Where'd They Get That Idea?

Issues and Ideas in Science and Mathematics

Volume I

STUDENT DIGITAL BINDER

TOUCHSTONES®
DISCUSSION PROJECT

About the Touchstones® Discussion Project

The Touchstones Discussion Project is a nonprofit organization founded on the belief that all people can benefit from the listening, speaking, thinking, and interpersonal skills gained by engaging in active, focused discussions. Since 1984, Touchstones has helped millions of students and others develop and improve these skills in school, work, and life. For more information about the Touchstones Discussion Project, visit www.touchstones.org.

The following images were used in the cover design:

Detail from Raphael's *The School of Athens*. 1509-1510.
Fra Mauro map. [c. 1450].
Planetary Smash-Up. 2009. NASA/JPL-Caltech.

Worksheet #1-A

i   **Individual Work**

Complete the following questions on your own.

1. Which ground rule do you think will be the hardest for the class to follow? Why?

2. Which ground rule will be hardest for you to follow? Why?

Complete question 3 after the discussion.

3. Choose one or two of the goals from page 7(a-k) that you would like to achieve through this program. Write their letters here.

    _____

    _____

Worksheet #1-B

Small Group Work

I. The chairperson of your group is responsible for organizing the group, making sure everyone participates, and presenting the group's answers to the whole class. The secretary is responsible for recording your group's answers. The participants are responsible for being cooperative and helping to make sure the group work gets done.

II. Form a circle with your chairs or turn on your camera to make sure each person in the group is included.

III. Each person in the group should share what he or she wrote down for #1 in Worksheet #1-A.

IV. Everyone in the group should decide on the one ground rule that will be the most difficult for the class to follow. Write your group's choice here. _____ Why did your group choose this ground rule?

Worksheet #2-A

Individual Work

i

1. Below, list three ways in which you believe having a huge amount of money would make you happy.

    a.

    b.

    c.

2. Below, list three ways in which you believe having a huge amount of money would cause you problems and make you unhappy.

    a.

    b.

    c.

Worksheet #2-B

Small Group Work

I. The chairperson of your group is responsible for organizing the group, making sure everyone participates, and presenting those answers to the whole class. The secretary is responsible for recording your group's answers. The participants are responsible for being cooperative and helping to make sure the group work gets done.

II. Form a circle with your chairs or turn on your camera to make sure each person in the group is included.

III. Compare your individual answers.

IV. In the space below, the secretary should write down as many suggestions as your group can think of on how to prevent the unhappiness or problems that wealth might cause without getting rid of it as Ti does. (The secretary should be prepared to share the group's responses.)

Worksheet #3-B

Small Group Work

I. Draw the leaf in front of you as carefully as you can. Make a list of one or two important features that would distinguish your leaf from any other leaf.

Important Features

a.

b.

II. Now draw a picture of a second leaf from the same type of tree. List some important ways that the two leaves are different. Compare with the other students in your small group.

Ways Leaves are Different

a.

b.

Journal

Choose one question, check its box, and answer it below.

❑ How does this story relate to your own drawings and observations of the leaves?

❑ What does the professor mean when he says that "a pencil is one of the best eyes?"

❑ How is the observation of the fish the best scientific lesson for the author?

❑ Why did the professor not allow the author to use artificial aids such as a microscope?

Worksheet #4-A

Work In Pairs

We have all said that two things or people were exactly the same or at least very similar to one another. Sometimes we feel that family members are very different but that two friends are just alike. Sometimes people, even when they look very different, are mistaken for one another because they are so similar in their opinions or behavior. Sometimes very close friends are mistakenly called by the other's name. Perhaps that has also happened to you. Things and people could be similar or the same in many different ways. Working in pairs, you will select four objects around you that you feel will be hard to find to be similar. Each pair will share its list with another pair and get another pair's list. Each must figure out at least one similarity among the four objects, and write this similarity in the space provided at the bottom of the page. An important part of mathematics and science is deciding which things we will group together. Often how we group things will greatly influence how we study them because we begin to concentrate on what they have in common. In today's class we will explore grouping things together and the ways in which we see what geometric figures have in common.

Look around you and choose four objects that have something in common but are not obviously related. When you are done, your teacher will ask you to share your list with another pair. You will then have to figure out what their four objects have in common and they will have to figure out what your four objects have in common.

Your List

1.

2.

3.

4.

What do these four things have in common?

Worksheet #4-B

Ⓢ

Small Group Work

I. Each group will need a pair of scissors. Cut out one set of figures from the handout your teacher gives you. *The figures need only to be separated from each other. They do not need to be cut out exactly!*

II. As a group, decide how you would organize the figures. Divide the figures into at least three different categories, but not more than five categories.

III. List the numbers of the figures in each category and a reason explaining why those figures are in the same category.

Category 1

Figure #'s: _____

Reason: _____

_____

Category 2

Figure #'s: _____

Reason: _____

_____
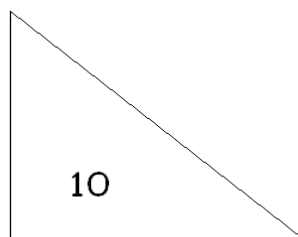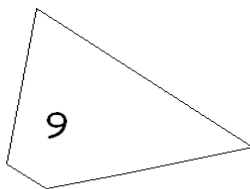
Category 3

Figure #'s: _____

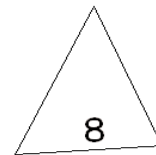Reason: _____

_____

Category 4
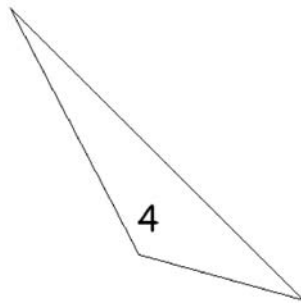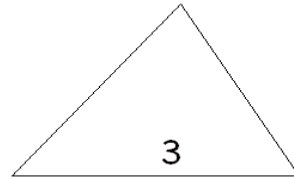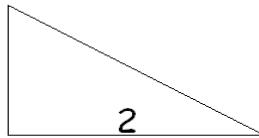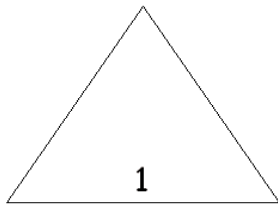
Figure #'s: _____

Reason: _____

_____

Category 5

Figure #'s: _____

Reason: _____
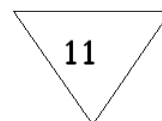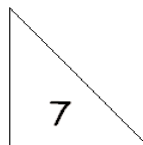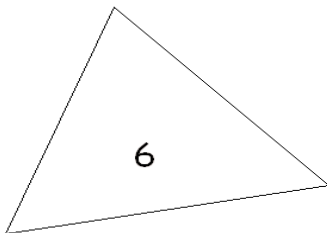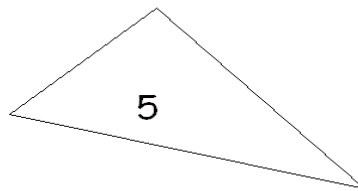
Note to Teacher: Photocopy or ask students to print pages 18-19 of the Student Volume before class so that students can cut out these figures.
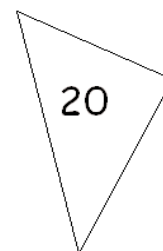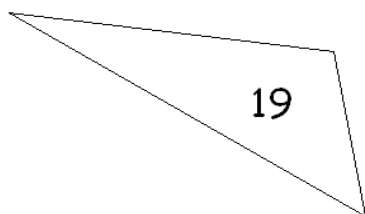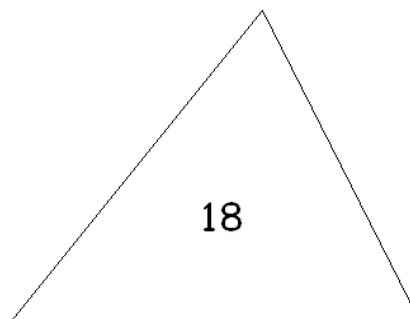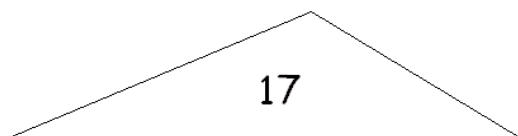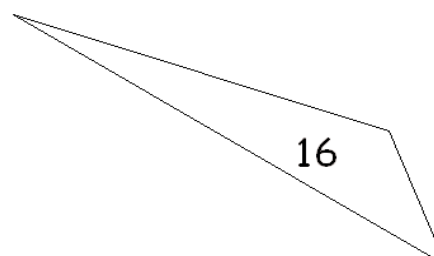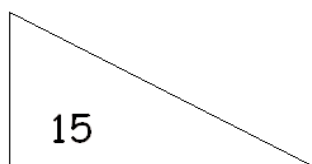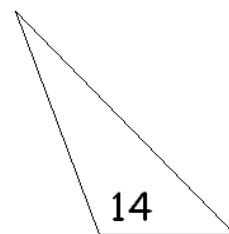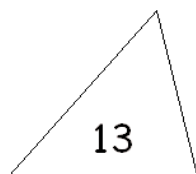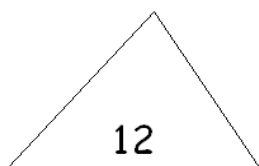
✏️ **Journal**

Euclid also grouped triangles according to the type of angles they have. An angle that looks like this (⌐) is called a right angle, a bigger angle is called obtuse, a smaller angle is called acute.

| A) Right Angle | B) Obtuse Angle | C) Acute Angle |

A) A **right-angled triangle** has one right angle, an angle measuring 90 degrees.

B) An **obtuse-angled triangle** has an obtuse angle, an angle greater than 90 degrees.

C) An **acute-angled triangle** has all three angles acute, all less than 90 degrees.

Which of the triangles that you cut out are right, which are obtuse, and which are acute? We have started you off with the first answer in each group.

Right: #2, _____

_____

_____

Obtuse: #4, _____

_____

_____

Acute: #1, _____

_____

_____

Worksheet #6

i

Ever since you were very young, you have probably been drawing pictures. Some of these were of animals or trees, other drawings were of buildings. Surprisingly, when we look at these pictures, we realize that the hardest thing to draw is a perfectly straight line. Since a straight line is the simplest line there is, this might puzzle us. In addition, though it is easy to tell if a line is not straight, it is very hard to tell if a line is perfectly straight even when we draw it with a ruler.

In this class, we will consider four different ways of explaining to someone how we would decide if a line is perfectly straight. You will discuss which way is best or come up with ideas for better ones.

1. Draw a straight line without any help.

2. Draw a straight line using a straight edge, like a ruler or book.

3. Which of the following lines is straighter between points A and B? Mark the circle for the one you choose.

A ⎯⎯⎯⎯⎯⌒ B   A ⌒ B

A ∿ B   A ∧∨∧ B
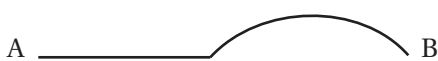
Journal

Which definition of a straight line do you prefer? Why?

Worksheet #7

Small Group Work

Imagine that while you were out walking in the woods, you noticed a certain type of small bird. You also saw that all of these birds were continually pecking at their feathers. As a group, try to come up with an explanation for this behavior.

Individual Work

This story about Feynman's walk with his father contains a lot of details, but the details are not equally important. Below is a list of six facts or details in the story. Number them according to how important you think they are, where 1 is the most important and 6 is the least important.

____ a. Feynman's father made up names for the bird they observed in several different languages.

____ b. Feynman knew his father's story wasn't exactly true.

____ c. The bird is called a brown-throated thrush.

____ d. Feynman and his father look at the birds and notice there is no particular time when the birds peck their feathers.

____ e. Feynman's father made up a story which connected lice, mites, sugar-like material, and how often birds peck their feathers.

____ f. The story takes place during the summer in the Catskill Mountains.

✏️ Journal

Write a story in which you present a main principle or lesson.

This is typical of children's stories. An example is the race between the tortoise and the rabbit. The tortoise is slow but always keeps moving. The rabbit is fast but stops and falls asleep, so he loses the race. The main principle is that consistent work can overcome a lack of talent. Ask friends or parents for help on this.

Worksheet #8

i

Individual Work

1. **Arrange the professions below according to whether you think they are more mathematical or intuitive.** Type or write the initial for each profession on the straight line to indicate whether you think the professions are closer to being intuitive or to being mathematical, which are at opposite ends of the line.

Intuitive _____ Mathematical

Lawyers (L)	Doctors (D)
Musicians (M)	Historians (H)
Engineers (E)	Teachers (T)
Cooks (C)	

2. **Are you mathematical or intuitive?** Place your initials on the straight line above to indicate where you think you belong. Explain why you placed yourself there.

S

Small Group Work

I. Appoint a chairperson and a secretary.

II. Compare your answers to question #1. Come up with one arrangement on which you all agree.

Intuitive _____ Mathematical

Journal

Why are some people afraid of mathematics?

Worksheet #9

Individual Work

i

1. What is the largest thing you have ever seen?

2. Could it have been larger?

3. Have you ever asked or been asked where the end of the universe is or how large the universe is? What do you think led you or the other person to ask this question?

Small Group Work

S

Appoint a chairperson and a secretary for your group.

I. How you would answer someone who asked where the end of the universe is?

Journal

Do you think the universe goes on forever or does it stop somewhere? Why?

Worksheet #10

Individual Work

i

1. **Which class in school do you think changes you the most?** Which has the least affect on what you are like? From the list below, choose which class changes you the most and which changes you the least. Write your answers in the space provided.

Language Arts
Math
Science
Social Studies
Physical Education
Art
Music

_____

Changes me the most.

_____

Changes me the least.

2. **Explain your choices.**
   a) Class that changes you the most:

   b) Class that changes you the least:

Small Group Work

S

I. Form a group with three or four other students who had the same answer to "Which class in school do you think changes you the most?"

II. Appoint a chairperson and a secretary. As a group, **try to come up with five ways that studying mathematics could change a person.**

Journal

In this lesson we have been considering how studying math could change you in other ways.
How do you think a person who made the effort to really study math would change? What would that person be like in other things he or she does?

Worksheet #11

i

Individual Work

1. **Using straight lines, try to divide the figures below into two symmetrical parts**. We have given you an example with an equilateral triangle. (An equilateral triangle has three sides that are all the same length.)

EXAMPLE
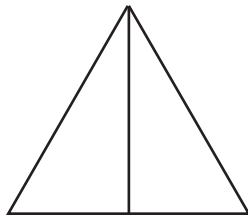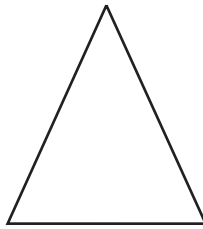
a. Equilateral Triangle   b. Isosceles Triangle   c. Square
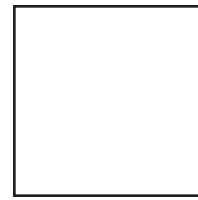
d. Rectangle   e. Circle

S
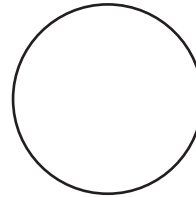
Small Group Work

I. **Compare your answers with the answers of the other members of your group.** As a group, decide how many different ways there are of cutting each figure into two symmetrical parts.

_____ Equilateral triangle

_____ Isosceles triangle

_____ Square

_____ Rectangle

_____ Circle

Journal

Did the proof convince you? Why or why not?

Worksheet #12

Individual Work

i

1. **Suppose you are a doctor conducting experiments on the use of a drug to cure cancer.** You are trying to figure out the right dose to use on humans and you know that using the wrong dose can be very dangerous. From the list below, decide what subjects you think it would be all right to use for experiments. Check the appropriate boxes. In addition, circle or highlight the one that you would most likely use for experiments.

   ❑   dogs

   ❑   people who volunteer

   ❑   monkeys

   ❑   mice

   ❑   people who are dying of cancer

   ❑   yourself and other scientists

Small Group Work

S

I. **Form a group with three or four other students who circled the same response as you.** Discuss and try to come to an agreement on reasons why that is the best animal or subject to be experimented on.

Journal

1. Was there a great deal of disagreement in this class discussion?

2. Why do you think there was so much agreement or disagreement on this subject?

Worksheet #13-A

Individual Work

i

1. The diagram below shows a flashlight pointed towards a mirror and a wall. The lines represent the actual path that light would travel from the flashlight to the mirror to the wall. The angle the light makes with the mirror, angle 1, is equal to the angle that it reflects from the mirror, angle 2.
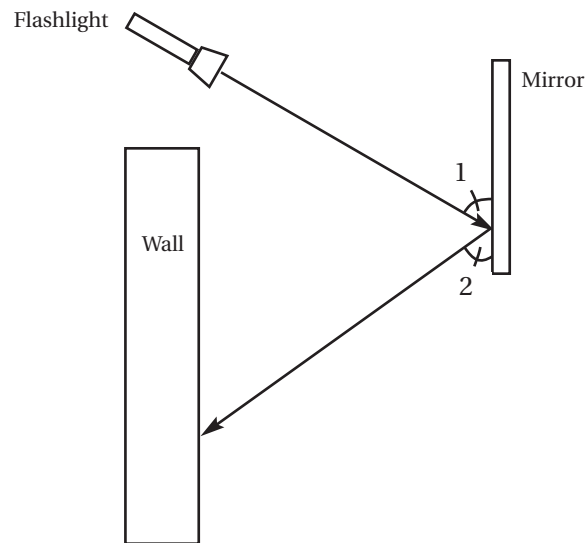
2. **How would you convince someone that the path shown is the actual path the light would travel without doing an experiment in which you shine the light on a mirror and measure the angles?** Write your answer below.

Worksheet #13-B

S

Small Group Work

I. **Compare your explanations with those from other members of your group.** Decide on one explanation for why the light would travel in that path.

✎ Journal

Would it surprise you if equal weights at equal distances did not balance? Suppose this is what you saw. How would you explain it?

Worksheet #14

Individual Work

i

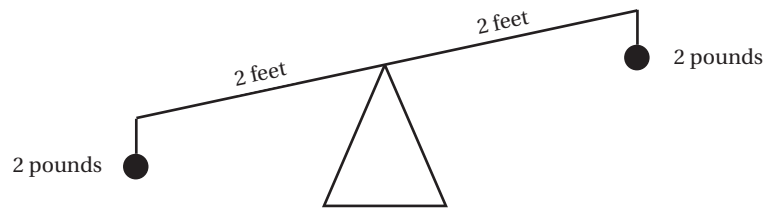Answer the following questions "Yes" or "No."

1. **Consider this line.**   _____
   We can draw one twice as long,   _____
   and then make that one twice as long.   _____
   Can we keep doubling this line without ever having to stop?

   ❑ YES   ❑ NO

2. **Is there one line that is longer or as long as any other line?** (In other words, is there a line that is longer than any other line?)

   ❑ YES   ❑ NO

3. **Can any number be doubled?**

   ❑ YES   ❑ NO

4. **Is there a number that is as large or larger than any other number?** (In other words, is there a number that is greater than any other number?)

   ❑ YES   ❑ NO

Small Group Work

S

I. **Consider lines that are very short.** Is there a line so short that even if we looked at it under a very powerful magnifying glass we would see that it couldn't be made shorter?

   ❑ YES   ❑ NO

II. **Draw the shortest line you can and use the magnifying glass to look at it.**

Journal

Based on the class discussion, would you change any of your answers from the worksheet? Explain your answers. Use the back of this page if you need more room.

1. **Consider this line.**   _____
    We can draw one twice as long,   _____
    and then make that one twice as long.   _____
    Can we keep doubling this line without ever having to stop?

    ❑ YES   ❑ NO

2. **Is there one line that is longer or as long as any other line?** (In other words, is there a line that is longer than any other line?)

    ❑ YES   ❑ NO

3. **Can any number be doubled?**

    ❑ YES   ❑ NO

4. **Is there a number that is as large or larger than any other number?** (In other words, is there a number that is greater than any other number?)

    ❑ YES   ❑ NO

Worksheet #15

Individual Work

i

We often try to convince others of something we believe. Have you ever had a disagreement with a friend about what was the best tasting food, TV show, singer, or basketball team? This has happened to all of us and there are different ways we use to try to convince someone we are right. Some people try to find things they know others will agree with and then use these to convince them about what they are now discussing. But you may do it in different ways. Some people like to show that a certain opinion is so silly that its opposite must be true.

1. **Suppose you are going to try to convince someone to agree with you.** Which of the topics listed below would be the easiest to convince someone to agree with you about? Mark that one with an "E". Which would be the hardest? Mark that one with an "H". Explain why you think it would be hard to convince the other person to agree with you about the one you marked "H".

    ___ Best TV show   ___ Best tasting food

    ___ Best song   ___ Best singing group

    ___ Best thing to do when angry with someone

2. **How would you try to convince the other person?** Would you try to show them that their choice does not make sense and therefore you are right? Or would you try to show them why you are right and therefore they must be wrong? Choose one approach and explain why.

Small Group Work

S

I. **As a group, decide which of the two proofs you like better.**

Journal

Below are a variety of circles. **If you took a ruler and measured the radius and diameter in each one and discovered that in each circle the diameter was two times the radius, would you believe this would be true of all circles?** How many circles of different sizes would you want to try before you completely believed it?
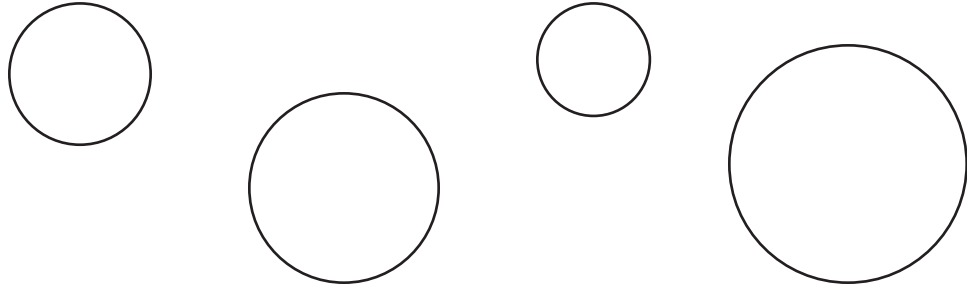
Do you need a proof like the one in the text to know that this would be true of all circles? Why or why not?

Worksheet #16-A

i

Individual Work

1. The list below has a few common notions from the text and one that was not in the text. After each one, write how true you think it is using the scale below. Is it true of everything, many things, few things, nothing?

Always True	= 4
Usually True	= 3
Sometimes True	= 2
Rarely True	= 1
Never True	= 0

_____ **a)** **Things that are equal to the same thing are also equal to one another.**
If A=B and B=C then A=C.

_____ **b)** **If equals are added to equals, the sums are equal.**
If A=B and C=D, then A+C=B+D.

_____ **c)** **The whole is greater than the part.**
A+B is greater than A.

_____ **d)** **A thing is equal to itself.**
A=A.

2. Do you think most students in your class would agree with your choices?

❑ YES   ❑ NO

3. Write down an opinion you think everyone in your class believes. This can be about anything and should not be one of those listed above.

Worksheet #16-B

Small Group Work

I.   Appoint a chairperson and a secretary. Be sure the secretary is ready to share the group's answers with the entire class.

II. Look at the two notions that received the highest score. Imagine a situation where those notions are not true, or not clearly true, and write it below.

Journal

1. **Write down something you think is absolutely true.** A test of this is that no-one could make you think it was false.

2. **Write down something you think is absolutely false.** A test would be that no-one could convince you that it is true.

Worksheet #17

Individual Work

i

1. **Are all inventions useful?** Explain your answer.

2. **Do scientists have any responsibility for how their discoveries are used?** Explain your answer.

3. **If you discovered a fact that was painful or dangerous to people, would you automatically tell them or consider keeping it secret?** For example, if you discovered that the earth was getting closer to the sun and that all life would be threatened, what would you do?

Small Group Work

Ⓢ

I. **Discuss your answers to all three questions with the other members of your group.**

Journal

Do you feel that we should learn the truth at all costs? Or do you think there are certain truths it would be better for us not to know? What would be an example of such a truth and why is it better for us not to know it?

Worksheet #18

i

Individual Work

Below are some definitions of a square and a circle and a straight line. Under these you will find a number of figures.

1. For the first three figures, write down why they are or are not really circles.

2. For the next group of three figures, write down why they are or are not really squares.

A **circle** is a single line all of whose points are the same distance from one point inside called the center.
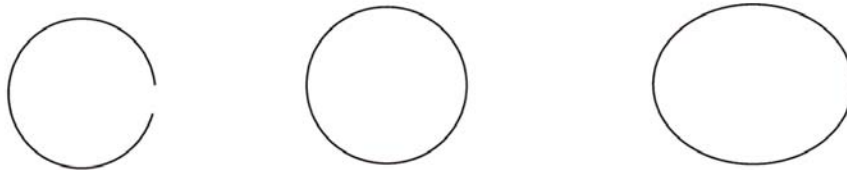
A **square** is a figure that has four equal straight lines as its sides, and four equal angles.

S
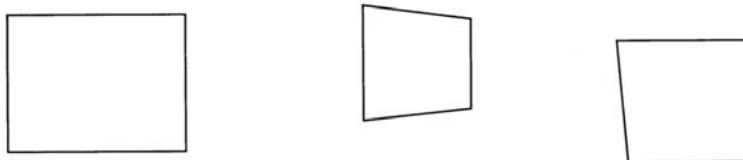
Small Group Work

I. As a group, discuss your answers to questions 1 and 2 of the individual work.

Journal

Do you think numbers or triangles and straight lines are more useful to us in our everyday activities? Mention a few ways you use them everyday. What would your life be like if we could not use geometry or arithmetic? What if, for example, every time you counted the change in your pocket, you got a different amount?