GeoGebra – Lesson 6

Using GeoGebra – Vectors
Grids, Axes and the Drawing Pad

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Key Concepts from GeoGebra

1. View Axes
2. Snap-to-grid points
3. Draw 2 position vectors  .
4. Draw the parallelogram and the resultant (sum vector).
5. Changing the grid, axes, etc.
6. Some GeoGebra functions and labeling
7. Matrix notation with Latex

Key Concepts from Mathematics - parallelogram

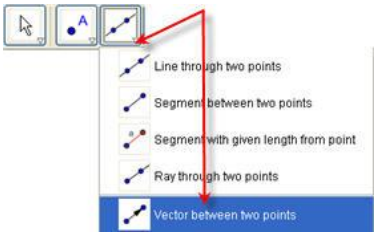
1. A *position vector* or *radius vector* is a vector that starts at the origin O so it is determined by the coordinates of its endpoint.
   For example: Let $\vec{u}$ be a position vector with endpoint P(2, -1).
   Then $\vec{u} = \overrightarrow{OP}$ and we can write $\vec{u} = 2\vec{i} - \vec{j}$ or in matrix form as: $\vec{u} = \begin{pmatrix} 2 \\ -1 \end{pmatrix}$.
   So, the general form for a position vector is then: $\vec{u} = u_x\vec{i} + u_y\vec{j} = \begin{pmatrix} u_x \\ u_y \end{pmatrix}$
2. Let $\vec{u}$ and $\vec{v}$ be position vectors. We want to find the *resultant* or *sum vector* $\vec{w} = \vec{u} + \vec{v}$. It will also be a position vector:
   $$\vec{w} = \vec{u} + \vec{v} = \begin{pmatrix} u_x \\ u_y \end{pmatrix} + \begin{pmatrix} v_x \\ v_y \end{pmatrix} = \begin{pmatrix} u_x + v_x \\ u_y + v_y \end{pmatrix}.$$
3. To draw the resultant, we first draw the vectors $\vec{u}$ and $\vec{v}$. We then draw the corresponding parallelogram using the techniques of lesson 1. The diagonal of this parallelogram is the resultant.

Script-o-matic

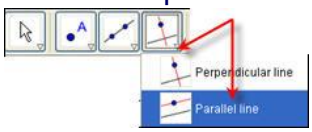
1. Turn on the axes: click on View -> *Axes* 

   The unit will be 1 on both the x and y axes.
   If you want, turn on the grid: click on View -> *Grid*.
2. Turn on snap-to-grid: click on Options -> *Point Capturing* -> On (Grid)

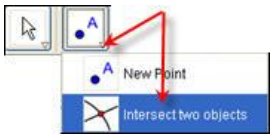
3. Draw 1 points at (0,0) -
   a. Click on  and then click at (0,0) – point A will be drawn. Notice that it is fixed (a dependent object)!
   b. Right-click and rename it O (the letter O - not zero).
4. Draw 2 points in the first quadrant – the points A and B.
   a. Notice that only points with whole number coefficients can be drawn. Try moving them you will see that they will only be allowed to 'land' on grid points.
   b. (I drew A 'above' B so that the determinant would be negative, but it doesn't matter since they are free objects.)
5. Draw vector
   a. Select vector tool:



   b. Then draw position vectors $\vec{u}$ and $\vec{v}$ by clicking on O and then on A and again on O and then on B.
6. Draw parallel lines 
   a. Select the parallel line tool:



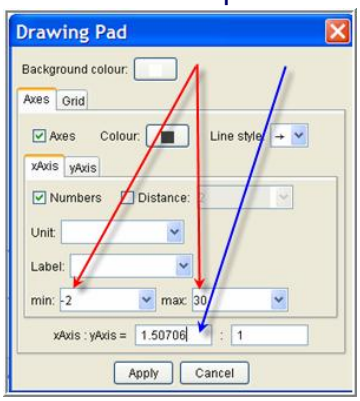
   b. Then click on $\vec{u}$ ($\overrightarrow{OA}$) and then on B to get the line parallel to $\vec{u}$ passing through B.
   c. Do the same for $\vec{v}$ ($\overrightarrow{OB}$) and A.

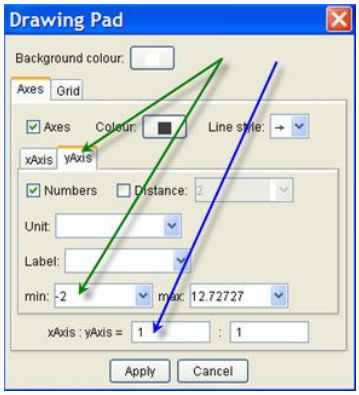
7. Draw intersecting point 
    a. Select the intersecting point tool:
    

    b. Click on one of the parallels and then on the other.
    c. A new point will appear - it will be named C.
8. Hide objects
    a. Double-click on one of the parallel lines (make sure the move tool is selected before clicking). The properties box will open. Deselect 'Show object' – the line will be hidden.
    b. Do the same for the other parallel line.
9. Select the line segment tool  and then draw line segments from A to C and from B to C.
10. Draw the resultant $\vec{w}$ vector
    a. Select vector tool: 
    b. Then draw position vectors $\vec{w}$ by clicking on O and then on C.
11. Move/Change labels
    a. Select the move tool: 
    b. Right-click on the letter A and select properties. Click on the arrow in the Show label and select Name & Value
    

    c. Do the same for B and C.
    d. Then click and drag each letter A,B,C 'outside' the parallelogram.
12. Change the colors/line styles of the $\overline{AC}$ and $\overline{BC}$ and of $\vec{w}$
    a. Right-click on the object and select properties.
    b. Change color by clicking on the blue rectangle and
    c. change line style by clicking on the arrow to see the choices.
13. Resize your window
    a. Click and drag any side of your window. Notice that it will always cut the axes from the bottom and from the right.
    b. Click and drag any corner to get say: ~700x630 (The reason for these dimension is in lesson 7). Probably you will have about -7 to 15 on the x-axis and -6 to 10 on the y-axis.
    c. Click Options -> *Drawing Pad*
    d. Type -2 for x-min and 30 for x-max (see figure below - red arrows) and then click in the left box of the xAxis: yAxis box (blue arrow).

This relationship will change.





e. Type 1 in this box
f. Click on yAxis tab and then enter -2 in the ymin box (green arrows).
g. Again, click in the left box of the xAxis: yAxis box (blue arrow) and enter 1. (You may have to go back and forth a couple of times to get -2,30 and -2, 12,7 and 1:1.)
h. Click on Apply

14. Finally, let's write the vector-matrix notation

a. To get $\vec{u} = \begin{pmatrix} a_x \\ a_y \end{pmatrix}$ (a_x and a_y will be the actual coordinates of A), click on ABC, select Latex formula and copy in the following text:
"\vec{ u } =\left(\begin{array}{c}" + (x(A)) + " \\ " + (y(A)) + " \\ \end{array} \right)"
Notice that x(A) is the GeoGebra formula for the x-coordinate of the point A! It is written (x(A)) in a Latex formula.
(The first time I did this I thought you had to define a variable in GeoGebra using the Input field, but then I saw you can just put the formula into another set of parentheses in the Latex formula.)

b. Repeat for $\vec{v}$ with B.

c. Finally, define a text $\vec{w}$ with the following text:
"\vec{ w }=\vec{ u }+\vec{ v } =\left(\begin{array}{c}" + (x(C)) + " \\ " + (y(C)) + " \\ \end{array} \right)"

15. If you want, label the vectors
I first drew line segments on top of the vectors, then found their midpoints (no midpoints of vectors possible…). Then I drew textboxes using latex - "\vec{ u }", 'connected' each textbox to the midpoints and then hid the segments and the midpoints.

16. You are done – save your file (we will need it for the next lesson).