PREFACE

Welcome to a Preview of the upcoming Electronic Book for B. Hyman, *Fundamentals of Engineering Design*, 2nd edition, Prentice-Hall, 2003. This Preview document contains selected samples of the hundreds of exercises and design projects that will be included in the E-Book. Each exercise and design project consists of a problem statement and solution, with the solution accessible only via use of a password.

Exercises

The Table of Contents contains hyperlinks to exercises, with every exercise keyed to a section in the textbook and the exercises at the end of each chapter. For example, the following hyperlink in the Table of Contents

Exercise 2.2.7/1(ChE, ME:1)

identifies the 7th exercise associated with the material covered in Section 2.2 of the textbook. The number after the slash mark indicates that this exercise also appears as Exercise 1 at the end of Chapter 2. All end-of-chapter exercises will appear in the E-Book. If there is no end-of-chapter counterpart, a zero will appear after the slash mark.

Each exercise is also coded to identify the students for which it is most appropriate. In the above example, Exercise 2.2.7/1 is considered particularly appropriate for chemical engineering and mechanical engineering students with a first-year college science, engineering science, and mathematics background.

Most exercises will be Mathcad 11 files; some may be Excel or Visio files or Mathcad files with Excel or Visio objects imbedded in them. Every exercise problem statement is accompanied by a solution/discussion which is contained in a hidden region that is accessible only to the instructor via a password. All exercises involving numerical parameters are "live" and allow the instructor to change the numerical value of any parameter and have the new solution generated automatically. All "live" mathematical expressions are displayed in black while text is displayed in blue.

Design Projects

The Table of Contents also contains hyperlinks to design projects. This will contain all projects included in the Design Projects section (see pp. 560 - 579) of the textbook plus many more. The first item listed in this part of the Table of Contents is a hyperlink to a matrix that summarizes the design techniques (e.g., problem formulation, optimization) and math/engineering science skills (e.g., statics, heat transfer) that are needed for each project. As with the exercises, each project is coded to identify the appropriate audience. And the quantitative aspects of each project are "live" Mathcad files so the accompanying solution can be regenerated automatically when the numerical value of any of the design parameters are changed. Also, each project calls for a deliverable in the form of a memo, technical report, engineering drawings, oral presentation, or technical poster. Generally, any project can have any of these formats. Language in the design project statement that specifies a particular format, schedule for completion, and grading criteria is colored green. Also included with each project is a template for a detailed score sheet that can be distributed with the project statement.

Preview of E-book

Table of Contents (excerpts)

Chapter 1. Introduction to Engineering Design

Chapter 2. Problem Formulation

2.2. Recognizing the Need <u>Exercise 2.2.7/1</u> (ChE, ME:1)

Chapter 5. Probabilistic Considerations in Design

5.2. Review of Basic Probability Concepts

Exercise 5.2.7/23 (CE, ME:2)

Design Projects

<u>Matrix (partial) of Design Techniques and</u> <u>Technical Skills for Each Project</u>

Project 42: Oil Barge (partial file) (CE, ME:3)

Exercise 2.2.7

Your client asks you to design a cleaner burning woodstove. Describe a plausible "need"that might have triggered that request. Then identify two approaches to satisfying that need other than designing a cleaner burning wood stove.

This is the problem statement for Exercise 2.2.7. This is what you would see when you click on Exercise 2.2.7 in the Table of Contents

Any region of a E-Book section, e.g., the above problem statement, can be copied into any other open Mathcad document. Once inserted into that other document, it can be edited.

🛱 Solution -

This "lock icon indicates the existence of the solution in a locked, hidden area that is accessible only via a password.

The material displayed on this page with yellow background are annotations. They are not part of the original E-Book, but can be added by any user via checking the "Annotate Book" command on the 'Book" menu. I have inserted these annotations here to explain various features of my E-Book.

By default, all annotations are temporary and disappear when you close the E-Book, and the E-Book is restored to its original form. However, you can choose to save annotations in several modes by using the commands on the "Book" menu. This includes saving annotations made in the current section of the E-Book, saving all annotations made since the E-Book was last opened, viewing the E-Book in either its original or annotated form, or deleting annotations to restore either individual sections or the entire E-Book to its original form.

Exercise 2.2.7

Your client asks you to design a cleaner burning woodstove. Describe a plausible "need"that might have triggered that request. Then identify two approaches to satisfying that need other than designing a cleaner burning wood stove.

Solution

Like many client requests of this type, the request for a cleaner burning wood stove may actually be the client's perceived approach to solving a more fundamental "need". A plausible "need" for a cleaner burning wood stove could be that there is excessive air pollution in communities that have many wood stoves installed. One approach to meeting this "need" is to develop a cleaner burning synthetic wood-type fuel as a replacement for burning natural wood logs in wood stoves. A second approach to meeting the "need" would be to regulate the circumstances under which wood stoves could be used. Either of these approaches may meet the "need" without requiring design of a cleaner burning wood stove.

Solution

This is the same file as that on page 3, but after the solution has been accessed via a password.

Exercise 5.2.7

A beam is subjected to a normally distributed random load characterized by its mean value $P_{mean} := 5000$ lb. and its standard deviation $s_P := 250$ lb. What is the probability that the value of the load will be between $P_1 := 5300$ lb. and $P_2 := 5500$ lb.?

This is the problem statement for Exercise 5.2.7

🛱 Solution - Mon Mar 10 15:43:34 2003 -

The locked, hidden area containing the solution can be time-stamped to record the last time it was used.

Exercise 5.2.7

A beam is subjected to a normally distributed random load characterized by its mean value $P_{mean} := 500($ lb. and its standard deviation $s_P := 250$ lb. What is the probability that the value of the load will be between $P_1 := 5300$ lb. and $P_2 := 5500$ lb.?

Solution

Using the cumulative normal distribution function [pnorm(value,mean,std)] built into Mathcad

 $pnorm(P_2, P_{mean}, s_P) = 0.977$ $pnorm(P_1, P_{mean}, s_P) = 0.885$

This is the same file as that on p.6, but after the solution has been accessed via a password.

 $Pr := pnorm(P_2, P_{mean}, s_P) - pnorm(P_1, P_{mean}, s_P)$

Pr = 0.092

Solution

Exercise 5.2.7

A beam is subjected to a normally distributed random load characterized by its mean value $P_{mean} := 5000$ lb. and its standard deviation $s_P := 300$ lb. What is the probability that the value of the load will be between $P_1 := 5300$ lb. and $P_2 := 5500$ lb.?

This is the same file as that on p. 6, but after the "live" numerical value for the standard deviation has been changed by the user.

Solution

Using the cumulative normal distribution function [pnorm(value,mean,std)] built into Mathcad

 $pnorm(P_2, P_{mean}, s_P) = 0.952$ $pnorm(P_1, P_{mean}, s_P) = 0.841$

 $Pr := pnorm(P_2, P_{mean}, s_P) - pnorm(P_1, P_{mean}, s_P)$

Pr = 0.111

Notice that the solution has been automatically updated.

Solution

		design skills									technical skills					
		problem form.	codes & stds	liability	prob. factors	concep gen.	engr econ	project plan.	decis. mkg.	optim.	thermo	fluids	heat trans.	statics	dynam.	strgth of mat.
Project	topic					°			•							
1	oxygen tanks					х										
2	nuclear waste					x										
3	string roll-up					x										
4	haz.waste					х										
5	egg cooker					х										
6	oil drilling															
7	optimum beam									х						x
8	car suspension														х	
9	electric car		х				x									
10	gas separator															
11	nat. gas con.						х									
12	new products	х				х										
13	refinery piping		х		х											
14	hypo. needle					х										
15	pressure vessel		x													
16	hor. spacer bar															
17	oil recovery					This		llu an	an Int	a al \						
18	food container		х			i nis (partia	illy col	mpiet	ea) n	iatrix (ordes	ign p	rojeci	s allo	NS
19	shuttle truss				х	in a true		4 I		- : + ·					161 -	
20	pipeline route					Instru	ICIOIS	to see	ect pr	oject	stnat	empn	asize	e spec	ITIC	
21	sprayboom					dia ata		- 1			a la se tra s				_	
22	drop gate					desig	n skili	s in a	speci	tic te	cnnica	ai con	iext a	ind at	а	
23	transbus					1			a da anti-							
24	cable puller					desir	ea iev		ecnni	cai sc	pnisti	catior	1.			
25	drill test rig										r -					
26	ASME contest															
27	flue gas						х									
28	drill sharpener															
29	recycling															
30	Trojan															
31	APAS															
32	soil sampler															
33	hayhook															
34	bouncing bottle															
35	bus tunnel					х										
36	refinery spill															
37	spag. bridge															
38	cement mill															
39	ladder std.										l					
40	leveling screw															
41	delta design															
42	oil barge		x									х		х		x
43	turnace		x		X					_	x		х			
44	vacuum pump				х		X		Х							
45	pump & piping		x				X				x	х				x
46	ball mill						X			X				x	X	

Project 42: Oil Barge

The emphasis of this project is on using codes/standards in making design decisions. In addition, this assignment provides opportunity to utilize your skills in preparing short memos and delivering oral presentations.

Project Definition modifications by the instructor.	

Our mechanical engineering design firm has secured the contract to design an oil barge. The client has requested an oil barge with the largest capacity possible, but the length *L* of the barge's cargo compartmer cannot exceed $L := 190 \cdot m$. The client also requested that the cargo hold be broken into six separate

compartments to prevent severe sloshing of the cargo. These compartments are formed by placing two longitudinal bulkheads spaced equally across the hold and a transverse bulkhead located amidships. The design should meet all Federal standards regarding double hulls and American Bureau of Shipping rules for section modulus and hull plate thickness. It should also meet stability requirements. The archive department has pulled prints from a previous oil barge we built; the hull geometry should remain the same and be scaled for this project (see Figures 1 and 2). The spacing of the longitudinal frames that separate the inner and outer hulls will be $FS := 24 \cdot in$. For ease of manufacture the thickness of all hold plate,

bulkhead plate, and frame plate will be the same as the hull plate. The deck plating must be of sufficient thickness to satisfy the American Bureau of Shipping rules on steel ship section modulus and all plate will fabricated from mild steel. Our shippard is located on Lake Union in Seattle but the barge will be in service elsewhere in the world so the barge must fit through the Chittenden Locks (see pp. 290-291 of the textboo

This is the first stage of designing the barge. It consists of selecting the length and width of the barge, and general cross-sectional configuration consisting of the depth of the double bottom (d_b) , the width of the double side (d_s) , the hull plate thickness (t_h) , and the thickness of the deck plating (t_d) . The number of frames and the cargo capacity also needs to be specified.

Note: Use the length *L* (Figure 1) throughout the codes and rules. The block coefficient is approximately 1 for a barge ($C_b := 1$). In the design calculations, ignore any stiffeners that might be employed to stiffen the steel plate and any other structural details. They will be determined during future design stages.

Deliverables:

Prepare a one-page memo to your client summarizing your recommendations. In addition, submit your design decisions and supporting analysis for grading purposes only. This material is due on Monday, May 10. Also, each design group will deliver a professional quality 10-minute oral presentation to their client during the Wed., May 12 project period.

Twenty percent of your grade will be based on your skills in writing a concise, easily understood memo. Another 20% will be based on the effectiveness of your oral presentation (according to the principles discussed in Sections 3.7 and 3.9 of the text). The remaining 60% of your grade will be based on your design decisions and supporting analysis as documented in your submission. This material shall be in a neat, easy to follow format (similar to a homework submission). Attach copies of sufficient reference material for me to determine that you have used the applicable standards/specs, and used them correctly.





Design Development

Overview of Design Approach

This is the beginning of the "solution" after thas been accessed via a password.

Figure 3 depicts the major steps in our approach to designing this barge. Each step is described in detail in the remainder of this document.

Preview of E-book



Figure 3. Overall Design Approach

1. Initial Size and Weight Estimate

Since our objective is to design the largest barge that can be accommodated by the Chittenden Locks, we begin our design by establishing barge dimensions based solely on the size constraints imposed by the Locks.

From a July 1998 telephone conversation with the person in the control tower at the Locks, the overall length of the large lock is 825 ft. However, because space must be provided to open the gates, the longest vessel that can be accommodated is $L_{01} := 760 \cdot ft$. However, the problem statement restricts the length of the cargo compartment to $L_1 := 190 \cdot m$. The width of the large lock is 80 ft. To allow for some maneuvering room on both sides, we will select the barge width to be $W := 78 \cdot ft$. The depth of the locks from the water level at low tide to the silt trap at the bottom of the lock is $D := 29 \cdot ft$. On this basis, let us assume that $H_1 := 25 \cdot ft$ of our barge is under water, with $H_2 := 10 \cdot ft$ above water.



Figure 4. Key Depth Parameters

Our first estimate for the depth of the barge is

The length of the cargo compartment is then found from Fig. 1 of the problem statement to be (using the Mathcad *if* function)

The entire "solution" file for this project covers 15 pages.

$$L := if(L_1 < L_{01} - 2 \cdot H, L_1, L_{01} - 2 \cdot H)$$
$$L = 623 ft$$

and the overall length of the barge is

$$L_{o} := L + 2 \cdot H$$
$$L_{o} = 693 \, ft$$

2. Double Hull Requirements

The federal requirements for double hulls are contained in 33 CFR 157.10d (using 7/1/97 edition). The distances between the inner and outer hulls along the side and bottom (ℓ_s and ℓ_d in Fig. 1) are prescribed in paragraph (c). The formulas to be used depend on the dead weight (*DWT*) of the ship (barge) expressed in terms of metric tons (*tonne = metric ton =* 2200 *lb*). As defined in 33 CFR 157.03, *DWT* is essentially the weight of the cargo. Since we already have a first estimate of the dimensions of the cargo compartment, all we need is an estimate for the density of the crude oil cargo. According to an oil industry trade association, the International Tanker Owners Pollution Federation Ltd. (ITOPF), the specific gravity of crude oil ranges from 0.80-0.95 (see www.itopf.com/fate.html). We choose a representative value of 0.9 for the specific gravity and estimate the density using the density of fresh water ρ_{fw} .

$$\rho_{fw} := 62.4 \cdot \frac{lb}{ft^3}$$

$$\rho_0 := 0.9 \cdot \rho_{fw}$$

$$DWT := \rho_0 \cdot H \cdot L \cdot W$$

$$DWT = 4.335 \times 10^4 \text{ tonne}$$

The side distance between the inner and outer hulls is calculated using paragraph (c)(1) as

$$\begin{aligned} d_{slarge} &:= if \Biggl[\Biggl[0.5 + \Biggl(\frac{DWT}{20000 \cdot tonne} \Biggr) \Biggr] \cdot m > 2 \cdot m, 2 \cdot m, \Biggl[0.5 + \Biggl(\frac{DWT}{20000 \cdot tonne} \Biggr) \Biggr] \cdot m \Biggr] \\ d_{slarge} &= 2 m \\ dslarge &:= if \Bigl(d_{slarge} < 1 \cdot m, 1 \cdot m, d_{slarge} \Bigr) \\ dslarge &= 2 m \end{aligned}$$

Design Development