Engineering Study Session—Mathematics

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1. **Calculator Considerations:** According to the NCEES website, the list of allowed calculators is reviewed annually, and "The only calculator models acceptable for use during the 2018 exams are as follows.

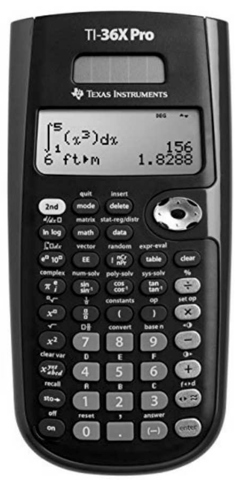
   - *Casio:* All fx-115 and fx-991 models. (Any Casio calculator must have "fx-115" or "fx-991" in its model name).
   - *Hewlett Packard:* The HP 33s and HP 35s models, but no others.
   - *Texas Instruments:* All TI-30X and TI-36X models. (Any Texas Instruments calculator must have "TI-30X" or "TI-36X" in its model name.)

   In response to student feedback, I am recommending that you take a serious look at the TI-36X calculator. It performs the following computations:

   - Vector Operations such as dot product, cross product, and norm of vectors.
   - Matrix Operations such as transpose, determinant, matrix arithmetic, and matrix inversion (for matrices that are 3×3 or less).
   - Numerical algorithms that will compute any definite integral and the derivative of any given function at a point and give the answer in decimal form.
   - Converting complex numbers between polar and rectangular form.
   - Solving systems of 2 linear equations in 2 unknowns.
   - Numerically solving quadratic and cubic equations.
   - Numerically solving any equation given an initial guess.

   In addition, you may view this TI-36X Pro Tips and Tricks for the FE Exam:

   https://www.prepfe.com/blog/2020/3/calculator-tips-and-tricks-for-the-fe-exam-ti-36x-pro



2. **Other Preliminary Considerations:** This is a multiple choice exam. A huge time saver on MC exams is, obviously, to *not* work certain problems. Rather, check the given choices to see which work. Also, if you forget some rules or identities, substitution can bail you out. Some examples from the FE Review Manual are:

   (a) Which value will satisfy the equation $\sin^2\theta + 4\sin\theta + 3 = 0$?

   Answer: Simply substitute the given values of θ to determine which gives an answer of 0.

   (b) Which of the following expressions are equivalent to $\csc\theta\cos^3\theta\tan\theta$?

Answer: Here, use a *non-standard* value of θ (i.e. not 0 or multiples of *pi*). Substitute that value of θ into the original expression and into each of the given expressions to determine which of them give the same output.

(c) What expression is equivalent to $\log\left(\frac{x}{y+z}\right)$?

Answer: Again, use "strange" values for x, y, and z; i.e. $x = 3$, $y = 7$, and $z = 5$. Substitute them into the expressions to determine which are equal. Of course, you don't want to use powers of 10, especially the number 1.

(d) What is the solution to the following system of equations:
$$\begin{aligned} 10x + 3y + 10z &= 5 \\ 8x - 2y + 9z &= 3 \\ 8x + y - 10z &= 7 \end{aligned}$$

Answer: Substitute the given values to see which ones satisfy *all* of the equations. Notice, however, that 5.10.5 asks you to find the inverse of a 3×3 matrix. You could multiply each matrix times the original to see which gives you the identity, but it is just as easy to use find the inverse directly on your calculator or use the adjoint to compute the inverse directly if the matrix is larger than a 3×3.

(e) Which of the following is a complete solution to the differential equation: $8y = e^{-2x} - 10y' - 2y''$, $y(0) = 1$, $y'(0) = -\frac{3}{2}$?

(A) $y = \frac{9}{4}e^{x} - \ln 2x$
(B) $y = \frac{9}{4}e^{x} - 2e^{4x}$
(C) $y = \frac{41}{108}e^{-x} - \frac{11}{108}e^{-4x} + \frac{1}{36}e^{-2x}$
(D) $y = e^{-x} + \frac{1}{4}e^{-4x} - \frac{1}{4}e^{-2x}$

Answer: Don't solve the DE and compare. (1) First, eliminate (A), (B), and (C) because they don't satisfy the initial conditions. (2) Second, if there were any choices left, substitute the function in for y, its derivative for y', and its second derivative for y'' into the DE to see if it works.

(f) **Integration:** Can't remember how to integrate a given function? Take the derivative of each of the possible answers to see which one matches. If none of them appear to match, because they are in a different form, substitute some strange value of x into each expression to see which gives you the same answer as the integrand. Alternatively, use your *TI=36X Pro* to find the integral and compare to the answers. If it is an indefinite integral $\left(\int f(x)\, dx\right)$, then evaluate it between two random points $\left(\int_{1.7}^{4.8} f(x)\, dx\right)$ and then check each M/C answer by evaluating and subtracting it (i.e. if one of the M/C answers is $4e^x - x^2$, then compute $(4e^x - x^2)|x = 4.8 - (4e^x - x^2,)|x = 1.7$ to see if it gives you the same answer.

3. **Missing Items from Formula Sheets:** according to the sample problems and the information given in each section, I noticed some deficiencies in the formula sheets. You may wish to commit the following items to memory so that you have them available to you.

- **Page 26-27, Parabola:** note that the distance from the center (or vertex) to the directrix is $\frac{p}{2}$.
- **Page 23, Polar Coordinates:** note that $\theta = \arctan\left(\frac{y}{x}\right) + \pi$ (or $+180°$) IF your x-coordinate is negative.
- **Page 23, Algebraic of Complex Numbers, Roots:** note that if a complex number is given in polar form, then taking the n^{th} root of it amounts to (1) taking the n^{th} root of the radius and (2) dividing the angle by n.
- **Page 34, Inverse of a Matrix:** It says that the inverse of a matrix is $A^{-1} = \frac{adj(A)}{|A|}$. Remember that $adj(A)$ is simply the transpose of the cofactor matrix. It says this in so many words, but their phrasing could be confusing.
- **Page 35, Matrix Identities:** The triple scalar product of three vectors, $A \cdot (B \times C)$ gives the volume of the parallelopiped determined by those three vectors. There is a sample problem to this effect, but the formula is not given on the sheet.
- **Page 34, Laplace Transforms:** When using these to solve linear DEs, remember that $\mathcal{L}[y'] = s\mathcal{L}[y] - y(0)$ and $\mathcal{L}[y''] = s^2\mathcal{L}[y] - s \cdot y(0) - y'(0)$.