INTEGRATED MATHEMATICS UNIT

TEACHER GUIDE

PROPORTION MATTERS

MATH

DIGITAL MEDIA ARTS

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Contents

MATH

Unit Overview

Proportion is a central concept in the world of art and design. The relationship of parts to the whole is a primary concern in any design task, and artists and designers frequently manipulate proportion to create effects. Editorial cartoonists, for example, are masters at creating an effect by exaggerating the proportions of their subject to make an editorial point. Animated character designers also exaggerate proportions to create human and non-human characters with distinct personalities.

In this unit, students explore head-to-body and facial feature proportions of humans and animated characters in order to understand the effect that proportion has on the viewer's perception of a character's personality. Students measure and calculate proportions and apply what they have learned by creating a character whose specific proportions are designed to create a particular effect.

Unit Length

4–5 50-minute sessions

Unit Project Description

For the unit project, students design their own animated character. They apply what they have learned about how to measure and calculate head-to-body and facial proportions, and how to use different proportions to create specific aspects of a character's personality. Students specify their character's head-to-body and facial proportions, create their character, and share their character with the class.

Assessment

Unit activities can serve as formative assessment tools. Use students' work to gather information about their progress and to identify concepts or skills to reinforce within your instructional practice. The following activities are particularly useful for formative assessment:

- Journal 1
- Activity 2A: Changing Characters' Body and Facial Proportions

The project-based nature of the unit allows students to demonstrate their learning through authentic and relevant applications. This unit's summative assessment consists of the following:

- An animated character design that includes specific head-to-body and facial proportions (Activity 2B)

The Assessment Checklist provides criteria for assessment and a suggested weight for each. If you wish to use a rubric, work with teachers in your grade level or subject area to develop a tool that is consistent with your school's assessment system.

Framing Questions

- How can body and facial proportions be expressed mathematically using fractions, ratios, and percentages?
- What kinds of information do facial and body proportions convey about a character?
- How can changes in facial and body proportions affect the audience's perception of a character's personality?
- How can artists design facial and body proportions to convey particular characteristics of a character?

Understandings

- Ratios can be used to determine unknown dimensions of an object.
- Facial and body proportions can be expressed mathematically.
- Facial and body proportions convey significant information about a character.
- Artists design characters' facial and body proportions to create specific effects in the way characters are perceived.

Where the Unit Fits In

Proportion Matters is a stand-alone one-week unit that can fit into a high school algebra, applied mathematics, or geometry course.

Integration with Foundations Courses

This unit integrates mathematics content and drawing skills. It can be taught before, at the same time as, or after the related units in *Foundations in Visual Arts* or *Foundations in Media and Digital Design: Animation & Gaming*.

Foundations in Visual Arts, Unit 5: Creating Characters

Students learn about the process of character development, and analyze the visual qualities of characters in movies and TV shows. For their unit project, students develop their own character. Students can apply what they've learned in *Proportion Matters* about ways that artists and designers use proportions to create a specific appearance and personality for their character.

Foundations in Media and Digital Design: Animation & Gaming, Unit 1: The Animated World

Students learn the techniques and principles of animation, including hand-drawn pencil-and-paper animation and computer-generated 2-D animation. For their unit project, students develop an idea for an animated movie and create animations of a character in a moment from the movie. Students can use the animated character they create in *Proportion Matters* as the basis for their short animations, or modify the character they developed in *The Animated World* for the unit project in *Proportion Matters*.

Multi-Disciplinary Teams

Use the following integrated units and integration suggestions for a school- or pathway-wide multi-disciplinary project.

Transforming Figures: The Mathematics of Animation (Algebra I/Geometry)
Students learn the mathematics behind animation, deepening their understanding of the illusion of motion. They create flipbooks by applying transformations to geometric objects, suggesting the illusion of motion from one frame to the next. Students taking this unit could create a flipbook that animates characters with specific head-to-body proportions.

Animating Labor History (U.S. History)

Students act as researchers working on an animated movie about an event in U.S. labor history. Through independent research and classroom activities, using both primary and secondary sources, students create biographies about the appearance, actions, and daily lives of the main characters in the animated movie. Students taking this unit could create a character for the *Proportion Matters* unit project that is based on one of these character biographies.

Casting a Novel Character

Students analyze characters and their development in fiction or biographies. They imagine one character from a written work as a main character in a TV show or movie and then craft both a monologue to introduce the character and a dialogue that reveals the character's development. Students taking this unit could base their character for the *Proportion Matters* unit project on the character they chose from a written work.

Student Prerequisites

Students should be able to convert among fractions, decimals, and percentages; have some experience with setting up and solving proportions; and have an understanding of the concept of similar figures and their proportional nature.

Pacing and Sequencing

Students may need more time to finish their character design final projects. You may want to coordinate with the media or art teacher for help with student drawing.

Alternately, you may coordinate with the media or art teacher to have students complete the character design and drawing in an art or media class.

Table of Activities

Part 1: Body and Facial Proportions (2 sessions)

Students analyze body and facial proportions of human and animated characters, and consider the effect of proportions on the audience's perception of these humans and characters. Students use ratios and set up proportions to determine head and height measurements. Students then calculate head : height ratios and ratios of facial features for images of humans and animated characters.

Activity 1A: Ratio Calculations: Vitruvian Man

Students complete a table of ideal human proportions based on Leonardo da Vinci's iconic drawing of Vitruvian Man. Students use the ratios to calculate dimensions of body features for different-sized individuals with Vitruvian Man's proportions. Students measure dimensions of head and height for humans and animated characters and calculate their head : height ratios.

Activity 1B: Measuring Facial Proportions

Students analyze how different facial proportions can affect the audience's perception of an animated character. Students measure facial features on images of human and animated characters, and calculate ratios related to the feature's position on the face and the width of the face.

Part 2: Designing with Body and Facial Proportions (2–3 sessions)

Students use scale factors and ratios to change the size of a character's head and the size and position of facial features. Students then design their own characters, using what they have learned about body proportions and facial proportions to inform their character's appearance and personality. Students specify head : height ratios and facial feature ratios to create a desired look, and then draw their character.

Activity 2A: Changing Characters' Body and Facial Proportions

Students discuss how differences in facial proportions affect an audience's perceptions of human and animated characters. Students use a scale factor to change a character's head : height ratio, then use the revised ratio to alter the character's appearance by enlarging or reducing the size of the character's head. Students use scale factors and ratios to revise both the position and width of a character's facial features.

Activity 2B: Using Body and Facial Proportions to Create a Character

Students design a character and specify a head : height ratio and facial feature ratios that express their character's personality. Students create their character and share it with the class.

Advance Preparation

- Internet resources, provided as links in *Media & Resources*, are recommended throughout the unit for student or in-class use. These Web sites have been checked for availability and for advertising and other inappropriate content. However, because Web sites' policies and content change frequently, we suggest that you preview the sites shortly before using them.
- Address any issues, such as firewalls, related to accessing Web sites or other Internet links at your school.
- Look at **Materials Needed** at the end of the unit and order or prepare any needed equipment or supplies.

Part 1: Body and Facial Proportions

Students analyze body and facial proportions on images of human and animated characters, and consider the effect of proportion on the audience's perception of these characters. Students use ratios and set up proportions to determine head and height measurements. Students then calculate head : height ratios and ratios of facial features for images of humans and animated characters.

Length

2 50-minute sessions

Advance Preparation

- Optional: For Activity 1A, select several images of animated characters with clearly differing head-to-body proportions, and decide whether to print them or display them digitally. (See *Media & Resources* for links to some examples.)
- Before Activity 1A, decide whether to use the *Proportion Matters* slide presentation to display the information on Handouts 2 and 3. (See *Media & Resources* for information about the slide presentation.)
- For Activity 1A, print one image for each student from **Appendix A: Head : Height Proportion Images** for students to use in their journal assignment. Use as many different people and characters as possible in order to get a variety of head : height ratio measurements.
- Before Activity 1B, when students learn about facial feature proportions, decide whether you will digitally project or print and display the images from **Appendix C: Facial Proportion Images**. You'll also need to print one image from **Appendix C** for each student so that students can make facial feature measurements. Use as many human and animated character faces as possible.
- Before Activity 1B, decide whether you will show students images from **Appendix B: Head: Height Proportion Answers** and/or images from **Appendix D: Human Facial Feature Ratios**. If you decide to show the images, determine whether you will digitally project or print and display the images.

Activity 1A: Ratio Calculations: Vitruvian Man

Students complete a table of ideal human proportions based on Leonardo da Vinci's iconic drawing of Vitruvian Man. Students use the ratios to calculate dimensions of body features for different-sized individuals with Vitruvian Man's proportions. Students measure dimensions of head and height for humans and animated characters and calculate their head : height ratios.

Understandings

- The relationships between body parts can be expressed mathematically using ratios.
- Human body ratios vary.
- A person's or character's appearance can be altered by varying his or her body ratios.

Materials Needed

- Optional: Printed or digital images of animated characters with varying body proportions (see *Advance Preparation*)
- **Handout 1: Unit Overview**
- **Assessment Checklist: Character Design**
- **Handout 2: Vitruvian Man Proportions**
- Optional: *Proportion Matters* slide presentation (see *Advance Preparation*)
- **Handout 3: Calculating Vitruvian Man Measurements**
- **Handout 4: Human Head : Height Ratios**
- Rulers
- Images of people and animated characters from **Appendix A: Head : Height Proportion Images** (one per student) (see *Advance Preparation*)
- **Handout 5: Journal Assignment**

1. Optional: Show students animated characters with varying proportions.
Display the images of animated characters. Ask students:

- What do you notice about the differences in the sizes of these characters' heads in relation to their bodies? What about the sizes of their facial characteristics, such as eyes and mouths?
- What effect do you think these visual properties have on your perception of the character?

2. Introduce the concept of *proportion*.
Tell students that in this unit they will look at how body and facial proportions can be quantified mathematically. They will then apply what they learn by designing an animated character with specific proportions.

Give students **Handout 1: Unit Overview** and have them read it. Distribute **Assessment Checklist: Character Design** so students can see how their work on the unit project will be assessed.

Explain that their work in this unit will help students become more accurate artists and will enable them to design characters that express clear personalities.

3. Introduce the Vitruvian Man.
Distribute **Handout 2: Vitruvian Man Proportions**. Explain that students are going to look at proportions of the human body. Tell students that Leonardo da Vinci was a 15th century engineer and architect, as well as an artist.

Teacher's Notes: Leonardo da Vinci and Vitruvian Man

Leonardo da Vinci wrote a treatise on human proportions in architecture, which included a description of ideal human body proportions as described by the Roman architect Vitruvius. See *Additional Resources for Teachers* for more information about Vitruvian Man.

Explain to students that the proportions of real human bodies vary from the ideal proportions of Vitruvian Man. Have students read the information on Handout 2.

4. Have students determine the ratios of Vitruvian Man's proportions.
On the board, draw a table similar to the table shown on Handout 2.

Note: If you are using the slide presentation *Proportion Matters*, project the first slide instead of drawing the table.

	1 finger	1 palm	1 head	1 cubit	1 height
Fingers					
Palms					
Heads					
Cubits					
Heights					

Ask students:

- What given dimensions are equal to one palm?

  Answer: *One palm is equal to four finger widths.*

Show students where to place the number 4 in the appropriate cell in the table. Work together as a class to use the information on Handout 2 to fill in the table with the other relationships described by da Vinci. Include the unit relationships in the table by writing the "1"s along the diagonal.

Note: The partially completed table should now look like this:

	1 finger	1 palm	1 head	1 cubit	1 height
Fingers	1	4			
Palms		1		6	
Heads			1		8
Cubits				1	4
Heights					1

Ask for suggestions on how to fill in the remaining cells of the table. Ask:

- How many fingers equal 1 cubit?

  Answer: *Since 4 fingers = 1 palm and 6 palms = 1 cubit, 24 fingers = 1 cubit.*

Write "24" in the appropriate cell of the table:

	1 finger	1 palm	1 head	1 cubit	1 height
Fingers	1	4		24	
Palms		1		6	
Heads			1		8
Cubits				1	4
Heights					1

Explain that the ratio of fingers to cubits is 24 to 1.

5. Have students complete the table on Handout 2.
Circulate and offer additional strategies as needed, based on your observations of student progress. If students need assistance, help them observe that the ratio between the numbers in any two columns (as well as the ratio between the numbers in any two rows) is a constant.

Point out, for example, that the ratio of fingers to palms is 4, so the numbers of fingers in the first row is always 4 times the number of palms in the second row. Similarly, point out that the ratio of cubits to height is 4, so the number of fingers, palms, and so on in the height column is always 4 times the number in the cubits column.

Once students understand the ratio between any two columns or rows, they can fill in the rest of the cells in those rows or columns of the table.

Teacher's Notes: Setting Up Proportions

You can have students set up a proportion to find the missing values in the table. For example, have students look at the four cells at the top left of the table and use the variable x to represent the unknown value:

	1 finger	1 palm
Fingers	1	4
Palms	x	1

Have students set up the proportion and solve for x:

$$\frac{1\text{ [finger]}}{x\text{ [palm]}} = \frac{4\text{ [fingers]}}{1\text{ [palm]}}$$

Remind students that the proportion can also be stated as "1 is to x as 4 is to 1."

$4x = 1$, so $x = \frac{1}{4}$.

Both numerators relate to the number of fingers, and both denominators relate to the number of palms. The ratio on the left describes the number of fingers and palms equal to 1 finger, and the ratio on the right describes the number of fingers and palms equal to 1 palm. Since the unknown value is the number of palms in 1 finger, that becomes the variable.

Students may also note that the proportion could have been set up this way:

$$\frac{1\text{ [finger]}}{4\text{ [fingers]}} = \frac{x\text{ [palms]}}{1\text{ [palm]}}$$

$1 = 4x$, so $x = \frac{1}{4}$.

With either setup, the result is the same.

Note: The completed table is given on the Teacher's Version of **Handout 2: Vitruvian Man Proportions**.

6. Discuss the table, noting the inverse relationships.
Observe with students that the table is symmetrical across the diagonal of unit relationships. Point out, for example:

- Four fingers equal one palm, and one finger is one-fourth the measure of one palm.
- Three palms equal one head, and one palm is one-third the measure of one head.
- Eight heads equal one height, and one head is one-eighth the measure of one height.

7. Have students calculate measurements using the Vitruvian proportions.
Distribute **Handout 3: Calculating Vitruvian Man Measurements**. Tell students that they are going to calculate the measurements in inches and feet of five different-sized individuals, using the Vitruvian Man proportions.

Point out that one measurement is given for each individual. Tell students to use the ratios from their completed tables on Handout 2 to help them calculate the remaining measurements on Handout 3. Have students complete Handout 3.

Teacher's Notes: Setting Up Proportions to Find Measurements

Again, students can set up a proportion to find the value of each unknown measurement. From Handout 2, students know that 4 fingers = 1 palm, and from Handout 3, they know that Individual A's finger measurement is $\frac{1}{2}$ an inch.

So, to calculate the palm measurement for Individual A, students can set up a proportion:

$$\frac{\frac{1}{2}\text{ (inch per finger)}}{1\text{ (fingers per finger)}} = \frac{x\text{ (inches per palm)}}{4\text{ (fingers per palm)}}$$

Solve for x:

$x = \frac{1}{2} \times 4$

$x = 2$

Students record a "2" in the cell for Individual A's palm on Handout 3.

Similarly, students know from Handout 2 that 3 palms = 1 head. Students can calculate the head measurement for Individual A by setting up a proportion:

$$\frac{2 \text{ (inches per palm)}}{1 \text{ (palms per palm)}} = \frac{x \text{ (inches per head)}}{3 \text{ (palms per head)}}$$

Solve for x:
$x = 2 \times 3$
$x = 6$

Students record a "6" in the cell for Individual A's head on Handout 3.

Students can continue setting up proportions to find the rest of the measurements on Handout 3.

8. Discuss students' answers to Handout 3.
Ask students to share their answers to Handout 3.

> **Note:** Students may note that not all the measurements found in Handout 3 are normal human dimensions (for example, some of the individuals are much taller than a human could be).

9. Introduce the term head : height ratio.
Have students refer to **Handout 2: Vitruvian Man Proportions**. Ask:

- How many heads tall is Vitruvian Man?

  Answer: *Eight heads tall*

Tell students that one height is the same measure as the length of eight heads. Explain that the ratio of head length to height, using heads as a unit of measurement, can be expressed as 1:8. This ratio is referred to as the head : height ratio. The *head : height ratio* of Vitruvian Man is 1:8 (in other words, he measures eight heads tall).

Ask students:

- How do you think the head : height ratios of real humans compare with Vitruvian Man?

10. Show students how to measure and calculate the head : height ratio.
Distribute **Handout 4: Human Head : Height Ratios** and give each student a ruler. Point out the images of two adults and a child. Remind students that the head : height ratio is the ratio of the head measurement to the height measurement.

Tell students that they are going to follow the steps on Handout 4 to measure each person's image and calculate the head : height ratio.

> **Note:** Tell students to measure the height of each person as if the person were standing against a wall—from the top of the head (not including the hair) to the heel.

Work together as a class to find the woman's head : height ratio.

> **Note:** The woman's head measurement is approximately 19 millimeters and her height measurement is approximately 139 millimeters. Her head : height ratio is 19:139. Because of variations in measurements, students' ratios throughout the unit may vary slightly from the answers given in this teacher guide.

Ask students:

- How can you express the ratio 19:139 in the standard ratio form of 1:*x*?

  Answer: *Set up a proportion:*

  $$\frac{19}{139} = \frac{1}{x}$$

  $$19x = 139$$

  $$x = \frac{139}{19}, \text{ or } \sim 7.3$$

  The woman's head : height ratio in standard form is 1:7.3.

> **Note:** Remind students that they can set up a proportion using three known values and a variable to represent the unknown value. They can then solve to find the value of the variable.

Have students find the head : height ratios for the images of the man and child. Discuss any differences between the adults' head : height ratios and the child's head : height ratio.

Tell students that adult humans typically have a head : height ratio from 1:6 to 1:8. In other words, adult humans range from 6 to 8 heads tall.

11. Have students calculate the head : height ratios of characters and people. Give each student one image of a person or animated character from **Appendix A: Head : Height Proportion Images** and **Handout 5: Journal Assignment**. Explain that students will measure their person's or character's height and head height and calculate the head : height ratio. Have students complete Journal 1.

Journal 1

Follow these steps to calculate the head : height ratio of the person or character your teacher gave you:

- Measure the character's head height.
- Measure the character's height.
- Calculate the head : height ratio.
- Express the head : height ratio in the standard ratio form 1:*x*.

Teacher's Notes: Measurement Precision

Students' measurements will vary slightly, depending on the precise locations of the endpoints of the line segments they drew to mark the top of the head, the bottom of the foot, and the chin. For example, the locations of the top of the head or the bottom of the foot may not be visible, so students can make an approximation.

When students express the head : height ratio in standard ratio form, suggest that they round their ratios to the nearest tenth.

Note: Journal 1 provides a good opportunity for formative assessment.

Handout 1:
Unit Overview

One of the most important tools that artists and designers use to give their characters a particular "look" or personality is proportion. For example, the relative sizes of a character's head, torso, and leg and arm lengths are all designed to give an overall effect to a character's appearance.

The relationships between the sizes of one body part and another can be expressed mathematically by using ratios.

Your work in this unit will revolve around the following questions:

- *How can body and facial proportions be expressed mathematically using fractions, ratios, and percentages?*
- *What kinds of information do facial and body proportions convey about a character?*
- *How can changes in facial and body proportions affect the audience's perception of a character's personality?*
- *How can artists design facial and body proportions to convey particular characteristics of a character?*

What You Will Do in This Unit

Examine the proportions of an ideal human body. Then, measure the body features of actual humans and animated characters, and calculate their body and facial proportions.

Look at the head-to-body and facial feature ratios of a variety of humans and animated characters. Analyze how differing ratios affect the perceptions of an animated character's appearance and personality.

Experiment with changing body and facial feature ratios. Use scale factors to change ratios, and discuss how the changes affect a character's appearance.

Design an animated character. Specify ratios for your character's body and facial features that express your character's personality, and then draw the character.

Unit Project

You will invent and design your own animated character, using what you've learned about calculating head-to-body and facial feature ratios, and about the effect that different proportions have on the way a character is perceived. You will describe your character, specify ratios to give your character the desired appearance, and then create your character, using your specified ratios.

Vocabulary Used in This Unit

Proportion: A statement of equality between two ratios, expressed in the form $\frac{a}{b} = \frac{c}{d}$. For example, $\frac{1}{3} = \frac{3}{9}$.

Ratio: A numeric relationship between two things (in this unit, between linear measures). Ratios can be expressed in a variety of forms, including "*a* to *b*," "*a*:*b*," and "$\frac{a}{b}$."

Scale factor: The ratio of the measures of corresponding parts of two similar figures.

Assessment Checklist:
Character Design

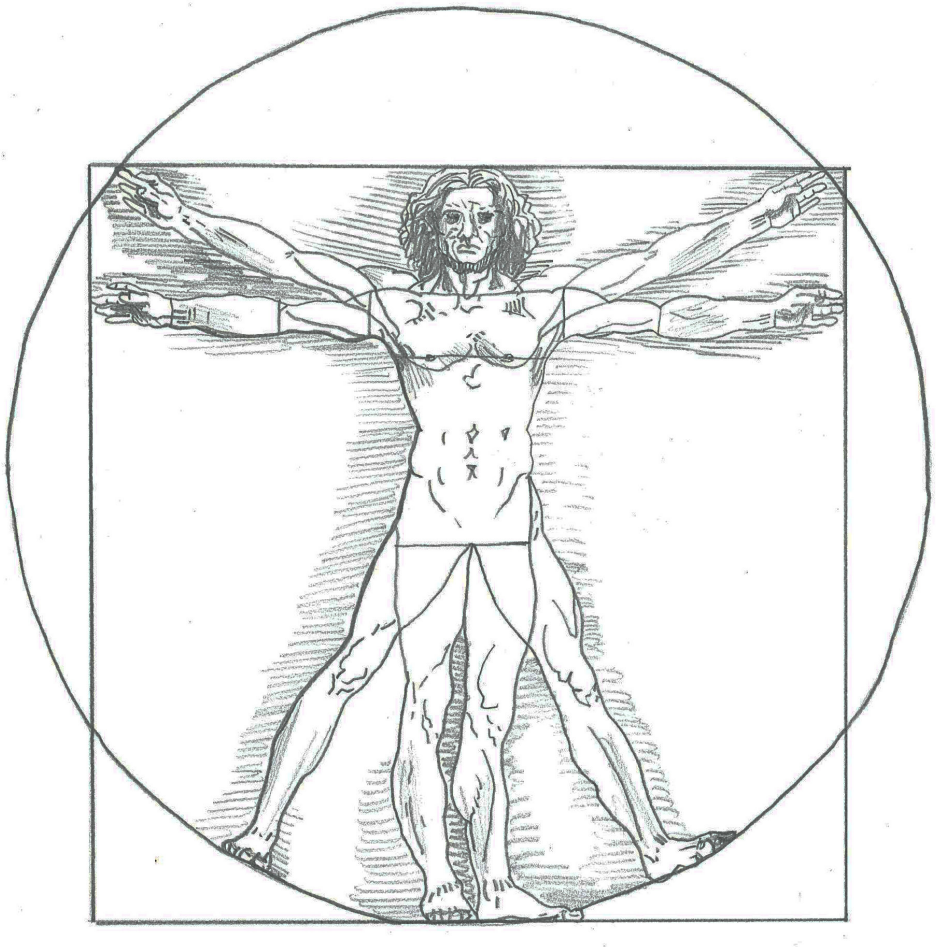
Use this assessment to help you design your character. Make sure to include all the requirements. Your teacher will use this assessment to evaluate your work.

Requirements	Percentage of Total Grade	Comments	
Character Design		**Student Comments**	**Teacher Comments**
Complete description of the character's qualities is provided.	10%		
Head : height ratio and facial proportions are specified.	10%		
Rationale convincingly explains why these proportions were chosen to express this character's characteristics.	10%		
Character has specified head : height proportion.	10%		
Character has specified eye, nose, and mouth position ratios.	30%		
Character has specified eye, nose, and mouth size ratios.	30%		
Total	**100%**		

Handout 2:
Vitruvian Man Proportions

Artists who render the human form must have an understanding of human anatomy and proportion. Leonardo da Vinci's study of human anatomy and proportion informed his work as an engineer and architect, as well as his painting.

In 1490, Leonardo da Vinci drew and described the ideal body proportions of the human male as recorded by the Roman architect Vitruvius, who used proportional human figures in his architectural designs.



Silhouette of Leonardo da Vinci's drawing of Vitruvian man.

Da Vinci described the body ratios that Vitruvius used:

- A palm is the width of four fingers
- A cubit is the width of six palms
- A man's height is four cubits
- The distance from the top of the head to the bottom of the chin is one-eighth of a man's height

Use the information above to fill in the ratios on the table of Vitruvian Man proportions:

	1 finger	1 palm	1 head	1 cubit	1 height
Fingers	*1*	*4*	*12*	*24*	*96*
Palms	$\frac{1}{4}$	*1*	*3*	*6*	*24*
Heads	$\frac{1}{12}$	$\frac{1}{3}$	*1*	*2*	*8*
Cubits	$\frac{1}{24}$	$\frac{1}{6}$	$\frac{1}{2}$	*1*	*4*
Heights	$\frac{1}{96}$	$\frac{1}{24}$	$\frac{1}{8}$	$\frac{1}{4}$	*1*

Handout 3:
Calculating Vitruvian Man Measurements

Leonardo da Vinci does not give actual measurements for Vitruvian Man. So, what would be the measurements in inches and feet of someone who has Vitruvian proportions?

Find the measurements of five different-sized individuals whose bodies have the same proportions as Vitruvian Man. The table below gives one measurement for each individual.

Use the Vitruvian proportions from your work on Handout 2 to help you calculate the missing measurements for each individual.

	finger	palm	head	cubit	height
Individual A	$\frac{1}{2}$″	*2″*	*6″*	*12″*	*48″*
Individual B	*$\frac{5}{8}$″*	$2\frac{1}{2}$″	*$7\frac{1}{2}$″*	*15″*	*60″*
Individual C	*$1\frac{1}{3}$″*	*$5\frac{1}{3}$″*	16″	*32″*	*128″*
Individual D	*$\frac{7}{8}$″*	*$3\frac{1}{2}$″*	*$10\frac{1}{2}$″*	21″	*84″*
Individual E	*$\frac{3}{8}$″*	*$1\frac{1}{2}$″*	*$4\frac{1}{2}$″*	*9″*	36″

Handout 4:
Human Head : Height Ratios

The three people in the image on this handout have different body proportions. Follow these steps to find the head : height ratio of each person:

- Line up the zero mark of a ruler with the top of the person's head (not including the hair).
- Look at the person's feet and decide which heel supports the person's body weight. (If the heel is not visible, make your best guess as to its location.)
- Line up the other end of the ruler with the heel supporting the body weight.
- Record the measurement in millimeters at the bottom of the person's chin to determine the measurement of the head.
- Record the measurement in millimeters at the person's heel to determine the person's height.
- Record the head : height ratio.
- Write the head : height ratio in the standard ratio form 1:*x*.

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Answers:

DF / DE = 1:5

AC / AB = 1:7.3

GI / GH = 1:6.8

Handout 5:
Journal Assignment

Complete the following journal assignment when you are instructed to do so by your teacher.

Journal 1

Follow these steps to calculate the head : height ratio of the person or character your teacher gave you:

- Measure the character's head height.
- Measure the character's height.
- Calculate the head : height ratio.
- Express the head : height ratio in the standard ratio form 1:*x*.

Activity 1B: Measuring Facial Proportions

Students analyze how different facial proportions can affect the audience's perception of an animated character. Students measure facial features on images of human and animated characters, and calculate ratios related to the feature's position on the face and the width of the face.

Understandings

- The relationships between facial features can be expressed mathematically using ratios.
- A person's or character's appearance can be altered by varying his or her facial features.

Materials Needed

- Students' copies of **Handout 5: Journal Assignment**
- Optional: Images from **Appendix B: Head : Height Proportion Answers** to be digitally projected or displayed
- Images from **Appendix C: Facial Proportion Images** to be digitally projected or displayed (see *Advance Preparation*)
- **Handout 6: Human Face Drawing**
- Rulers
- Optional: Additional copies of **Handout 6: Human Face Drawing**
- Optional: **Appendix D: Human Facial Feature Ratios** to be digitally projected or displayed
- Images from **Appendix C: Facial Proportion Images** (one per student) (see *Advance Preparation*)
- **Handout 7: Facial Proportion Worksheet**
- **Handout 8: Sample Facial Proportion Ratios**

1. Collect students' data from Journal 1.
On chart paper or the board, create a table similar to the one shown below, leaving the Head : Height Ratio column blank. Have students report their calculations of head : height ratios from Journal 1. Write the ratios in the table.

Character	Head : Height Ratio
Man	1:7.2
Woman	1:7.1
Boy	1:5.3
Young girl	1:3.8
Ginormica	1:5.7
President Hathaway	1:3.4
General Monger	1:3.2
Dr. Cockroach	1:2.7
Insectosaurus	1:2.5
Gallaxhar	1:2.7
Missing Link	1:2.6
Po	1:3.5
Shifu	1:3
Tigress	1:4.8

Note: **Appendix B: Head : Height Proportion Answers** shows each character with measurements drawn and ratios calculated. You may want to post or project the images from **Appendix B** so the class can see all the characters' measurements.

Ask students the following questions:

- What problems did you encounter in measuring your character?

  Possible answer: *Finding the top or the bottom of the head; finding the point on the heel of the foot*

- How do the head : height ratios for the animated characters compare to those for the human characters?

Note: Ginormica's ratio of 1:5.7 is close to the normal human range, which is approximately 1:7. General Monger and President Hathaway's ratios (just over 1:3) are slightly lower than that of the young girl and would be normal for a human baby.

- What is the visual effect of head size on how the audience perceives the character?

  Possible answer: *A larger head size tends to make a character look younger and more child-like. Except for Ginormica, the animated characters have a small head : height ratio (i.e., their heads are a greater proportion of their bodies than average adult humans). This tends to make them look cute rather than scary, even though they may be monsters or other potentially frightening characters.*

Note: You may want to mention to students that animated superheroes may have a head : height ratio of 1:8 or more, which can make them look strong and powerful.

2. Discuss the variety of facial proportions in characters.
Project digitally or display the faces from **Appendix C: Facial Proportion Images**. Have students share their observations about facial features. Ask:

- What differences do you notice in the size and placement of the characters' facial features?

  Possible answer: *Some characters have eyes near the top of the head, while other characters' eyes are in the middle of the face.*

3. Demonstrate how to measure vertical positions of the eye, nose, and mouth.
Tell students that artists use a variety of schemes to characterize typical proportions of the adult human face. Artists use these schemes as a guideline for drawing.

Explain that the placement of the eyes, nose, and mouth can be described in terms of distance from the bottom of the face, or distance from the chin. Each distance can then be used in a ratio that expresses the relationship of the feature's position to the height of the head.

Distribute **Handout 6: Human Face Drawing** and point out the line drawing of the human face. Give each student a ruler, and show them how to measure the vertical position of each facial feature. Have students collect the following measurements:

- ***Height of the head:*** Draw a line segment down the center of the face. Label each end point.
- ***Height of the eyes:*** Find the center point between the eyes. Mark and label a point on the line segment at this position.

- ***Height of the nose:*** Find the center of the bottom of the nose. Mark and label a point at this position.
- ***Height of the mouth:*** Find the bottom edge of the upper lip. Mark and label a point at this position.

> **Note:** Measuring the height of the mouth from the bottom of the upper lip accommodates a mouth measurement for a character with an open mouth.

Tell students to measure the length of each segment, from the chin to the segment's end point.

4. Show students how to find the eye, nose, and mouth position ratios.
Tell students that they will use their measurements from Handout 6 to set up proportions and find the facial feature position ratios, just as they set up proportions to find the head : height ratios for their character from Journal 1.

Have students find the following ratios:

- Eye height to head height
- Nose height to head height
- Mouth height to head height

If necessary, review how to set up the proportions and express them in the standard ratio form 1:*x*.

Teacher's Notes: Facial Feature Position Ratios

Remind students that to reduce the ratios to the 1:*x* form, they must divide both the numerator and the denominator measurements by the numerator. Remind students to round to the nearest tenth.

In the face on Handout 6, the eye height is [approximately 88 mm] and the head height is [approximately 187 mm], so the ratio of the eye height to the head height is 1:2.1.

The ratio of nose height to head height is 1:3.6

The ratio of mouth height to head height is 1:5.3.

5. Show students how to find the eye, nose, and mouth width ratios.

> **Note:** You may want to give students another copy of **Handout 6: Human Face Drawing** to use for their facial width measurements.

Have students first measure the head width at the widest part of the face. Tell students that on humans this is generally near the middle of the face, but on animated characters the widest part of the face can be higher or lower.

Have students measure the width of each facial feature on Handout 6, as follows:

- ***Eye:*** Measure the width of one eye
- ***Nose:*** Measure the width at the base of the nose
- ***Mouth:*** Measure the width from corner to corner

Tell students to use their measurements to set up proportions to find the width ratio for each feature. Remind students to express the ratios in the standard ratio form 1:*x*.

Teacher's Notes: Facial Feature Width Ratios

The face on **Handout 6: Human Face Drawing** has the following width ratios:

- The ratio of eye width to face width is 1:5
- The ratio of nose width to face width is 1:4.6
- The ratio of mouth width to face width is 1:3.2

Appendix D: Human Facial Feature Ratios shows the human face drawing from Handout 6 with the position and width ratios labeled. You may want to digitally project or display **Appendix D** so the class can see all the ratios.

Teacher's Notes: Using GeoGebra to Measure Facial Proportions

An alternate method for measuring facial proportions is to use GeoGebra, free mathematics software that can be used online or downloaded to computers.

You will need to locate images of faces that you or the students can import into GeoGebra, such as faces of comic book characters, other animated characters, or humans.

Once the images of faces are imported into GeoGebra, students can determine the facial feature ratios by doing the following:

1. Drawing a segment from the top of the head to the bottom of the chin to determine head height
2. Marking points on the segment at the level of the eyes, nose, and mouth
3. Measuring the distance from the chin point to the marked points on the eyes, nose, and mouth
4. Recording the eye, nose, and mouth position ratios for the face

Repeat the steps above for the width of the face, drawing segments to measure the width of the face, eyes, nose, and mouth, and recording the width ratios.

See *Additional Resources* for Teachers for more information about using GeoGebra.

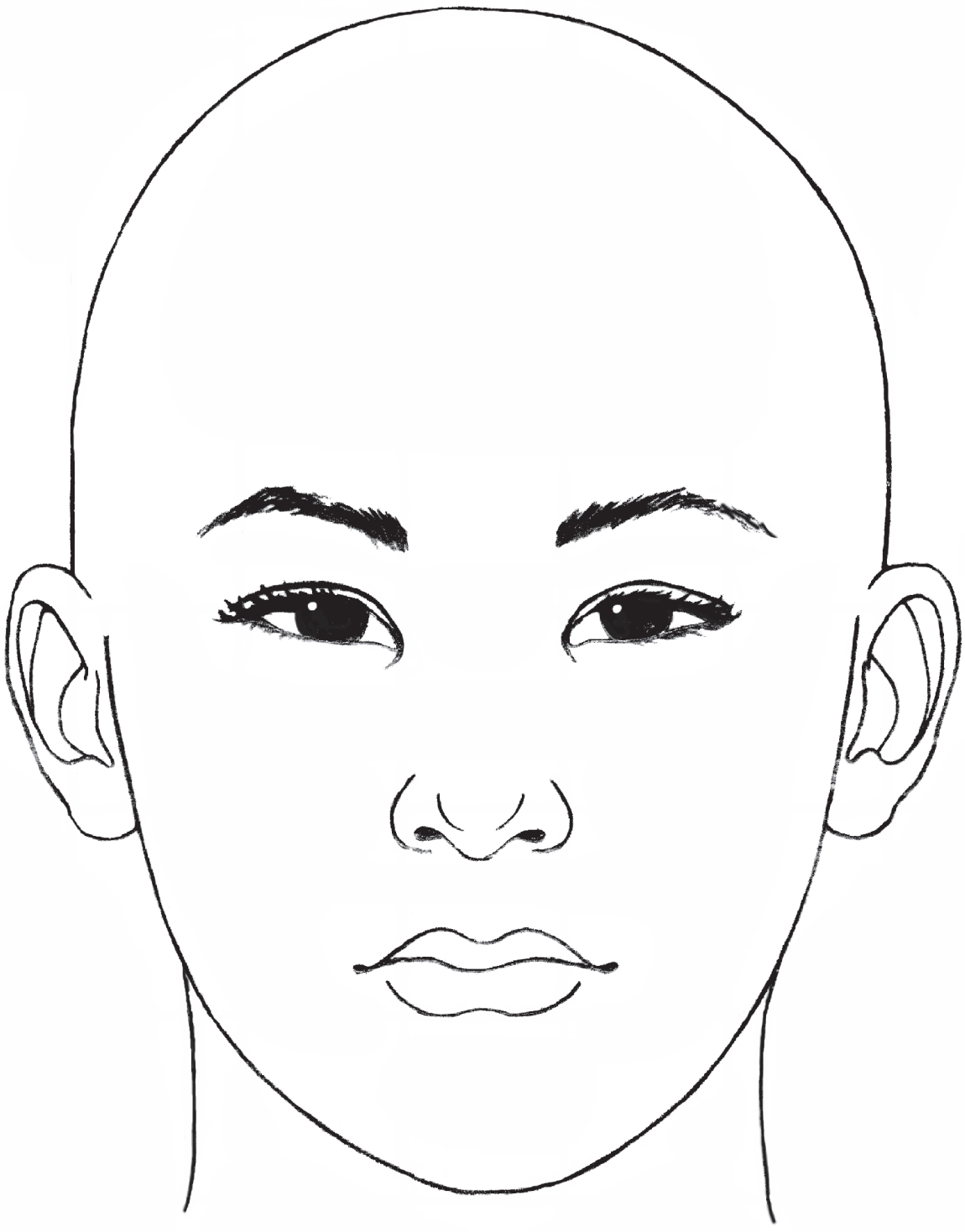
6. Have students find facial feature ratios for a character's face.
Give each student one printed image from **Appendix C: Facial Proportion Images**. Distribute **Handout 7: Facial Proportion Worksheet** and **Handout 8: Sample Facial Proportion Ratios**.

Tell students they are going to measure the facial features of their assigned image, calculate the position ratios and width ratios, and record their measurements and ratios on Handout 7.

Explain that students can refer to Handout 8 as they measure the facial features on their assigned image.

> **Note:** Remind students to measure to the nearest millimeter. If students need additional time to complete Handout 7, assign it as homework.

Handout 6:
Human Face Drawing



Drawing courtesy of Brenda Hoddinott, http://drawspace.com

Handout 7:
Facial Proportion Worksheet

Your teacher will assign you an image of a human or animated character. Measure the human's or animated character's facial features, and record your measurements in the table below. Make all measurements to the nearest millimeter.

When you have all the measurements, calculate the position ratio and width ratio for each facial feature. Express each ratio in the standard form 1:*x*, and record it in the table below.

Human's or character's name (if given): _____

Human's or character's head height: _____

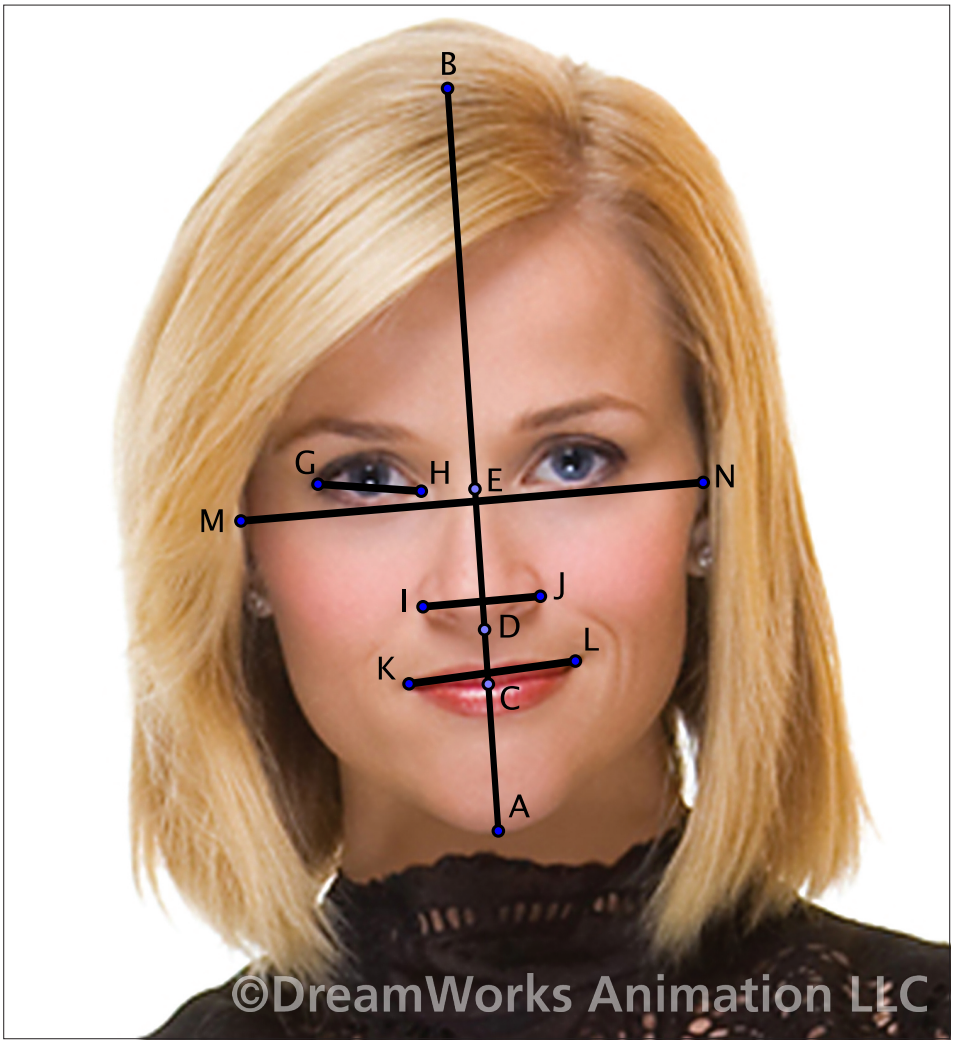
	Measurement (from chin to facial feature)	**Position ratio** (ratio of feature's distance from chin to head height)
Eye position		
Nose position		
Mouth position		

Human's or character's head width: _____

	Measurement (width of facial feature)	**Width ratio** (ratio of feature's width to head width)
Eye width		
Nose width		
Mouth width		

Handout 8:
Sample Facial Proportion Ratios

You can use this handout for reference as you complete **Handout 7: Facial Proportion Worksheet**, measuring the facial features and calculating the position and width ratios for your assigned image.



Reese Witherspoon, voice of Susan/Ginormica in *Monsters vs Aliens*.
Image courtesy of DreamWorks LLC.

eye position
AE / AB = 1:2.2

nose position
AD / AB = 1:3.6

mouth position
AC / AB = 1:5.2

eye width
GH / MN = 1:4.4

nose width
IJ / MN = 1:3.9

mouth width
KL / MN = 1:2.7

Head height: 98 mm

	Measurement (from chin to facial feature)	**Position ratio** (ratio of feature's distance from chin to head height)
Eye position	45 mm	1:2.2
Nose position	27 mm	1:3.6
Mouth position	19 mm	1:5.2

Sample Calculation:

Eye Position: $\frac{45}{98} = \frac{1}{x}$

$45x = 98$

$x = \frac{98}{45} \approx 2.2$

Eye Position Ratio: 1:2.2

Head width: 62 mm

	Measurement (width of facial feature)	**Width ratio** (ratio of feature's width to head width)
Eye width	14 mm	1:4.4
Nose width	16 mm	1:3.9
Mouth width	23 mm	1:2.7

Sample Calculations:

Eye Width: $\frac{14}{62} = \frac{1}{x}$

$14x = 62$

$x = \frac{62}{14} \approx 4.4$

Eye Width Ratio: 1:4.4

Part 2: Designing with Body and Facial Proportions

Students use scale factors and ratios to change the size of a character's head and the size and position of the character's facial features. Students then design their own characters, using what they have learned about body proportions and facial proportions to inform their character's appearance and personality. Students specify head : height ratios and facial feature ratios to create a desired look, and then draw their character.

Length

2–3 50-minute sessions

Advance Preparation

- Before Activity 2A, decide whether you will have students use computers or paper and pencil to change the image size and facial features of their character.

  If students will use computers:

  - Decide what software they will use, obtain and install the software, and familiarize yourself with it. (See *Media & Resources* for information on image editing software.)
  - Determine how to arrange access to the number of computers needed.
  - Consider grouping students in pairs or teams for their computer work.

  If students will use paper and pencil:

  - Decide whether to have students use a photocopier. If you or your students have access to a photocopier with an enlarging and reducing function (ideally, one that can enlarge and reduce images in increments of 1 percent), consider having students use it to change their character's image size.

Teacher's Notes: Computer Software vs. Paper and Pencil Methods

Each method has advantages and disadvantages.

Image Editing Software

Pros:	*Cons:*
1. Image looks good. 2. Can use any enlargement/ reduction ratio.	1. Computer access may be limited. 2. Students may not be familiar with software.

Paper, Pencil, and Photocopier

Pros:	*Cons:*
1. May offer a wide range of enlargement/reduction ratios.	1. May offer a limited range of enlargement/reduction ratios.

Paper, Pencil, and Scissors

Pros:	*Cons:*
1. No extra equipment is needed.	1. Can be messy. 2. Requires drawing skills.

Teacher's Notes: Using Photocopiers

If students will use a photocopy machine to enlarge or reduce their character heads or facial features, decide how they will have access to the machine.

You may want to collect students' head and facial graphics for you to photocopy on a school machine and then return at the next class. This requires another class session to complete the activity. Alternatively, students could use home photocopiers if their machine is capable of enlarging and reducing in increments of 1 percent.

- Before Activity 2A, decide whether you will use one image or multiple images from **Appendix A** for students to create a character with a transformed head. Print or make copies of the selected images for students. (If students are using computers to transform heads, you will need to locate and provide other images of animated characters.)
- For Activity 2A, if students are using paper and pencil instead of computer software, print or make additional copies of **Handout 11: Face and Features**. Students can use scissors to cut and paste the features in new positions on the image of the face.

Activity 2A: Changing Characters' Body and Facial Proportions

Students discuss how differences in facial proportions affect an audience's perception of human and animated characters. Students use a scale factor to change a character's head : height ratio, then use the revised ratio to alter the character's appearance by enlarging or reducing the size of the character's head. Students use scale factors and ratios to revise both the position and width of a character's facial features.

Understandings

- A scale factor can be used to create similar figures.
- Specifying body ratios helps to define a character's appearance.

Materials Needed

- **Handout 9: Facial Proportions Table**
- Optional: *Proportion Matters* slide presentation
- Students' completed copies of **Handout 7: Facial Proportion Worksheet**
- **Handout 10: Ratio Transformation Worksheet**
- Optional: Copies of images from **Appendix A** or images of other animated characters (see *Advance Preparation*)
- Optional: Image editing software (see *Advance Preparation*)
- Optional: Rulers and scissors
- Optional: Centimeter graph paper
- **Handout 11: Face and Features**
- Optional: Image file of head depicted on Handout 11 (see *Media & Resources* for a link to this file)

1. Collect students' facial proportion data from Handout 7.
Distribute **Handout 9: Facial Proportions Table**. Draw a similar table on the board.

> **Note:** If you are using the *Proportion Matters* slide presentation, you can display the slide that shows the Facial Proportions Table instead.

Have students refer to their completed **Handout 7: Facial Proportion Worksheet** and report the position ratios and width ratios they found for their character's facial features. Record the ratios for each human and animated character in the table on the board. Have students add these ratios to the table on Handout 9.

> **Note:** The Teacher's Version of Handout 9 includes the ratios in the table. **Appendix E: Facial Proportion Images Answers** shows how these ratios were obtained.

2. Have students compare the facial feature ratios of adult humans and babies.
Ask students:

- What differences do you note between the baby's facial proportions and the adult humans' proportions?

  Possible answer: *The ratios for the baby's nose and mouth positions are higher than the adults' ratios.*

- Without looking at the baby's photo, what does a higher ratio mean for the baby's mouth position?

  Possible answer: *A higher ratio means that the baby's mouth position is lower than the adults'.*

3. Discuss how animated characters' facial proportions differ from humans'.
Have students consider one facial feature at a time—for example, have them look at how animated characters' eye sizes differ from human eye sizes.

4. Discuss how artists use proportion to depict animated characters.
Explain that artists give cartoon or animated characters proportions that differ from typical human proportions as a technique of characterization.

Have students consider animated characters with a particular feature, such as eyes larger than typical human eyes. Focus on how the feature affects students' perception of the character. For example, ask:

- What effect does eye size have on a character's appearance?

  Possible answer: *Characters with large eyes can appear more baby-like or cute. On the other hand, very large eyes, as in the Dr. Cockroach character, can make a character appear more alien.*

Make sure that students understand how changing the head : height ratio and the proportion of each facial feature can affect a viewer's perception of a character.

5. Show students how to find a scale factor to change a ratio.
Tell students that they are now going to learn how to change these ratios and to observe how these changes affect their perceptions of a character.

Remind students that similar figures have the same proportions but are different sizes.

> **Note:** To illustrate this, you can draw a pair of similar triangles on the board, one twice the size of the other.

Explain that the size difference can be expressed as a scale factor. You can use the scale factor to multiply any dimension of one figure to find the corresponding dimension of a similar figure.

For example, suppose a character has a head : height ratio of 1:6, and you want the character to have a head : height ratio of 1:4. You need to find the scale factor that, when multiplied by the head size of the original image, will expand or reduce the head so that the proportions have changed in the new image. Once you determine the scale factor, you'd simply multiply the character's head height by the scale factor to find the character's new head height. The new head is similar to the old head, but larger; the overall image (head and body) is not similar to the original, because the proportion of the head in relation to the body has changed.

Teacher's Notes: Using a Scale Factor to Enlarge and Reduce

Example 1: *Enlarge a head : height ratio*
The starting head : height ratio is 1:6. The desired ratio is 1:4. Here's how to find the scale factor:

- *Step 1*: Set up an equation, using the variable s to represent the scale factor. Express the starting ratio (1:6) and the desired ratio (1:4) as fractions. The starting ratio multiplied by the scale factor equals the desired ratio:

$$\frac{1}{6}s = \frac{1}{4}$$

- *Step 2*: $\frac{1}{6}s$ can be expressed as $\frac{s}{6}$:

$$\frac{s}{6} = \frac{1}{4}$$

- *Step 3*: Cross multiply:

$$4s = 6$$

- *Step 4*: Divide both sides by the coefficient of *s*:

$$s = \frac{6}{4}$$

- *Step 5*: Change the fraction to a decimal:

$$s = 1.5$$

The scale factor is 1.5. Dilating the head of a character that has a head : height ratio of 1:6 by a scale factor of 1.5 will create a figure with a head : height ratio of 1:4.

Example 2: *Reduce a head : height ratio*

The starting head : height ratio is 1:4. The desired ratio is 1:7.

$$\frac{1}{4}s = \frac{1}{7}$$

$$\frac{s}{4} = \frac{1}{7}$$

$$7s = 4$$

$$s = \frac{4}{7} = \sim 0.57$$

Teacher's Notes: Scale Factor Shortcut

Students may realize that the scale factor is the denominator of the fraction they start with over the denominator of the fraction they end with. Students can use this relationship to compute the scale factor without having to set up and solve equations.

Make sure students understand that increasing the head : height ratio decreases the size of the head by a scale factor from 0 to 1. The smaller the scale factor, the smaller the size of the head becomes. To decrease the head : height ratio, they should enlarge the size of the head by a scale factor greater than 1.

Note: If students will use pencil and paper, they can multiply the character's original measurement by the scale factor to find the new measurement. If students will use a photocopier or software, they can express the scale factor as a percentage and enlarge or reduce by that percentage.

Teacher's Notes: Expressing Scale Factor as a Percentage

Image editing software and photocopiers use percentages to express scale factors. Tell students to multiply the scale factor by 100 to express the scale factor as a percentage. For example, to enlarge a character's head by a scale factor of 1.5, enlarge the character's head by 150%.

6. Have students create a character with a transformed head.
Give students **Handout 10: Ratio Transformation Worksheet**.

Display the image (or images) of a person or character from **Appendix A** on which you will transform the head : height ratio—or, if students are using software to complete their transformations, display one of the images of animated characters that you located.

Ask students to suggest a specific ratio, between 1:2 and 1:10, that they think will have an interesting effect on the character's appearance.

> **Note:** You can have the whole class work on one person or character or have students work individually or in teams to transform different people or characters.

Have students compute the scale factor and write it on Handout 10.

Have students use the scale factor to transform the character's head and find the measurements for the new head size. They should record their measurement on Handout 10.

> **Note:** If students are using paper and pencil, they will need to draw an image of a new head with the correct measurements. Give them centimeter graph paper to draw on.

Have students create a character with the new head size, using software, a copy machine, or printed copies of the image.

7. Show students how to use a scale factor to change facial proportions.
Explain that students will now use a scale factor to change facial proportions in the same way that they changed head : height proportions. For example, to change a mouth width ratio of 1:2.5 to a ratio of 1:3, they should set up an equation, solve for the scale factor, and then use the scale factor to find the measurements of the revised mouth width.

Tell students that they can revise the size of any facial feature—eye, nose, or mouth—in the same way.

8. Have students create a human face with transformed facial features. Distribute **Handout 11: Face and Features** and have students find the width ratios for the eyes, nose, and mouth. Have students record the width ratios on Handout 10.

> **Note:** Students can also use the width ratios they found in Activity 1B, since the head on Handout 11 is the same head as on **Handout 6: Human Face Drawing**.

Tell students that they are going to change the size of the eyes, nose, and mouth.

Have students select specific size ratios that they think will have an interesting effect on the eyes, nose, and mouth. Have students work to compute scale factors for the eyes, nose, and mouth and record them on Handout 10.

Tell students to use the scale factor to transform the size of the eyes, nose, and mouth, using software, a copy machine, or paper and pencil. Be sure that students record the new measurements for each facial feature on Handout 10.

> **Note:** If students are using software, have them use the image file for the head depicted on Handout 11. When they have transformed the facial features on the head, have them print the new versions of the facial features and cut them out. If students are using paper and pencil, they will need to draw new facial features.

9. Have students choose new position ratios for the eyes, nose, and mouth. Tell students that they are now going to change the position of the eyes, nose, and mouth on the human figure's face.

Have students choose new position ratios for the eyes, nose, and mouth that they think will create an interesting effect. Be sure that students record the original and new measurements for each facial feature on Handout 10.

> **Note:** Students will need to use the original position measurements they recorded during Activity 1B for the head on Handout 6.

Have students place the transformed eyes, nose, and mouth they created in the previous step onto Handout 11. Tell them to measure and place the features in the new positions on the face.

> **Note:** Suggest that students apply animated character facial proportion ratios (such as those from Handout 9) to the human face. See **Appendix F: Sample Answers for Activity 2A, Handout 10** for examples.

> **Note:** Activity 2A provides a good opportunity for formative assessment.

Handout 9:
Facial Proportions Table

Fill in the table below with the data that you and your classmates found.

Answers are given in the table below.

	Position Ratios			Width Ratios		
	Eye position	**Nose position**	**Mouth position**	**Eye width**	**Nose width**	**Mouth width**
Humans						
Woman	*1:2.1*	*1:3.3*	*1:4.3*	*1:5.8*	*1:4.4*	*1:3.1*
Will Arnett	*1:2.1*	*1:3.5*	*1:5.2*	*1:5*	*1:4.7*	*1:2.8*
Baby	*1:2.4*	*1:3.8*	*1:5.2*	*1:5.4*	*1:4.4*	*1:3.5*
Animated Characters						
Dr. Cockroach	*1:1.8*	*none*	*1:8*	*1:2.1*	*none*	*1:5.3*
General Monger	*1:1.5*	*1:2.3*	*1:2.6*	*1:5.9*	*1:3.2*	*1:2.4*
President Hathaway	*1:1.5*	*1:2.3*	*1:2.5*	*1:4.4*	*1:3.3*	*1:1.6*
Missing Link	*1:1.2*	*1:1.3*	*1:1.5*	*1:6.5*	*1:4.3*	*1:1.1*
Po	*1:1.5*	*1:2.5*	*1:3.1*	*1:8.4*	*1:3.9*	*1:3.1*
Ginormica	*1:2.8*	*1:4.4*	*1:5.3*	*1:3.6*	*1:7.7*	*1:2.6*

Handout 10:
Ratio Transformation Worksheet

Head Transformation

Transform the size of a character's head in relation to its body.

First, pick a character on whom you will transform the head : height ratio.

Next, change the character's head : height ratio. Use a specific ratio from 1:2 to 1:10 that you think will have an interesting effect on the character's appearance.

Character's name: _____

Character's height: _____

	Original measurement of head height	Original head : height ratio	New head : height ratio	Scale factor	New measurement of head height
Head height					

Facial Feature Size Transformation

Transform the size and position of the facial features of the figure on Handout 11 by changing the ratio of each facial feature. For each feature, use a new ratio that you think will have an interesting effect on the figure's appearance.

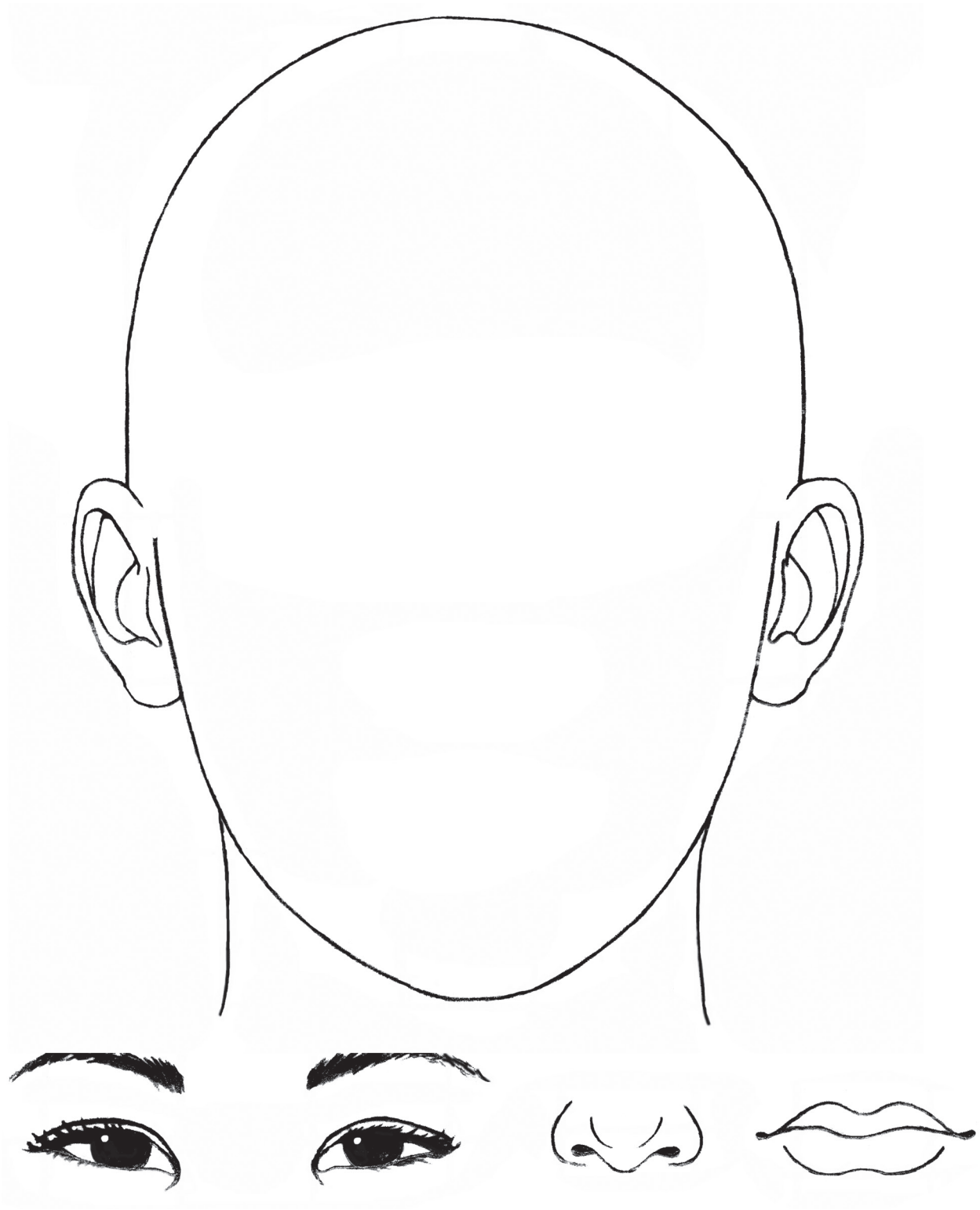
Figure's head width: _____

	Original measurement	Original ratio	New ratio	Scale factor	New measurement
Nose width					
Mouth width					
Eye width					

Figure's head length: _____

	Original measurement (from chin to facial feature)	Original ratio	New ratio	Scale factor	New measurement (from chin to facial feature)
Nose position					
Mouth position					
Eye position					

Handout 11:
Face and Features



Drawing courtesy of Brenda Hoddinott, http://drawspace.com

Activity 2B: Using Body and Facial Proportions to Create a Character

Students design a character and specify a head : height ratio and facial feature ratios that express their character's personality. Students create their character and share it with the class.

Understandings

- Facial and body proportions convey significant information about a character.
- Artists design characters' facial and body proportions to create specific effects in the way characters are perceived.

Materials Needed

- **Handout 12: Character Design Worksheet**
- Optional: Centimeter graph paper
- Students' copies of **Assessment Checklist: Character Design**

1. Review with students what they have learned about proportion.
Have students share their transformed characters and faces from Activity 2A.

Review the head : height ratio and facial proportions as factors in character appearance. Ask students:

- What have you learned about how the proportions of animated characters affect how an audience perceives those characters?

  Possible answers: *Students may observe that human characters with enlarged heads look childlike and that animated characters often have heads that are proportionally larger than human heads. Reducing the size of an animated character's head can make it appear more human. Students may also note that animated characters often have eyes that are bigger than humans.*

2. Discuss character design with students.
Give students **Handout 12: Character Design Worksheet**. Tell students that before they create a character, they need to determine what characteristics they'd like it to have. Have them consider the attributes listed on the worksheet, decide what they want for their character, and then determine the head : height ratio and facial proportions that best express these characteristics.

3. Have students draw their characters to their chosen specifications.
Once students have completed Handout 12, have them begin drawing their characters.

> **Note:** You may want to approve students' completed handouts before they begin working on their drawings.

You may want students to draw the head and the whole character separately on centimeter graph paper.

Teacher's Notes: Time Needed for Drawing Characters

Drawing the characters will probably require more time than one class period. In one class period, students should be able to complete their pre-planning, select their head : height and facial feature ratios, and begin their drawings.

If time is limited, have students draw only the head, or have the entire character drawing be a homework assignment.

4. Allow time for students to share and discuss their character designs.
Have students share their characters with the class, describing whether they were able to achieve their desired effect based on their chosen ratios.

Have students complete the Student Comments section of **Assessment Checklist: Character Design**.

Handout 12:
Character Design Worksheet

Type of character (human, animal, superhero, etc.):

Approximate age (young, teen, adult, senior):

Gender:

Personality:

Other visual characteristics (such as jewelry or clothing):

Head : height ratio: _____

Facial proportions:

	Position ratio	Width ratio
Eyes		
Nose		
Mouth		

What these proportions will convey about this character:

Appendix A: Head : Height Proportion Images

© Abel Mitja Varela

© Catherine Yeulet

© Franck Boston

© alarifoto

Ginormica from *Monsters vs. Aliens*. Image courtesy of DreamWorks LLC.

President Hathaway from *Monsters vs Aliens*. Image courtesy of DreamWorks LLC.

General Monger from *Monsters vs Aliens*. Image courtesy of DreamWorks LLC.

Dr. Cockroach from *Monsters vs Aliens*. Image courtesy of DreamWorks LLC.

Insectosaurus from *Monsters vs Aliens*. Image courtesy of DreamWorks LLC.

Gallaxhar from *Monsters vs Aliens*. Image courtesy of DreamWorks LLC.

The Missing Link from *Monsters vs Aliens*. Image courtesy of DreamWorks LLC.

Po from *Kung Fu Panda*. Image courtesy of DreamWorks LLC.

Shifu from *Kung Fu Panda*. Image courtesy of DreamWorks LLC.

Tigress from *Kung Fu Panda*. Image courtesy of DreamWorks LLC.

Appendix B: Head : Height Proportion Answers

AC / AB = 1:8

AC / AB = 1:7.4

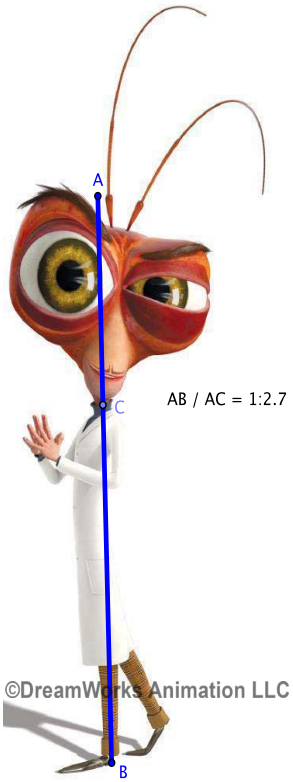
AC / AB = 1:5.3

AC / AB = 1:3.8

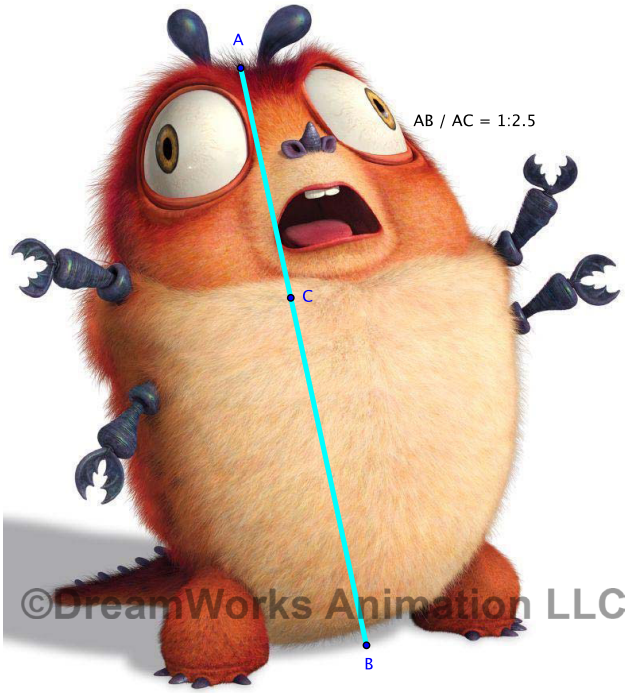
Ginormica from *Monsters vs Aliens*.
Image courtesy of DreamWorks LLC.

President Hathaway from *Monsters vs Aliens*.
Image courtesy of DreamWorks LLC.

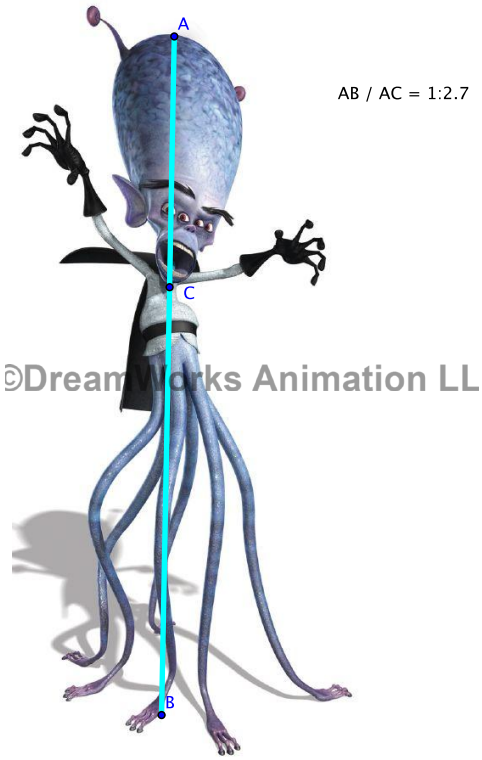
General Monger from *Monsters vs Aliens*.
Image courtesy of DreamWorks LLC.



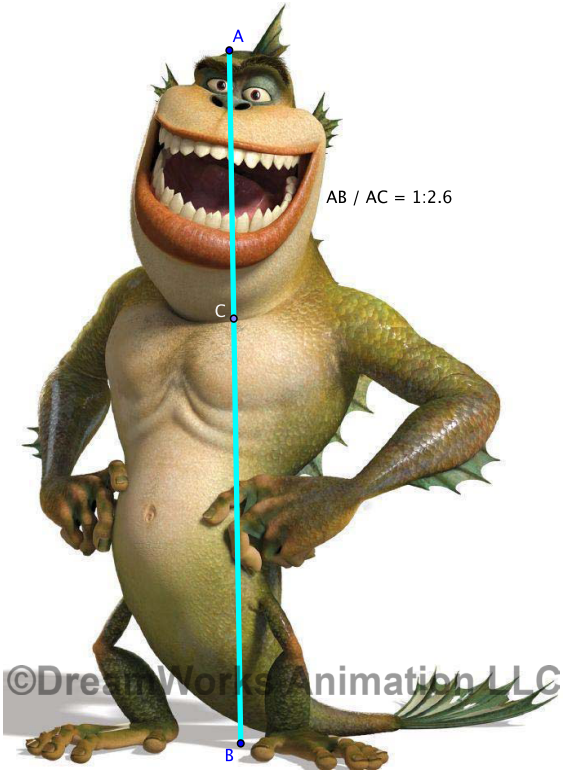
Dr. Cockroach from *Monsters vs Aliens*.
Image courtesy of DreamWorks LLC.



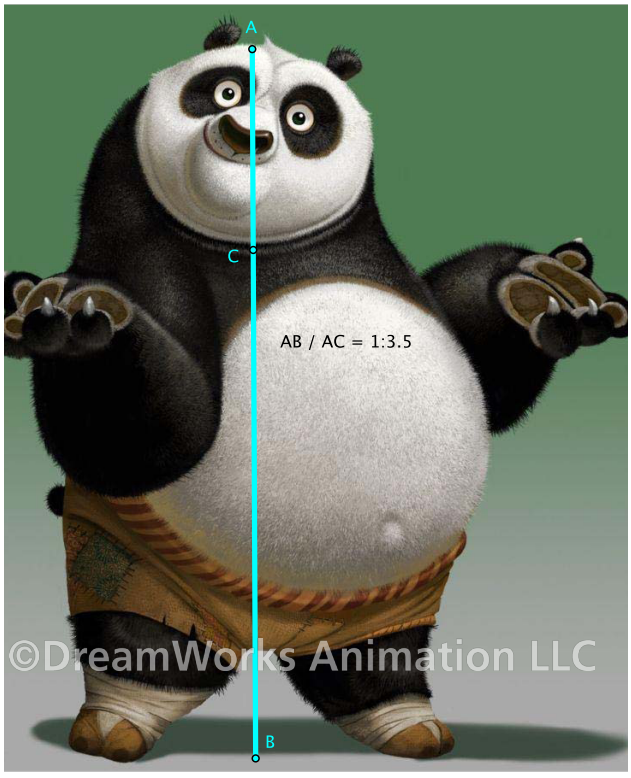
Insectosaurus from *Monsters vs Aliens*.
Image courtesy of DreamWorks LLC.



Gallaxhar from *Monsters vs Aliens*.
Image courtesy of DreamWorks LLC.



The Missing Link from *Monsters vs Aliens*.
Image courtesy of DreamWorks LLC.



Po from *Kung Fu Panda*.
Image courtesy of DreamWorks LLC.

Shifu from *Kung Fu Panda*. Image courtesy of DreamWorks LLC.

Tigress from *Kung Fu Panda*. Image courtesy of DreamWorks LLC.

Appendix C: Facial Proportion Images

Photo courtesy of Aurora Kurland

© Darren Wise

Will Arnett, the voice of The Missing Link from *Monsters vs Aliens*. Image courtesy of DreamWorks LLC.

Dr. Cockroach from *Monsters vs Aliens*. Image courtesy of DreamWorks LLC.

General Monger from *Monsters vs Aliens*. Image courtesy of DreamWorks LLC.

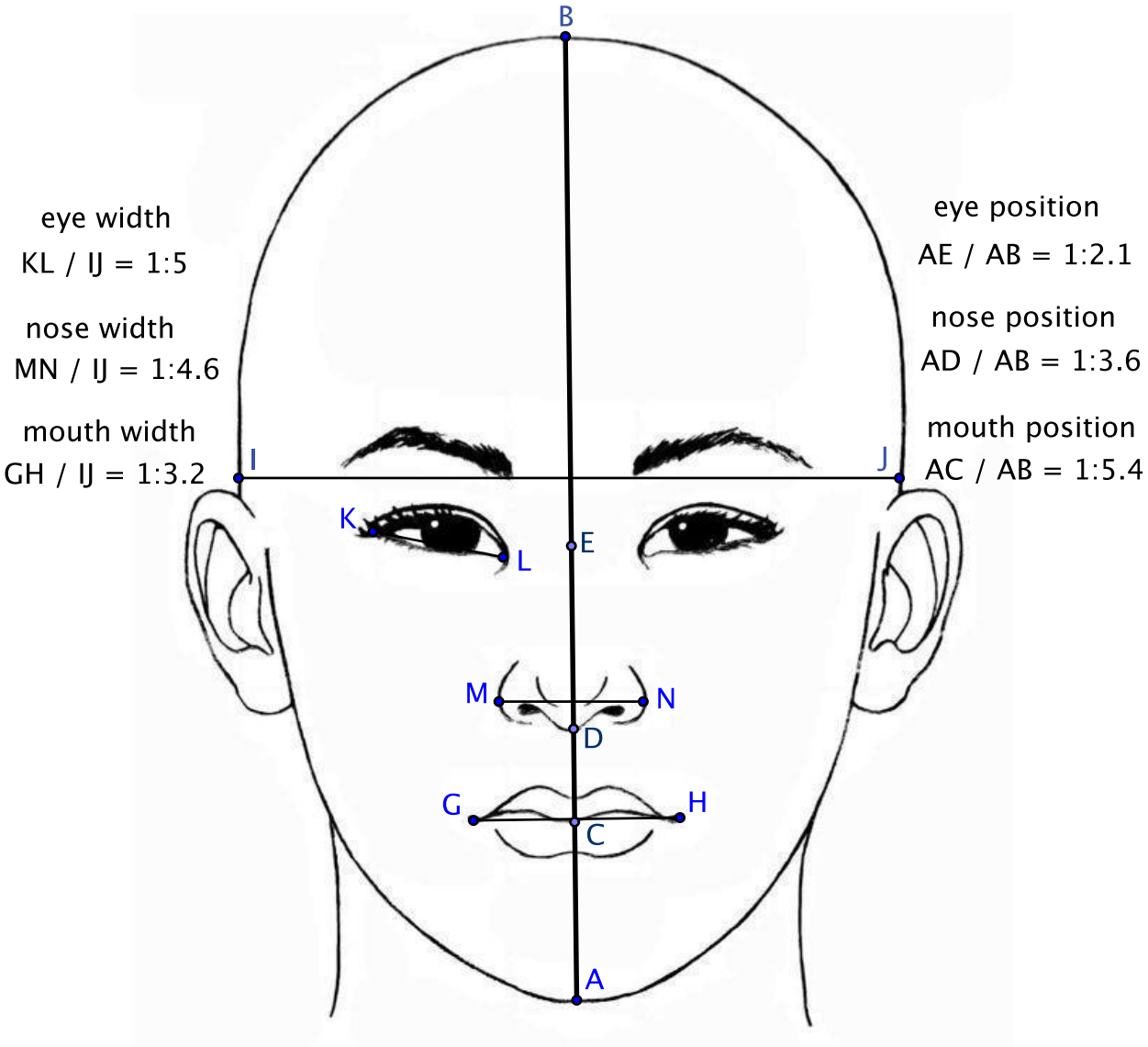
President Hathaway from *Monsters vs Aliens*. Image courtesy of DreamWorks LLC.

The Missing Link from *Monsters vs Aliens*. Image courtesy of DreamWorks LLC.

Po from *Kung Fu Panda*. Image courtesy of DreamWorks LLC.

Ginormica from *Monsters vs Aliens*. Image courtesy of DreamWorks LLC.

Appendix D: Human Facial Feature Ratios



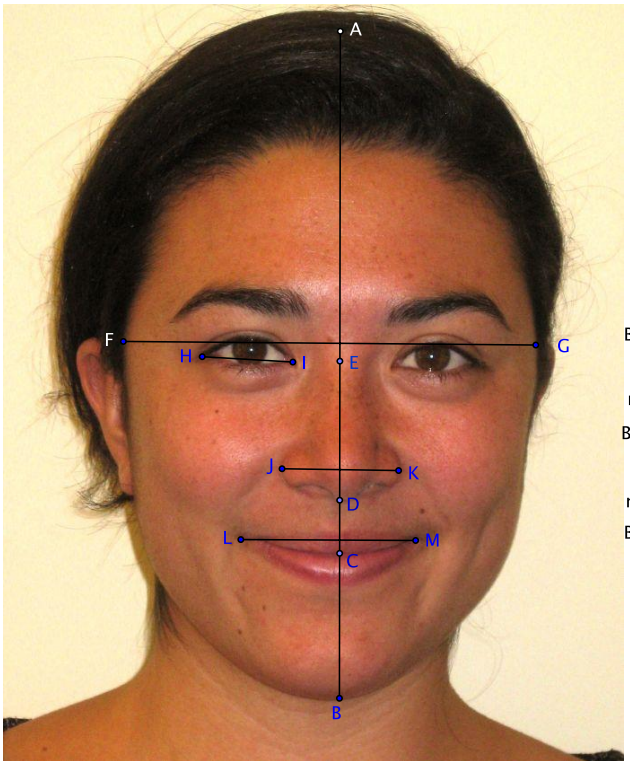
Drawing courtesy of Brenda Hoddinott, http://drawspace.com

Appendix E: Facial Proportion Images Answers

eye width
HI / FG = 1:4.5

nose width
JK / FG = 1:3.5

mouth width
LM / FG = 1:2.4



eye position
BE / AB = 1:2

nose position
BD / AB = 1:3.4

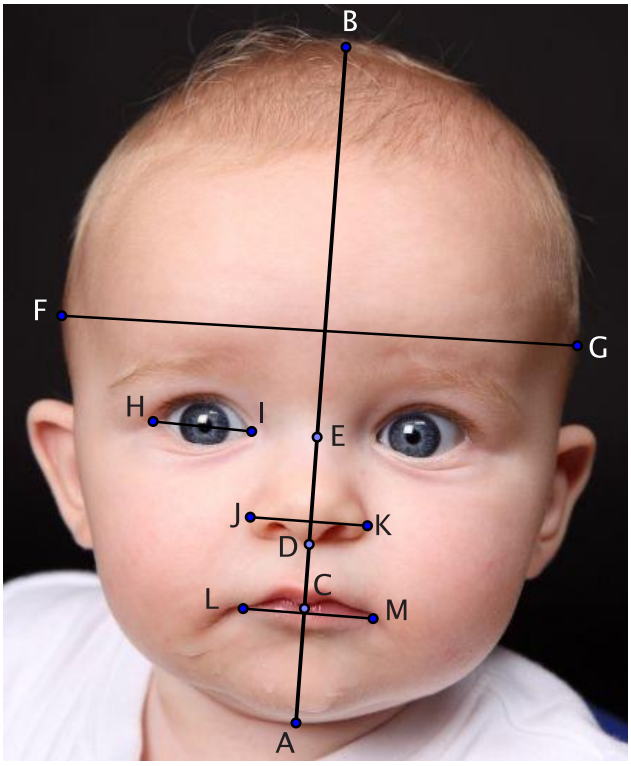
mouth position
BC / AB = 1:4.6

Photo courtesy of Aurora Kurland

eye width
HI / FG = 1:5.2

nose width
JK / FG = 1:4.4

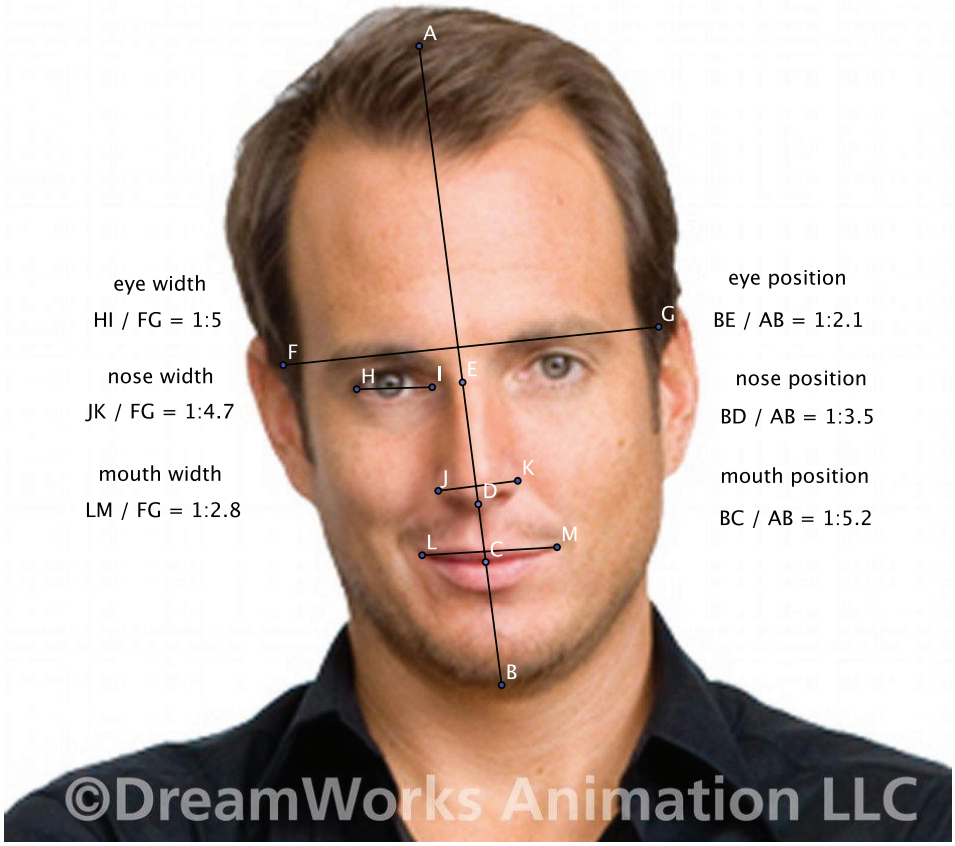
mouth width
LM / FG = 1:4



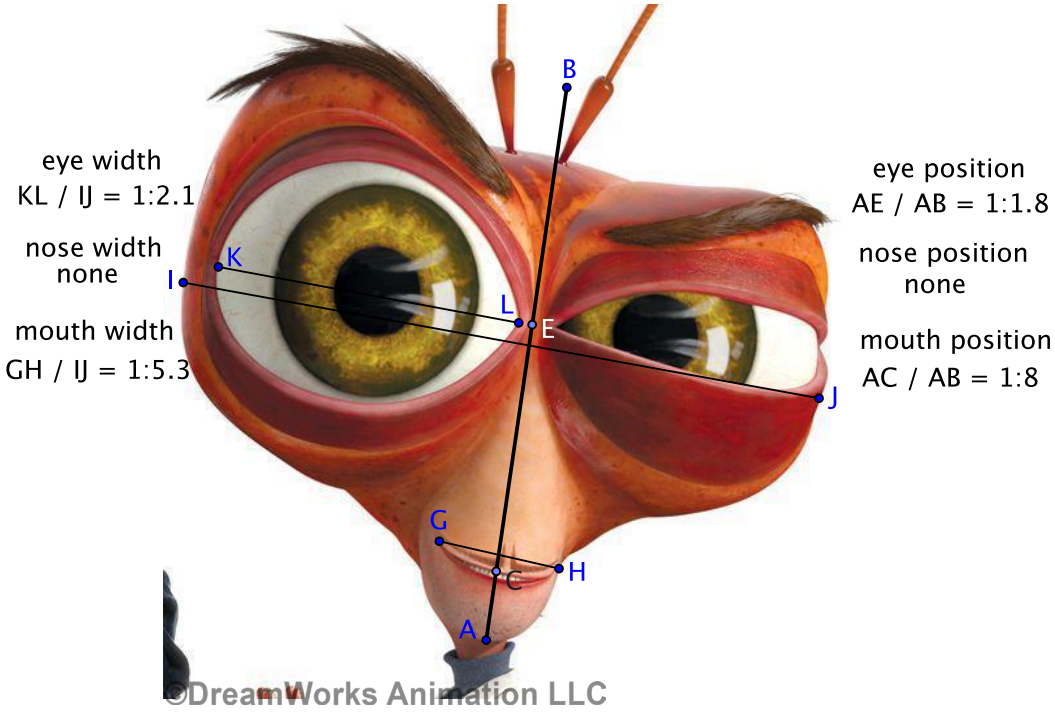
eye position
AE / AB = 1:2.4

nose position
AD / AB = 1:3.8

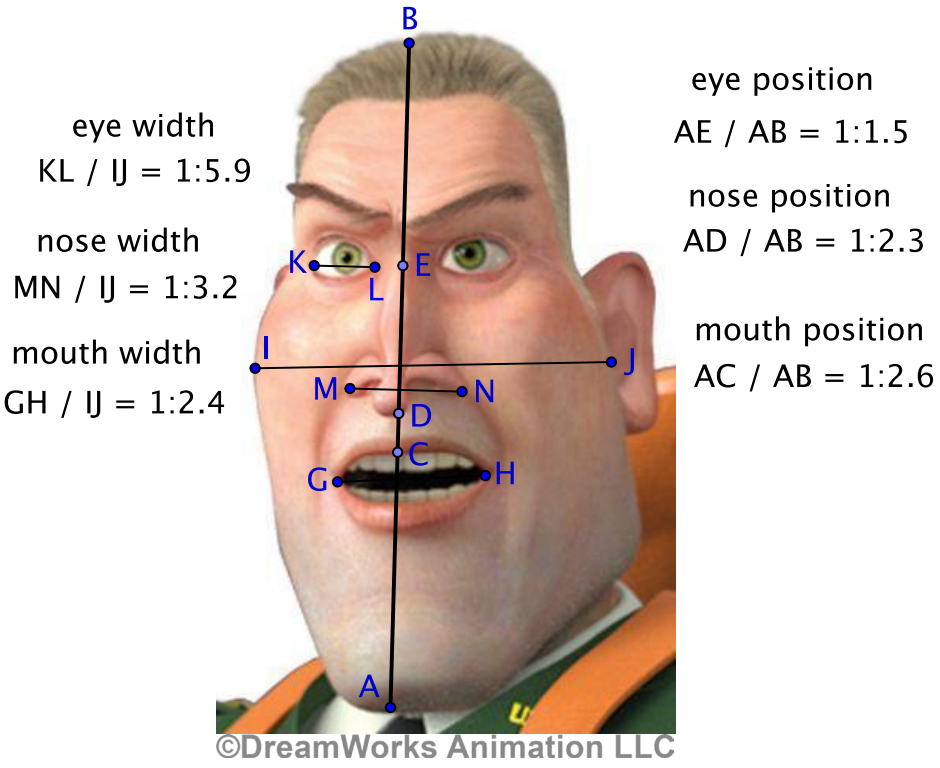
mouth position
AC / AB = 1:5.9



Will Arnett, the voice of The Missing Link from *Monsters vs Aliens*. Image courtesy of DreamWorks LLC.



Dr. Cockroach from *Monsters vs Aliens*. Image courtesy of DreamWorks LLC.



eye width
KL / IJ = 1:5.9

nose width
MN / IJ = 1:3.2

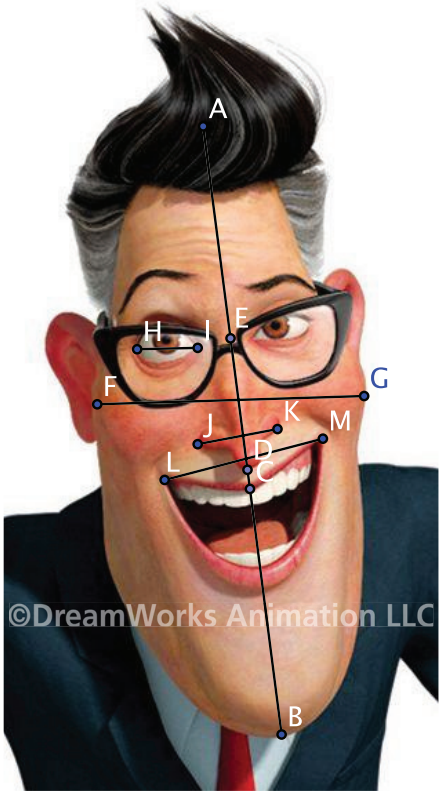
mouth width
GH / IJ = 1:2.4

eye position
AE / AB = 1:1.5

nose position
AD / AB = 1:2.3

mouth position
AC / AB = 1:2.6

General Monger from *Monsters vs Aliens*. Image courtesy of DreamWorks LLC.



eye width
HI / FG = 1:4.4

nose width
JK / FG = 1:3.3

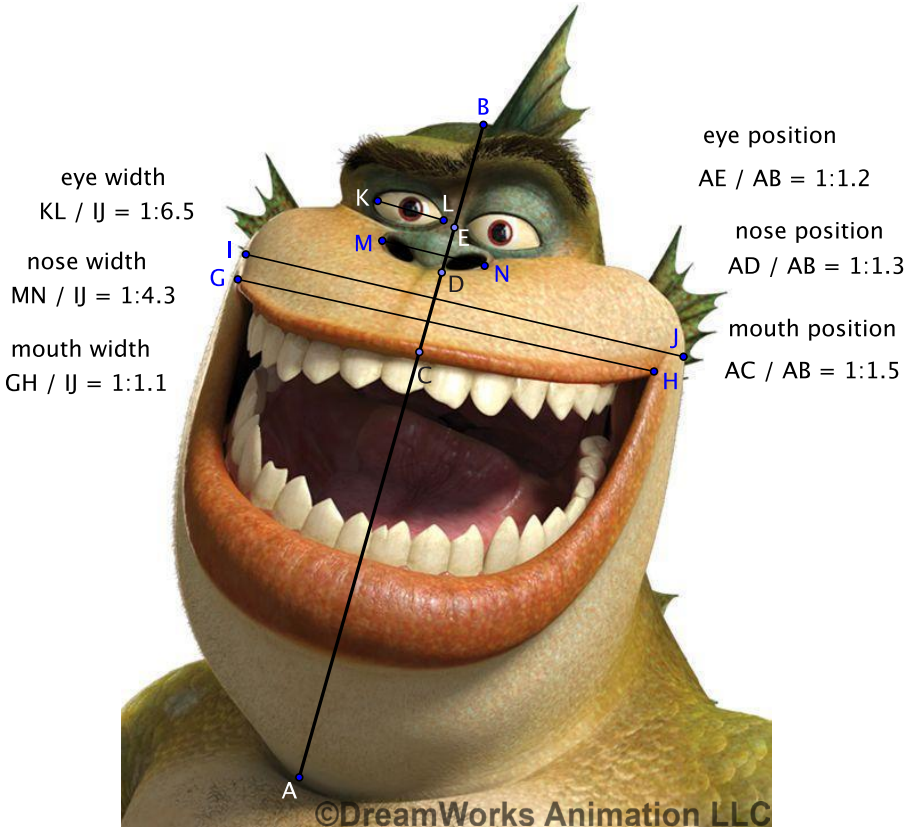
mouth width
LM / FG = 1:1.6

eye position
BE / AB = 1:1.5

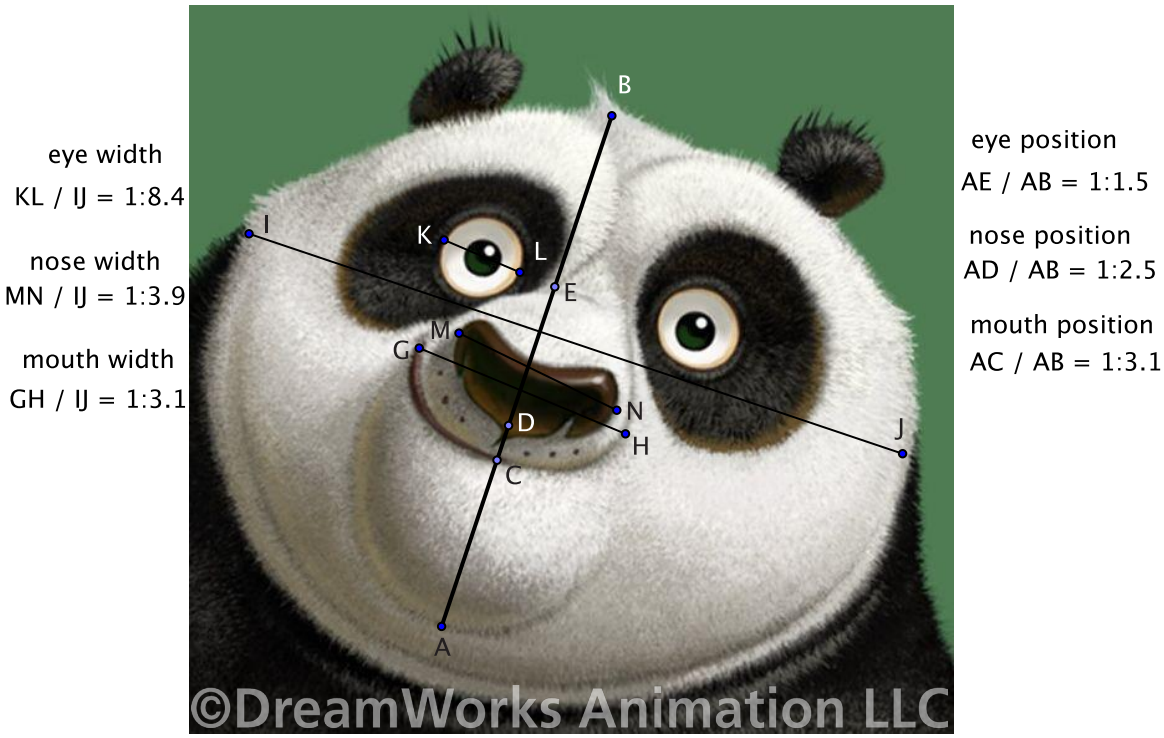
nose position
BD / AB = 1:2.3

mouth position
BC / AB = 1:2.5

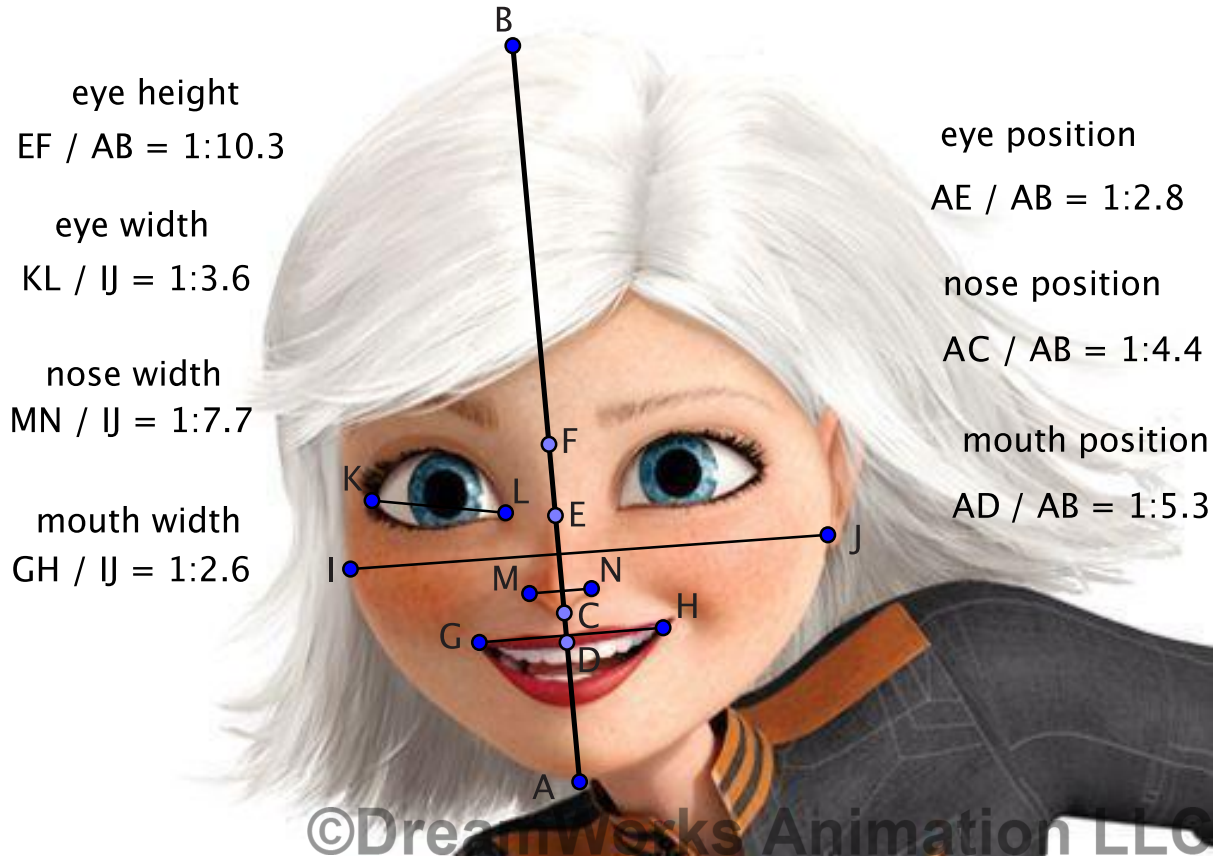
President Hathaway from *Monsters vs Aliens*. Image courtesy of DreamWorks LLC.



The Missing Link from *Monsters vs Aliens*. Image courtesy of DreamWorks LLC.

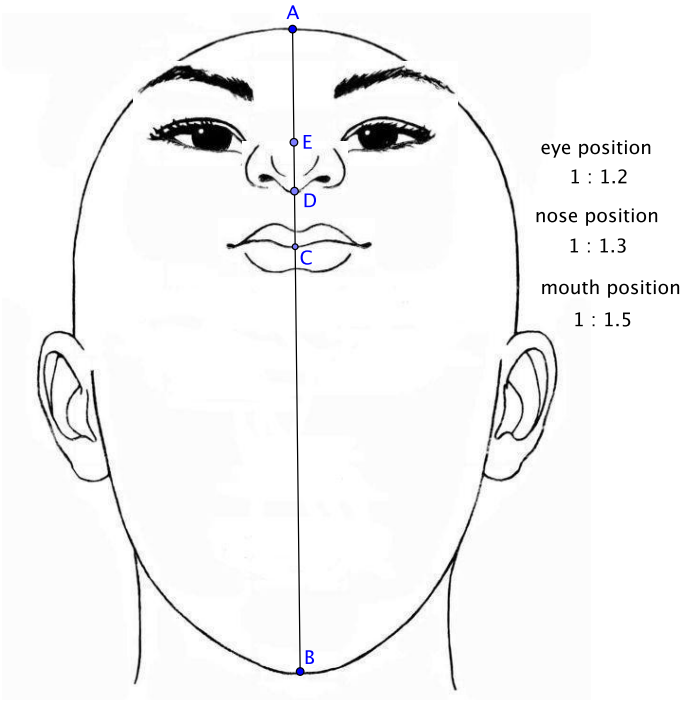


Po from *Kung Fu Panda*. Image courtesy of DreamWorks LLC.

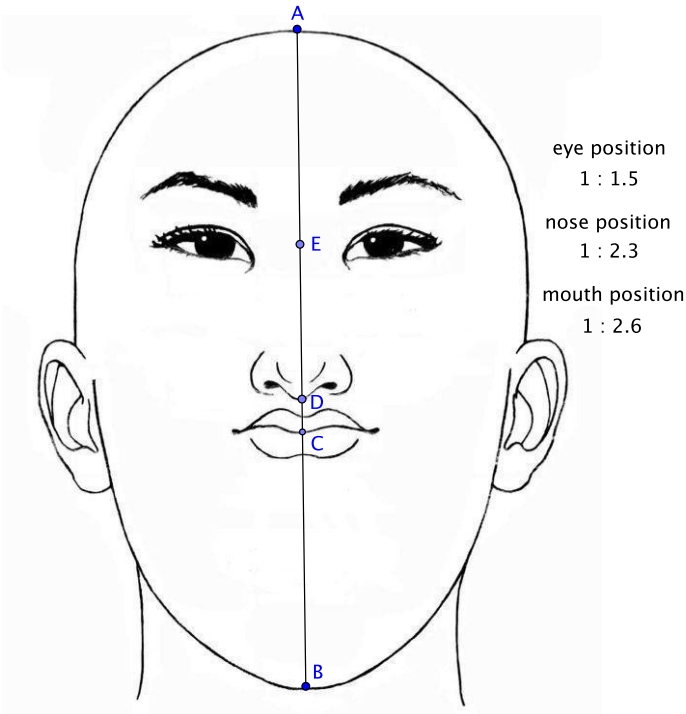


Ginormica from *Monsters vs Aliens*. Image courtesy of DreamWorks LLC.

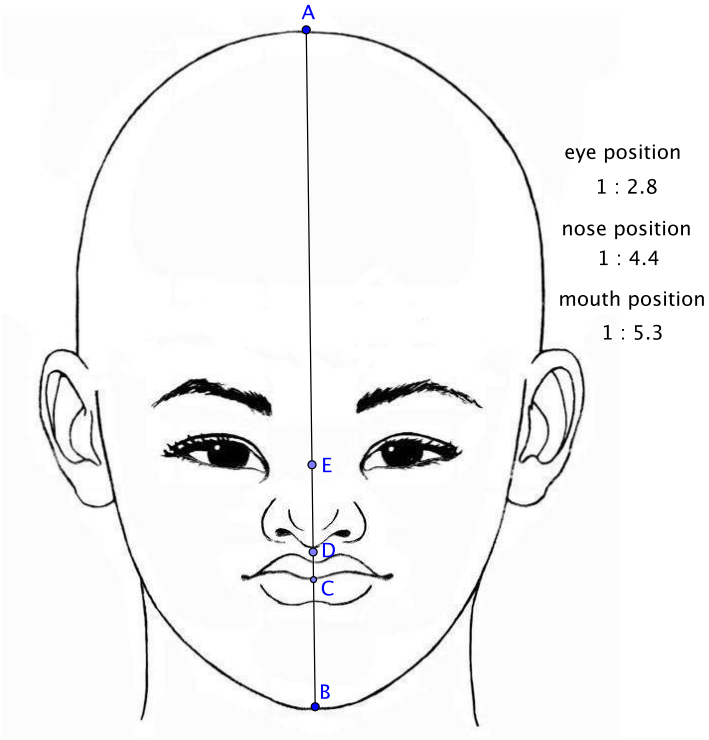
Appendix F:
Sample Answers for Activity 2A, Handout 10



The Missing Link proportions



General Monger proportions



Ginormica proportions

Materials Needed

Throughout Unit

- Optional: Digital projector or slide projector (for projecting handouts and student work)
- Chart paper and markers

Part 1: Body and Facial Proportions

Art Supplies and Other Equipment

- Rulers

Handouts

- **Handout 1: Unit Overview**
- **Assessment Checklist: Character Design**
- **Handout 2: Vitruvian Man Proportions**
- **Handout 3: Calculating Vitruvian Man Measurements**
- **Handout 4: Human Head : Height Ratios**
- **Handout 5: Journal Assignment**
- **Handout 6: Human Face Drawing**
- **Handout 7: Facial Proportion Worksheet**
- **Handout 8: Sample Facial Proportion Ratios**

Examples of Media Resources

- Optional: Printed or digital images of animated characters with varying body proportions (see *Advance Preparation*)
- Optional: *Proportion Matters* slide presentation (see *Advance Preparation*)
- Images of people and animated characters from **Appendix A: Head : Height Proportion Images** (one per student) (see *Advance Preparation*)
- Optional: Images from **Appendix B: Head : Height Proportion Answers** to be digitally projected or displayed
- Images from **Appendix C: Facial Proportion Images** to be digitally projected or displayed (see *Advance Preparation*)
- Optional: **Appendix D: Human Facial Feature Ratios** to be digitally projected or displayed
- Images from **Appendix C: Facial Proportion Images** (one per student) (see *Advance Preparation*)

Advance Preparation

- Optional: For Activity 1A, select several images of animated characters with clearly differing head to body proportions, and decide whether to print them or display them digitally. (See *Media & Resources* for links to some examples.)
- Before Activity 1A, decide whether to use the *Proportion Matters* slide presentation to display the information on Handouts 2 and 3. (See *Media & Resources* for information about the slide presentation.)
- For Activity 1A, print one image for each student from **Appendix A: Head : Height Proportion Images** for students to use in their journal assignment. Use as many different people and characters as possible in order to get a variety of head : height ratio measurements.
- Before Activity 1B, when students learn about facial feature proportions, decide whether you will digitally project or print and display the images from **Appendix C: Facial Proportion Images**. You'll also need to print one image from **Appendix C** for each student so that students can make facial feature measurements. Use as many human and animated character faces as possible.
- Before Activity 1B, decide whether you will show students images from **Appendix B: Head: Height Proportion Answers** and/or images from **Appendix D: Human Facial Feature Ratios**. If you decide to show the images, determine whether you will digitally project or print and display the images.

Part 2: Designing with Body and Facial Proportions

Art Supplies and Other Equipment

- Optional: Image editing software (see *Advance Preparation*)
- Optional: Rulers and scissors (see *Advance Preparation*)
- Optional: Centimeter graph paper

Handouts

- **Handout 9: Facial Proportions Table**
- **Handout 10: Ratio Transformation Worksheet**
- **Handout 11: Face and Features**
- **Handout 12: Character Design Worksheet**

Examples of Media Resources

- Optional: *Proportion Matters* slide presentation
- Optional: Copies of images from **Appendix A** or images of other animated characters (see *Advance Preparation*)
- Optional: Image file of head depicted on Handout 11 (see *Media & Resources* for a link to this file)

Items Students Need to Bring

- Completed copies of **Handout 7: Facial Proportion Worksheet**
- Copies of **Assessment Checklist: Character Design**

Advance Preparation

- Before Activity 2A, decide whether you will have students use computers or paper and pencil to change the image size and facial features of their character.

  If students will use computers:

  - Decide what software they will use, obtain and install the software, and familiarize yourself with it. (See *Media & Resources* for information on image editing software.)
  - Determine how to arrange access to the number of computers needed.
  - Consider grouping students in pairs or teams for their computer work.

  If students will use paper and pencil:

  - Decide whether to have students use a photocopier. If you or your students have access to a photocopier with an enlarging and reducing function (ideally, one that can enlarge and reduce images in increments of 1 percent), consider having students use it to change their character's image size.

Teacher's Notes: Computer Software vs. Paper and Pencil Methods

Each method has advantages and disadvantages.

Image Editing Software	
Pros:	*Cons:*
1. Image looks good. 2. Can use any enlargement/ reduction ratio.	1. Computer access may be limited. 2. Students may not be familiar with software.
Paper, Pencil, and Photocopier	
Pros:	*Cons:*
1. May offer a wide range of enlargement/reduction ratios.	1. May offer a limited range of enlargement/reduction ratios.
Paper, Pencil, and Scissors	
Pros:	*Cons:*
1. No extra equipment is needed.	1. Can be messy. 2. Requires drawing skills.

Teacher's Notes: Using Photocopiers

If students will use a photocopy machine to enlarge or reduce their character heads or facial features, decide how they will have access to the machine.

You may want to collect students' head and facial graphics for you to photocopy on a school machine and then return at the next class. This requires another class session to complete the activity. Alternatively, students could use home photocopiers if their machine is capable of enlarging and reducing in increments of 1 percent.

- Before Activity 2A, decide whether you will use one image or multiple images from **Appendix A** for students to create a character with a transformed head. Print or make copies of the selected images for students. (If students are using computers to transform heads, you will need to locate and provide other images of animated characters.)
- For Activity 2A, if students are using paper and pencil instead of computer software, print or make additional copies of **Handout 11: Face and Features**. Students can use scissors to cut and paste the features in new positions on the image of the face.

Media & Resources

These recommended Web sites have been checked for availability and for advertising and other inappropriate content. However, because Web site policies and content change frequently, we suggest that you preview the sites shortly before using them.

Media & Resources are also available at http://dma.edc.org and at http://dmamediaandresources.pbworks.com, a Wiki that allows users to add and edit content.

Part 1: Body and Facial Proportions

Activity 1A: Ratio Calculations: Vitruvian Man

Images of Animated Characters

DC Cartoon Archives Model Sheets
http://dcanimated.toonzone.net/Model%20Sheets/modmain.htm

Don Bluth Turnaround Model Sheets
www.donbluthanimation.com/_Don_Bluth_Animation_Cyber_Garage_Project_turnaround_model_sheets.html

How to Draw Elfquest: Character Charts
www.elfquest.com/fun/CharModels2.html

Klasky Csupo Animation Lessons: Turnarounds
www.cooltoons2.com/various/artlessons/turnarounds.html

Teen Titans Art and Design: Original Turnarounds and Model Sheets
www.titanstower.com/source/animated/artmodelsheets.html

Slide Presentation

Go to the DMA Web site page for *Proportion Matters* and click on *Media & Resources* for Part 1 to find a link to the Proportion Matters slide presentation.
http://dma.edc.org/unit/proportion-matters-algebra-1-geometry

Activity 1B: Measuring Facial Proportions

Additional Images and Information on the Animated Characters Pictured in the Handouts

King Fu Panda animated characters
www.kungfupanda.com/

Monsters vs Aliens animated characters
www.monstersvsaliens.com/

Part 2: Designing with Body and Facial Proportions

Image Editing Software

GIMP (Gnu Image Manipulation Program)
www.gimp.org

Paint.net
www.getpaint.net

Photoshop
www.photoshop.com

Photoshop Elements
www.adobe.com/products/photoshopel/

Activity 2A: Changing Characters' Body and Facial Proportions

Go to the DMA Web site page for *Proportion Matters* and click on *Media & Resources* for Part 2 to find a link to an image of the head depicted on Handout 11.
http://dma.edc.org/unit/proportion-matters-algebra-1-geometry

Additional Resources for Teachers

These recommended Web sites have been checked for availability and for advertising and other inappropriate content. However, because Web sites' policies and content change frequently, we suggest that you preview the sites shortly before using them.

Part 1: Body and Facial Proportions

Activity 1A: Ratio Calculations: Vitruvian Man

Vitruvian Man

General Information

en.wikipedia.org/wiki/Vitruvian_Man

Leonardo's Original Vitruvian Man drawing

upload.wikimedia.org/wikipedia/commons/1/11/Uomo_Vitruviano.jpg

Drawing Resources

Tutorial: Anatomy and Proportion

www.idrawdigital.com/2009/01/tutorial-anatomy-and-proportion/

Drawing Human Figures in Correct Proportions

www.drawinghowtodraw.com/drawing-lessons/drawing-faces-lessons/proportions-human-figures-bodies.html

Activity 1B: Measuring Facial Proportions

Web Sites on Proportions in Art and Cartooning

www.idrawdigital.com/2009/01/tutorial-anatomy-and-proportion/

www.animatormag.com/video/instructional/facial-proportions-cartooning/

www.sailorenergy.net/Tutorials/HOWTOVaryingPorportions01.html

Geogebra Software

For downloading and help using GeoGebra software:

www.geogebra.org/cms/

Specific tips on using GeoGebra for this unit:

Using GeoGebra to Measure and Mark Imported Graphic Characters

Note: As software changes over time, you may need to modify these instructions.

Set Rounding to 1 decimal place in the Options Menu. To insert an image in the Graphics Window:

- Select the Insert Image Tool (purple flower icon)
- Click in the Graphics Window where you want the lower left corner of the image to appear
- Double-click the name of the image in the Open window

To move an image:

- Click the Arrow Tool, then drag the image

To fix an image photo to background so that it cannot be accidentally dragged:

- Right-click to bring up image dialog
- Click Fix Object so that checkmark shows

To make the points and measurements stand out in front of the image:

- Click Style in the Object Properties window, and move the slider to 50 to lighten the image

To create a proportion text box:

- Select the Insert Text tool
- Click in the Graphics View window
- Type in the text box, substituting the names of the appropriate points:

  "BE / AB = " + (distanceBE / distanceAB)

To change the appearance of text labels:

- Right-click on a label
- Select Object Properties
- In the Object Properties Window, you can now change the label's font, color, and position

To change the size of all labels:

- Use Font Size in the Options Menu

Standards

This unit was developed to meet the following standards.

Common Core Standards for Mathematics, High School

- Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios) *[G-MG]*

NCTM Standards

- Identify essential quantitative relationships in a situation and determine the class or classes of functions that might model the relationships *[Algebra A.3.A]*.
- Use geometric ideas to solve problems in, and gain insights into, other disciplines and other areas of interest such as art and architecture *[Geometry G.4.E]*.
- Recognize and apply mathematics in contexts outside of mathematics *[Connections CO.3]*.
- Use representations to model and interpret physical, social, and mathematical phenomena *[Representations R.3]*.

CTE AME Industry Sector Foundation Standards

5.0 Problem Solving and Critical Thinking

Students understand how to create alternative solutions by using critical and creative thinking skills, such as logical reasoning, analytical thinking, and problem-solving techniques:

5.1 Apply appropriate problem-solving strategies and critical thinking skills to work-related issues and tasks.
5.5 Understand the application of research and analysis skills to the creation of content.

10.0 Technical Knowledge and Skills

Students understand the essential knowledge and skills common to all pathways in the Arts, Media, and Entertainment sector:

10.6 Know the appropriate skills and vocabulary of the art form.
10.7 Understand and analyze the elements of the art form.

11.0 Demonstration and Application

Students demonstrate and apply the concepts contained in the foundation and pathway standards.

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