

Computer Activity 1 (3-4-5 Triangle)

1. Open the program *Wingeom*. If a tip shows, click close. Click Window. Check to make sure that there is a check beside Use defaults. Then select 2-dim.
2. Right-click in the window to form point A . Right-click at another place to make point B . Near the middle of the window, right-click to make point C (so that A , B , and C form a triangle). The location of each point is indicated by an open circle.
3. At point A , hold down the left mouse button and drag to point B to form \overline{AB} . Similarly, form \overline{BC} & \overline{CA} .
4. Click Meas. Type AB and press **Enter** on the keyboard. Type BC and press **Enter**. Type CA and press **Enter**. Then press **Esc** (a key near the upper left corner of the keyboard). The upper left corner of the screen should now show the lengths of the line segments.
5. Click Btms and select Drag vertices.
6. Move the mouse to point B and drag it around until BC is *close* to 3.00. That is, drag until the length of BC is a number that rounds to 3.00 (or possibly 3.01 or 2.99 – but 3.00 is preferred).
7. Move the mouse to point A and drag it until CA is close to 4.00.
8. Now try to keep CA close to 4.00 while dragging point A until AB is close to 5.00. If this requires dragging off the window, then drag all the points away from the edge and start over at step 6.
9. Once BC is close to 3.00, CA is close to 4.00, and AB is close to 5.00, then click Meas. Type $\angle BCA$ and press **Enter** and then press **Esc**. Make sure you have typed the “ \angle ” symbol—the *less than* symbol on the keyboard. In this program, that symbol is used to represent the measure of an angle. Record data in the following chart to two decimal places. **Always include the degree symbol when recording angle measurements in degrees.**

$BC =$ _____ $CA =$ _____ $AB =$ _____ $m\angle BCA =$ _____

10. Click Circle and select Circumcircle. The letters ABC should already be in the edit control. Click ok. A circle through A , B , & C should appear with its center (D) on \overline{AB} .
11. Drag point D to the middle of the window (the other points will follow).
12. Carefully drag point C in such a way that D stays on \overline{AB} . Drag C until $BC \approx CA$. Be sure that the center of point D is on \overline{AB} . Record data in the following chart to two decimal places.

$BC =$ _____ $CA =$ _____ $AB =$ _____ $m\angle BCA =$ _____

Computer Activity 2 (Equilateral Triangle Construction)

1. Open the program *Winggeom*. If a tip shows, click close. Click Window. Check to make sure that there is a check beside Use defaults. Then select 2-dim.
2. Right-click in the window to form point A . Right-click at another place to make point B .
3. At point A , hold down the left mouse button and drag to point B to form \overline{AB} .
4. Click Circle. Select Radius-center. Make sure the window says “centered at B”.
5. Click to the left of the words “circle through” to place a bullet there. Type A . Click draw. The program might automatically change the zoom level to fit the circle on the screen.
6. While in the same window, change the top line to say “centered at A” and change the next line to say “circle through B”. Click draw. Then press **[Esc]**.
7. Click Point. Choose Intersection. Then choose Circle-Circle. In the top window, select center B; through A. In the bottom window, select center A; through B. Click mark. Press **[Esc]**.
8. At point A , hold down the left mouse button and drag to point C to form \overline{AC} . Likewise form \overline{BC} .
9. Click Meas. Type $\angle CAB$ and press **[Enter]**. Type $\angle ABC$ and press **[Enter]**. Type $\angle BCA$ and press **[Enter]**. Press **[Esc]**. Record data in the following chart to *two* decimal places.

$$m\angle CAB = \underline{\hspace{2cm}} \quad m\angle ABC = \underline{\hspace{2cm}} \quad m\angle BCA = \underline{\hspace{2cm}}$$

10. Form \overline{CD} . Click Point. Choose Intersection. Then choose Line-Line. Make sure the one line is AB and the other line is CD . Click mark. Press **[Esc]**.
11. Click Meas. Type AB/BC and press **[Enter]**. Type BE/BC and press **[Enter]**. Type CE/BC and press **[Enter]**. Type $(BE/BC)^2 + (CE/BC)^2$ and press **[Enter]**. Type $\angle CEB$ and press **[Enter]**. Type $\angle BCE$ and press **[Enter]**. Press **[Esc]**. Record data in the following chart to *three* decimal places.

$$\frac{AB}{BC} = \underline{\hspace{2cm}} \quad \frac{BE}{BC} = \underline{\hspace{2cm}} \quad \frac{CE}{BC} = \underline{\hspace{2cm}} \quad m\angle CEB = \underline{\hspace{2cm}}$$

$$\left(\frac{BE}{BC}\right)^2 + \left(\frac{CE}{BC}\right)^2 = \underline{\hspace{2cm}} \quad m\angle BCE = \underline{\hspace{2cm}}$$

12. Click Btms. Select Drag vertices. Drag point A around. How many of the measurements change as point A is dragged around?

Computer Activity 3 (Euclid's Compass)

1. Open the program *Wingeom*. If a tip shows, click close. Click Window. Check to make sure that there is a check beside Use defaults. Then select 2-dim.
2. Right-click in the window to form point A . Right-click at other places to mark points B & C such that the three points form a triangle.
3. At point A , hold down the left mouse button and drag to point B to form \overline{AB} . Also form \overline{AC} .
4. Click Circle. Select Radius-center. This brings up the draw circle or arc dialog box. Make sure the window says "centered at C ".
5. Click to the left of the words "circle through" to place a bullet there. Type A . Click draw. The program might automatically change the zoom level to fit the circle on the screen.
6. While in the same window, change the top line to say "centered at A " and change the next line to say "circle through C ". Click draw. Then press **[Esc]**.
7. Click Point. Choose Intersection. Then choose Circle-Circle. In the top window, select center C ; through A . In the bottom window, select center A ; through C . Click mark. Press **[Esc]**. Form \overline{AD} and \overline{CD} .
8. Click Btns. Select Drag vertices. Drag points around so that it is obvious that $AB < AC$.
9. Click Line and select Extensions. Type AD , CD . Click ok. This forms \overrightarrow{AD} & \overrightarrow{CD} .
10. Click Circle. Select Radius-center. Make sure the window says "centered at A ". Make sure there is a bullet to the left of the words "circle through". Make sure it says "circle through B ". Click draw. Write the names of all the points in the diagram.
11. Click Point. Choose Intersection. Then choose Line-Circle. This brings up the intersection dialog box. Type AD for the line. Select center A ; through B . Click mark. What letter did the computer assign to the point just marked?
12. Using the draw circle or arc dialog box, draw a circle centered at D that passes through the point just marked. Click close.
13. In the intersection dialog box, select that circle. Type CD for the line. Mark the points of intersection of the circle and line CD . Click close.
14. Click Meas. Type AB and press **[Enter]**. Type CI and press **[Enter]**. Type CH and press **[Enter]**. Press **[Esc]**. Which length is the same as AB ?
15. Drag point B so that $AB > AC$. Which length is the same as AB ?
16. Look at the circle centered at D (i.e., $\odot D$). Observe that it intersects \overrightarrow{CD} at two points. Drag point C until the circle centered at D intersects \overrightarrow{CD} at only 1 point. Which length is undefined?

Computer Activity 4 (SSS Construction)

1. Open the program *Wingeom*. If a tip shows, click close. Click Window. Check to make sure that there is a check beside Use defaults. Then select 2-dim.
2. Right-click in the window to form points A , B , C , D , & E . so they are arranged as a pentagon.
3. Form \overline{AB} , \overline{AC} , \overline{BC} , & \overline{ED} .
4. Click Line and select Extensions. Type ED. Click ok. This forms \overrightarrow{ED} .
5. Click Circle. Select Radius-center. Make sure the window says “centered at E” and make sure there is a bullet beside “circle radius”. Type AB for the circle radius. Click draw.
6. Click Point. Choose Intersection. Then choose Line-Circle. Type ED for the line and select the circle. Click mark. Press **[Esc]**.
7. Draw a circle centered at the point just marked and with radius BC .
8. Draw a circle centered at E and with radius AC . Click close.
9. Click Point. Choose Intersection. Then choose Circle-Circle. Select a different circle in each window (do **not** select center E; through F) and click mark. Click close.
10. Form \overline{EK} & \overline{GK} .
11. Click Meas. Type AB and press **[Enter]**. Also do this for BC , AC , GK , EK , & EG . Press **[Esc]**.
12. Click Btms. Select Drag vertices. Drag A so that AB , BC , & AC are all different.
13. Which length is the same as AB ?
14. Which length equals BC ?
15. Which length equals AC ?

Computer Activity 5 (Orthocenters)

1. Open the program *Wingeom*. If a tip shows, click close. Click Window. Check to make sure that there is a check beside Use defaults. Then select 2-dim.
2. Right-click in the window to form points A , B , & C in the shape of a triangle.
3. Click Line and select Lines. Type AB , BC , CA . Click ok.
4. Click Line and choose Perpendiculars and choose Altitudes.
5. Draw the perpendicular to line AB from point C . Then draw the perpendicular to line BC from A . Then draw the perpendicular to line CA from B . Then click close.
6. Click Btms. Select Drag vertices. Drag A , B , or C around so that the intersection of the altitudes is inside the triangle.
7. Click Line and select Extensions. Type AE , EA , BF , FB , CD , DC . Click ok.
8. Click Edit. Select Highlights and then Markings. In the where box, type ADC . For the type, choose perp bracket. Click mark. Then type AFB and click mark. Then type AEB and click mark. Press **Esc**.
9. Notice that the three altitudes of $\triangle ABC$ intersect at a single point. That point is the **orthocenter** of $\triangle ABC$. Click Point. Choose Special. Then choose Orthocenter. Make sure that ABC is in the edit control. Click ok. This marks the orthocenter of $\triangle ABC$ with point G .
10. Click Meas. Type $\angle ACB$ and press **Enter**. Press **Esc**. Drag point C so that it is on point G . What is $m\angle ACB$ to two decimal places?
11. Drag A so that G is outside $\triangle ABC$ and C is inside $\triangle ABG$. What point in the diagram is the orthocenter of $\triangle ABG$?
12. What point is the orthocenter of $\triangle ACG$? It may help to drag points around.
13. What point is the orthocenter of $\triangle BCG$?

Computer Activity 6 (Incenter)

1. Open the program *Winggeom*. If a tip shows, click close. Click Window. Check to make sure that there is a check beside Use defaults. Then select 2-dim.
2. Right-click in the window to form points A , B , & C in the shape of a triangle. Form \overline{AB} , \overline{BC} , and \overline{CA} .
3. Click Line. Choose Angles. Then choose Bisect old. Type ABC , BCA , CAB and click ok.
4. Notice that the three angle bisectors intersect at a single point. That point is the **incenter** of $\triangle ABC$. Click Point. Choose Special. Then choose Incenter. Make sure that ABC is in the edit control. Click ok. This marks the incenter of $\triangle ABC$ with point G .
5. Click Line and choose Perpendiculars and choose Altitudes. Draw the perpendicular to line AB from point G . Click close.
6. The **incenter** is the center of the circle inscribed in the triangle. The sides of the triangle are tangent to that circle. Click Circle. Choose Radius-center. Draw the circle centered at G that passes through H . Click close.
7. Click Meas. Type ABC and press **Enter**. This calculates the area of polygon ABC .
Type $[per] (ABC)$ and press **Enter**. This calculates the perimeter of polygon ABC .
Type $[per] (ABC) / 2$ and press **Enter**. This calculates the semiperimeter of $\triangle ABC$. Type GH and press **Enter**. This calculates the radius of the incircle. Press **Esc**.
8. Click Btms. Select Drag vertices. Drag A , B , or C around until GH is close to 1.00.
9. To two decimal places, what is the area of $\triangle ABC$? What is the semiperimeter of $\triangle ABC$?
10. Drag A , B , or C around until GH is close to 1.50.
11. Click Meas. Type $GH * [per] (ABC) / 2$ and press **Enter**. Type $GH * [per] (ABC) / (2 * ABC)$ and press **Enter**. Press **Esc**. To two decimal places, what is the value of the last measurement?
12. Drag A , B , or C around until GH is close to 2.00. What is the relationship between the perimeter and the area of the triangle?

Computer Activity 7 (Circumcenter, Orthocenter, and Centroid)

1. Open the program *Winggeom*. If a tip shows, click close. Click Window. Check to make sure that there is a check beside Use defaults. Then select 2-dim.
2. Right-click in the window to form points A , B , & C in the shape of a triangle. Form \overline{AB} , \overline{BC} , and \overline{CA} .
3. Click Line. Choose Perpendiculars. Then choose Perpendicular bisectors. Type AB , BC , CA and then click ok.
4. Notice that the perpendicular bisectors intersect at a single point. That point is the **circumcenter** of $\triangle ABC$. Click Point. Choose Special. Then choose Circumcenter. Make sure that ABC is in the edit control. Click ok. This marks the *circumcenter* of $\triangle ABC$ with point J .
5. The circumcenter of $\triangle ABC$ is the center of the circle that passes through all three vertices of the triangle. Click Circle. Choose Radius-center. Draw the circle centered at J that passes through A . Click close.
6. Click Btns. Select Drag vertices. Drag A , B , or C around until J is on \overline{AB} .
7. Click Meas. Type $\angle ACB$ and press **Enter**. Type AJ/AB and press **Enter**. Press **Esc**. To two decimal places, what is $m\angle ACB$? What is $\frac{AJ}{AB}$?
8. Drag A , B , or C around until J is outside of $\triangle ABC$.
9. Click Point. Choose Special. Then choose Orthocenter. Make sure that ABC is in the edit control. Click ok. This marks the *orthocenter* of $\triangle ABC$ with point K .
10. Suppose a convex polygon is cut out of stiff paper or cardboard. Then suppose someone holds the polygon flat and attempts to balance the polygon on the tip of a pencil. The point at which the polygon balances is called the **centroid**. Click Point. Choose Special. Then choose Polygon centroid. Make sure that ABC is in the edit control. Click ok. This marks the *centroid* of $\triangle ABC$ with point L .
11. Click Meas. Type JL and press **Enter**. This measures the distance from the circumcenter to the centroid. Type LK and press **Enter**. This measures the distance from the centroid to the orthocenter. Type LK/JL and press **Enter**. Type LB/HL and press **Enter**. Type LC/DL and press **Enter**. Type LA/FL and press **Enter**. Press **Esc**. What is the $\frac{LK}{JL}$ to two decimal places?
12. Drag A , B , or C around until J is inside of $\triangle ABC$. What is the $\frac{LK}{JL}$ to two decimal places?

Computer Activity 8 (Inscribed Angles and Cyclic Quadrilaterals)

1. Open the program *Winggeom*. If a tip shows, click close. Click Window. Check to make sure that there is a check beside Use defaults. Then select 2-dim.
2. Right-click in the window to form points A , B , & C in the shape of a triangle. Form \overline{AB} , \overline{BC} , and \overline{CA} .
3. Click Point. Choose Special. Then choose Circumcenter. Make sure that $\triangle ABC$ is in the edit control. Click ok. This marks the circumcenter of $\triangle ABC$ with point D .
4. Click Circle. Choose Radius-center. Draw the circle centered at D that passes through A . Click close.
5. Click Meas. Type $\angle ACB$ and press **Enter**. Type $\angle ADB$ and press **Enter**. Type $\angle ACB / \angle ADB$ and press **Enter**. Press **Esc**. To two decimal places, what is the value of $\frac{m\angle ACB}{m\angle ADB}$?
6. Right-click somewhere *on* the circle that is *not* on the same side of \overline{AC} as is B . This places point E on the circle. Form \overline{EA} & \overline{EB} .
7. Click Btms. Select Drag vertices. Drag E along the circle. If E was correctly placed, then it should stay on the circle as it is dragged even if you try to drag it off the circle. When done dragging, be sure E is not on the same side of \overline{AC} as B . If E doesn't stay on the circle as E is dragged, then follow these instructions:
 - Click Edit and select Undo.
 - Click Edit and select Undo.
 - Click Edit and select Undo. Point E should now be gone.
 - Click Btms and select Segments.
 - Now start again at step 6.
8. Click Meas. Type $\angle AEB$ and press **Enter**. Type $\angle ACB / \angle AEB$ and press **Enter**. Press **Esc**. What is the value of the ratio to two decimal places?
9. Click Line. Choose Segments. Type EC . Click ok.
10. Click Meas. Type $\angle AEC + \angle ABC$ and press **Enter**. Press **Esc**. To two decimal places, what is $m\angle AEC + m\angle ABC$?
11. Since quadrilateral $ABCE$ is inscribed in a circle, it is called a *cyclic quadrilateral*. For a cyclic quadrilateral, $Area = \sqrt{(s-a)(s-b)(s-c)(s-d)}$ where $s = \frac{a+b+c+d}{2} = \text{semiperimeter}$. To assist in doing calculations, a user-defined formula will be created in *Winggeom*. This formula will take the semiperimeter of $ABCE$ and subtract the length of the indicated side. *Do not type any spaces when following the instructions in these paragraphs*. Click Edit and select Functions. In the "name" box type s . In the "name(x) =" box type $[per] (ABCE) / 2 - x$. Press **Enter**. In the box under the enter button should be the expression $S(X) = [PER](ABCE)/2 - X$. Click close.
12. Click Meas. Type $[s] (AB) * [s] (BC) * [s] (CE) * [s] (EA)$ and press **Enter**. Type $ABCE^2$ and press **Enter**. Press **Esc**. What do you observe about these two values?

Computer Activity 9 (Midsegment Triangle and Centroid)

1. Open the program *Winggeom*. If a tip shows, click close. Click Window. Check to make sure that there is a check beside Use defaults. Then select 2-dim.
2. Right-click in the window to form points A , B , & C in the shape of a triangle. Form \overline{AB} , \overline{BC} , and \overline{CA} .
3. Click Point. Choose on Segment. Make sure that the “relative to segment” box says BC and the “coordinate” box says $1/2$. Click mark to mark the midpoint of \overline{BC} with point D . Then mark the midpoint of \overline{AC} with E . Then mark the midpoint of \overline{AB} with F . Click close.
4. Form \overline{AD} , \overline{BE} , \overline{CF} , \overline{DE} , \overline{EF} , and \overline{FD} . The first three line segments are the **medians** of $\triangle ABC$. The last three line segments are the **midsegments** of $\triangle ABC$ and form the **midsegment triangle**.
5. Observe that the three medians intersect at a single point. That point is the **centroid** of $\triangle ABC$. Click Point. Choose Special. Then choose Polygon centroid. Make sure that DEF is in the edit control. Click ok. This marks the centroid of $\triangle DEF$ with point G . Observe that the centroid of the midsegment triangle is the same as the centroid of the original triangle.
6. Click Meas. Type AB/DE and press **Enter**. Press **Esc**. To two decimal places, what is $\frac{AB}{DE}$?
7. Click Point. Choose Intersection. Then choose Line-Line. Mark the intersection of \overline{AD} & \overline{EF} . Then mark the intersection of \overline{BE} & \overline{DF} . Then mark the intersection of \overline{CF} & \overline{DE} . Click close.
8. Click Meas. Type AD/DG and press **Enter**. Type AD/DH and press **Enter**. Type DH/GH and press **Enter**. Press **Esc**. To two decimal places, write the values of those three ratios in order.
9. Click Circle. Select Circumcircle. Type ABC , DEF , HIJ . Click ok. Click Line. Select Segments. Type KL and click ok.
10. Click Btms and select Drag vertices. Then drag A , B , or C until $\angle ACB$ is clearly obtuse and points K , L , & M are outside of $\triangle ABC$. Observe that it looks like M is on \overline{KL} . Click Meas. Type KL/KM and press **Enter**. Press **Esc**. Write the value of that ratio to two decimal places.

Computer Activity 10 (Polyhedra and Euler)

1. Open the program *Wingeom*. If a tip shows, click close. Click Window. Check to make sure that there is a check beside Use defaults. This time, select **3-dim**. Click Units and select Polyhedral and choose Classics. In the list box, regular tetrahedron should be selected. Click build. Click close. Press any one of the arrow keys on the keyboard. The solid should rotate. Try pressing another arrow key, and then another, and then another. How many faces does this solid have? How many edges? How many vertices? Calculate $F + V - E$ where F = number of faces, V = number of vertices, and E = number of edges.
2. Click the close button (the **x**) in the upper right corner of the window. When a window asks if changes should be saved, **click no**. Again, click Window and select 3-dim. Click Units and select Polyhedral and choose Classics. In the list box, choose regular octahedron. Click build. Click close. Use arrow keys to rotate the solid. In order, write the number of faces, edges, and vertices. Calculate $F + V - E$.
3. Click the close button (the **x**) in the upper right corner of the window. When a window asks if changes should be saved, **click no**. Again, click Window and select 3-dim. Click Units and select Polyhedral and choose Classics. In the list box, choose regular dodecahedron. Click build. Click close. Use arrow keys to rotate the solid. In order, write the number of faces, edges, and vertices. Calculate $F + V - E$.
4. Click the close button (the **x**) in the upper right corner of the window. When a window asks if changes should be saved, **click no**. Again, click Window and select 3-dim. Click Units and select Polyhedral and choose Classics. In the list box, choose regular icosahedron. Click build. Click close. Use arrow keys to rotate the solid. How many faces meet at each vertex? How many faces does this solid have?
5. Click the close button (the **x**) in the upper right corner of the window. When a window asks if changes should be saved, **click no**. Again, click Window and select 3-dim. Click Units and select Polyhedral and choose Classics. Select Archimedean. In the list box, choose truncated cube. Click build. Click close. Name the two shapes used for the faces of this polyhedron.
6. Use arrow keys to rotate the solid. In order, write the number of faces, edges, and vertices. Calculate $F + V - E$.
7. Click the close button (the **x**) in the upper right corner of the window. When a window asks if changes should be saved, **click no**. Again, click Window and select 3-dim. Click Units and select Polyhedral and choose Antiprism. Type 4 for the number of base edges. Click build. Click close. Use the arrow keys on the keyboard to move the polyhedron around. How many vertices does it have? How many edges does it have?
8. Click the close button (the **x**) in the upper right corner of the window. When a window asks if changes should be saved, **click no**. Again, click Window and select 3-dim. Click Units and select Polyhedral and choose Prism. Type 4 for the number of base edges. Click build. Click close. Use the arrow keys on the keyboard to move the polyhedron around. How many vertices does it have? How many edges does it have?

Computer Activity 11 (Circle Tangents)

1. Open the program *Winggeom*. If a tip shows, click close. Click Window. Check to make sure that there is a check beside Use defaults. Then select 2-dim.
2. Right-click in the window to form points A & B . Click Circle and choose Radius-center.
3. Draw the circle centered at B that passes through A .
4. Right-click somewhere outside of the circle to form point C . Then form \overline{BC} .
5. Now draw the circle centered at B that passes through C . Also draw the circle centered at C that passes through B .
6. Click Point. Choose Intersection. Then choose Circle-Circle. Then mark the intersection of these two circles: center B ; through C and center C ; through B . Click close.
7. Form \overline{DE} . Click Point. Choose Intersection. Then choose Line-Line. Mark the intersection of \overline{CB} & \overline{DE} . Click close.
8. Draw the circle centered at F that passes through B . Click close.
9. Click Point. Choose Intersection. Then choose Circle-Circle. Then mark the intersection of these two circles: center B ; through A and center F ; through B . Click close.
10. Click Line and choose Lines. Type CG , CH and click ok. Form \overline{BG} & \overline{BH} .
11. Click Meas. Type $\angle BGC$ and press **Enter**. Type $\angle BHC$ and press **Enter**. Type $\angle GBH$ and press **Enter**. Type $\angle GCH$ and press **Enter**. Press **Esc**. Write both of the first two angle measures to two decimal places.
12. Click Btms and select Drag vertices. Drag A , B , or C until F is on the original circle (the one centered at B and through A). To two decimal places what is $m\angle GBH$? What is $m\angle GCH$?

Computer Activity 12 (Hexagon Construction)

1. Open the program *Wingem*. If a tip shows, click close. Click Window. Check to make sure that there is a check beside Use defaults. Then select 2-dim.
2. Right-click in the window to form points A & B . Click Circle and choose Radius-center.
3. Draw the circle centered at B that passes through A . Then draw the circle centered at A that passes through B . *Do not close the dialog box*. You may want to drag the dialog box so it doesn't cover any of the design.
4. Click Point. Choose Intersection. Then choose Circle-Circle. Then mark the intersection of the two circles. *Do not close the dialog box*.
5. Draw the circle centered at C that passes through A . Then draw the circle centered at D that passes through A .
6. Mark the intersection of these two circles: center B ; through A and center C ; through A .
7. Mark the intersection of these two circles: center B ; through A and center D ; through A .
8. Draw the circle centered at E that passes through C . Click close. Mark the intersection of these two circles: center B ; through A and center E ; through C . Click close.
9. There should now be six points on the original circle (the circle centered at B). Form the line segments between consecutive vertices to create a regular hexagon inscribed in the circle.
10. Click Edit and select Delete and choose Circle. Delete the bottom four circles in the list. Click close. There should now be a single circle with a hexagon inscribed in it.
11. Click View and select Window to reposition the design in the window. Then press **Page↑** (*Page Up*) on the keyboard to increase the size of the design until part of the design is not in view. Then press **Page↓** (*Page Down*) until all the design is visible.
12. Click Meas. Type $[pie]$ (BA) and press **Enter** to calculate the area of the circle with radius BA .
13. Starting with point A and going clockwise, type the six points that are the vertices of the hexagon and press **Enter** to calculate the area of the hexagon.
14. Calculate the ratio of the area of the hexagon to the area of the circle. For example, if the vertices of the hexagon are A, C, E, I, H , and D , then type $ACEIHD/[pie]$ (BA) and press **Enter**. Write the displayed ratio.
15. Extra Credit: Write the exact value for the ratio of the area of a regular hexagon to the area of the circle in which the hexagon is inscribed. SHOW WORK.

Computer Activity 13 (Pentagon Construction)

1. Open the program *Winggeom*. If a tip shows, click close. Click Window. Check to make sure that there is a check beside Use defaults. Then select 2-dim.
2. Right-click in the window to mark points A & B .
3. Draw the circle centered at B that passes through A .
4. Click Line and select Lines. Type \overline{AB} and click ok.
5. Click Point and select on Segment. Make sure the “relative to segment box” says \overline{AB} . Type 2 in the “coordinate” box. Click mark. This should place C at the other place the line and circle intersect.
6. Make sure the “relative to segment box” says \overline{AB} . Type $1/2$ in the “coordinate” box. Click mark and then click close.
7. Draw the circle centered at C that passes through A . Draw the circle centered at A that passes through C .
8. Click Point. Choose Intersection. Then choose Circle-Circle. Mark the intersection of these two circles: center C ; through A and center A ; through C . Form \overline{EF} .
9. Click Point. Choose Intersection. Then choose Line-Circle. Mark the intersection of \overline{EF} & the circle with center B that passes through A .
10. Draw the circle centered at D that passes through G . Mark the intersection of \overline{AC} & the circle with center D that passes through G . Click close.
11. Draw the circle centered at G that passes through I . Mark the intersection of these two circles: center B ; through A and center G ; through I .
12. Draw the circle centered at K that passes through G . Draw the circle centered at L that passes through G .
13. Mark this intersection of circles: center B ; through A and center K ; through G . Mark this intersection of circles: center B ; through A and center L ; through G . Click close.
14. Form \overline{GK} , \overline{KM} , \overline{MP} , \overline{PL} , \overline{LG} . If this has been done correctly, these line segments should form an inscribed regular pentagon in the original circle.
15. Click Meas. Type $\angle LGK$ and press **Enter**. What is $m\angle LGK$ to two decimal places?
16. Type LK/GK and press **Enter**. Press **Esc**. What is that value to three decimal places?

Computer Activity 14 (Reflections and Rotations)

1. Open the program *Wingem*. If a tip shows, click close. Click Window. Check to make sure that there is a check beside Use defaults. Then select 2-dim.
2. Click Point and select Coordinates. A set of axes should automatically appear on the screen. In the coordinates window, set $x = 1$ and $y = -2$. Click mark. Then mark $(3, -2)$. Then mark $(3, -1)$.
3. Form \overline{AB} , \overline{BC} , & \overline{CA} .
4. Click Edit. Choose Highlights and select Line attributes. In the lines box, type AB, BC, CA. In the thickness box, type 3. Click apply. Press **[Esc]**. Press **[Ctrl]+[D]** to put dots at the vertices.
5. In order, mark the points $(0, -2)$, $(4, 2)$, and $(-2, 2)$. Click close. Form \overline{DE} & \overline{DF} .
6. Click Transf and choose Mirror. In the vertices box, type A-C. Type DE for the mirror. Click draw. This **reflects** $\triangle ABC$ across \overline{DE} to form $\triangle A'B'C'$. In the vertices box, type A' - C'. For the mirror, type DF. Click draw. Click close.
7. Click Meas. Type A" and press **[Enter]**. Type B" and press **[Enter]**. Type C" and press **[Enter]**. Type $\angle FDE$ and press **[Enter]**. Type $\angle A''DA$ and press **[Enter]**. Type $\angle B''DB$ and press **[Enter]**. Type $\angle C''DC$ and press **[Enter]**. Type $2 * \angle FDE$ and press **[Enter]**. The last four measurements should be the same. Press **[Esc]**.
8. Observe the equality of the angle measurements involving A'', B'', and C''. This equality shows that $\triangle A''B''C''$ can be formed by **rotating** $\triangle ABC$ about point D. To one decimal place, list the coordinates of the three vertices of $\triangle A''B''C''$.
9. To three decimal places, what is $m\angle FDE$ and what is $m\angle A''DA$? The second angle measurement is the **angle of rotation** about point D that would transform $\triangle ABC$ into $\triangle A''B''C''$.
10. The reflection across the two lines is equivalent to a rotation about the point where the lines intersect. How is the angle of rotation related to the angle between the two lines?

Name _____

Computer Activity 15 (Segment Fraction Construction)

1. Open the program *Winggeom*. If a tip shows, click close. Click Window. Check to make sure that there is a check beside Use defaults. Then select 2-dim.
2. Right-click in the window at places that are far apart to mark points A & B . Fairly close to A , mark C at a spot that is obviously not on line AB . Form \overline{AB} .
3. Click Line and select Rays. Type AC and click ok.
4. Click Point. Choose on Segment. Make sure that AC is in the “relative to segment” box. Type 2 in the coordinate box. Click mark. Type 3 in the coordinate box. Click mark. Type 4 in the coordinate box. Click mark. Type 5 in the coordinate box. Click mark. Click close.
5. Form \overline{GB} . Click Line and select Parallels. Draw the parallel to line GB that is through C . Click close.
6. Click Point. Choose Intersection. Then choose Line-Line. Mark the intersection of \overline{AB} & \overline{CH} . Click close.
7. Use the measurement box to calculate the value of $\frac{AI}{AB}$. Write the answer as a fraction.

Name _____

Computer Activity 15 (Segment Fraction Construction)

1. Open the program *Winggeom*. If a tip shows, click close. Click Window. Check to make sure that there is a check beside Use defaults. Then select 2-dim.
2. Right-click in the window at places that are far apart to mark points A & B . Fairly close to A , mark C at a spot that is obviously not on line AB . Form \overline{AB} .
3. Click Line and select Rays. Type AC and click ok.
4. Click Point. Choose on Segment. Make sure that AC is in the “relative to segment” box. Type 2 in the coordinate box. Click mark. Type 3 in the coordinate box. Click mark. Type 4 in the coordinate box. Click mark. Type 5 in the coordinate box. Click mark. Click close.
5. Form \overline{GB} . Click Line and select Parallels. Draw the parallel to line GB that is through C . Click close.
6. Click Point. Choose Intersection. Then choose Line-Line. Mark the intersection of \overline{AB} & \overline{CH} . Click close.
7. Use the measurement box to calculate the value of $\frac{AI}{AB}$. Write the answer as a fraction.

Computer Activity 16 (Quadrilateral Tessellation)

1. Open the program *Winggeom*. If a tip shows, click close. Click Window. Check to make sure that there is a check beside Use defaults. Then select 2-dim.
2. Click Point and choose Coordinates. Type -1 for x and leave y alone. Click mark. Then mark $(0, 3)$, $(2, 0)$, & $(1, -1)$ in that order. Click close.
3. Form \overline{AB} , \overline{BC} , \overline{CD} , & \overline{DA} . Press **Ctrl**+**A** to make the axes disappear.
4. Click Point. Choose on Segment. Type BC in the “relative to segment” box. Make sure that $1/2$ is in the coordinate box. Click mark. Click close.
5. Click Transf and choose Rotate. In the vertices box, type A-D. Click ok.
6. Click Edit and select Delete and choose Point. Type E. Click ok.
7. Click Transf and choose Translate. Leave the vertices box alone. Change the vector to AC. Click ok. This makes a copy of the original design and translates that copy.
8. Again click Transf and choose Translate. Leave the vertices box alone. Change the vector to BD. Click ok.
9. Again click Transf and choose Translate. Leave the vertices box alone. Change the vector to BE. Click ok.
10. Again click Transf and choose Translate. Leave the vertices box alone. Change the vector to AC' . Click ok.
11. Again click Transf and choose Translate. Leave the vertices box alone. Change the vector to MA. Click ok.
12. Again click Transf and choose Translate. Leave the vertices box alone. Change the vector to C_1D' . Click ok.
13. The resulting design is an example of a **tessellation**. If the transformations have been done correctly, points A , B , C , and D should be near the middle of the tessellation. Right-click point A . This makes the edit coordinates dialog box appear. Press **Del** (*Delete*) on the keyboard to remove the value for x . Then press **Enter**. The purpose of this is to make point A so it is not bound to a specific point. Now right-click point B . Press **Del**. Press **Enter**. Also right-click point C . Press **Del**. Press **Enter**.
14. Click Btns and choose Drag vertices. Drag A , B , C , or D around to change the look of this tessellation with quadrilaterals. Observe that dragging point D only changes the position of the tessellation in the window. This is because point D is fixed to a specific position in the coordinate plane. Thus when point D is dragged, the entire coordinate plane is dragged.
15. Remember which quadrilateral is $ABCD$. Press **Ctrl**+**L** *twice* to make the labels disappear. Now drag A , B , C , or D around to change the look of this tessellation.
16. Press **Ctrl**+**D** *five times* so the marks for the vertices disappear. Again, drag to change appearance. When done dragging, make sure that $ABCD$ is a quadrilateral. How many quadrilaterals congruent to quadrilateral $ABCD$ are in the design? Include quadrilateral $ABCD$ in the count.

Computer Activity 17 (Angle Bisector Construction)

1. Open the program *Winggeom*. If a tip shows, click close. Click Window. Check to make sure that there is a check beside Use defaults. Then select 2-dim.
2. Right-click in the window to mark points A , B , & C in the shape of a triangle. Click Line and choose Rays. Type AB , AC . Click ok.
3. Click Circle and choose Radius-center. Draw the circle centered at A that goes through B .
4. Click Point. Choose Intersection and select Line-Circle. Make sure AC is in the line box. Select the circle. Click mark. Click close.
5. Draw the circle centered at D that goes through B . Draw the circle centered at B that goes through D . Click close.
6. Click Point. Choose Intersection and select Circle-Circle. Mark the intersection of the circles with centers D & B . Click close.
7. Click Btms and choose Drag vertices. If point F is not in the interior of $\angle BAC$, drag point B around point A until point F is in the interior of $\angle BAC$.
8. Click Line and choose Rays. Type AF . Click ok. Click Meas. Type $\angle BAF / \angle BAC$ and press **Enter**. Press **Esc**. Write the value of the ratio as a fraction.
9. Make sure both G & F are in the interior of $\angle BAC$. If they aren't, drag point B around point A until both G & F are in the interior of $\angle BAC$.
10. Click Point. Choose Intersection and select Line-Circle. Make sure AB is in the line box. Select the circle with center B . Click mark. Click close.
11. Click Meas. Type $AI \cdot AH$ and press **Enter**. Type $AG \cdot AF$ and press **Enter**. Press **Esc**. What is the relationship between $AI \cdot AH$ and $AG \cdot AF$?

Computer Activity 18 (Law of Sines)

1. Open the program *Wingeom*. If a tip shows, click close. Click Window. Check to make sure that there is a check beside Use defaults. Then select 2-dim.
2. Click Point. Select coordinates. Mark these sets of coordinates in order: (1, 1), (4, 1), (0, 3), (-1, -3), (4, -3), (0, -1). Click close.
3. Form \overline{AB} , \overline{BC} , \overline{CA} , \overline{DE} , \overline{EF} , & \overline{FD} . From the diagram, it is obvious that $\overline{BC} \cong \overline{EF}$. Write another congruence statement involving two other line segments in the diagram.
4. Write a congruence statement involving two angles in the diagram.
5. Are the triangles congruent?
6. Click Meas. Type $CB / [\sin] (\angle CAB)$ and press **Enter**. Type $CA / [\sin] (\angle CBA)$ and press **Enter**. Type $AB / [\sin] (\angle BCA)$ and press **Enter**. Type $FE / [\sin] (\angle FDE)$ and press **Enter**. Type $FD / [\sin] (\angle FED)$ and press **Enter**. To two decimal places, predict the value of $\frac{DE}{\sin F}$.
7. The value of DE can be easily calculated from the diagram. What is DE ?
8. What is $m\angle F$?

Computer Activity 18 (Law of Sines)

1. Open the program *Wingeom*. If a tip shows, click close. Click Window. Check to make sure that there is a check beside Use defaults. Then select 2-dim.
2. Click Point. Select coordinates. Mark these sets of coordinates in order: (1, 1), (4, 1), (0, 3), (-1, -3), (4, -3), (0, -1). Click close.
3. Form \overline{AB} , \overline{BC} , \overline{CA} , \overline{DE} , \overline{EF} , & \overline{FD} . From the diagram, it is obvious that $\overline{BC} \cong \overline{EF}$. Write another congruence statement involving two other line segments in the diagram.
4. Write a congruence statement involving two angles in the diagram.
5. Are the triangles congruent?
6. Click Meas. Type $CB / [\sin] (\angle CAB)$ and press **Enter**. Type $CA / [\sin] (\angle CBA)$ and press **Enter**. Type $AB / [\sin] (\angle BCA)$ and press **Enter**. Type $FE / [\sin] (\angle FDE)$ and press **Enter**. Type $FD / [\sin] (\angle FED)$ and press **Enter**. To two decimal places, predict the value of $\frac{DE}{\sin F}$.
7. The value of DE can be easily calculated from the diagram. What is DE ?
8. What is $m\angle F$?

Computer Activity 19 (Annulus Area)

1. Open the program *Winggeom*. If a tip shows, click close. Click Window. Check to make sure that there is a check beside Use defaults. Then select 2-dim.
2. Right-click in the window to form points A , B , & C .
3. Click Circle and select Radius-center. Draw the circle centered at C that passes through B . Then draw a circle centered at C that has a radius of 5. Then draw a circle centered at A with a radius of 3. Click close.
4. Click Btns and select Drag vertices. Drag B or C until $CB < CD$.
5. Click Edit, select Highlights, and choose Fill regions. Click the yellow box in the palette that appears. In the dialog box, select the curve with center C that passes through D . Make sure that bullet is selected. Click fill.
6. Click the blue box in the palette. Select the curve with center C that passes through B . Click fill. Click close.
7. The yellow region between the two circles is an example of an **annulus**. Click Meas. Type $[pie]$ (AE) and press **Enter**. This calculates the area of the circle with radius AE . Type $[pie]$ (CD) - $[pie]$ (CB) and press **Enter**. This calculates the area of the yellow annulus. Type CB and press **Enter**. Press **Esc**.
8. Drag B or C until the two area measurements are the same to at least one decimal place. To two decimal places, what is CB ?

Computer Activity 19 (Annulus Area)

1. Open the program *Winggeom*. If a tip shows, click close. Click Window. Check to make sure that there is a check beside Use defaults. Then select 2-dim.
2. Right-click in the window to form points A , B , & C .
3. Click Circle and select Radius-center. Draw the circle centered at C that passes through B . Then draw a circle centered at C that has a radius of 5. Then draw a circle centered at A with a radius of 3. Click close.
4. Click Btns and select Drag vertices. Drag B or C until $CB < CD$.
5. Click Edit, select Highlights, and choose Fill regions. Click the yellow box in the palette that appears. In the dialog box, select the curve with center C that passes through D . Make sure that bullet is selected. Click fill.
6. Click the blue box in the palette. Select the curve with center C that passes through B . Click fill. Click close.
7. The yellow region between the two circles is an example of an **annulus**. Click Meas. Type $[pie]$ (AE) and press **Enter**. This calculates the area of the circle with radius AE . Type $[pie]$ (CD) - $[pie]$ (CB) and press **Enter**. This calculates the area of the yellow annulus. Type CB and press **Enter**. Press **Esc**.
8. Drag B or C until the two area measurements are the same to at least one decimal place. To two decimal places, what is CB ?

Computer Activity 20 (Euler Line and 9-point Circle)

1. Open the program *Winggeom*. If a tip shows, click close. Click Window. Check to make sure that there is a check beside Use defaults. Then select 2-dim.
2. Right-click in the window to mark points A , B , & C in the shape of a triangle. Click Line and select Lines. Type AB , BC , CA . Click ok.
3. Click Edit, select Highlights and choose Line attributes. In the lines box, type $ABCA$. In the thickness box, type 3. Click apply. Press **[Esc]**.
4. Click Point. Select Special and choose Circumcenter. Click ok. Click Point. Select Special and choose Orthocenter. Click ok. Form \overline{DE} .
5. Click Btms and select Drag vertices. Drag A , B , or C until E is close to C and D is close to \overline{AB} . Position the points so that D & E are inside the triangle where E is far enough away from C to avoid confusion. Also make sure that BC is clearly longer than AC . Click View and select Window.
6. Click Line and select Lines. Type AE , BE , CE . Click ok. Click Point. Select Intersection and choose Line-Line. Mark the intersection of \overline{AE} & \overline{BC} . Mark the intersection of \overline{BE} & \overline{AC} . Mark the intersection of \overline{CE} & \overline{AB} . Click close.
7. Click Point. Select on Segment. In the “relative to segment” box, type AE . Click mark. Then type BE and click mark. Then type CE and click mark. Then type DE and click mark. Then type AB and click mark. Then type BC and click mark. Then type CA and click mark. Click close.
8. Click Circle and select Radius-center. Draw the circle centered at L that passes through G . Click close. Of the points marked in the diagram, the circle should pass through 9 of them. Thus this circle is call the **9-point circle**. List the 9 points that are on this circle.
9. Click Point. Select Special and choose Polygon centroid. Click ok. Observe that the centroid is on a line segment that was already drawn. This line is called the **Euler line**. List the four points on the Euler line.
10. Click Circle and select Incircle. Click ok. The incircle should be tangent to the 9-point circle.
11. Click Circle and select Excircle. Click ok. Click Circle and select Excircle. Type BCA . Click ok. Click Circle and select Excircle. Type CAB . Click ok. This draws circles that are externally tangent to the triangle and are tangent to the lines containing the edges of the triangle. These are **excircles**. Since the excircles are so large, they may extend beyond the window.
12. Click View and select Window. Then click View and select Last window. How is each of the excircles related to the 9-point circle?

Computer Activity 21 (Hyperbolic Geometry)

1. Open the program *Winggeom*. If a tip shows, click close. Click Window. Check to make sure that there is a check beside Use defaults. Then select **Hyperbolic**. In hyperbolic geometry, the parallel postulate doesn't hold.
2. Right-click in the white disk to form point *A*. *All of the geometry needs to be done inside the white disk*. Right-click at another place to make point *B*.
3. At point *A*, hold down the left mouse button and drag to point *B* to form \overline{AB} .
4. Click Circle. Select Radius-center. Make sure the window says "centered at B".
5. Click to the left of the words "circle through" to place a bullet there. Type A. Click draw.
6. While in the same window, change the top line to say "centered at A" and change the next line to say "circle through B". Click draw. Then press **[Esc]**.
7. Click Point. Choose Intersection. Then choose Circ-Circ. In the top window, select center B; through A. In the bottom window, select center A; through B. Click mark. Press **[Esc]**.
8. At point *A*, hold down the left mouse button and drag to point *C* to form \overline{AC} . Likewise form \overline{BC} .
9. Click Meas. Type $\angle CAB$ and press **[Enter]**. Type $\angle ABC$ and press **[Enter]**. Type $\angle BCA$ and press **[Enter]**. Press **[Esc]**. Record data in the following chart to *two* decimal places.

$$m\angle CAB = \underline{\hspace{2cm}} \quad m\angle ABC = \underline{\hspace{2cm}} \quad m\angle BCA = \underline{\hspace{2cm}}$$

10. Form \overline{CD} . Click Point. Choose Intersection. Then choose Line-line. Make sure the one line is AB and the other line is CD. Click mark. Press **[Esc]**.
11. Click Meas. Type $\frac{AB}{BC}$ and press **[Enter]**. Type $\frac{BE}{BC}$ and press **[Enter]**. Type $\frac{CE}{BC}$ and press **[Enter]**. Type $(\frac{BE}{BC})^2 + (\frac{CE}{BC})^2$ and press **[Enter]**. Type $\angle CEB$ and press **[Enter]**. Type $\angle BCE$ and press **[Enter]**. Press **[Esc]**. Record data in the following chart to *three* decimal places.

$$\frac{AB}{BC} = \underline{\hspace{2cm}} \quad \frac{BE}{BC} = \underline{\hspace{2cm}} \quad \frac{CE}{BC} = \underline{\hspace{2cm}} \quad m\angle CEB = \underline{\hspace{2cm}}$$

$$\left(\frac{BE}{BC}\right)^2 + \left(\frac{CE}{BC}\right)^2 = \underline{\hspace{2cm}} \quad m\angle BCE = \underline{\hspace{2cm}}$$

12. Click Btms. Select Drag vertices. Drag point *A* around. How many of the measurements change as point *A* is dragged around?
13. As point *A* is dragged close to point *B*, what is $m\angle BCE$ to 1 decimal place?

Computer Activity 22 (Spherical Geometry)

1. Open the program *Winggeom*. If a tip shows, click close. Click Window. Check to make sure that there is a check beside Use defaults. Then select **Spherical**. In spherical geometry, the parallel postulate doesn't hold. There are no parallel lines.
2. Right-click near the middle of the white disk to form point A . *All of the geometry needs to be done inside the white disk*. Right-click at another place to make point B .
3. At point A , hold down the left mouse button and drag to point B to form \overline{AB} .
4. Click Circle. Select Radius-center. Make sure the window says "centered at B".
5. Click to the left of the words "circle through" to place a bullet there. Type A. Click draw.
6. While in the same window, change the top line to say "centered at A" and change the next line to say "circle through B". Click draw. Then press **[Esc]**.
7. Click Point. Choose Intersection. Then choose Circ-Circ. In the top window, select center B; through A. In the bottom window, select center A; through B. Click mark. Press **[Esc]**.
8. At point A , hold down the left mouse button and drag to point C to form \overline{AC} . Likewise form \overline{BC} .
9. Click Meas. Type $\angle CAB$ and press **[Enter]**. Type $\angle ABC$ and press **[Enter]**. Type $\angle BCA$ and press **[Enter]**. Press **[Esc]**. Record data in the following chart to *two* decimal places.

$$m\angle CAB = \underline{\hspace{2cm}} \quad m\angle ABC = \underline{\hspace{2cm}} \quad m\angle BCA = \underline{\hspace{2cm}}$$

10. Form \overline{CD} . Click Point. Choose Intersection. Then choose Line-line. Make sure the one line is AB and the other line is CD. Click mark. Press **[Esc]**.
11. Click Meas. Type AB/BC and press **[Enter]**. Type BE/BC and press **[Enter]**. Type CE/BC and press **[Enter]**. Type $(BE/BC)^2 + (CE/BC)^2$ and press **[Enter]**. Type $\angle CEB$ and press **[Enter]**. Type $\angle BCE$ and press **[Enter]**. Press **[Esc]**. Record data in the following chart to *three* decimal places.

$$\frac{AB}{BC} = \underline{\hspace{2cm}} \quad \frac{BE}{BC} = \underline{\hspace{2cm}} \quad \frac{CE}{BC} = \underline{\hspace{2cm}} \quad m\angle CEB = \underline{\hspace{2cm}}$$

$$\left(\frac{BE}{BC}\right)^2 + \left(\frac{CE}{BC}\right)^2 = \underline{\hspace{2cm}} \quad m\angle BCE = \underline{\hspace{2cm}}$$

12. Click Btms. Select Drag vertices. Drag point A around. How many of the measurements change as point A is dragged around?
13. As point A is dragged close to point B , what is $m\angle BCE$ to 1 decimal place?

Computer Activity 23 (More Spherical Geometry)

- Open the program *Wingeom*. If a tip shows, click close. Click Window. Check to make sure that there is a check beside Use defaults. Then select **Spherical**. In *Wingeom*, spherical geometry is done on a sphere with a radius of 1. The white disk is the visible portion of the surface of the sphere. What is the *exact* value of the circumference of a sphere with a radius of 1?
- Right-click near the *bottom* edge of the white disk to form point *A*. Right-click near the *left* edge of the white disk to form point *B*. Click Line and select Lines. Type \overline{AB} and click ok. What is the exact value of the length of a 90° arc of a circle with a radius of 1?
- Click Line, select Perpendiculars and choose General. Click draw to draw the line through *B* that is perpendicular to \overline{AB} . Then change the through point to *A* and click draw to draw the line through *A* that is perpendicular to \overline{AB} . Click close. To two decimal places, what is the approximate length of a 90° arc of a circle with a radius of 1?
- Click Point. Select Intersection and choose Line-Line. Mark the intersection of \overrightarrow{AD} & \overrightarrow{BC} . Point *F* should display at an intersection. Click close. What is the exact surface area of a sphere with a radius of 1?
- Click Line, select Perpendiculars and choose General. Then draw the line through *F* that is perpendicular to \overline{BF} . Click close. What is the exact value of one-eighth of the surface area of a sphere with a radius of 1?
- Click Point. Select Intersection and choose Line-Line. Mark the intersection of \overrightarrow{AB} & \overrightarrow{FG} . Click close. To two decimal places, what is one-eighth of the surface area of a sphere with a radius of 1?
- Click Edit, select Delete and choose Line. Type \overline{AD} and click ok. Click Edit, select Delete and choose Point. Type \overline{ACDG} and click ok. Click Meas. Type \overline{HB} and press **Enter**. Type \overline{BF} and press **Enter**. Type \overline{FH} and press **Enter**. Type $\angle FHB$ and press **Enter**. Type \overline{FHB} and press **Enter**. Press **Esc**. To two decimal places, what is the area of $\triangle FHB$?
- Classify $\triangle FHB$ according to its sides. Also, classify $\triangle FHB$ according to its angles.
- Click Point. Select on Segment. In the “coordinate” box, type #. In the “relative to segment” box, type \overline{BF} . Click mark. Then type \overline{FH} and click mark. Then type \overline{HB} and click mark. Click close. Click Line and select Lines. Type \overline{AD} , \overline{DC} , \overline{CA} and click ok. Click Meas. Type \overline{AD} and press **Enter**. Type \overline{DC} and press **Enter**. Type \overline{CA} and press **Enter**. Type $\angle CAD$ and press **Enter**. Type \overline{CAD} and press **Enter**. Type \overline{CFA} and press **Enter**. Type $\overline{CAD}/\overline{CFA}$ and press **Enter**. Press **Esc**. Classify $\triangle CAD$ according to its sides. Also, classify $\triangle CAD$ according to its angles.
- Click Anim and select # slider. While watching the area of $\triangle CAD$, click the arrow to the left of the slider. When the area of $\triangle CAD$ is the smallest, what is the ratio of its area to the area of $\triangle CFA$? Round the answer to two decimal places. In finding the answer, it may be helpful to also click the arrow to the right of the slider.
- In the top edit control of the current value of # dialog box, type 1.2322795 and press **Enter**. What is $m\angle CAD$?
- If part of $\triangle CAD$ is not visible, click Btms and select Drag vertices. Drag points until all of $\triangle CAD$ is visible. To five decimal places, what is the area of $\triangle CAD$?
- Click Meas. Type $(0.5[\arcsin](2/3)+90)/90$ and press **Enter**. Write the result rounded to 3 decimal places.
- If the value of # were exactly the value of $(\frac{1}{2}\arcsin(\frac{2}{3})+90^\circ)\cdot\frac{1}{90^\circ}$, what would be the exact area of $\triangle CAD$?
Hint: Study the 3 previous exercises. The answer to #12 should look like a familiar number.

Computer Activity – 3D Coordinates

- Open the program *Winggeom*. If a tip shows, click close. Click Window. Check to make sure that there is a check beside Use defaults. Then select **3-dim**. Click Point and select Coordinates (absolute).
- Click mark to label $A(0,0,0)$. Then change x to 2 and click mark to label $B(2,0,0)$. Change y to 3 and click mark to label $C(2,3,0)$. Change x to 0 and click mark to label $D(0,3,0)$. Click close. Press **Ctrl** + **A** to make the axes appear. Click View. Choose Axes. Then choose Arrows to add arrows to the axes.
- Click Transf and choose Normal translate. Change distance to 6 and click ok. Eight points should be displayed.
- Click Linear and choose Convex hull. In the vertices box, type $A-D'$ and click ok. This should draw a box with those eight points as its vertices. To zoom out, press **Page↓** (*Page Down*) *four times*.
- Click View. Choose Display. Then choose Painted and dotted to display the invisible lines. To rotate the view, press **←** (*Left Arrow*) *three times*.
- Click Meas. Type B' and press **Enter**. Type D' and press **Enter**. Press **Esc**. The coordinates of D' should be $(0,3,6)$. Write the coordinates of B' .
- Write what you think are the coordinates of C' .
- Click Meas. Type C' and press **Enter**. Type $D'B$ and press **Enter**. Type $D'D^2 + DC^2 + CB^2$ and press **Enter**. Press **Esc**. If your answer to the previous question was wrong, cross it out and write the correct answer beside it. What is the distance from D' to B' ?
- Study the measurements and write an equation that looks similar to the Pythagorean theorem. The equation should have the expressions $D'B$, $D'D$, DC , and CB in it. Hint: $D'B^2$ will be one part of the equation.
- Click Linear and choose Segment or face. Type BD' , $B'D$, AC' , $A'C$ and click ok. This should draw four segments that intersect in the middle of the box. Write the coordinates of the intersection point. Hint: Consider the average of the coordinates of A and C' .
- To mark the intersection point, click Point and choose 1 relative coordinate. Change relative to segment to AC' and click mark. Click close.
- Click Transf and choose Rotate. Change vertices to $A-E$. Change angle to 360° . Change around axis to CC' . Click ok. Click Linear and choose Convex hull. In the vertices box, type $E'CA0B0D0$ and click ok (each 0 is a digit and not a letter). This draws a pyramid.
- Click Meas. Type E and press **Enter**. Type $A0$ and press **Enter**. Press **Esc**. Write the coordinates of E .
- Click Anim and select # slider. In the 2nd line of the dialog box is a “slider.” While watching the x -coordinate of A_0 , click the arrow at the *left* of the slider until the x -coordinate is a whole number. Write the coordinates of A_0 .
- Continue clicking the arrow at the *left* of the slider until the x -coordinate of A_0 is again a whole number. Point D_0 should be on \overline{BC} . Write the coordinates of A_0 .

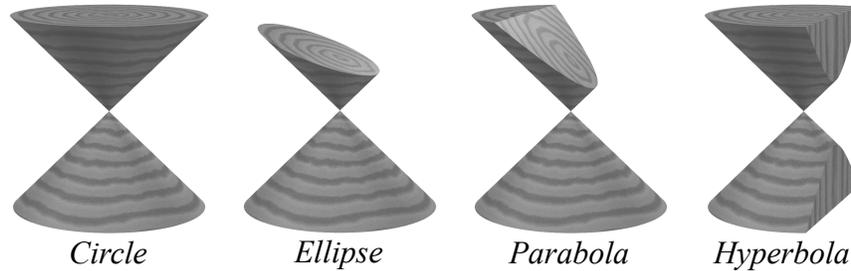
Computer Activity – Ellipse

1. Open the program *Winggeom*. If a tip shows, click close. Click Window. Check to make sure that there is a check beside Use defaults. Then select 2-dim.
2. Right-click near the middle of the window to mark point A . Right-click near the left of the window to mark point B .
3. Form \overline{AB} . Click Circle and choose Radius-center. Draw the circle centered at A that passes through B . Click close.
4. Click Point and select on Segment. Make sure the “relative to segment box” says AB . Type the symbol # in the “coordinate” box. Click mark. This should place C on \overline{AB} . Click close.
5. Click Point. Choose Random point. Then choose on Circle. Click on center A ; through B so it is selected. Click ok. This should place D on $\odot A$. Hopefully, D is not on top of B . If it is (or if it is not visible), click Btms and select Randomize sliding points. This should place D somewhere else on $\odot A$.
6. Form \overline{AD} and \overline{CD} . Click Line. Choose Perpendiculars. Choose Perpendicular bisectors. Type CD and click ok.
7. Click Point. Choose Intersection. Then choose Line-Line. Mark the intersection of \overleftrightarrow{EF} and \overline{AD} . Click close. Point G should now be on \overline{AD} .
8. Click Btms and select Drag vertices. Drag D . It should stay on $\odot A$ as you drag. Watch the motion of G as you drag D . As D moves around $\odot A$, point G follows a special path. **If you are ever unable to drag D , click Btms and select Randomize sliding points. This should place D somewhere else on $\odot A$.**
9. To see the path of G , click Anim and select Tracing. Click new. Click to the left of the word “vertex” to place a bullet there. Type D . Then in the “pen on vertex” box, type G . Click ok. This should draw a red oval. Now close the tracing inventory dialog box.
10. Drag D around $\odot A$. Point G should stay on the red oval as D moves around $\odot A$. The red oval is an **ellipse**. Planets, comets, and asteroids move in elliptical paths around the sun. Points A and C are the **foci** of the ellipse. Observe that \overline{EG} is **tangent** to the ellipse at G .
11. Click Meas. Type AC/AB and press **Enter**. Type $CD/(CA+AD)$ and press **Enter**. Type $\angle CAG$ and press **Enter**. Press **Esc**. While dragging D around $\odot A$, observe the value of $\frac{CD}{CA+AD}$. To three decimal places, what is the maximum value of $\frac{CD}{CA+AD}$?
12. If the sun is located at **focus** A and a comet traveling around the red ellipse is located at G , then the speed of the comet is proportional to the value of $\frac{CD}{CA+AD}$. The comet moves fastest when $\frac{CD}{CA+AD}$ is a maximum. At that location, what is $m\angle CAG$ to one decimal place?
13. Click Anim and select # slider. In the top edit control of the **current value of #** dialog box, type 0.8 and press **Enter**. This changes the **eccentricity** of the ellipse to 0.8 . Do not close the **current value of #** dialog box. To three decimal places, what is the value of $\frac{AC}{AB}$?
14. Drag D around $\odot A$. To three decimal places, record both the *maximum* and *minimum* values of $\frac{CD}{CA+AD}$. Recall that the speed of the comet or asteroid or planet is proportional to $\frac{CD}{CA+AD}$.
15. In the top edit control of the **current value of #** dialog box, type 0.2056 and press **Enter**. This forms an ellipse with the same eccentricity as the orbit of the planet Mercury. Observe that the ellipse looks almost like a circle. Drag D around $\odot A$. To three decimal places, record both the *maximum* and *minimum* values of $\frac{CD}{CA+AD}$. The results should show that when Mercury is farthest from the sun, it travels about 65.9% as fast as it does when it is closest to the sun.

Computer Activity – Conics Introduction

1. Open the program *Wingeom*. If a tip shows, click close. Click Window. Check to make sure that there is a check beside Use defaults. Then select 2-dim. Click Point and select Coordinates. Click mark to label $A(0,0)$. Then change y to 1 and click mark to label $B(0,1)$. Change y to -1 and click mark to label $C(0,-1)$. Change y to 0 and change x to $-4\$$ and click mark to label $D(-4\$,0)$. Point D should be located near $(-1.3,0)$. Change x to $5\#$ and click mark to label $E(5\#,0)$. Point E should be near $(3.3, 0)$. Click close.
2. Form \overline{CD} . Then click Circle and choose Radius-center. Change the “centered at” box to B. Change the “circle radius” box to AE. Click draw to form the circle centered at B that has a radius of AE . Click close.
3. Click Line and select Parallels. Change the “through point” box to E. Click draw to form the line parallel to \overline{CD} that passes through E . Do not click close. This way the draw parallel dialog box will be available later.
4. Click Point. Choose Intersection. Then choose Line-Line. Change the first “line” box to YY. In *Wingeom*, you can use the name YY to refer to the y -axis. The second “line” box should say EG. Click mark. Click close.
5. In the draw parallel dialog box, change the “parallel to” box to XX and the “through point” box to H. Click draw to form the line parallel to the x -axis that passes through H . Click close.
6. Click Point. Choose Intersection. Then choose Line-Circle. Change the “line” box to HI. Click on center B; through F so it is selected. Click mark to label the intersection points K and J . Click close.
7. Click Meas. Type AD/AC and press **[Enter]**. Type H and press **[Enter]**. Press **[Esc]**. The y -coordinate of H should be 2.5. What is the value of $\frac{AD}{AC}$ to three decimal places?
8. Click Anim and select # slider. In the top edit control of the current value of # dialog box, type -1 and press **[Enter]**. This should make $\odot B$ really large. What is the new y -coordinate of H ? Do not close any “slider” dialog box until the end of this activity.
9. In the 2nd line of the dialog box is a “slider.” While pressing down on the arrow at the *right* of the “slider”, observe points K and J . Do not be alarmed if K and J disappear for a while! They should reappear if you hold down the slider long enough. Once the “slider” stops sliding, press the arrow at the *left* of the slider and again observe K and J . Keep pressing on the left arrow until K and J appear near the bottom of the window. To see the paths of K and J , click Anim and select Tracing. Click new. A bullet should be to the left of #. Change steps to 787. Change low to -1.4 and change high to 1.4 . Then in the “pen on vertex” box, type K. Click ok. This should draw two red curves. Now click new in the tracing inventory dialog box. This time, change the “pen on vertex” box to J. Again, change steps to 787, change low to -1.4 and change high to 1.4 . Click ok. This should add red curves to the right side of the window. Now close the tracing inventory dialog box.
10. The curves traced by K and J are part of a **hyperbola**. Because of inaccuracies, part of the hyperbola may be missing where it crosses the y -axis. A hyperbola has two **branches**. Points K and J should be on the lower branch of the hyperbola. What is the value of y where the lower branch of the hyperbola crosses the y -axis?
11. Hold down the arrow on the *right* of the # slider and watch K and J follow the path of the hyperbola. Then click the arrow on the *left* of the # slider until the y -coordinate of H is 1.5. Click Anim and select \$ slider. In the top edit control of the current value of \$ dialog box, type 0.25 and press **[Enter]**. This draws a red **parabola**. To one decimal place, write an estimate for the value of y where the parabola crosses the y -axis.
12. Click the arrow on the *left* of the \$ slider until the value of \$ is 0.18. This draws an **ellipse**. The value of $\frac{AD}{AC}$ is the **eccentricity** of the ellipse. What is that value to two decimal places?
13. Click the arrow on the *right* of the \$ slider and watch the curve change from an **ellipse** to a **parabola** to a **hyperbola**. What is the eccentricity of the hyperbola when its lower branch crosses the y -axis at $C(0, -1)$?

Computer Activity – The Unit Circle and Sine and Cosine



1. Consider a cone that continues forever both up and down. The *Circle* illustration shows a portion of such a cone. If the cone is sliced using a horizontal plane, then the intersection of the plane and the cone forms a **circle**. This can be seen on the top of the *Circle* illustration. If the plane is tilted a little bit, then the intersection of the plane and the cone forms an **ellipse**. This can be seen at the top of the *Ellipse* illustration. If the slicing plane is tilted so that it is at the same angle as the side of the cone, then the intersection of the plane and the cone forms a **parabola**. Part of a parabola can be seen at the top of the *Parabola* illustration. Since the cone continues forever upward, the parabola also continues forever upward. If the plane slices both the top and bottom portions of the cone, then the intersection forms a **hyperbola**. The hyperbola consists of two branches. The hyperbola continues forever both up and down. Part of a hyperbola is visible on the right of the *Hyperbola* illustration. The circle, ellipse, parabola, and hyperbola are **conic sections**. This activity focuses on the circle. Open the program *Wingeom*. If a tip shows, click close. Click Window. Check to make sure that there is a check beside Use defaults. Then select 2-dim. Click Point and select Coordinates. Click mark to label $A(0,0)$. Then change x to 1 and click mark to label $B(1,0)$. Click close.
2. Click Circle and select Radius-center. Draw the circle centered at A that passes through B . Click close. To zoom, press **[Page↑]** (*Page Up*) on the keyboard. Keep pressing **[Page↑]** until the circle almost fills the window.
3. Click Anim and select # slider. In the top edit control of the current value of # dialog box, type -360 and press **[Enter]**. Change it to 360 and press **[Enter]**. Change it to 30 and press **[Enter]**. Do not close this dialog box. Click Point and select on Circle. For the coordinate, type the symbol #. Click mark. Click close.
4. Form \overline{AC} . Click Meas. Type # and press **[Enter]**. Type $[x]$ (C) and press **[Enter]**. Type $[y]$ (C) and press **[Enter]**. Press **[Esc]**. The value of $[x]$ (C) is the x -coordinate of C and is the **cosine** of $m\angle BAC$. The value of $[y]$ (C) is the y -coordinate of C and is the **sine** of $m\angle BAC$. The measurements should show that 0.5 is the y -coordinate of C . Write the x -coordinate of C to 3 decimal places.
5. Use the top edit control of the current value of # dialog box to change the value of # to 150. Press **[Enter]**. To 3 decimal places, write both the x - and y -coordinates of C . Remember that these values are the *cosine* and *sine* of $m\angle BAC$.
6. Change the value of # to 210 and press **[Enter]**. To 3 decimal places, write the *cosine* and *sine* of $m\angle BAC$.
7. Change the value of # to 330 and press **[Enter]**. To 3 decimal places, write the *cosine* and *sine* of $m\angle BAC$.
8. Click Anim and select Graph window. This should display a new window. In that new window, click Graph and select Inventory. Click on $[y]$ (C) to select it. Click new. Change steps to 721, low to -360 , and high to 360. Click ok. Then close the tracing inventory dialog box. Change the value of # to 45 and press **[Enter]**. The graph window should show a curve with a cursor shaped like a plus sign on the curve. This curve plots the value of $[y]$ (C). That is, it plots the *sine* of $m\angle BAC$. To place the cursor at a high point on the curve, change the value of # to 90 and press **[Enter]**. To 3 decimal places, what is the sine of $m\angle BAC$?
9. In the 2nd line of the current value of # dialog box is a “slider.” Click on the arrow to the *right* of the slider until the cursor is on the horizontal axis. To 3 decimal places, what is the sine of $m\angle BAC$?

Computer Activity – Linkage Introduction

1. Open the program *Winggeom*. If a tip shows, click close. Click Window. Check to make sure that there is a check beside Use defaults. Then select 2-dim. Click Point and select Coordinates. Click mark to label $A(0,0)$. Then change x to -4 and click mark to label $B(-4,0)$. Change x to 3.5 and click mark to label $C(3.5,0)$. Change x to -2 and click mark to label $D(-2,0)$. Click close. Press $\boxed{\text{Ctrl}} + \boxed{\text{A}}$ to make the axes disappear.
2. Click Circle and choose Radius-center. Draw the circle centered at B that passes through D . Then draw the circle centered at A that passes through C . **Do not click close.**
3. Click Point and choose on Circle. Change center-pt to BD and change coordinate to 360° . Click mark. Click close. Now draw the circle centered at E that has a radius of 3 . **Do not click close.**
4. Click Point. Choose Intersection. Then choose Circle-Circle. In the top box select center A ; through C and in the bottom box select center E ; through F . Click mark. Click close.
5. Now draw the circle centered at H that has a radius of 5 . Then draw the circle centered at C that has a radius of 2 . Click close.
6. Click Point. Choose Intersection. Then choose Circle-Circle. In the top box select center H ; through I and in the bottom box select center C ; through J . Click mark. Click close.
7. Click Edit. Choose Delete. Then choose Circle. Select center A ; through C and click delete. Select center E ; through F and click delete. Select center H ; through I and click delete. Select center C ; through J and click delete. Click close.
8. Click Edit. Choose Delete. Then choose Point. Type $DGF IJ$ and click ok.
9. Click Transf and choose Mirror. Change vertices to H and change in mirror to KL . Click draw. Click close. Then form \overline{BE} , \overline{EH} , \overline{HA} , \overline{HL} , \overline{HK} , \overline{KC} , \overline{LC} , $\overline{LH'}$, and $\overline{KH'}$.
10. Click Anim and select Tracing. Click new. Change pen on vertex to H' . Click ok. This should draw a vertical red segment through H' . Now close the tracing inventory dialog box. Click File and select Save As. Save using a name you will remember. This way you can recover your work if *Winggeom* crashes.
11. Click Anim and select # slider. *Never close this dialog box during this activity.* Click cycle and watch point E move around $\odot B$ as H' moves up and down on the red line segment. **While an animation is in progress, do not move the mouse.** If *Winggeom* crashes, check with your teacher about running it in compatibility mode for Windows XP (Service Pack 3). To stop the motion, press $\boxed{\text{Q}}$ on the keyboard. This design shows one way to create a mechanical linkage that uses pivoting rods to convert circular motion of E to back-and-forth linear motion of H' without using a sliding connection. A device of this type can also convert back-and-forth linear motion into circular motion.
12. If you haven't yet done so, press $\boxed{\text{Q}}$. Click Meas. Type 360° and press $\boxed{\text{Enter}}$. Type H' and press $\boxed{\text{Enter}}$. Type HK and press $\boxed{\text{Enter}}$. Type $H'K$ and press $\boxed{\text{Enter}}$. Press $\boxed{\text{Esc}}$. In the top edit control of the current value of # dialog box, type 0 and press $\boxed{\text{Enter}}$. The coordinates of H' should be near $(6.5, 1.69)$. In the 2nd line of the dialog box is a "slider." Click on the arrow to the *right* of the slider while watching the y -coordinate of H' . To two decimal places, what is the smallest value for the y -coordinate?
13. Continue to click on the arrow to the *right* of the slider while watching the y -coordinate of H' . To two decimal places, what is the largest value for the y -coordinate?
14. In the current value of # dialog box, click cycle. Observe that $HKH'L$ is always a parallelogram. What special type of parallelogram is $HKH'L$?
15. Observe that $HKCL$ is not a parallelogram. What special type of quadrilateral is $HKCL$?

Before exiting *Winggeom*, be sure to stop any animation by pressing $\boxed{\text{Q}}$.

Computer Activity – Linkage Surprise

1. Open the program *Wingeom*. If a tip shows, click close. Click Window. Check to make sure that there is a check beside Use defaults. Then select 2-dim. Click Point and select Coordinates. Click mark to label $A(0,0)$. Then change x to $-%$ and click mark to label $B(-%,0)$. Point B should be near $(-0.5, 0)$. Change x to $-%+\$$ and click mark to label $C(-%+\$,0)$. Point C should be near $(-0.2,0)$. Click close. Press **Ctrl**+**A** so the axes disappear.
2. Click Anim and select \$ slider. In the top edit control of the current value of \$ dialog box, type 3.5 and press **Enter**. **Do not close any slider dialog box.** Click Anim and select @ slider. In the top edit control of the current value of @ dialog box, type 3.6 and press **Enter**. Click Anim and select & slider. In the top edit control of the current value of & dialog box, type 4 and press **Enter**. Click Anim and select % slider. In the top edit control of the current value of % dialog box, type 4 and press **Enter**.
3. Click Circle and choose Radius-center. Draw the circle centered at B that passes through C . Then draw the circle centered at A that has a radius of @. **Do not click close.**
4. Click Point and choose on Circle. Change center-pt to BC and change coordinate to 360#. Click mark. Click close. Now draw the circle centered at E that has a radius of &. Click close.
5. Click Point. Choose Intersection. Then choose Circle-Circle. In the top box select center A ; through D and in the bottom box select center E ; through F . Click mark. Click close. Click Edit. Choose Delete. Then choose Circle. Select each circle and then click delete until all three circles are deleted from the diagram. Click close. Click Edit. Choose Delete. Then choose Point. Type CDFG and click ok.
6. Form \overline{BE} , \overline{EH} , and \overline{HA} . Click Point and choose on Segment. Change relative to segment to EH and change coordinate to ? and then click mark. Click close. Click Anim and select Tracing. Click new. Change pen on vertex to C. Click ok. This should draw a red curve through C . Now close the tracing inventory dialog box. Click File and select Save As. Save using a name you can remember.
7. Click Anim and select # slider. Click cycle and watch point E move in a circular path around B as C follows the path of the red curve. **Do not move the mouse during the animation.** If *Wingeom* crashes, check with your teacher about running it in compatibility mode for Windows XP (Service Pack 3). To stop the motion, press **Q** on the keyboard. This design shows a way to make a mechanical linkage consisting of only three rods such that a point on the middle rod traces out an intriguing path as another rod rotates with simple circular motion. Press **Q** if you haven't yet.
8. Click Meas. Type 360# and press **Enter**. Type <BEH and press **Enter**. Type C and press **Enter**. Press **Esc**.
9. In the top edit control of the current value of # dialog box, type 0.1 and press **Enter**. The display should show that $m\angle BEH \approx 20.7^\circ$. In the 2nd line of the dialog box is a "slider." Click the arrow to the *right* of the slider while watching the y -coordinate of C . To two decimal places, what is the y -coordinate of C when C is at its lowest point?
10. Click Anim and select ? slider. In the top edit control of the current value of ? dialog box, type 1.5 and press **Enter**. The bottom part of the resulting red curve is not drawn accurately because of how rapidly C travels that path. In the current value of # dialog box, click cycle and observe the motion of C as it travels completely around the red curve. To stop the motion, press **Q** on the keyboard. In the top edit control of the current value of # dialog box, type 0 and press **Enter**. The display should show $m\angle BEH \approx 145.3^\circ$. While watching the y -coordinate of C , click the arrow to the right of the slider. To one decimal place, what is the y -coordinate of C when C is at its highest point?
11. Change the value of \$ to 6 and press **Enter**. Change the value of @ to 7 and press **Enter**. Change the value of & to 8.9 and press **Enter**. Change the value of ? to 0.2 and press **Enter**. Change the value of # to 0 and press **Enter**. The red curve should be indented and C should be at the indented part of the curve. While observing $m\angle BEH$, click the *right* arrow in the current value of # dialog box. To the nearest degree, what is the smallest value of $m\angle BEH$?

Computer Activity – Rotating Rods

1. Open the program *Wingeom*. If a tip shows, click close. Click Window. Check to make sure that there is a check beside Use defaults. Then select 2-dim.
2. Click Point and select Coordinates. Click mark to label $A(0,0)$. Then change x to 2 and click mark to label $B(2,0)$. Click close. Press $\boxed{\text{Ctrl}} + \boxed{\text{A}}$ to make the axes disappear.
3. Form \overline{AB} . Click Line and choose Angles and choose New angles. Change angle size to $360\#$ and click draw. Do not click close. Click Point and choose on Segment. Change relative to segment to AC and change coordinate to $2/AC$ and then click mark. Do not click close.
4. Click Line and choose Perpendiculars and choose General. Change perpendicular to to YY and then click draw. This draws a line through D that is perpendicular to the y -axis. Click close. In the draw angle dialog box, change initial ray to DE and change angle size to $360\#@$. Click draw. Click close.
5. In the new point dialog box, change relative to segment to DF and change coordinate to $\$/DF$. Click mark. Click close. Click Line and choose Extensions. Type $AD \quad DG$ and click ok.
6. Click Edit and choose Delete and choose Line. Type $AB \quad DE$ and click ok. Click Edit and choose Delete and choose Point. Type $BCEF$ and click ok.
7. Click Anim and select Tracing. Click new. Change steps to 360, change high to 2, and change pen on vertex to G . Click ok. This should draw a red curve through G . Now close the tracing inventory dialog box. Click File and select Save As. Save using a name you can remember.
8. Click Anim and select # slider. In the top edit control of the current value of # dialog box, type 2 and press $\boxed{\text{Enter}}$. Click cycle and watch point G follow the path of the red curve. **Do not move the mouse during an animation.** Observe that \overline{DG} rotates half as fast as \overline{AD} . Press $\boxed{\text{Q}}$ on the keyboard to stop the animation. Do not close any “slider” dialog box.
9. To change the design, click Anim and select \$ slider. In the top edit control of the current value of \$ dialog box, type 2 and press $\boxed{\text{Enter}}$. Part of the red curve should now pass through point A . In the current value of # dialog box, click cycle. How does the length of \overline{DG} compare with AD ?
10. If an animation is in progress, press $\boxed{\text{Q}}$ to stop it. Click Meas. Type $360\#$ and press $\boxed{\text{Enter}}$. Type $360\#@$ and press $\boxed{\text{Enter}}$. Type G and press $\boxed{\text{Enter}}$. Press $\boxed{\text{Esc}}$. Change # to 0 and press $\boxed{\text{Enter}}$. Point G should be at $(4, 0)$. Observe that the red curve intersects itself. Click the arrow to the *right* of the # slider while watching D . Point D should twice pass through the point where the red curve intersects itself. The 1st time D is at the intersection, G should be at $(-2, 2)$. Write the coordinates of G the 2nd time that D is at the intersection point.
11. Click Anim and select @ slider. In the top edit control of the current value of @ dialog box, type 3.5 and press $\boxed{\text{Enter}}$. Change # to 0 and press $\boxed{\text{Enter}}$. Click the arrow to the *right* of the # slider while watching G . What is the value of $360\#$ the first time that point G is on point A ?
12. Change @ to -1 and press $\boxed{\text{Enter}}$. Change \$ to 1 and press $\boxed{\text{Enter}}$. The red curve should be an ellipse. Change # to 0 and press $\boxed{\text{Enter}}$. Click the arrow to the *right* of the # slider while watching G . Write the coordinates of G when it is farthest to the left.
13. Change @ to -4 and press $\boxed{\text{Enter}}$. As the segments rotate, point G passes through the midpoint of \overline{AD} . In the current value of # dialog box, click cycle. As \overline{AD} makes one complete rotation, how many times does G pass through the midpoint of \overline{AD} ?

Before exiting *Wingeom*, be sure to stop any animation by pressing $\boxed{\text{Q}}$.