



# NanoScience and Nanotechnology Applications



## Student's Worksheets





Colophon



IRRESISTIBLE is a project on teacher training, combining formal and informal learning focused on Responsible Research and Innovation. It is a coordination and support action under FP7-SCIENCE-IN-SOCIETY-2013-1, ACTOVITY 5.2.2. Young people and science: Topic SiS.2013.2.2.1-1 Raising youth awareness to Responsible Research and Innovation through Inquiry Based Science Education. The project IRRESISTIBLE is funded by the EU as FP-7 project number 612367

[www.irresistible-project.eu](http://www.irresistible-project.eu)

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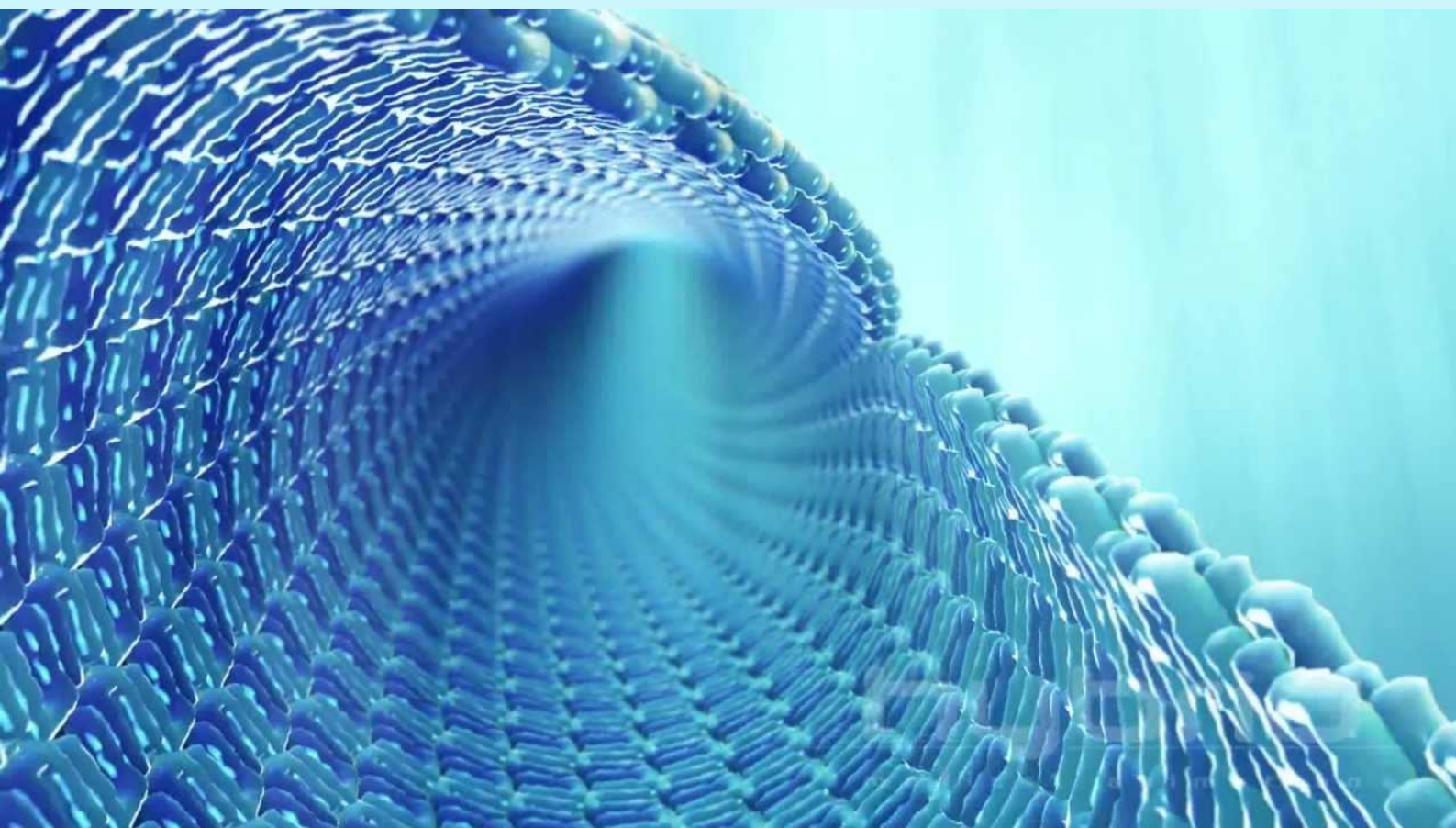


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University of Crete  
Eugenides Foundation

# Student' s Worksheets

for the activities of Nanoscience &  
Nanotechnology Applications



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# Worksheet 1

# ➤ Activity 1

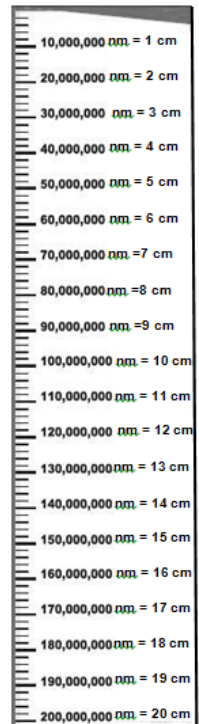
## WHAT'S THE LENGTH OF MY PEN IN NANOMETERS?

### Materials needed:

- Normal ruler
- Ruler in nanoscale

### Activity description:

1. How long do you think your pen is in nanometers?  
Write down your estimation in the 1<sup>st</sup> column of the following table.  
Do the same for the other items too.
2. Using your normal ruler measure the items in the table below and write down your measurement in the 2<sup>nd</sup> column.
3. Make any corrections you wish on your original estimation
4. Finally, measure the same items with the nanoruler and complete the 3<sup>rd</sup> column of the table.



Items	Estimation (nm)	Measurement (cm)	Measurement (nm)
Pen's length			
Shoe's length			
Palm's width			
Thumb's length			
Book's thickness			

## ➤ Activity 2

How many times would you have to cut to approach nano?

### Materials needed:

- paper strips 1m long
- scissors
- ruler

### Activity description:

1. Take a paper strip of 1 meter.

How many times do you think you should slice the strip in 1/10th until it gets a length of one nanometer?

.....

2. Cut the paper strip into 10 equal parts.
3. Take one of the ten parts and cut it into 10 equal parts. Repeat this process as many times as you can.

How many times do you believe you can to slice up the strip?

.....

4. Now carry out the above procedure

How many times did you manage to slice up the strip?

.....

What is this difficulty due to?

.....

How would you choose to cut a 1 meter wide strip of paper to achieve a  $10^{-9}$  m size strip?

.....

After the discussion with your teacher and classmates, what is your conclusion about nanometers size?

.....

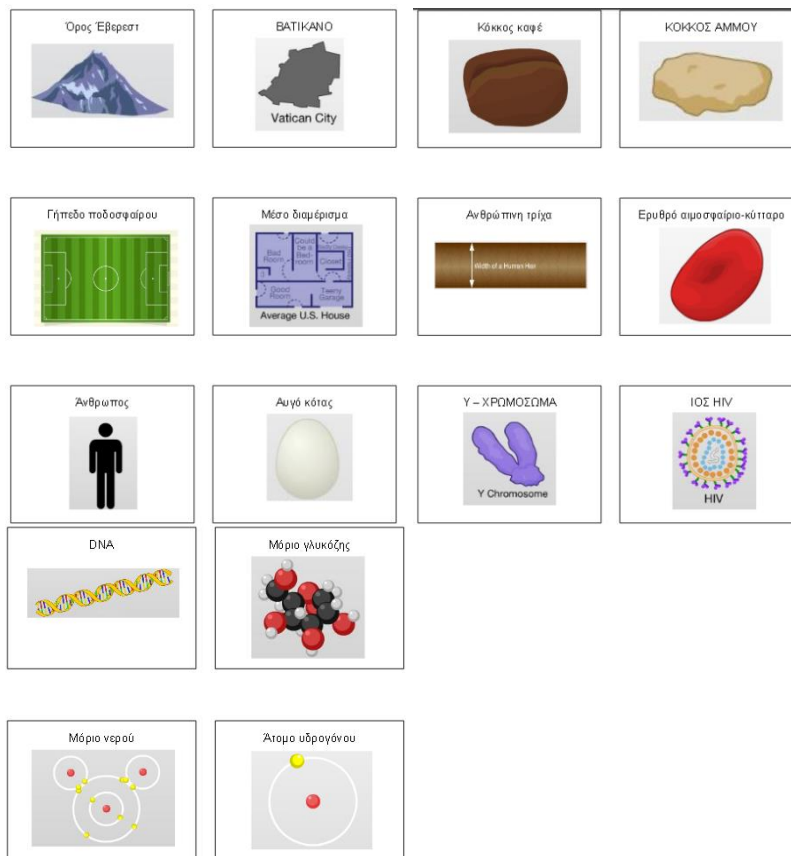
## ➤ Activity 3

### Materials needed:

- Cards, portraying objects/entities with different size ranging from macroscale to atoms
- multimedia application “Scale of the Universe”: <http://htwins.net/scale2/>

### Activity description:

1. Arrange the cards with the images you were given in ascending order of size of the entities depicted



2. Write in the following table the entities in ascending order of size



1.	7.	13.
2.	8.	14.
3.	9.	15.
4.	10.	16.
5.	11.	17.
6.	12.	18.

Try to justify your arrangement

.....

.....

3. Explore the application "The scales of universe» (<http://htwins.net/scale2/>) attempting to locate the entities depicted in the tabs and their size.

4. Check the arrangement initially made and then, where appropriate, make the necessary corrections.



1.	7.	13.
2.	8.	14.
3.	9.	15.
4.	10.	16.
5.	11.	17.
6.	12.	18.

The order of which elements is the same in the first and second arrangement?

.....

The order of which elements is different in the first and second arrangement?

.....

In your opinion, what are the reasons for those differences?

.....

2

# Worksheet 2

## ➤ Activity 4

### Materials needed:

- Pieces of potato in different sizes
- Hydrogen Peroxide ( $\text{H}_2\text{O}_2$ )
- Two plastic cups

### Activity description:



1. Cut one of the two potato pieces you are given in smaller pieces.

What do you think will happen if you impregnate the big and the smaller pieces simultaneously, in the two different cups containing hydrogen peroxide solutions? Will they react the same way?

.....  
.....

2. With the help of your classmates impregnate the big and the smaller pieces simultaneously, in the two different cups containing hydrogen peroxide solutions.

What do you observe?

.....

Did the phenomenon evolve according to your prediction or not? If not what went differently?

.....  
.....

Why do you believe the two samples reacted differently? Explain.

.....  
.....  
.....

After the discussion with your teacher and classmates, what is your conclusion for the relation of pieces' size and the reaction's rate?

.....



3

# Worksheet 3

## ➤ Activity 5

### Lower Secondary Education Version

#### Materials needed:


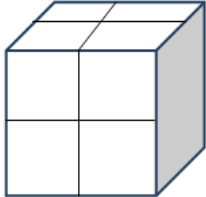
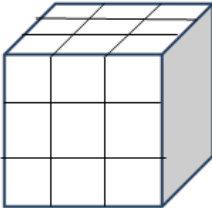
- ✓ Paper cubes (1 large cube, 8 medium cubes, 27 small cubes)
- ✓ Ruler



#### Activity description:

1. You are given 3 cubes, one large integer, one aggregation consisting of 8 medium cubes and one aggregation consisting of 27 small cubes.
2. Measure the edge of the large cube, of one medium cube and one small cube and write down your measurements in the table below.
3. Calculate the volume of the large cube ( $V=a^3$ ), the volume of the aggregation of 8 medium cubes and the volume of the aggregation of 27 small cubes and write down your results in the table below.
4. Unfold the cubes and calculate the surface of the large cube ( $S=6a^2$ ), the total surface of the 8 medium cubes and the total surface of the 27 small cubes and write down your results in the table below.
5. Calculate the ratio  $S/V$  for each cube / aggregation of cubes and write down your results in the table below.



	Edge a (cm)	Volume (cm <sup>3</sup> )	Total Surface (cm <sup>2</sup> )	S/V ratio
				
				
				

Order the S/V fractions in ascending order.

.....

Do you observe any relation between S/V ratio and the size of each cube?

.....

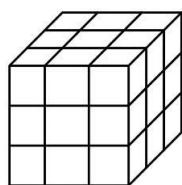
After the discussion with your teacher and classmates, what is your conclusion for the relation of S/V ratio and cubes edge dimension?

.....

## ➤ Activity 5

### Upper Secondary Education Version

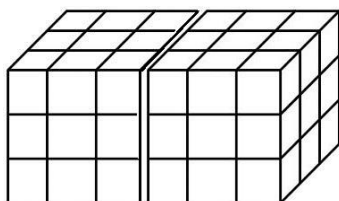
Suppose you have a paper cube of 1m edge. Fill the empty cells in Table 1, by making the appropriate calculations.



**Table 1**

$V_1 \text{ (m}^3\text{)}$	$S_1 \text{ (m}^2\text{)}$	$S_1/V_1 \text{ (m}^{-1}\text{)}$

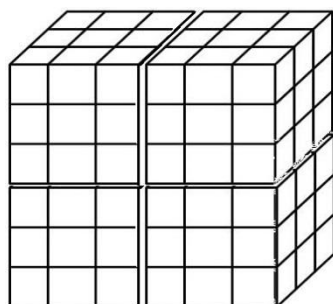
Double the total volume of paper cube in first activity and then fill in the empty cells in Table 2, by making the appropriate calculations



**Table 2**

$V_2 \text{ (m}^3\text{)}$	$S_2 \text{ (m}^2\text{)}$	$S_2/V_2 \text{ (m}^{-1}\text{)}$

Double the total volume of paper cube of the second activity and then fill in the empty cells in Table 3, by making the appropriate calculations



**Table 3**

$V_3 \text{ (m}^3\text{)}$	$S_3 \text{ (m}^2\text{)}$	$S_3/V_3 \text{ (m}^{-1}\text{)}$

Compare  $S_1/V_1$ ,  $S_2/V_2$  and  $S_3/V_3$  and come up with conclusions for the relation of  $S/V$  ratio and cubes edge dimension.

.....  
 .....



# Worksheet 4

# ➤ Activity 6

## Primary Education Version

Mary has a terrible headache. What would you propose her to do to make the effervescent tablet dissolve more quickly in the water?

.....

.....

.....



### Materials needed:

- ✓ effervescent tablets
- ✓ Plastic can with lid (eg film roll case)

### Activity description:

1. Cut one of the two effervescent tablets you are given in smaller pieces.

What do you think would happen if you infused the 2 tablets (the integer and the grated one) simultaneously, in the 2 different cases and close the lid? Justify your answer

.....

.....

2. With the help of your classmates infuse the 2 tablets (the integer and the grated one) simultaneously, in the 2 different cases and close the lid quickly.

What do you observe?

.....

Did the phenomenon evolve according to your prediction or not? If not what went differently?

.....

.....

Using your knowledge from previous activities explain why the 2 samples reacted differently.

.....

.....

After the discussion with your teacher and classmates, what is your conclusion for the relation of the tablet's pieces' size and the reaction's rate?

.....  
.....

# ➤ Activity 6

## Secondary Education Version

Mary has a terrible headache. What would you propose her to do to make the effervescent tablet dissolve more quickly in the water?

.....

.....

.....



### Test your idea!

Describe an experiment that would show that the dissolution rate of the effervescent tablets depends on the size of the tablet's pieces.

### Suggested materials:

- ✓ effervescent tablets
- ✓ plastic can with lid/ glass/ balloons
- ✓ stopwatch

### 1. Formulate your hypothesis.

.....

.....

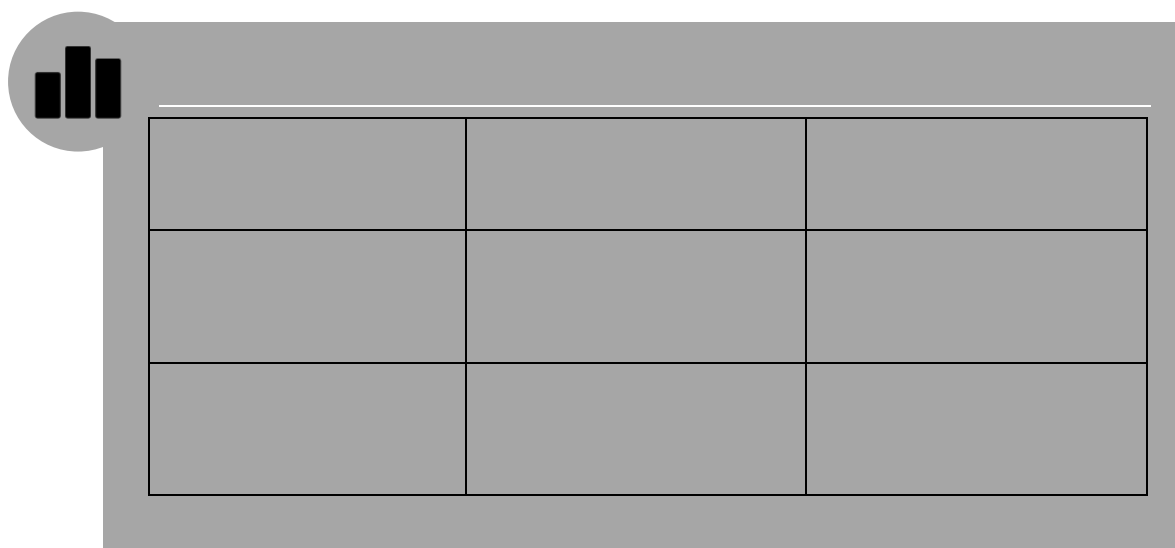
### 2. Fill in the following table:

Which variable will you manipulate?	Which variable will you measure?	Which other variables will you control?



3. Now conduct your experiment

4. Collect your data in the following table:



A grey rectangular box containing a table and a bar chart icon. The bar chart icon is located in the top-left corner of the box, showing three vertical bars of increasing height. The table is a 3x3 grid with empty cells for data entry.


What do you observe?

.....

Did the phenomenon evolve according to your prediction or not? If not what went differently?

.....

.....

After the discussion with your teacher and classmates, what is your conclusion for the relation of the tablet's pieces' size and the reaction's rate?

.....

.....



5

# Worksheet 5

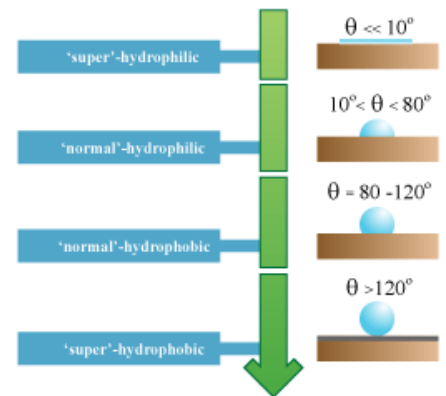
## ➤ Activity 7

### Materials needed:

- ✓ pipettes
- ✓ different types of surface (plastic, paper, nano-tex, silver foil, wax paper...)
- ✓ plant leaves (water lilies, tulips...)
- ✓ an android tablet with “Photo Measures Lite” application

### Activity description:

1. Using the pipette pour water drops of the same size on the each surface.
2. Observe their shape carefully and design a side view of the drop in the 1<sup>st</sup> column of the table below
3. Using the android tablet application Photo Measures Lite, take a photo of the side view of each droplet , calculate the contact angle and write it down in the 2<sup>nd</sup> column of the table below.
4. Consulting the image aside characterize each material as super-hydrophilic, hydrophilic, hydrophobic or super-hydrophobic using the 3<sup>rd</sup> column of the table





Materials	Side view of droplet	Contact angle	Surface characterization
Filtering paper			
Glass			
Nanotex			
Plastic			
Waterlily leaf			
Rose leaf			

Do you observe any similarities between the nanotex and the water-lily leaf?

.....

What do you believe they are due to?

.....

## ➤ Activity 8

### Materials needed:

- fine dust (finely ground garden clay), fine ash, cocoa
- tap water
- different types of surface (plastic, paper, nano-tex, silver foil, wax paper...)
- plant leaves (water lilies, tulips...)
- video projector
- videos: "Lotus effect" <https://www.youtube.com/watch?v=M9wKko4ur7A>  
 "NanoTech" <https://www.youtube.com/watch?v=EeJz7iPPy1Y>

### Activity description:

1. **Place the surfaces on a book. Sprinkle some dust on each surface and using the pipette pour water drops of the same size on the each one of them.**

If you created an inclination would the water drops flow the same way or there would be a difference?

.....

Would the surfaces be equally wet by the drop flowing?

.....

2. **Create an inclination and watch carefully the drop as it flows.**

What do you observe?

.....

Did the phenomenon evolve according to your prediction or not? If not what went differently?

.....

.....

Is the dust equally removed by the drop passage?

.....

Are the surfaces equally wet by the drop flowing?

.....

What do you believe the difference in the behavior of these materials is due to?

.....

.....

After watching the videos and discussing with your teacher and classmates how would you explain the hydrophobic behavior of lotus leaf and Nano-tex?

.....







# Worksheet 6

## ➤ Activity 10

### Materials needed:

- ✓ distilled water
- ✓ distilled water with droplets of milk
- ✓ milk
- ✓ NaCl solution
- ✓ H<sub>AuCl</sub><sub>4</sub> solution
- ✓ citrate solution
- ✓ gold solutions
- ✓ 6 glass beakers

### Activity description:

**1. You are given 7 beakers containing different solutions.**

If you pointed at them a red laser beam do you think they would interact with it the same way? Justify your answer.

.....

.....

**2. Point at the multiple beakers a red laser beam and observe it as it passes through the solution samples**

What do you observe?

.....

Did the phenomenon evolve according to your prediction or not? If not what went differently?

.....

.....

Is the light scattered the same way or not?

.....

.....

What do you think this is due to?

.....

3. *Colloidal solutions scatter visible light in oblique directions in the particle boundaries, since the dispersed particles have dimensions comparable to the wavelength of incident radiation.* According to this fact characterize the sample solutions as COLLOIDAL or NOT COLLOIDAL in the table below



Solution Sample	Type of solution
Distilled Water	
Distilled water with droplets of milk	
Milk	
NaCl solution	
HAuCl <sub>4</sub> solution	
Citrate solution	
Gold solutions	





# Worksheet 7

## ➤ Activity 11

### Materials needed:

- ✓ Video projector
- ✓ “Ferro Fluid Tests” <https://www.youtube.com/watch?v=kL8R8SfuXp8> (0:40” – 3:12”)
- ✓ Magnets
- ✓ iron filings
- ✓ glass beakers containing ferrofluid

### Activity description:

1. You are given a couple of magnets, some iron filings on a paper-sheet and a beaker with ferrofluid.

What do you think would happen if you approached the magnet at the iron filings? Justify your answer.

.....

.....

What would you expect to happen if you approached the magnet at the jar with the ferrofluid? Justify your answer.

.....

.....

2. Now approach the magnet underneath the paper-sheet with the iron filings.

What do you observe?

.....

How do you explain it?

.....

Did the phenomenon evolve according to your prediction or not? If not what went differently?

.....

.....

3. Now approach the magnet underneath the beaker with the ferrofluid.

What do you observe?

.....

How do you explain it?

.....

Did the phenomenon evolve according to your prediction or not? If not what went differently?

.....

.....

Are there any similarities or differences between the shapes the ferrofluid and the iron filings take when interacting with the magnet?

.....

.....

After watching the videos and discussing with your teacher and classmates how would you explain the magnetic behavior of the ferrofluid?

.....




# Worksheet 8



# ➤ Construction Planning Activity (D' Acquisto, 2006)

## Activity description:

1. List all tasks that need to be accomplished
2. As a team, divide the tasks among yourselves
3. Create a timeline for accomplishing the tasks in with the team
4. Meet regularly to update your plan and make adjustments as needed




Task	Student	Due Date

# ➤ Materials, Supplies and Equipment Activity

(D' Acquisto, 2006, p.151)

## Activity description:

1. Review your exhibit drawing and make a list of the artifacts images and objects in your display. Also list all the other materials that you will need to create your display, such as batteries, hinges, buzzers and shirt boxes.
2. Make a list of all the supplies that you will need to create your exhibit, such as card stock, butcher paper, double-sided tape, adhesive spray, scissors and rulers.
3. Make a list of all the equipment that you will need to create your exhibit, such as a slide projector, a DVD player, a tape recorder, light sources, and extension cords.



Materials	Supplies	Equipment