Glass, rubber, oil, asphalt, fiberglass, porcelain, ceramic, quartz, (dry) cotton, (dry) paper, (dry) wood, plastic, air, pure water

Slide 5



In 1906 Thomson was awarded the Nobel Prize in physics for his research into the discharge of electricity in gases.



Nobel medal (Front & back)

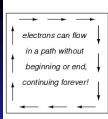
Slide 6

In 1904, British engineer John A. Fleming developed the first **bi-polar vacuum tube**, which allows electric current to flow only in one direction.

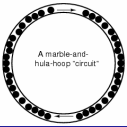


Fleming Vacuum tube

Slide 7

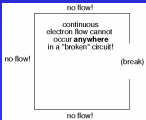


electrons can flow in a path without beginning or end, continuing forever!



A marble-and-hula hoop "circuit"

*A *circuit* is an unbroken loop of conductive material that allows electrons to flow through continuously without beginning or end.



no flow! continuous electron flow cannot occur anywhere in a "broken" circuit! no flow! no flow! Switch control (I/O) (break)

Slide 8

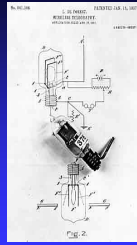
In 1906, American physicist Lee de Forest invented the **tri-polar vacuum tube**, which could amplify a small signal and made wireless voice transmission possible.



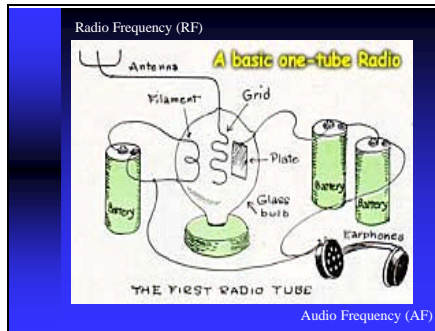
Lee De Forest Vacuum Tube

Slide 9

De Forest called his device the Audion Tube. At the right is the original Audion patent, dated January, 1907. The Audion was used to receive, amplify, or transmit radio signals.



Slide 10




Slide 11



In 1914, de Forest sold his innovation to AT&T for \$50,000.

Slide 12

Deforest never received a Nobel prize. But he was awarded an Oscar in 1959 for his invention which brought sound to the motion picture.



Slide 13

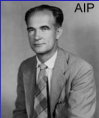
De Forest is called "the Father of Radio"




Vacuum tube radios

Slide 14

In 1947, William Shockley, Walter Brattain & John Bardeen invented the **TRANSISTOR**, which is a semi-conductor-based amplifier.



Shockley



Shockley, Brattain & Bardeen

Slide 15




Slide 16

Semi-conductors, such as silicon and germanium allow electrons flow through them in a controllable manner under special conditions. This property makes semi-conductors useful in the production of transistors.

Slide 17

Silicon makes up 27.8% of the earth's crust. It is the second most abundant element in nature, surpassed only by oxygen.

Silicon can be found in quartz, flint, and beach sand amongst many others. And it is the main component in building materials like cement, brick, and glass.



A small image of a globe showing the Earth, with the chemical symbol 'Si' in yellow text overlaid on the right side.

Slide 18

Symbol: Si
Atomic Number: 14
Atomic Mass: 28.0855
Proton: 14 Neutron: 14
Electronic Configuration:
2, 8, 4
Classification: Metalloid



Quartz





Sand

Slide 19

Vacuum Tube
vs.
Semi-conductor based Transistor

The vacuum tube is hot, bulky, fragile and short-lived. The transistor is much smaller, could do the job faster, more reliably and with 1 million times less power.



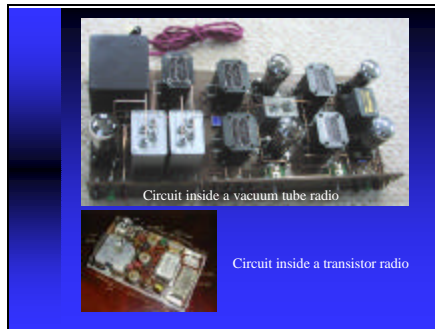
Slide 20

So the transistor quickly replaced the vacuum tube in its role to control currents, amplify signals and serve as a switch in a circuit.

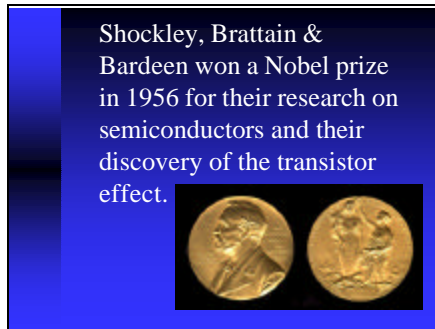
Slide 21



Slide 22





Slide 23



Slide 24

In 1958, American engineers Jack Kilby and Robert Noyce

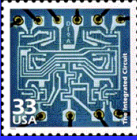


Kilby Noyce

separately invented the first **integrated circuits (IC)**.

Slide 25

The integrated circuit also known as the CHIP is a piece of semiconductor with many transistors all etched into it. This invention opened up a new world of micro-electronic applications.



Slide 26

The chips manage data by controlling electron flow to make words, numbers, sounds, images and colors. They are used worldwide by manufacturers of electronic appliances and indirectly by nearly every human on earth.

Slide 27

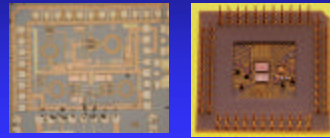
Kilby was awarded the Nobel Prize in Physics in 2000 for his role in the invention of the integrated circuit.



Kilby and his first integrated circuit

Slide 28

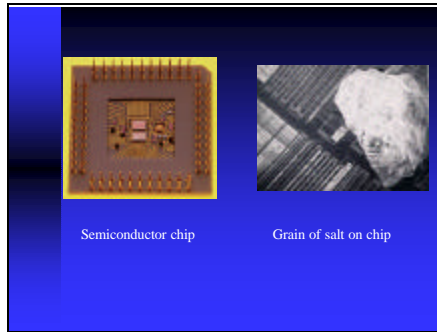
Today, scientists use etching, photolithography and other techniques to create much smaller transistors on the surface of the semiconductor silicon.



Slide 29

The original IC had only five electronic components and was the size of an adult's pinkie finger. Today an IC smaller than a penny can hold 125 million components.

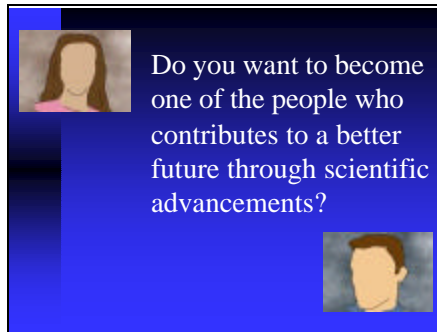
Slide 30



Slide 31



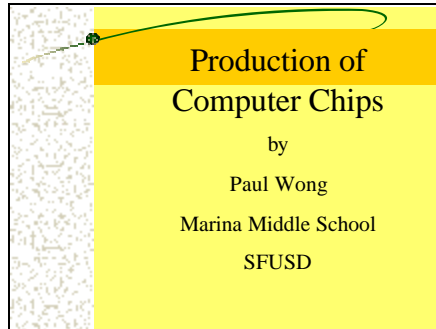
Slide 32



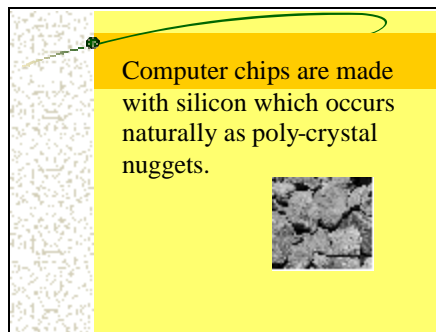
Appendix 6

Power Point Presentation: Production of Computer Chips

Slide 1

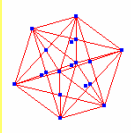


Slide 2




Slide 3

Three dimensional structure of a
Single Crystal Silicon




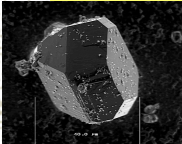
Slide 4

A poly-crystal silicon is formed by many small single crystals with different orientations and cannot be used for semiconductor devices.





Slide 5

Poly-crystal silicon nuggets are melted with small quantities of Group III or Group IV elements such as boron and phosphorus, in order to have the desired electrical properties.




Boron Phosphorus

Slide 6





The materials are heated above 1420°C, the melting point of silicon. A single crystal silicon seed is placed on the melt and slowly pulled to form an ingot inside a crystal pulling chamber.

Slide 7



While cooling, the atoms in the melted silicon orient themselves to the same crystal structure of the seed. It takes one week to one month to grow a silicon ingot, depending on the size.

Slide 8




The ingot is then ground and sliced into thin discs called wafers. A diamond edge saw is used for cutting accurately.

Grinding

Cutting

Slide 9

The wafers are then lapped both sides to remove saw marks and surface defects.

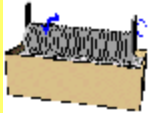


Lapping

The diagram shows a circular wafer being lapped on a rotating surface. The wafer is positioned on a rotating disc, and the lapping process is shown as a series of overlapping circles, indicating the removal of surface defects.

Slide 10

Wafers are then etched in an acid solution to remove the microscopic cracks and surface damage caused by lapping.



Etching

The diagram shows a wafer being etched in an acid solution. The wafer is placed in a container, and the etching process is shown as a series of vertical lines, indicating the removal of microscopic cracks and surface damage.

Slide 11

The wafers are polished to a mirror surface by a combined mechanical-chemical action, using abrasives.



Polishing


Slices

The diagram shows a wafer being polished on a rotating surface. The wafer is positioned on a rotating disc, and the polishing process is shown as a series of overlapping circles, indicating the removal of surface defects. The second diagram shows a cross-section of a wafer, labeled 'Slices', showing the internal structure.

polishing

Slide 12


The wafers are finally cleaned using ultra-pure water and chemicals.



Cleaning


Slide 13

The polishing and cleaning processes have to be done in a very clean room. Workers must wear cleanroom suits that are designed to not collect any dust particles.




Slide 14

working in a cleanroom



- Suit made of ultra clean material
- Battery pack for air filter system
- 2 pairs of gloves nylon & latex
- 2 pieces of foot gear disposable shoe covers & outer booties
- Mask
- Footwear air filter
- 2nd shoe cover
- Full set of working glasses
- Cap

Slide 15



Putting on a cleanroom suit can take 30 to 40 minutes. A pro can do it in 5 minutes.

Slide 16

The wafer is now ready for making computer chips.



Slide 17

The silicon wafer will be etched with millions of tiny transistors hundred times smaller than a human hair.



Human Hair Thickness
0.0035 inch
0.0889 mm

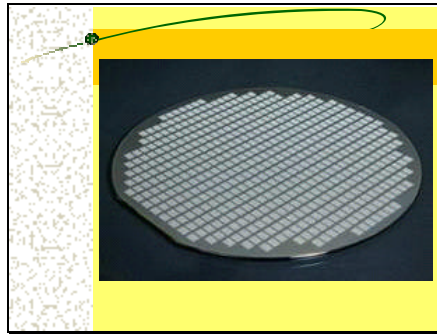
100-micrometer Wafer
0.0004 inch
0.01016 mm

2,000 Transistors
100-micrometer Wafer

Wafer
100 Micrometers
0.0039 inch

Figure 1

Slide 18



Slide 19

A group of circuit designers will start by working on circuit schematics to be used in the computer chip.

Schematic diagram for light beam amplifier and sound-effects generator (using a 555 timer IC and speaker). The light striking Q1 generates a siren-like sound.

The schematic diagram shows a 555 timer IC connected to a speaker and a light sensor (Q1). The circuit is designed to generate a siren-like sound when the light sensor is triggered. The diagram includes various electronic components such as resistors, capacitors, and a speaker, connected to the 555 timer IC.

Slide 20

A computer program will turn the schematic into a computer layout.

The computer-generated layout shows the physical arrangement of components on a circuit board. The layout is color-coded, with blue lines representing the traces and various colored shapes representing the components. The layout is shown on a dark background, highlighting the intricate design of the circuit board.

Slide 21

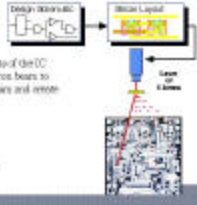
The Mask-Making Process

The Process

- Start with a clean glass plate with a uniform deposition of chromium
- Computer generated layout of the IC drive a laser beam or electron beam to precisely remove chromium and create the mask or reticle

Design Drivers:

- increased design rule
- long write times
- New Product Acceleration

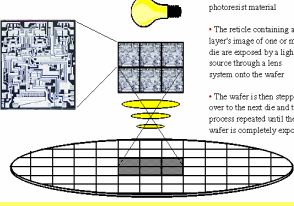


The diagram illustrates the mask-making process. It starts with a 'Design Reticle' (a grid with a pattern) and a 'Glass Plate' with a 'Chromium Layer'. A laser beam is used to remove the chromium in specific areas, creating a 'Mask' with a pattern. The mask is then used to create a 'Wafer' with a pattern.

Slide 22

Photolithography Process

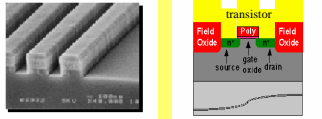
- The wafer is coated with photoresist material
- The reticle containing a layer's image of one or more die are exposed by a light source through a lens system onto the wafer
- The wafer is then stepped over to the next die and the process repeated until the wafer is completely exposed



The diagram illustrates the photolithography process. It shows a 'Wafer' being coated with 'Photoresist Material'. A 'Reticle' (a grid with a pattern) is used to expose the wafer to light through a 'Lens System'. The wafer is then stepped over to the next die and the process is repeated until the wafer is completely exposed.

Slide 23

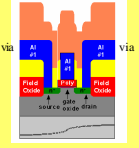
The photoresist material is then developed and an etching process is used to leave the patterns on the wafer. There are about 20 mask layers in each IC.



The image shows a microscopic view of a wafer on the left and a cross-section diagram of a transistor on the right. The diagram labels the 'transistor' structure, including 'Field Oxide', 'Poly', 'Gate', 'source', 'drain', and 'Field Oxide'.

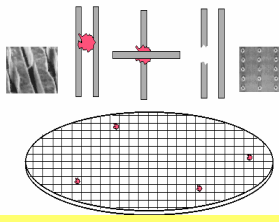
Slide 24

Using the same photolithography process, "via" holes are etched in the silicon chips for connecting all the components in the integrated circuit.



Slide 25

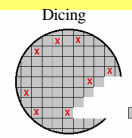
The wafer is then tested and the defected one inked.




Slide 26

The wafer is diced into individual chips and packaged for different applications.

Dicing




Wire-bonding

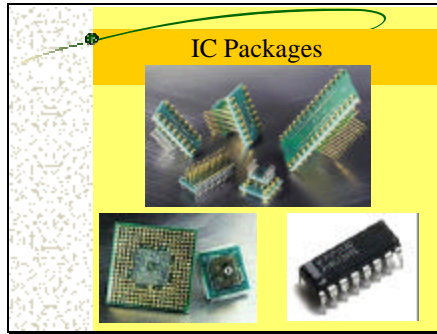


• Turning the wafer into a packaged chip

Packaging



Slide 27



Slide 28



Appendix 7

A microprocessor (IC) about the size of a dime, contains millions of microscopic transistors. The tiniest speck of dust to a chip would be like a Godzilla-sized footprint to us, and it could ruin thousands of transistors. So the production of microprocessors has to be in a cleanroom.

A class 1 cleanroom has less than 1 particle and a class 10 cleanroom has less than 10 particles $>0.5\mu\text{m}$ in size per ft^3 of air respectively. In a classroom, there could be 5 million particles per cubic foot.

Example:

In a class 10 cleanroom, how many particles are there in one cubic yard of air?

$$1 \text{ yd} = 3 \text{ ft}$$

$$1 \text{ yd}^3 = (3 \text{ ft})^3$$

$$= 3 \times 3 \times 3 \text{ ft}^3$$

$$= 27 \text{ ft}^3$$

$$\frac{10 \text{ particles}}{1 \text{ ft}^3} = \frac{x \text{ particles}}{1 \text{ yd}^3}$$

becomes

$$\frac{10 \text{ particles}}{1 \text{ ft}^3} = \frac{x \text{ particles}}{27 \text{ ft}^3}$$

or

$$\frac{10}{1} = \frac{x}{27}$$

Cross-multiplying,

$$x(1) = 10(27)$$

$$x = 270$$

Exercise 1:

In a class 10 cleanroom, how many particles are there in one cubic meter of air?

$$1 \text{ m} = 3.3 \text{ ft}$$

Exercise 2:

If our classroom is a class 10 cleanroom, how many dust particles would there be?

Appendix 8

Some Measurements of Silicon Wafers

Diameter (mm)	Thickness (μm)	Weight (g)	Area (cm^2)	Volume (cm^3)	Density (g/cm^3)
100	525	9.6			
125	625	17.9			
150	675	27.8			
200	725	53.0			
300	775	128.0			

Appendix 9

Portfolio

The portfolio you are going to work on is a meaningful collection of your work that tells the effort you have put in, your learning progress, and your achievement over the course of this math and science unit

The portfolio should include

- Journal entries
- Web research
- Math work
- Graphs & Charts
- Reflections

All items from the above list should be accompanied by explanations on the significance of the work.

On top of the Portfolio Rubrics, the following list of question could be helpful for you to prepare your portfolio:

- What are the reasons for including this work in your portfolio?
- What problems did you encounter? How did you solve them?
- What goal did you set for yourself? How well did you accomplish them?
- If you could work further on this piece, what would you do?
- How does this relate to what you have learned before?
- Of the work you have done recently, what do you feel most confident about?
- Of the work you have done recently, what do you feel not too clear and want to find out more?

Portfolio Rubrics

CATEGORY	Proficient (4)	Advanced (3)	Basic (2)	Beginning (1)
Organization	Content is well organized using a table of contents, headings or bulleted lists to group related material.	Uses headings or bulleted lists to organize, but the overall organization of topics appears flawed.	Content is logically organized for the most part.	There was no clear or logical organizational structure, just lots of facts.
Math Content	All problems are completed. 90-100% of the steps and solutions have no mathematical errors.	Almost all of the problems are completed. Almost all (80-89%) of the steps and solutions have no mathematical errors.	More than half of the problems are completed. Most (70-79%) of the steps and solutions have no mathematical errors.	None or a few of the problems are completed. Less than 70% of the steps and solutions have no mathematical errors.
Graphs	A creative title is clearly printed at the top of the graph. The axes are clearly labeled and units are included. A graph is accurately produced.	Title is clearly printed at the top of the graph. The axes are clearly labeled. A graph is accurately produced.	A title is present at the top of the graph. The axes are labeled. A graph is there.	A title is not present. The axes are not labeled. A graph is there.
Science Content	Covers topic in-depth with details and examples. Subject knowledge is excellent.	Includes essential knowledge about the topic. Subject knowledge appears to be good.	Includes essential information about the topic but there are 1-2 factual errors.	Content is minimal OR there are several factual errors.
Information Gathering	Accurate information taken from several sources in a systematic manner. All sources are referenced.	Accurate information taken from a couple of sources in a systematic manner. Most sources are referenced.	Accurate information taken from a couple of sources but not systematically. A few sources are referenced.	Information taken from only one source and/or information not accurate. Source is not referenced.
Journal	All entries are made and all are dated and neatly entered.	Most entries are made and most of the entries are dated and neatly entered.	Several entries are made and most of the entries are dated and legible.	Few entries are made AND/OR many entries are not dated or very difficult to read.