EML 3002L | **M.E. Tools Lab** | **09/29/15**
Mathcad only | *Van Dommelen* | *12:30-1:45 pm*

NO CELL PHONES. NO HEADPHONES/BUDS. NO CALCULATORS. You may only have a pen or pencil with you and use this exam sheet for scratch paper. ONLY MATHCAD AND ITS HELP MAY BE ACTIVE ON YOUR COMPUTER. REMAIN SEATED AT ALL TIMES. WE WILL PICK UP YOUR FINAL PRINT OUT.

FILE PATH AND NAME IN THE LEFT HEADER, YOUR NAME IN THE RIGHT HEADER. "PAGE N OF NN" IN THE CENTER FOOTER.

SAVE FREQUENTLY, AS 1, 2, 3, ... A CRASH IS NO EXCUSE FOR ANYTHING. SAVE BEFORE PRINTING/PREVIEWING!!! YOU MUST HAVE ENOUGH PRINT QUOTA.

After translation into mathematics, *only* Mathcad may be used to solve the full problem *as posed*. Use the appropriate procedures as covered in the lectures. Answers must be boxed.

1. (40%) The temperature distribution in a bar is described by the temperatures x_1, x_2, x_3, and x_4 at 4 equally spaced points along the bar. These temperatures satisfy the equations

$$\begin{aligned} x_1 - x_2 &= 0 \\ x_1 - 2x_2 + x_3 &= 1 \\ x_2 - 2x_3 + x_4 &= 1 \\ x_4 &= 0 \end{aligned}$$

   (a) Check whether these equations have a meaningful solution. If so, find it, if not, not.

   (b) Repeat, except replace the fourth equation by $-x_3 + x_4 = 0$. Make this change without recreating the entire matrix from scratch.

2. (20%)

   (a) Plot the two functions $\cos(x)$ and x^2 in the same graph from 0 to 2, y-axis from -1 to 2, title "Function Comparison". (If you have difficulties plotting, you may want to check whether what you are using as function variable already has a value.)

   (b) Now use the interval method to find the positive root x_1 where the two functions are equal. The values of the end points of the interval must be integers, and you must check the end point function values for acceptability. Explain why yours are acceptable.

3. (30%) Consider the following measured data on the elongation dl of a linear spring versus the force it supports:

dl_m in:	0.32	0.65	0.97	1.30	1.62	1.95	2.27	2.60
F_m lbf:	9	20	29	37	49	57	67	73

   (a) Use linear regression (least squares) to approximate the force-displacement relationship by a straight line function $F_\text{lr}(dl)$. This function must use the units in for dl and lbf for F.

   (b) Plot both the data, as circles, and the straight line representation, as a continuous line, in the same graph with axes from 0 to 80 lbf, respectively 0 to 3 in.

4. (10%) The density of a bar is given by

$$\rho = \left(2 + 3\frac{x}{\ell} + \frac{x^2}{\ell^2}\right)\rho_0 \qquad \ell = 5 \text{ in} \qquad \rho_0 = 4\,\frac{\text{lbm}}{\text{in}}$$

   Find the exact mass of the bar in lbm by *symbolically* integrating ρ over the length of the bar.