PROBLEM SOLVING

Practice of engineering involves the application of accumulated knowledge and experience.
A professional engineer is expected to approach, analyze, and solve a range of technical problems intelligently and efficiently. Problems can vary from single-solution, simple problem to extremely complex, open- ended problems tha require a multidisciplinary team of engineers.

A distinguishing characteristic of a qualified engineer is the ability to solve technical problems. Mastery of problem solving involves a combination of art and science. By *science* we mean the knowledge of the principles of mathematics, chemistry, physics, mechanics, and other technical subjects that must be learned so that they can be applied correctly. By *art* we mean the proper judgment, experience, common sense, and know-how that must be used to reduce a real-life problem to such a form that science can be applied to its solution. To know when and how rigorously science should be applied and whether the resulting answer reasonably satisfies the original problem is an art.

Skill, intelligence

- Much of the ability of successful problem solving comes from formal education in school or from continuing education after graduation.
- But most of the art of problem solving cannot be learned in a formal course; it is a result of intelligence, which comes from birth, common sense, and experience. However, systematic approach in a logical and organized method can make problem solving more effective

Before the solution to any problem is undertaken, whether by a student or a practicing professional engineer, a number of important ideas must be considered. Think about the following questions: How important is the answer to a given problem? Would a rough, preliminary estimate be satisfactory, or is a high degree of accuracy demanded? How much time do you have and what resources are at your disposal? In an actual situation, your answers may depend on the amount of data available or the amount that must be collected, the sophistication of equipment that must be used, the accuracy of the data, the number of people available to assist, and many other factors. Most complex problems require some level of computer support such as a spreadsheet or a math analysis program. What about the theory you intend to use? Is it state of the art? Is it valid for this particular application? Do you currently understand the theory, or must time be allocated for review and learning? Can you make assumptions that simplify without sacrificing needed accuracy? Are other assumptions valid and applicable?

The engineering method for problem solving

- It consists of six basic steps:

1. *Recognize and understand the problem (most difficult part)*
2. *Accumulate data and verify accuracy (all related data; such as size, temperature, electrical characteristics, physical and mechanical properties ...find some others by calculating or substituding. Deal only with items that can be verified)*
3. *Select the appropriate theory or principle*
4. *Make necessary assumption (If solution to real problem does not exist then simplifications can make the problem solvable)*
5. *Solve the problem (Mathematical model (equation/ s are to be solved, preferable using analytical method, i.e. İntegration. If analytical method is not applicable use numerical method; finite element, finite volume methods. If number of unknowns is greater than the number of equations then use trial and error method (writing a software a computer is used, or making some experiments try to decrease unknows, or use some form of graphical solutions) Result is to be shown with appropriate significant digits*
6. *Verify and check results (Ensure that solution is mathematically correct and that units have been correctly specified. **Check if the answer is reasonable**.*

Presentation of Problem Solving

Engineers should follow the steps parallel to the steps of problem solving in representing/documenting the solution:

1. *Problem statement:* Statement should be a summary of the given information, clearly state what is to be determined by using which data

2. *Diagram:* Draw a diagram; free-body diagram, schematic drawing...

3. *Theory:* Equations, governing equation...Mathematical model

4. *Assumptions:* Explicitly list assumptions..

5. *Solution Steps:* Show completely all steps taken in obtaining the solution...

6. *Identify results and verify accuracy:* Clearly identify (double underline) the final answer. Do not forget to write the units. Check solution accuracy

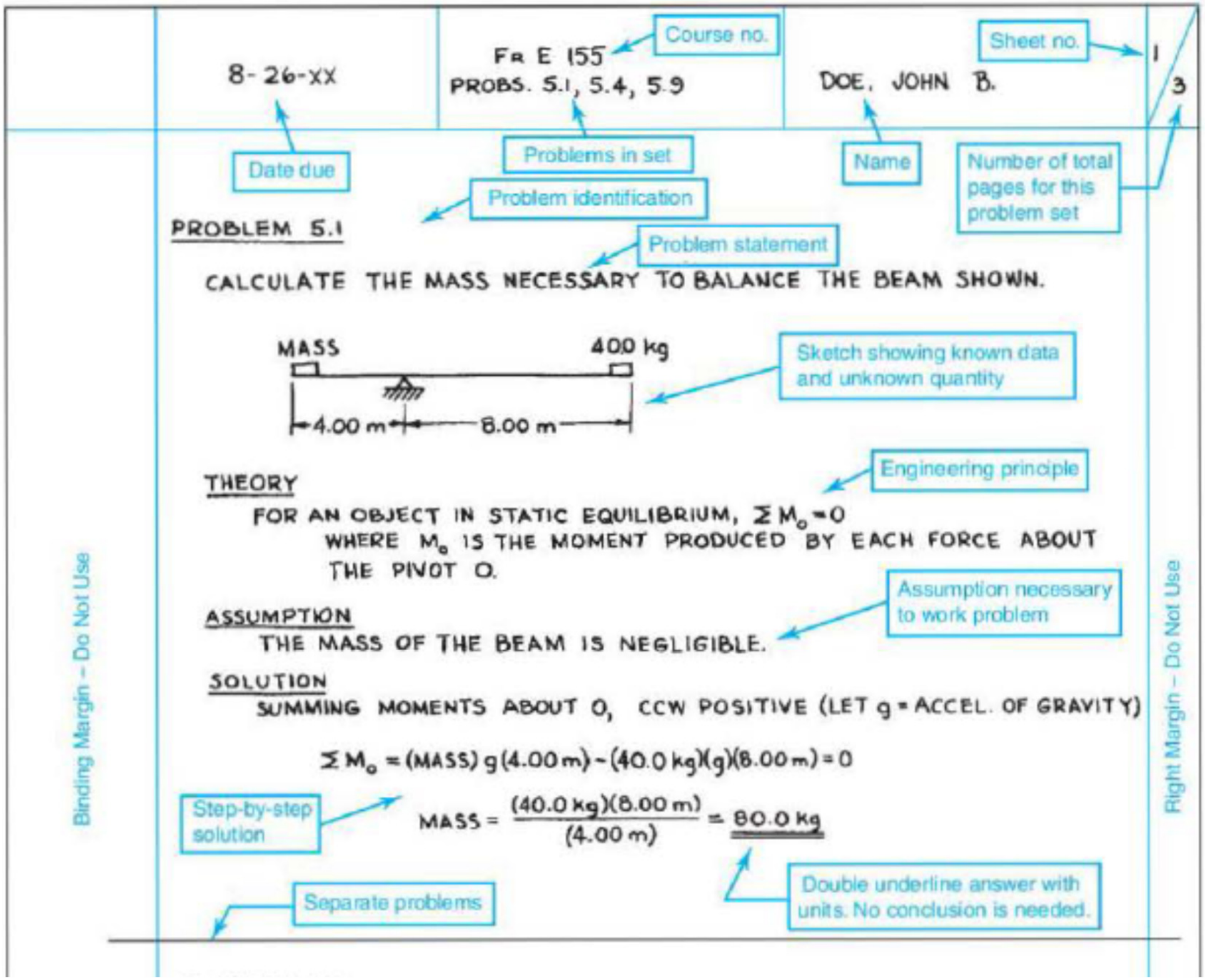
7. *Discussion/Coclusion:* It is important to write a concise summary of the result. What do the results mean? Whether the results are reasonable...

Once the problem has been solved and checked, it is necessary to present the solution according to some standard. The standard will vary from school to school and industry to industry.

On most occasions, your solution will be presented to other individuals who are technically trained, but you should remember that many times these individuals do not have an intimate knowledge of the problem. However, on other occasions, you will be presenting technical information to persons with nontechnical backgrounds. This may require methods that are different from those used to communicate with other engineers; thus, it is always important to understand who will be reviewing the material so that the information can be clearly presented.

Greek name	Greek letter	
	Lower case	Capital
Alpha	α	A
Beta	β	B
Gamma	γ	Γ
Delta	δ	Δ
Epsilon	ϵ	E
Zeta	ζ	Z
Eta	η	H
Theta	θ	Θ
Iota	ι	I
Kappa	κ	K
Lambda	λ	Λ
Mu	μ	M

Greek name	Greek letter	
	Lower case	Capital
Nu	ν	N
Xi	ξ	Ξ
Omicron	o	O
Pi	π	Π
Rho	ρ	P
Sigma	σ	Σ
Tau	τ	T
Upsilon	υ	Υ
Phi	ϕ	Φ
Chi	χ	X
Psi	ψ	Ψ
Omega	ω	Ω


8-26-XX
FR E 155
PROBS. 5.1, 5.4, 5.9
DOE, JOHN B.
1
3
Course no.
Sheet no.
Date due
Problems in set
Name
Number of total pages for this problem set
Problem identification
PROBLEM 5.1
Problem statement
CALCULATE THE MASS NECESSARY TO BALANCE THE BEAM SHOWN.
MASS
40.0 kg
4.00 m
8.00 m
Sketch showing known data and unknown quantity
Engineering principle
THEORY
FOR AN OBJECT IN STATIC EQUILIBRIUM, ΣM_O = 0
WHERE M_O IS THE MOMENT PRODUCED BY EACH FORCE ABOUT THE PIVOT O.
Assumption necessary to work problem
ASSUMPTION
THE MASS OF THE BEAM IS NEGLIGIBLE.
SOLUTION
SUMMING MOMENTS ABOUT O, CCW POSITIVE (LET g = ACCEL. OF GRAVITY)
ΣM_O = (MASS) g (4.00 m) − (40.0 kg)(g)(8.00 m) = 0
Step-by-step solution
MASS = (40.0 kg)(8.00 m) / (4.00 m) = 80.0 kg
Double underline answer with units. No conclusion is needed.
Separate problems
Binding Margin – Do Not Use
Right Margin – Do Not Use

Date: 10-14-xx

MECH 206

John Q. Public

Problem

Analyze the buckling load for steel columns ranging from 50 to 100 ft long in increments of 5 ft.
The cross-sectional area is 7.33 in^2, the least radius of gyration is 3.19 in and modulus of elasticity is 30×10^6 lb/in^2.
Plot the buckling load as a function of column length for hinged ends and fixed ends.

Theory

Euler's equation gives the buckling load for a slender column.

$$F_B = \frac{n\pi^2 EA}{(L/r)^2}$$

where

F_B = buckling load, lb
E = modulus of elasticity, lb/in^2 3.00E+07
A = cross-sectional area, in^2 7.33
L = length of column, in
r = least radius of gyration, in 3.19
The factor n depends on the end conditions: If both ends are hinged, $n = 1$;
if both ends are fixed, $n = 4$; if one end is fixed and the other is hinged, $n = 2$

Assumption: The columns being analyzed meet the slenderness criterion for Euler's equation

Solution

Length, ft	Buckling load (fixed), lb	Buckling load (hinged), lb
50	245394	61348
55	202805	50701
60	170412	42603
65	145204	36301
70	125201	31300
75	109064	27266
80	95857	23964
85	84911	21228
90	75739	18935
95	67976	16994
100	61348	15337

Discussion: The buckling load decreases with length for end conditions. The buckling load for the fixed ends condition is always higher, but becomes closer to the hinged condition with increased length.