ABSTRACT
The recent spate of the popular, original TV series CSI (Crime Scene Investigations) television series has spawned similar series entitled CSI- Miami and CSI-New York. The reasons can vary but most critics cite the exposure to the audience of the expert use of very sophisticated investigative tools: from advanced computers, to fingerprint comparatives to mass spectrometers and the ability to derive logical solutions to crime-related problems. The reality is that these T.V. programs exhibit the talents of intelligent, technically adept staff using state-of-the-art technical tools. No advanced theories or indebt research need be considered here; the solution to the problem-at-hand lies in the experienced use of tools-of-the-trade and the inherent intelligence of the user. But isn’t this a description of the charter for Engineering Technology programs and the students who we teach?

This paper describes the use of the CSI\textsuperscript{1}-type plots to appeal to and attract the engineering technology students to the excitement that awaits them if they have the ability to solve a real-life engineering problem, taken directly from the recent news accounts, and using engineering technology to help solve the problem. The student is thus witnessing the power of the engineering technology to solve ‘real-world’ problems even as they are being entertained.

Introduction
Consider the following common questions from less than enthusiastic students: “When will I use this information?” or “Will this be on the test?”

We have all heard these questions before. Usually it is more evident in the freshmen classes where the high school years have not been shaken off by the engineering student. Both of these questions are routinely asked of students who may not be exactly thrilled over the long and difficult learning that must precede their ability to use the engineering technology that is being taught.

\textsuperscript{1} CSI in this conference paper is an anagram for Case Study Instruction as it may be used in the instruction of Engineering Technology students in a variety of engineering technology subjects
Any Instructor who has been teaching for a little while realizes sooner or later that a good instructor must keep the information interesting and current as well as, let’s face it, deliver that information with some level of entertainment. It is also this author’s experience that the instruction of any engineering technology subject is benefited by the Instructor having something new and original in each course that is taught. This later requirement sometimes takes considerable discipline; for there is always something else that seems to require the Instructor’s undivided attention and thus keeps competing with curriculum development.

In short the old adage of learning the 3-R’s is still in vogue for the student but there’s another new adage that this author is suggesting may be worth considering for Instructors in engineering technology—the 3E’s: 

Entertain, Enliven and Educate.

But now consider the following vignettes that have been gleaned from newspaper articles during the last several months preceding the preparation of this paper. In their reading, the reader should ask him/herself if these vignettes are interesting, current, their solution relevant to applied engineering technology and perhaps somewhat entertaining? Do the solutions of these problems help to contribute to the empowerment of the student who successfully solves each problem? Do they force the student to derive and state assumptions regarding the problem and require that assumed values for some of the unknown parameters be provided; values that textbook author would typically provide? This later requirement of the student is one of the major benefits of utilizing this technique in the instruction of the engineering technology student for it has been observed that the “shy” engineering novice will be stymied in his/her solution when parameters are not very well specified by the author or the instructor. The lesson that is learned in these CSI applications is that the experienced engineer or engineering student must come to the problem with a boldness that will enable the student to assume certain values of unknown parameters. Certainly these assumptions are to be checked against the “reality” of the problem before the student/engineer accepts the derived answer.²

Some CSI-type vignettes: A “real-world” application of engineering technology

Case Study Instruction in Heat Transfer #1 (i.e. CSI-Heat Transfer #1): The Ice Man Cometh... with Some Heat Transfer Knowledge

A public relations article by a master magician Mr. David Blaine is found in the newspaper promoting his most recent stunt. The stunt involves being sealed in a tomb of ice while standing, motionless for over 61 hours. Mr. Blaine was dressed only in khakis slacks, a sweater and boots. There is an opening in the ice for a catheter and for the admission of air for breathing and an occasional drink of water... contrary to the old adage about bringing “coals to Newcastle”. After the world-record setting time in this solitary tomb, the magician is removed. Although physically exhausted the magician appears otherwise unharmed despite his 61 hour ordeal. He cites his unique talent for bringing his body into a state of virtual suspended animation as the reason for his survival.

² These Case Study stories have been paraphrased by the author to make them concise and hopefully a bit more entertaining and informative than the original “journalistic” rendition.
in the freezing temperature. Mr. Blaine’s colleagues (i.e. competitor magicians) claim that, on the contrary, the stunt reveals no “magical” talent …after all what’s an igloo but a spherical ice chamber and you don’t see Eskimos on live T.V. touting suspended animation.

Question: What is the actual temperature inside the ice tomb during this stunt? List all assumptions.

Case Study Instruction (CSI) in Heat Transfer # 2: Road Rage with a Coffee to Go.
The inevitable Boston traffic jam was now over 25 minute long for the driver. His impatience was only slightly tempered by the coffee that he purchased shortly before finding himself in the traffic jam. However, his impatience was being stoked by the driver of the car in front of him who, in a manner that made that driver look polite, was allowing vehicles to cut-into the coffee drinker’s lane. Apparently, there were many drivers who didn’t understand the wording on the sign: “Road Work In Progress-Merge Left” until the right lane disappeared. After 25 minutes of slow and stalled traffic and with the polite driver continuing to add to the frustration of the coffee drinker, the coffee drinking driver has had enough. With just enough room to maneuver out of the lane and position himself along side the “good Samaritan”, he not-so-politely offers the Samaritan a suggestion that is quite offending and when mocked, throws his partially consumed coffee through the now open window of the polite driver and succeeds in dampening the spirits of the Samaritan driver. The good Samaritan driver is more than shocked by this assault and is reported to need the services of an Emergency Room; this according to the police officer who is quickly called to the scene of the road rage incident. The morning papers indicate that the coffee drinker has been arrested for assault with a weapon: a hot cup of coffee and is awaiting charges as well as a possible civil suit for the physical harm suffered by the victim.

Question: Estimate the temperature of the “hot” cup of coffee that has been reported to have harmed the driver. Is it hot enough to cause the reported harm to the driver? List all assumptions.

CSI-Dynamics #1: New Jersey Boasts Its Fastest and Tallest Roller Coaster
A news item in the Boston Globe (Sept 29, 2004) comes at a perfect time for use in the author’s instruction of Dynamics. A new roller coaster has been commissioned for the Six Flags Great Adventure Park in Jackson, N.J. The new roller coaster can accelerate the cars to 128 miles per hour in 3.5 seconds. Its highest point in the ride is 456 ft off the ground. At one point in the ride, the coaster cars will spin 270 degrees as it falls from the highest point before reaching its lowest point and then rapidly accelerates to a height of 129 ft which the designers say will make the riders “…feel weightless”.

Question: What is the acceleration of the car as it reaches its top speed? What is the minimum radius of curvature for the track required to make the rider feel weightless? What are the g-forces that the rider will feel at the bottom of the track during the ride?
What would be the trajectory should the coaster car be accidentally “launched” from the 129 ft. high point? List all assumptions.

CSI-Dynamics/Stress Analysis³: A Simple Pendulum in Name Only

Apparently a new X-treme sport for some engineering and non-engineering enthusiasts alike is swinging from very, very tall towers. Not satisfied with the typical tree swing, five world-record pendulum swingers decide to swing from the towers of the Tampa Bay Bridge. Using a 180 ft. steel cable with a tensile strength of 1,800 lbs, the five friends (combined weight of approximately 900 lbf) swing together having first taken care to make the pendulum cable taut (no sudden impact cable failure for these smart, intrepid “fliers”). Unfortunately the cable does break if not as expected by the swingers then as expected by physics and some stress analysis that may have been applied by any of the engineering technology students who should have been consulted.

Question: At what angle does the 180 ft. steel cable exceed its maximum allowable tensile strength? How many engineering technology students were among the swingers? List all assumptions.

CSI-Stress Analysis: No Longer an Amusement Ride

The consequences of a failure in a seemingly simple engineered mechanical element can be disastrous. A newspaper account of one such fatal accident appeared in the Boston Globe on September 21, 2004. A carnival ride caused the death of a rider when a “simple” bolt was found to have failed during the ride. The ride consists of a series of spins and twirls at high speed and the riders are constrained by lap and shoulder restraints. An investigation of the remnants of the damaged carriage indicated that an undersized bolt had been used during the recent on-site assembly of the carriage to the powered arms of the ride.

Question: What were the forces exerted on the mechanical assembly during the ride and what size bolt should have been used? List all assumptions including your assumption for a Safety Factor for this ride.

The Proposed CSI Pedagogy

The proper method of presenting the solutions to CSIs such as these is as critical as the relevance of the CSIs themselves to the engineering curriculum that is to be taught. This author proposes the following methodology as appropriate for engineering students and consistent with the typical engineering solutions methodology used to solve the more routine “end of the chapter problems”. A solution to CSI-Heat Transfer #1 will be used as a worked example of the methodology.

³ This vignette is taken from a very interesting book by Mark Eberhart (Why Things Break—Understanding the World by the Way it Comes Apart", Three Rivers Press; page 126) who uses a news item in a similar manner- to entertain, enliven and educate the reader as well as, no doubt, his students. Note: fortunately no fatalities were caused by this error in judgment and applied engineering technology.
1. Draw an engineering diagram that schematically covers all of the relevant information contained in the worded problem. For the solution of CSI-Heat Transfer #1, the author has chosen to use a spreadsheet platform for its solution. The drawing does not need to be artistic but certainly complete with any known and/or assumed parameter values given as shown in figure 1.

![Diagram](image_url)

Figure 1. Spreadsheet sketch of CSI-Heat Transfer #1 problem. Values in the bold boxed cells are known or assumed values.

2. Label this engineering diagram with all of the known and unknown parameters as may be determined and/or inferred from the problem statement. For the example shown in figure 1, the values for the known and/or assumed system parameters are placed in bold boxes. All other parameters have been calculated.

3. State all assumptions that pertain to the problem. This is a major procedural step in the solution process and one of the main purposes of using the CSI pedagogy. While most “end of the chapter problems” also require that all assumptions be stated clearly, the CSI problems do not come with clear nor often complete definitions of all of the parameters that are “in-play” with the solution to the problem. On the contrary, the CSI problems require that the practitioner assume quite a bit more than may normally be required or available in a textbook-type problem. But this is a good thing; despite the initial confusion and apprehension of the student! This author is known by his students to frequently espouse the
engineering reality that: “Engineers live and die by their assumptions”. This is not a warning but rather an encouragement to have the student make assumptions that are practical and that can be tested by applying a “reality check” to the resulting answer. An assumption for a value of a parameter that is otherwise not given may be absolutely necessary to attain an answer. It is certainly a means of allowing the student’s solution to “flow” unimpeded toward a solution rather than wait for the number of unknowns in the problem to match the number of available equations. In this example, it is assumed that the man’s body is liberating energy at a rate of 2,100 (dietary) calories per day or 350 btu/hr and that the specific heat of the body is 1.2 Btu/Lbm/F. The heat transfer convection coefficients are also assumed to have the values shown. Finally, and probably most important, it is assumed that the air passage openings do not allow warm air to enter the ice tomb and maintain the interior temperatures to a comfortable level.

4. Set up the appropriate physical equations that must be used to solve for the unknown parameter(s). The equations stem from all of the physical laws available to the engineer/student: Laws of Thermodynamics (particularly the Conservation of Energy), Newton’s Laws (including laws of static equilibrium, conservation of linear and angular momentum), Maxwell’s Laws, etc. For this problem, the First law of thermodynamics is used together with the equations for convection and radiation heat transfer to and from the body and through the walls of the ice chamber. The heat transfer network is shown at the top of figure 1.

5. Present the answer in a graphical format such as shown in figure 2. This format helps the practitioner as well as his/her audience more thoroughly understand the problem particularly if the assumptions used in step 3 required the introduction of an assumed parameter(s),

6. Check the reality of the solution by applying the well known Reality or Sanity Check to the answer(s). This is a major part of the solution but also a major part
of the education of an engineering student; requiring the student to step-back and look at the answer for any unreasonableness in the magnitude or sign-sense. It not only is necessary for the ultimate qualification of the answer but also gives evidence of the maturing of the engineering student into an experienced engineering practitioner. For this example, an air temperature of 50 F was calculated. This temperature, although uncomfortable, certainly can be survived by a healthy person for 61 hours. More interesting perhaps is the use of the programmed spreadsheet to quickly calculate the answers to some ‘extreme’ limits that may be assumed if only for the sake of verifying whether the answers to these extended limits are reasonable. For example, if the ice chamber volume is reduced, an interior temperature of 55 F is calculated. If in addition to this change, it is assumed that the body heat does not heat the interior air via respiration, then the interior air temperature is reduced to 47 F.

7. One last step; one that the author requires of all soon to be graduate engineers…eliminate all unnecessary decimal points in the answer! The engineering student must realize the accuracy to which the solution to the problem must agree. The advent of the spreadsheet is no reason why 5 or six decimal places should be displayed. All of the answers shown above are properly given without any decimal points given the accuracy of the model.

The solution of these CSIs is important but for this paper the solutions are not as important as the suggested pedagogy that they represent. The solutions to these problems are not difficult for the reader who is also likely to be an interested and hopefully a sympathetic instructor. The author suggests that the continued use of such real world engineering applications in the instruction of every engineering technology student will provide that student with relevant and current engineering examples. The result is an instruction that is entertaining for the student who has been enlivened while educated with the engineering principals that must be learned. What’s more? You the Instructor can not only entertain and enliven the class-room experience for the student but also be entertained and enlivened by the variety of news items that frequently abound with vignettes such as those noted in this paper. In both instances the self efficacy of the practitioner (the student as well as the Instructor) is increased. Perhaps the qualitative results of this pedagogy can be measured by the absence of that refrain: “Where am I going to use this information again?”

This pedagogy has an even more subtle result. Assuming that the student is requested by the Instructor to find one or two similar CSIs and brings them to class; the student is forced to peruse the local newspapers, magazines and professional journals for new and relevant material. This begins to have the student actually keep informed of local and maybe national events as it may affect not only their citizenship but also their career choice. By having the student review “outside” material even the young (freshman and sophomore) student begins to appreciate the need for an awareness of events outside their academic community. While it may seem unnecessary to resort to such practices to keep engineering students fully aware of engineering developments if not applications around them, this author has found it essential to do so. For it has been long recognized that the
level of engineering work required of an engineering student often supplants any extra curricula activity, even activity related to engineering interests.

Conclusion
This author has used the CSI pedagogy to some success in a variety of classrooms. The students usually immediately recognize the reference and welcome the opportunity to see real-world examples solved by the Instructor. The students also seem to find it even more interesting to have the Instructor try to extemporaneously solve a CSI-type problem that is brought into the classroom by a student. For example, consider the following.

CSI-Stress Analysis: Boston Red Sox World Series Victory Celebration
The recent World Series Victory by the Boston Red Sox caused several students to be late to the 9:15 am class the next morning. One such victim of the Series victory suggested that he was late having investigated the stress analysis of the metal straps that hold-up a Huntington Ave sign on the sign post. The sign is approximately 1 ½ feet long and attempted to hold a 165 lbm “object” with point loads at the 1 ft and 1 ½ ft marks. The two straps were measured to each have a cross section of 0.75” x 0.125” (thick).

Question: Should the sign have failed? Note: The fact that the student has the sign in the classroom is not to be considered in the formation of the analysis.

Biography:
Francis A. Di Bella, P.Eng. is an Assistant Professor, Northeastern University, Boston, MA.; College of Engineering, School of Engineering Technology. Mr. Di Bella’s professional engineering research interests involve the practical, engineering applications of Thermo-fluid and Machine Design sciences within the Mechanical Engineering discipline.

Specific areas of interest include all aspects of energy systems including generation, storage, conservation and a variety of innovative applications of renewable energy including thermal air chimney integrated with solar energy, wind turbines integrated with ocean wave power generating systems, classical solar and hydropower as well as advanced hybrid vehicles using turbo charger-generator concepts to improve range or increase load. All of these interests are exhibited in course instruction in heat transfer, thermodynamics, fluid dynamics via the case study methodology.

Prof. Di Bella is also involved in all aspects of creative product concept genesis, design and product development. Product development extends the gamut from systems to prevent Road Rage to emergency repair of ruptured natural gas pipelines. University application of this interest includes instruction in the following courses: Machine Design, Statics and Dynamics, Intro. to Design and Intro. to Product Design as well as student Capstone Design Projects. He is also the Faculty Advisor for the Student’s Mini-Baja vehicle competition. He and his colleagues have instituted a Capstone Senior Design Project course for engineering technology students that includes an integrated group of Computer, Electrical and Mechanical Engineering Technology students. He has also structured an Intro. to Product Design course for non-engineering majors as part of the University’s new School of Technological Entrepreneurship.

In 2002 Prof. Di Bella was awarded the University wide Excellence in Teaching Award for his innovative contributions to the teaching of engineering students. He was awarded the College of Engineering Excellence in Teaching Award in 2004.