AC 2008-790: A SPREADSHEET TEMPLATE WITH SCALED GRAPH OPTIONS USEFUL FOR ENGINEERING CLASSES

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A Spreadsheet Template with Scaled Graph Options Useful for Engineering Classes

Abstract

This paper describes a spreadsheet template using Microsoft Office Excel® with scaled graph capabilities. This template permits the students organize their calculations and print-out and make scaled graphs, which are necessary for a better understanding of an engineering problem.

The template has two parts. The first part is prepared to make the necessary calculations with a format typically used in engineering offices. The second part permits scaled graphs useful to represent the problem and its solution. Both parts may be linked using the capabilities of Excel®.

When the student finishes an engineering problem using this template it is expected a calculation sheet with a professional presentation. However, the instructor must encourage that each step necessary for the calculation shall be clearly explained and documented.

A survey performed show the acceptation of the template by the students, and the adaptation of this tool to different subjects and for the workplace.

Introduction

The spreadsheet Microsoft Office Excel®[1] is a powerful tool that may be used to solve engineering problems, principally because it has a significant number of useful functions, it is user-friendly, and because it comes with the computer program Visual Basic for Applications (VBA), which may be used to create macros, functions or solve problems involving iterations, conditionals or loops. However, if the spreadsheet is not planned the output may be difficult to read and understand by others.

An ideal calculation spreadsheet must show the input, the references about the formulae, conclusive results, and a scaled graph showing the data and the results. The spreadsheet must be printed-out in an easy to read format with a professional presentation. It is an advantage for the students to use a template with these important characteristics, which will permit them to make interesting spreadsheets to solve engineering problems in a presentable manner.

Description of the Spreadsheet Template

The spreadsheet template presented in this paper has two important parts, the first is used for the calculations and the second one is used to make a scaled graph of the problem studied. This tool was developed with Excel-03 and tested successfully with the latest version, Excel-07.

The first part permits to make the necessary calculations to obtain a numerical answer, mainly using Excel® functions. Eventually, if the problem is more complex, the user may use VBA algorithms to solve it. The formatting of the spreadsheet is similar to a calculation sheet used in engineering offices, preparing students to make professional presentations.

Table 1 shows the setup used to create the template, which is presented in Figure 1. Additionally, a macro is created to fix the column width in any moment prior to the print-out. The user must check that all the input data and calculations are inside the print-out.

The instructor must encourage a proper description of the input data or partial results, correct reference of the formulae, and the presentation of results accompanied with respective comments or conclusions. If, at the end, the spreadsheet contains verified calculations, is self explained, and has a legible print-out, then the document may be used in the future with confidence, which is the base for professional calculations.

Table 1. Setup of the Calculation Sheet Template

Characteristic	**Value**
Font size	12
Column width	8.43
Row height	15
Insert page number at right bottom	Yes
Row 1	Name of 'Company'
Row 2	Made by, Date, Subject, Sheet #
Row 3	Check by, Date, Job #
Row 4	File name (="FILE: "&CELL("FILENAME",A1))
Row 5	Program name
Row 6	Blank
Row 1 to 6	Head for each page: Page setup/Rows to repeat at top: $1:$6
Margins	Top: 0.5
	Header: 0.5
	Bottom: 1.0
	Footer: 0.4
	Left: 0.75
	Right 0.4
Orientation	Portrait or Landscape
Saving as	NameOfTemplate.xlt (for templates)

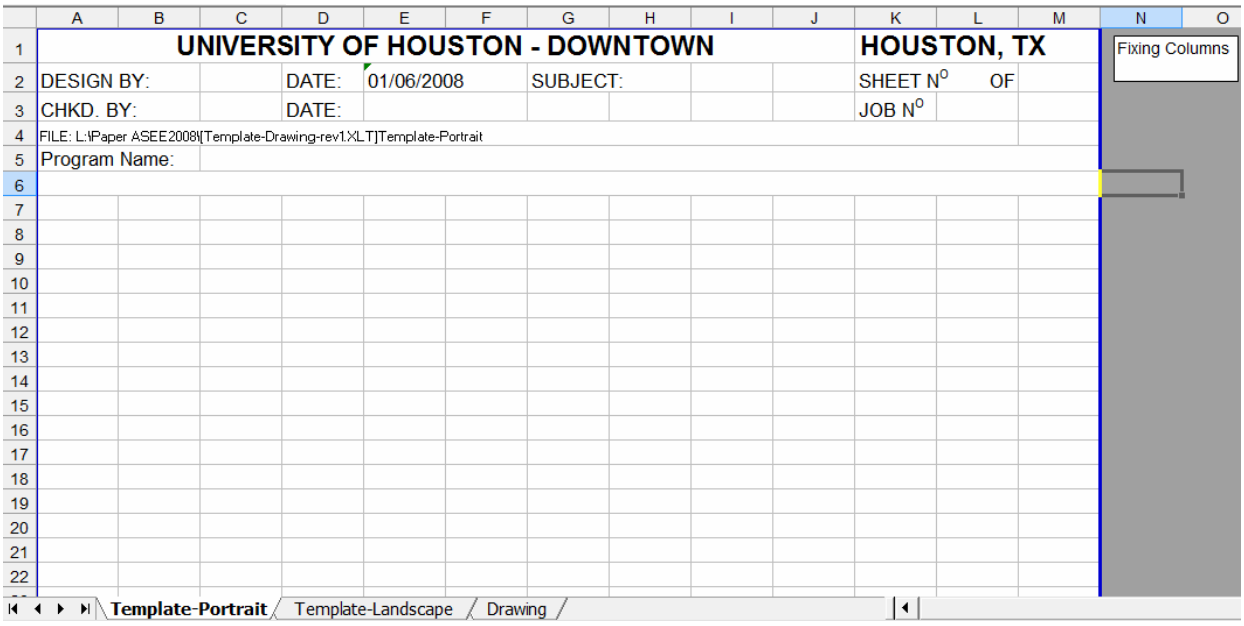


Figure 1. First part of the template showing the head and a macro to fix the column width.

The second part of the template facilitates the drawing of scaled graphs, permitting the representation of the problem and its solution. The student can import the information from the first part, select the appropriate scale and draw the location of nodes, lines, geometric figures, and text. Figure 2 shows the input data needed. The user must indicate the column and row of the bottom left corner of the drawing, define the paper size, and the scale wanted. The scale may be customized to the printer of the user with the adjustment factors.

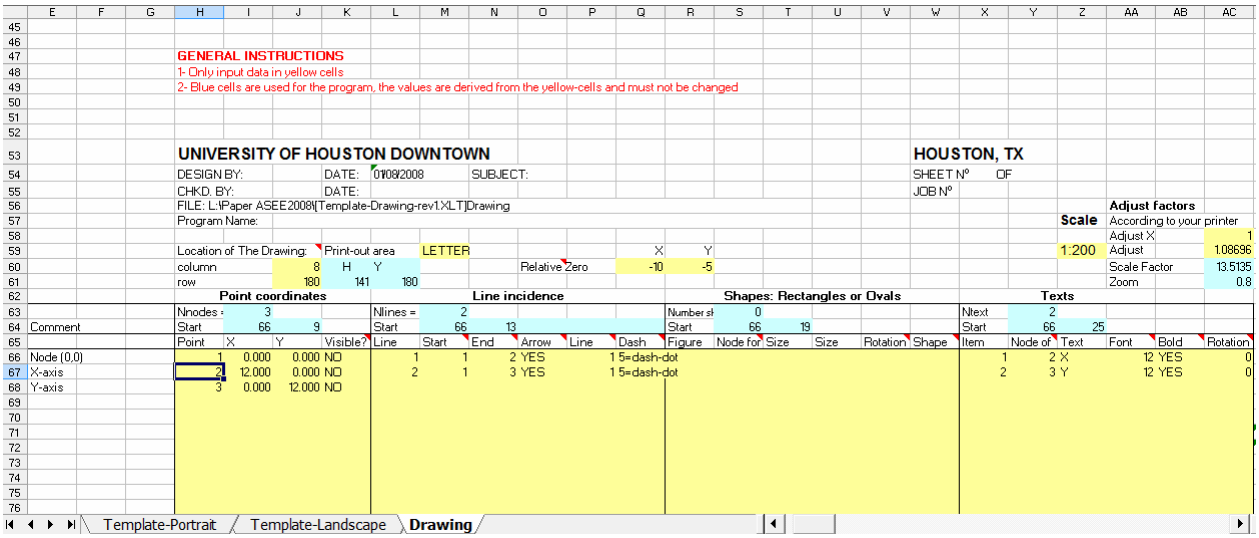


Figure 2. Second part of the template showing the data needed to make scaled graphs.

Each point or node is represented by its coordinates and there is an option to visualize the node. The lines are drawn using its incidence, which consist of the start and end node for each line. The lines may be drawn with arrow, different widths, and with different dash or solid styles. The shapes may be squares or ovals, their location is defined using the coordinates of the node located in the center of the figure, the size along both coordinates also shall be input, and the shape also may be rotated. The position of the texts is defined using a node located in the center of the text-box; the user can change the font-size, the bolding and its rotation.

The graph tools used in this spreadsheet are developed using VBA, following the methodology described by Tito[2]. Figure 3 shows the command buttons developed to make the drawings. The button 'Drafter' contains programming codes that permit the drawing of the nodes, lines, shapes and text in the area previously defined by the user. The button 'Delete Drawings' is useful to restart the drafting process. With the button 'Point Coordinates' the user can open an interactive screen to look the coordinates of any point.

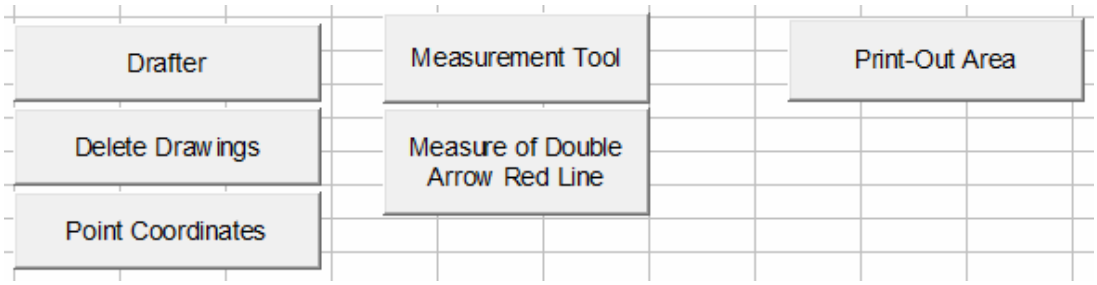


Figure 3. Command buttons used to make the scaled graph

The 'Measurement Tool' generates a double arrow red line which can be located in any position where the measurement is needed. Finally, the 'Print-Out Area' button permits the user to select the area to be printed, adjusting the cell size and deleting all the drawings inside. Figure 4 shows the graph area, by default the coordinate axes are shown, but the user can remove if it is not needed. The print-out permits the student to measure distances using the correct scale, and to visualize the problem with its answer.

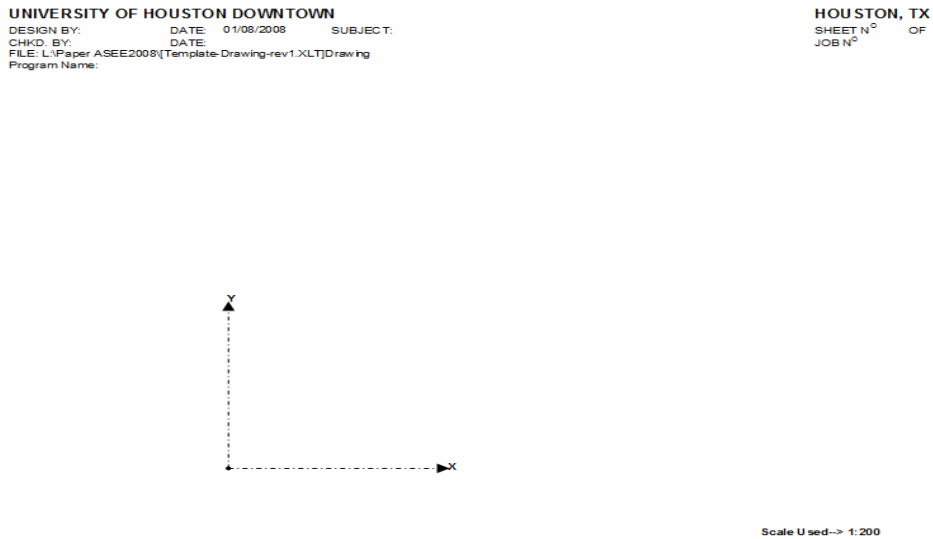
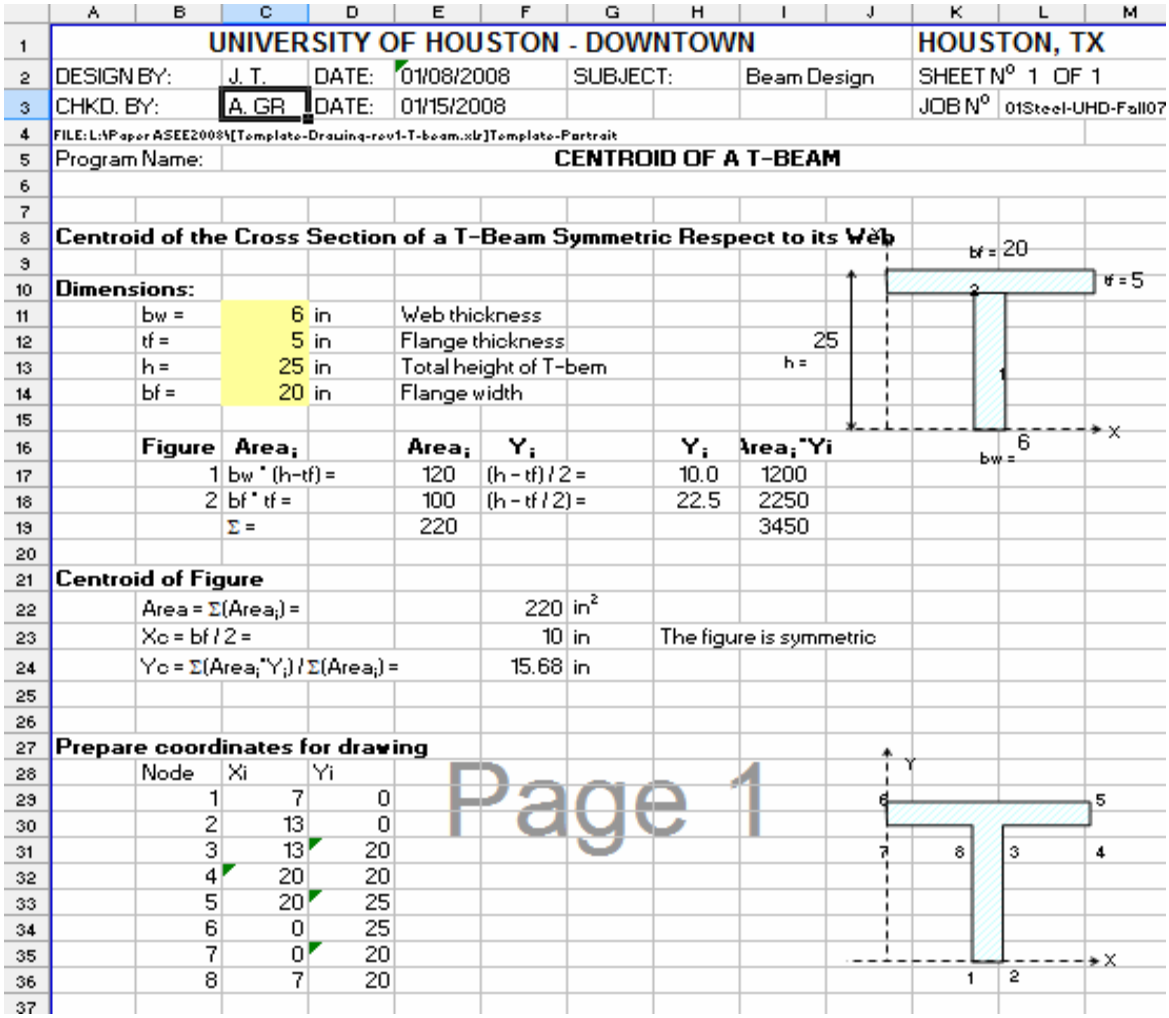


Figure 4. Print-out of the Template

Example using the template

The template may be used for different kinds of problems; one of these is the calculation of the centroid of a T-beam section, which is useful for beam design. The calculation is done using the formulae explained in the spreadsheet, as shown in Figure 5. It is important that the instructor emphasize in the importance of the description of each input parameter, the equations, and the results. The elaboration of non-scaled sketches helps for the understanding of the calculation process.



1	UNIVERSITY OF HOUSTON - DOWNTOWN										HOUSTON, TX		
2	DESIGN BY:	J. T.	DATE:	01/08/2008	SUBJECT:		Beam Design				SHEET N° 1 OF 1		
3	CHKD. BY:	A. GR	DATE:	01/15/2008							JOB N°	01Steel-UHD-Fall07	
4	FILE: L:\Paper ASEE2008\[Template-Drawing-rev1-T-beam.xls]Template-Portrait												
5	Program Name:					CENTROID OF A T-BEAM							
6													
7													
8	**Centroid of the Cross Section of a T-Beam Symmetric Respect to its Web**												
9													
10	**Dimensions:**												
11		bw =	6	in	Web thickness								
12		tf =	5	in	Flange thickness								
13		h =	25	in	Total height of T-bem								
14		bf =	20	in	Flange width								
15													
16		**Figure**	**Area$_i$**		**Area$_i$**	**Y$_i$**		**Y$_i$**	**Area$_i$*Yi**				
17		1	bw * (h-tf) =		120	(h - tf) / 2 =		10.0	1200				
18		2	bf * tf =		100	(h - tf / 2) =		22.5	2250				
19			Σ =		220				3450				
20													
21	**Centroid of Figure**												
22		Area = Σ(Area$_i$) =				220	in^2						
23		Xc = bf / 2 =				10	in	The figure is symmetric					
24		Yc = Σ(Area$_i$*Y$_i$) / Σ(Area$_i$) =				15.68	in						
25													
26													
27	**Prepare coordinates for drawing**												
28		Node	Xi	Yi									
29		1	7	0									
30		2	13	0									
31		3	13	20									
32		4	20	20									
33		5	20	25									
34		6	0	25									
35		7	0	20									
36		8	7	20									
37													

Figure 5. Centroid of a T-Beam. Input data, calculations and results

The results are shown in a scaled graph, as presented in Figure 6, in this way the student can see the problem and the solution graphically. Also, the print out of the entire problem is easy to perform, which improves the presentation, and facilitate the debugging of the spreadsheet.

UNIVERSITY OF HOUSTON DOWNTOWN HOUSTON, TX

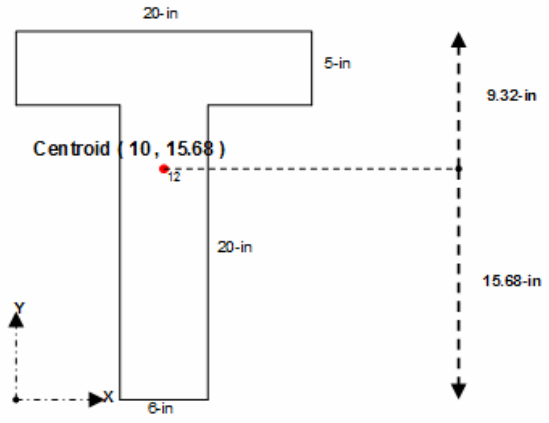
DESIGN BY: J. T. DATE: 01/08/2008 SUBJECT: Beam Design SHEET N° OF

CHKD. BY: A. GR DATE: 01/15/2008 JOB N° 01Steel-UHD-Fall0

FILE: L:\Paper ASEE2008\[Template-Drawing-rev1-T-beam.xls]Drawing

Program Name: CENTROID OF A T-BEAM

Centroid of the Cross Section of a T-Beam Symmetric Respect to its Web



Scale Used--> 1/8

Figure 6. Centroid of a T-Beam – Scaled graph showing the T-Beam and the results.

Acceptation of the template by the students

The students learn to work with the template quickly, principally because they can use all the Excel® capabilities, and because this template helps to organize their final presentation which may be improved with scaled graphs.

Table 2 shows a summary of a survey among students, which indicates that they are using the template in different subjects and also in their workplace. The graph option of the template may be used to explain the Cartesian coordinates, which is very important for their future academic and professional development.

Finally, the instructor may use the template to assign some homework, like improvements or customization for a specific problem.

Table 2. Survey between a group of 15 students about the template

In how many classes do you use of the template?	Why do you use of the template?	Improvements recommended to the template	About the graph option of the Template	Professional use of the template	Do you recommend of the Template to others?
7 students use in 1 class 5 students use in 5 classes 2 students use in 3 class 1 student use in 4 class	6 students because they need calculations and charts 4 students because it is easy to work 1 student because he needs graphs	3 students answered that the program need improvements	8 students answered that they used the graph option for other classes 2 students said that they have difficulties with the graph option, mainly because the x-y coordinates	6 students answered that they are using the template in their workplace	10 students answered that they recommend the template to others

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Conclusions

The Excel® spreadsheets are powerful tools that may be used to solve engineering problems. The students can improve their work presentation using a template where the print-out is formatted and that is able to make scaled drawings. The use of this template permits a better understanding of the problem studied, and the students are willing to use it for different classes and also in their workplace.

Bibliography

1. Microsoft Office Excel 2003. Part of Microsoft Office Professional Edition 2003. Microsoft Corporation.
2. Tito J., Gomez-Rivas A. "Use of spreadsheets with Scaled Graphics to Teach Structural Engineering". Proceeding of the 2006 American Society of Engineering Education, Annual Conference and Exposition. Honolulu, Hawaii, June 2007.