Using AutoCad Graphics Software for Solving Problems in Statics for Engineering Technology

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Presenting a study that will create a way for students to enhance their understanding of problems in statics. The objective of this study is to help students solve problems in statics graphically and analytically simultaneously. This can be done with the help of AutoCad and the table command with capabilities of Excel Spreadsheet. The student when exposed to equations in statics would be able to visualize the calculations that are taking place, further enhancing their understanding of the field. If utilized, this simple concept could greatly increase the student's understanding of solving problems in statics and strength of materials on the computer.

The concept is quite simple; the student would first draw a string polygon and visualize the resultant force, as well as all the forces acting. The student can then enter the magnitudes and directions of each force in a table located on screen. As the student enters the required data, formulas similar to those in Excel Spreadsheet capabilities within the Table command will provide the student with all x and y components, as well as the resultant force and angle. This allows the student to understand the problem analytically via the table, and graphically via the AutoCad representation. In essence, the goal is to enhance the students understanding of statics by using modern design computer software. Computer technology is the wave of the future; it is in the student's best interest to familiarize themselves with this current technology.

Section 1:

When approaching problems in statics, various methods can be utilized. Two of these methods are done graphically while one is done analytically. The problem for many students is that they cannot grasp this concept as quickly as they are capable of. A very good way to solve this problem is to use the technology that we have at our disposal. Students, with the help of AutoCad, can greatly enhance their understanding of problems in statics.

CONSTRUCTION OF TWO FORCE COPLANAR SYSTEM ON AUTOCAD AND FINDING THE RESULTANT USING THE PARALLELOGRAM LAW AND THE ANALYTICAL METHOD

PROCEDURE:

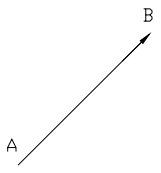
1. Start AutoCad
2. From startup dialog box pick **Use a Wizard**
3. Select **Quick Setup** and press **ok**
4. Pick **Decimal** under select the unit of measurement and press **Next**
5. Under width type **11.00** and **8.50** under length.(Scale 1in.=1lb)
6. Press **Finish**
7. Type **Z** enter
8. Type **All** enter
9. Create following layers using layer command

Name	Color	Line type	Line weight
Angle	White	Continuous	Default
DIM	White	Continuous	Default
F1	Red	Continuous	Default
F2	Blue	Continuous	Default
Resultant	Green	Continuous	Default

10. Create the following dimensioning styles using the Dimension style manager

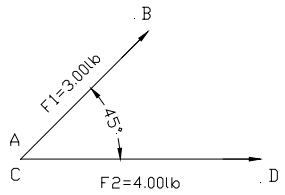
Name	Lines	Symbols and Arrows	Text	Primary Units
Angle DIM	Suppress DIM line 1 off Suppress DIM line 2 off Suppress EXT line 1 on Suppress EXT line 2 on	Arrow Size .180"	Text Height .180" Text Alignment: Dimension line	Unit Format: Decimal Precision: 0.00"
Force 1 DIM	Suppress DIM line 1 on Suppress DIM line 2 on Suppress EXT line 1 on Suppress EXT line 2 on	Arrow Size .180"	Text Height .180" Text Alignment: Dimension line	Unit Format: Decimal Precision: 0.00" Prefix: F1= Suffix: lbs.
Force 2 DIM	Suppress DIM line 1 on Suppress DIM line 2 on Suppress EXT line 1 on Suppress EXT line 2 on	Arrow Size .180"	Text Height .180" Text Alignment: Dimension line	Unit Format: Decimal Precision: 0.00" Prefix: F2= Suffix: lbs.
Resultant DIM	Suppress DIM line 1 on Suppress DIM line 2 on Suppress EXT line 1 on Suppress EXT line 2 on	Arrow Size .180"	Text Height .180" Text Alignment: Dimension line	Unit Format: Decimal Precision: 0.00" Prefix: R= Suffix: lbs.

11. Select **F1** layer from layer controls
12. Press **L** enter
13. Type **2.0,2.0** in response to Specify first point
14. Type **@3.0<45** enter
15. Press **Esc**
16. Click **Single line text** from the Draw pull down menu and label point **A** and **B**

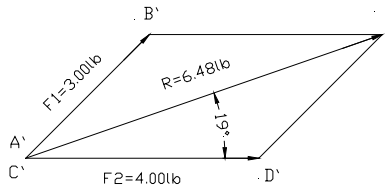


(Arrowheads can be added by using Quick Leader in dimensioning)

17. Select **F2** from layer controls
18. Press **L** enter
19. Type **2.0,2.0** in response to Specify first point
20. Type **@4<0** enter
21. Press **Esc**
22. Click **Single line text** from the Draw pull down menu and label point **C** and **D**



23. Show each force using appropriate layer and dimension style
24. Select Force **AB** and click **Copy**
25. For Specify base point type **2.0,2.0** enter
26. For Specify second point type **10.0,2.0** enter
27. Press **Esc**
28. Click **Single line text** from the Draw pull down menu and label point **A`**and **B`**
29. Select Force **CD** and click **Copy**
30. For Specify base point type 2**0,0** enter
31. For Specify second point type **8.0,0** enter
32. Press **Esc**
33. Click **Single line text** from the Draw pull down menu and label point **C`** and **D`**
34. Select Force **A`B`** and click **Copy**
35. For Specify base point click point **A`**
36. For Specify second point click point **D`**
37. Press **Esc**
38. Select Force **C`D`** and click **Copy**
39. For Specify base point click point **C`**
40. For Specify second point click point **B`**
41. Press **Esc**
42. Select **R** layer from layer controls
43. Press **L** enter
44. For Specify base point click point **A`**
45. For Specify second point click opposite corner
46. Show each force using appropriate layer and dimension style



47. Select **Table…** from Draw pull down menu and create the table by entering the following values. You can edit the table using the grip function in AutoCad to display the proper appearance

Columns	Column width	Data Rows	Row Height
7	2.0	3	1

48. Click **Ok**
49. For Specify insertion point type **2.0,8.0** enter
50. Fill out the table using the following format

Analytical Calculation				
	Magnitude (lb)	Direction	R=√F1²+F2²-2(F1 F2)cos45	Angle the resultant makes with the x axis arcsin(F1/R)sin(180-45)
F1				
F2				
R (lb)			SQRT(B3^2+B4^2+2*B3*B4*COS(C3))	asin((B3/D5)*sin(180-45))

51. Enter the Magnitude and Direction of F1 and F2 and activate the formulas in the table by putting "=" in front of each formula

Analytical Calculation				
	Magnitude (lb)	Direction	R=√F1²+F2²-2(F1 F2)cos45	Angle the resultant makes with the x axis arcsin(F1/R)sin(180-45)
F1	3	45		
F2	4	0		
R (lb)			6.48	19

The resultant of the two force coplanar system has been found to be 6.48 lb at an angle of 19°.

In addition to simple problems in statics, more complex problems can analyzed as well. In the next section, a five force coplanar system will be examined using the polygon rule.

Section 2:

CONSTRUCTION OF FIVE FORCE COPLANAR SYSTEM ON AUTOCAD AND FINDING THE RESULTANT USING THE POLYGON RULE AND THE ANALYTICAL METHOD

PROCEDURE:

1. Start AutoCad
2. From startup dialog box pick **Use a Wizard**
3. Select **Quick Setup** and press **ok**
4. Pick **Decimal** under select the unit of measurement and press **Next**
5. Under width type **110.00** and **85.00** under length.(Scale 1in. = 10 kips)
6. Press **Finish**
7. Type **Z** enter
8. Type **All** enter
9. Create following layers using layer command

Name	Color	Line type	Line weight
Angle	White	Continuous	Default
DIM	White	Continuous	Default
F1	Red	Continuous	Default
F2	Blue	Continuous	Default
F3	Magenta	Continuous	Default
F4	Cyan	Continuous	Default
F5	Yellow	Continuous	Default
Resultant	Green	Continuous	Default

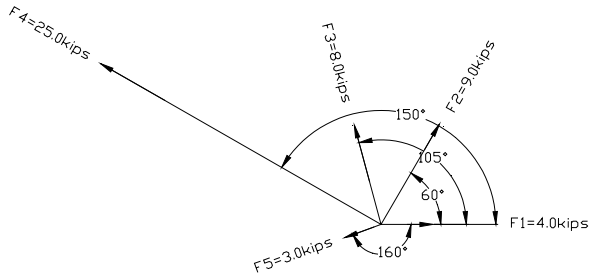
10. Create the following dimensioning styles using the Dimension style manager as shown on the next page

Name	Lines	Symbols and Arrows	Text	Primary Units
Angle DIM	Suppress DIM line 1 off Suppress DIM line 2 off Suppress EXT line 1 on Suppress EXT line 2 on	Arrow Size .180"	Text Height .180" Text Alignment: Dimension line	Unit Format: Decimal Precision: 0.00"
Force 1 DIM	Suppress DIM line 1 on	Arrow Size .180"	Text Height .180"	Unit Format: Decimal

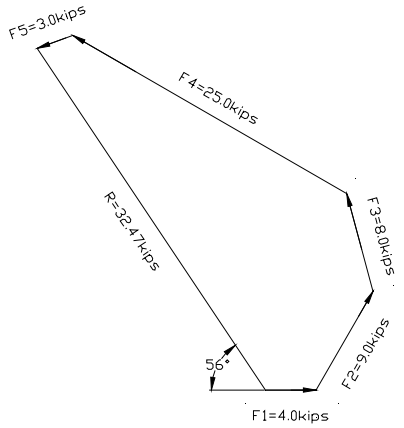
	Suppress DIM line 2 on Suppress EXT line 1 on Suppress EXT line 2 on		Text Alignment: Dimension line	Precision: 0.00" Prefix: F1= Suffix: kips
Force 2 DIM	Suppress DIM line 1 on Suppress DIM line 2 on Suppress EXT line 1 on Suppress EXT line 2 on	Arrow Size .180"	Text Height .180" Text Alignment: Dimension line	Unit Format: Decimal Precision: 0.00" Prefix: F2= Suffix: kips
Force 3 DIM	Suppress DIM line 1 on Suppress DIM line 2 on Suppress EXT line 1 on Suppress EXT line 2 on	Arrow Size .180"	Text Height .180" Text Alignment: Dimension line	Unit Format: Decimal Precision: 0.00" Prefix: F3= Suffix: kips
Force 4 DIM	Suppress DIM line 1 on Suppress DIM line 2 on Suppress EXT line 1 on Suppress EXT line 2 on	Arrow Size .180"	Text Height .180" Text Alignment: Dimension line	Unit Format: Decimal Precision: 0.00" Prefix: F4= Suffix: kips
Force 5 DIM	Suppress DIM line 1 on Suppress DIM line 2 on Suppress EXT line 1 on Suppress EXT line 2 on	Arrow Size .180"	Text Height .180" Text Alignment: Dimension line	Unit Format: Decimal Precision: 0.00" Prefix: F5= Suffix: kips
Resultant DIM	Suppress DIM line 1 on Suppress DIM line 2 on Suppress EXT line 1 on Suppress EXT line 2 on	Arrow Size .180"	Text Height .180" Text Alignment: Dimension line	Unit Format: Decimal Precision: 0.00" Prefix: R= Suffix: kips

11. Select **F1** layer from layer controls
12. Press **L** enter
13. Type **40.0, 22.0** in response to Specify first point
14. Type **@4.0<0** enter
15. Press **Esc**
16. Select **F2** layer from layer controls
17. Press **L** enter
18. Type **40.0, 22.0** in response to Specify first point
19. Type **@9.0<60** enter
20. Press **Esc**
21. Select **F3** layer from layer controls
22. Press **L** enter
23. Type **40.0, 22.0** in response to Specify first point
24. Type **@8.0<105** enter
25. Press **Esc**
26. Select **F4** layer from layer controls
27. Press **L** enter
28. Type **40.0, 22.0** in response to Specify first point
29. Type **@25.0<150** enter

30. Press **Esc**
31. Select **F5** layer from layer controls
32. Press **L** enter
33. Type **40.0, 22.0** in response to Specify first point
34. Type **@3.0<200** enter
35. Press **Esc**
36. Show each force using appropriate layer and dimension style



37. Select **F1** and click **Copy**
38. For Specify base point type **40.0,22.0** enter
39. For Specify second point type **80.0,12.0** enter
40. Press **Esc**
41. Select **F2** and click **Copy**
42. For Specify base point click on tail of **F2**
43. For Specify second point click on head of **F1`**
44. Press **Esc**
45. Select **F3** and click **Copy**
46. For Specify base point click on tail of **F3**
47. For Specify second point click on head of **F2`**
48. Press **Esc**
49. Select **F4** and click **Copy**
50. For Specify base point click on tail of **F4**
51. For Specify second point click on head of **F3`**
52. Press **Esc**
53. Select **F5** and click **Copy**
54. For Specify base point click on tail of **F5**
55. For Specify second point click on head of **F4`**
56. Press **Esc**
57. Select **R** layer from layer controls
58. Press **L** enter
59. For Specify base point click on tail of **F1`**
60. For Specify second point click on head of **F5`**
61. Show each force using appropriate layer and dimension style



62. Select **Table…** from Draw pull down menu and enter the following values. You can edit the table using the grip function in AutoCad to display the proper appearance

Columns	Column width	Data Rows	Row Height
7	10	6	1

63. Click **Ok**
64. For Specify insertion point type **22.0,80.0** enter
65. Fill out the table using the following formula

Analytical Analysis						
	Magnitude (kips)	Direction	x component =Fcos°	y component =Fsin°	R=√x²+y²	Angle made by the resultant with the X axis arctan(Ry/Rx)
F1			B3*cos(C3)	B3*sin(C3)		
F2			B4*cos(C4)	B4*sin(C4)		
F3			B5*cos(C5)	B5*sin(C5)		
F4			B6*cos(C6)	B6*sin(C6)		
F5			B7*cos(C7)	B7*sin(C7)		
R (kip)			Sum(D3:D7)	Sum(E3:E7)	SQRT((D8*D8) +(E8*E8))	atan(E8/D8)

66. Enter the Magnitude and Direction of F1, F2, F3, F4, and F5 and activate the formulas by entering a "=" in front of each formula

Analytical Analysis						
	Magnitude (kips)	Direction	x component =Fcos°	y component =Fsin°	R=√x²+y²	Angle made by the resultant with the X axis arctan(Ry/Rx)
F1	4	0	4.00	0.00		
F2	9	60	4.50	7.79		
F3	8	105	-2.07	7.73		
F4	25	150	-21.65	12.50		
F5	3	200	-2.82	-1.03		
R (kip)			-18.04	27.00	32.47	-56

The resultant of the five force coplanar system has been found to be 32.5 kips at an angle of 56.2° from the –x axis.

The use of computers in Engineering Technology must be expanded in order to take full advantage of all the sources available to the student. By graphically plotting forces, the student can visualize what is taking place. This used in conjunction with the analytical method is the basis for this study. The student will be able to plot the known forces graphically while also incorporating the formulas derived from the analytical method.

Using the table command functions that AutoCad provides will enable the student to incorporate all these methods into one single project. This is the power of using AutoCad to solve problems in statics. In addition to coplanar force systems, AutoCad can also aid in solving various other problems in statics and strength of materials. This subject will be expanded on in later studies.

References:

Cheng, Fa-Hwa. Statics and Strength of Materials. 2nd Edition. New York, New York: McGraw-Hill, 1997.