Introduction to Engineering Design
with
Professional Development One

Young engineers hard at work…

http://www.youtube.com/watch?v=hlczxXqez-Y

THE DESIGN LAB at Rensselaer

Introduction to Engineering Design with Professional Development One

THE DESIGN LAB at Rensselaer

Agenda

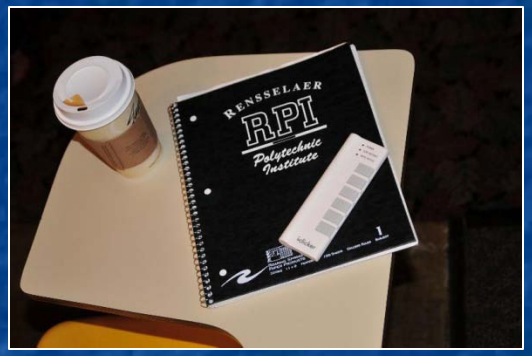
- Professionalism
  - 5 minutes – James Reed
- The Engineering Design Process
  - 35 minutes – Mark Anderson & James Reed
- iClicker Survey
  - 10 minutes
- Introduce and Administer the MBTI tool
  - 60 minutes – Archer Center Team

Professionalism

- Arrive on time to class and remain for full class period
- Refrain from laptop use unless taking class notes or instructed to use for activity
- Turn cell phones off and do not text during class
- Give your full attention to the lecturer and class activities

What To Bring To All Lectures

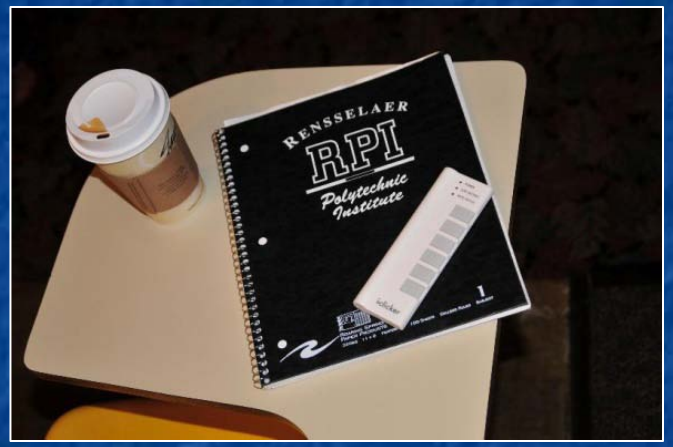
- Laptop
  - fully charged!
- Writing Materials
- Textbook
- iClicker
  - Registered!
  - Working!
  - Fresh / spare batteries!



Coffee is Optional

Your Design Engineering Experience

iClicker Time



- A – 1 – 3 years
- B – 3 – 5 years
- C – 5 – 10 years
- D – 10+ years
- E – None, I'm taking IED!

What is covered in IED ?

- Professional Development
- Teamwork
- Communication
- Design Process

One of the most important courses you may take!

Design Project 1

- Preparation
  - Break into 4 person groups
  - You'll need writing materials
- Draw a Vehicle
  - Create one drawing per group
  - Use the full sheet of paper (make picture large)
- Time Limit – 3 Minutes
- Any Questions?

Questions

1. Did you have enough information?
2. Did you know what to do?
3. What process did you use for creating the drawing?
4. Did everyone have input to the drawing?

Design Project 2

- Preparation
  - Break into the same 4 person groups
  - You'll need writing materials
- Assign Metrics To Your Requirements
  - Copy down the list on the overhead
  - What measurement units apply to each?
  - Answer "How much / How many" for each item
- Time Limit – 3 Minutes

Questions

1. Could you assign units to all your items?
2. Are the “How Much / How Many” numbers reasonable?
3. What process did you use for selecting the units and numbers?
4. Did everyone have input to the units and numbers?

Design Project 3

- Preparation
  - Break into 4 person groups
  - You'll need writing materials
- Draw a Vehicle
  - Create one drawing per group
  - Make a completely new drawing – do not just modify the previous one
  - Use the full sheet of paper (make picture large)
  - Your vehicle must meet the listed requirements, units & numbers
- Time Limit – 3 Minutes

Questions

1. How did your design change? Why?
2. Are the “How Much / How Many” numbers still looking reasonable?
3. What process did you use for creating the drawing?
4. Did everyone have input to the drawing?

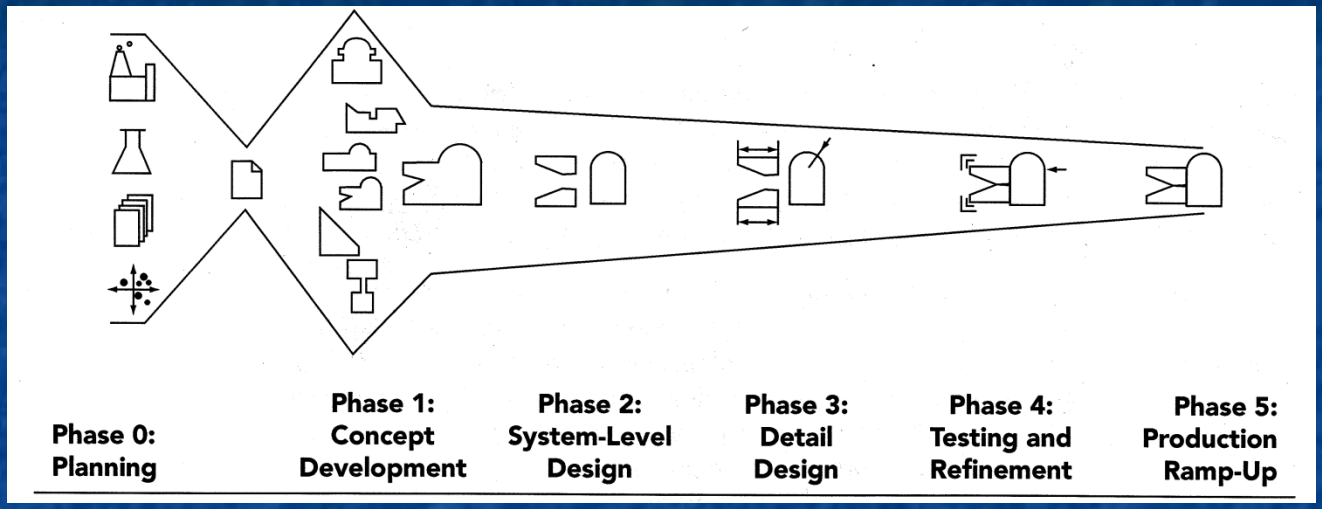
Design Project 4

- Preparation
  - Break into 4 person groups
  - You'll need writing materials
- Draw a Vehicle
  - Create three additional drawings per group
  - Make completely new drawings – do not just modify the previous ones
  - Use the full sheets of paper (make picture large)
  - Your vehicle must meet the listed requirements
- Time Limit – 3 Minutes

Questions

1. How did your design change? Why?
2. Are the “How Much / How Many” numbers still reasonable?
3. What process did you use for creating the new drawings?
4. Did everyone have input to the drawing?
5. Of **all** the drawings, which is the team favorite and why?

A “Generic” Product Development Process

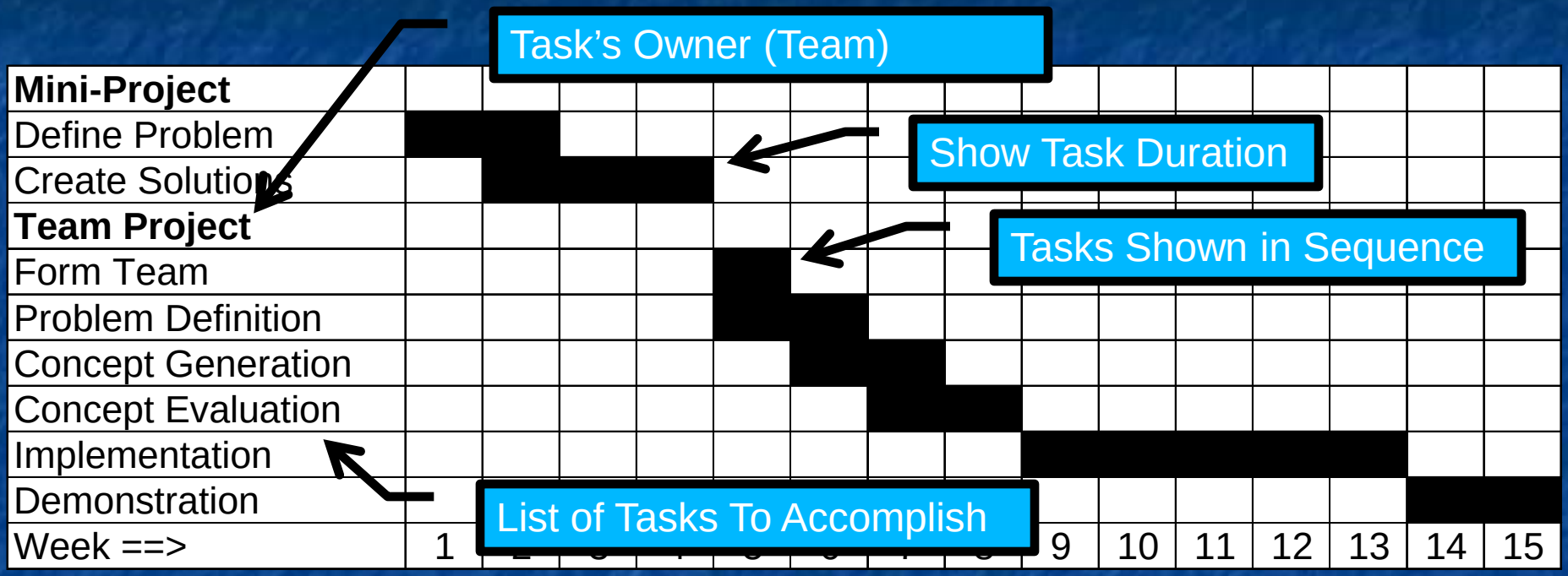


Textbook: Exhibit 2.2)

From This Generic Process, Our Course Focus will be:

- Identify Customer Needs — Design Project 1
- Establish Target Specifications — Design Project 2
- Generate / Select Concepts — Design Project 3 & 4
- System-Level Design
- Subsystem-Level Design
- Build / Test

Course Plan Gantt Chart Example



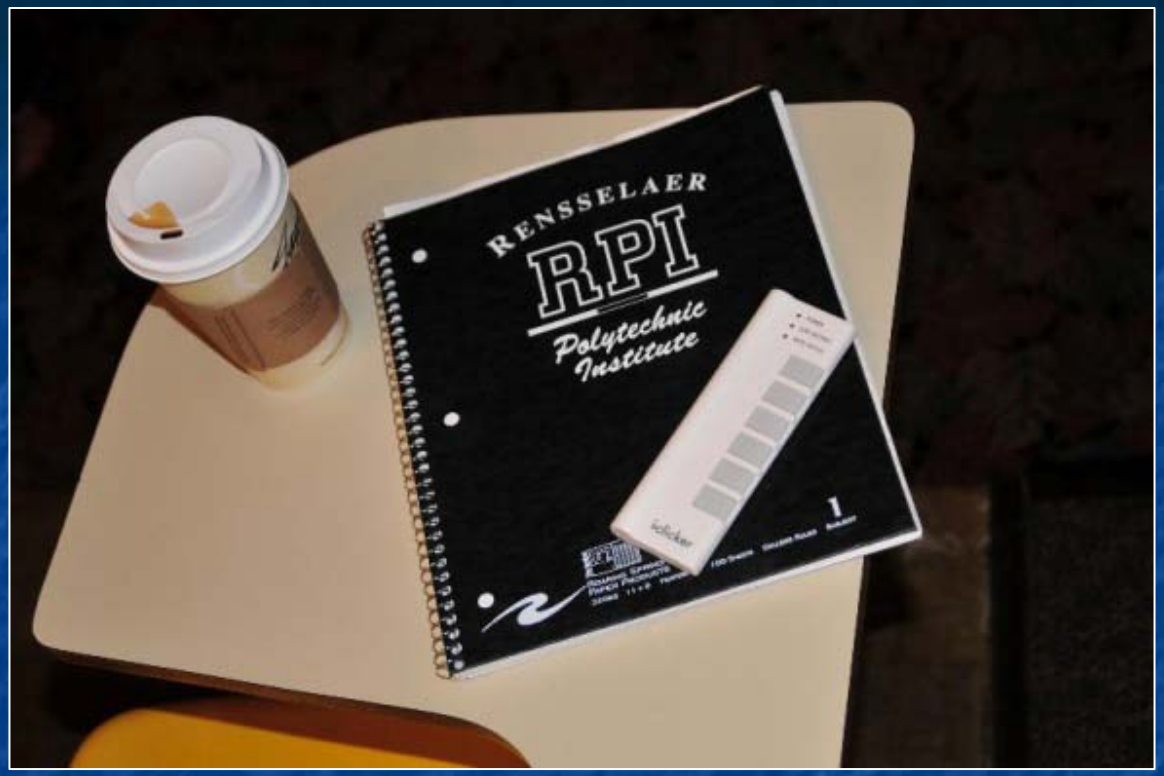
Two 2 hour lab sessions ➔ 2 projects

One 2 hour lecture ➔ Quizzes

What is covered in IED ?

- Professional Development
- Teamwork
- Communication
- Design Process

One of the most important courses you may take!



Survey Time!

iClickers Out & Ready Please!

Which of the following is used to define a design problem?

A. System Schematics
B. Sketches
C. CAD Models
D. Specifications
E. Circuit Diagram

All of the following items list common issues that arise during and with the engineering design process **except**:

A. Poor teamwork and communication
B. Premature convergence on a design concept
C. Putting new unproven technology on a product development timeline
D. Too much time and resources to get things done
E. Unclear and/or incomplete problem definition

All of the following are typically found on a GANTT chart **except**:

A. Project activities
B. Relative timing of activities
C. Cost for materials and supplies
D. Team member responsibilities
E. Implied precedence relationships of project activities

Lecture expectations include:

A. I will arrive on time
B. I have done the assigned readings
C. I will have my laptop, iClicker and textbook
D. I will use my laptop only for class work and only when directed
E. All of the above

MBTI Information

- What is the MBTI?
- Based on Carl Jung's theory of psychological development; 4 areas of human behavior
- Most statistically valid and reliable self-report instrument
- Widely used in industry
- A great tool to understand yourself and others

Preference

- MBTI looks at our preferences in 4 dichotomies of human behavior
- Two preferences in each dichotomy
- Demonstration of preference

MBTI Administration

- Not a test; no right or wrong answers
- Write your name and section number on the bubble sheet—do not write in the booklet!
- Do not spend a long time on any one question or ask others for assistance
- Answer in your "shoes-off self" frame of reference
- You will get your results in IED Class during week #3

MBTI: When Completed

Please place your MBTI Bubble sheets and Booklets in the designated location on the table that corresponds with your section number seat location

Section 3
Lu & Knowles

Section 10
Schumer & Gross

Section 2
Hoffman & Gross

Section 1
Hoffman & McCloskey

Section 4
J. Morris & Knowles

Section 7
Schumer & Schierenbeck

Section 14
Schumer & Persoon

Section 12
Foley & Persoon

Section 11
Caracappa & Reed

Section 13
Caracappa & Allard

Section 5
VanBuren & Allard

Section 6
VanBuren & Allard

Section 9
Foley & Allard

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Section 9
Swalla & Gross

Section 12
Swalla & Gross

Section 7
Schummer & Gross

Section 10
Allard & Foley

Section 1
Zhou & Teitelman

Section 5
Mendonca & Knowles

Section 6
Mohamed & Westbrook

Section 8
Mohamed & Westbrook

Section 4
Zhou & Reed

Section 13
Hoffman & Reed

Section 11
Sreepada & Persoon

Section 3
Hsu & Persoon

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Introduction to Engineering Design

Aren Paster
Jeff Morris

- Interpreting customer needs (Ch#4)
- Establishing design specifications (Ch#5)
- Background Information for Classroom Activities 2-2, 3-1 and 4-2
- Technical Writing

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LECTURE OUTLINE

1. **Customer Requirements & Technical Specs (~ 1 hr)**

   a. Challenges

   b. Mini-lecture on Chapter 4 (15 mins)

   c. Mini Demonstration

   d. Exercises (15 mins)

   e. Mini-lecture on Chapter 5 (10 mins)

2. **Technical Writing (~ 1 hr)**

Learning objectives

1. Identify major categories of **customer requirements**
2. Understand steps and approaches for gathering customer data
3. Organize a random collection of customer requirements
4. Identify and apply guidelines for writing **customer need statements**
5. Distinguish between **customer requirements** and **design specifications**
6. Assign appropriate **metrics** to **design specs**
7. Define **competitor benchmarking**
8. Describe approaches for establishing **target design specifications**

Learning objectives

Ch#4

1. Identify major categories of **customer requirements**
2. Understand steps and approaches for gathering customer data
3. Organize a random collection of customer requirements
4. Identify and apply guidelines for writing **customer need statements**
5. **Customer requirements vs. design specifications**
6. Distinguish between customer requirements and design specifications
7. Assign appropriate metrics to design specs
8. Define competitor benchmarking
9. Describe approaches for establishing target design specifications

Ch#5

Engineering a Product Design

- Over 1,000,000 new product designs are introduced into market each year

Q. What % of these designs become successful?

✓ **50% of product designs are successful**

Why would your "design" fail???

Engineering a Product Design
-Anticipated Challenges-

- Unclear problem definition
- Lack of customer inputs

- Conflicting design parameters
- Lack of teamwork
- Poor planning

- Over budget
- High cost

- Wrong concept solution
- Wrong technology
- Product failure
- Late to market
- Logistics
- Poor quality control

i-clicker question (Design Failure)

Q. Which of the following factors are responsible for failure of the product designs?

1. Unclear Problem Definition
2. Lack of Customer Needs
3. Neglecting ‘validation’ & ‘testing’ steps
4. Lack of Team Work
5. All of the above

Interpreting Customer Needs

A crucial early step in the engineering design process

“1. a thing used for transporting people or goods, esp. on land, such as a car, truck, or cart.” - Google

Vehicles

www.rpi.edu

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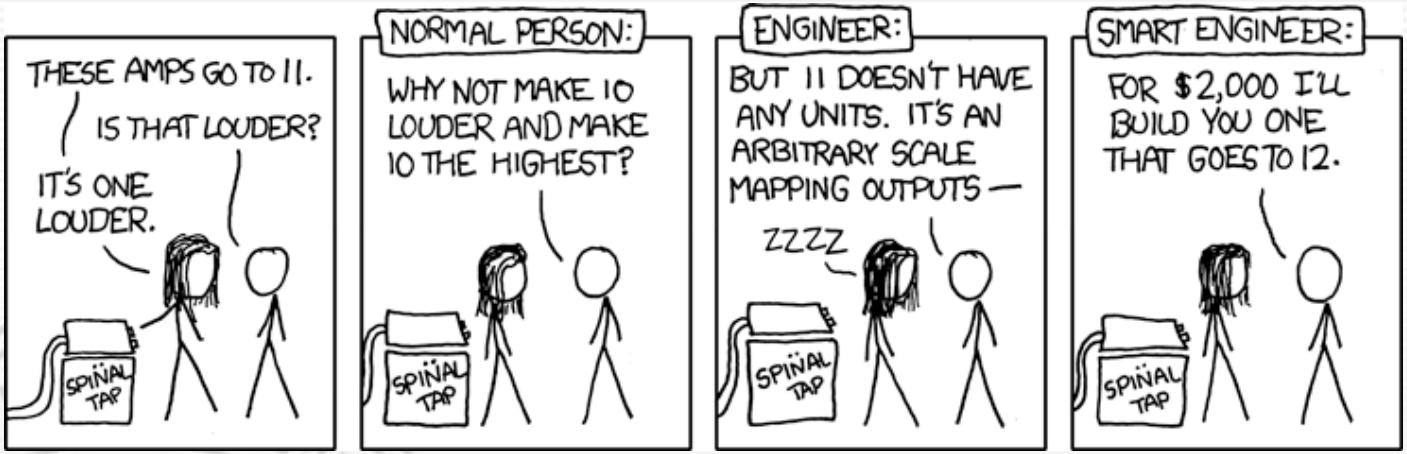
Customer Need – move X from pt A to pt B

Interpreting Customer Needs

Watch Short Video # 2

Source: http://www.youtube.com/watch?v=EbVKWCpNFhY



Source: http://www.youtube.com/watch?v=XuzpsO4ErOQ&feature=related

i-clicker question (Customer Requirements)

Q. We have mini project “final” competition on 2/20/13. When is the right time to look at Customer requirements?

A. I am waiting to obtain my ‘prototype’

B. My ‘partner’ will make the decision

C. Early in the design process

D. On 2/19/13

E. None of the above

Customer Interrogation Techniques

The Art of Eliciting Customer Needs Data:

1) When and why do you use this type of product?
2) Take us through its typical use.
3) What do you like about existing products?
4) What do you dislike about existing products?
5) Issues and/or improvements about product?

Customer Requirements vs. Design Specifications

- Customer Requirements
  - ✓ Expressed in terms of the end user
  - ✓ "The voice of the customer"
  - ✓ Often independent of a specific design concept

- Design Specifications
  - ✓ Expressed in quantitative terms
  - ✓ "The voice of the engineer"
  - ✓ Based upon:
    - ❖ Customer requirements
    - ❖ Technical feasibility
    - ❖ Competitor benchmarks

5-step method: Interpreting customer needs

1. Gather raw data from customers
2. Interpret the raw data in terms of customer needs
3. Organize the customer needs: i) Primary, ii) Secondary, and iii) Tertiary
4. Establish the relative importance of the needs
5. Reflect on the results and the process

Exercise #1

Mini-Project Rules on LMS list

Constraints and Specifications.

Work backwards and determine the Customer Needs which these specs satisfied. Ie: Why was the mini-project engineered this way?

Who is Mini-Project Customer?

1. 10 year old boy
2. Aren Paster
3. Your IED instructor
4. IED student sitting next to you
5. Parents of 6-12 year old children

Mini-Projects Constraints

Need	Constraint
Physical safety	Fire from side of machine
Physical safety	No combustion
No Damage	No glue, nails
Physical safety / No Damage	No liquid counterweights
Legitimate Design	No attachments to projectile
Liability	MUST be safe, instructor approval

Mini-Projects Specifications

Customer need	Specification	Metric
No damage	pressure	< 5 psi
Safety	voltage	< 24V
Safety	Distance from operator to firing mechanism	1 ft
Educational	Acceptable working descriptions on Internet	0

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Exercise #2

Juggling Equipment Specifications

Karamazov Brothers

- between one ounce and 10 pounds
- no jagged edges
- no bigger than a breadbox

Mousetrap Wheels

+ View Larger Image

Click thumbnail to view larger version.

Lx Wheel (100 pack)

A Pitsco Exclusive

Product ID: W30846 | **Product Type:** W

The *Lx* (front) *Wheel* takes on a mo
speed of the *GT* series, *Nitro*, and (
durability.

Specs | **Resources**

Overall Diameter: 34.05 mm

Overall Width: 13.18 mm

Tire Width: 2 mm

Hole Diameter: Uses a 1/8" diameter axle

Mass: 2.52 g

Quantity: pkg of 100

+ View Larger Image

Click thumbnail to view larger version.

Super C Wheel

A Pitsco Exclusive

Product ID: W27142 | **Produ**

This wheel from Pitsco is s
five-spoke, star-styled, chr
top-performing dragsters.

Along with the hub design
manufactured for your CO
dragster, along with the *N*
dragster!

Tires and hubs are shippe

Specs | **Resources**

Overall Diameter: 36.5 mm

Overall Width: 11.8 mm

Tire Width: 3.25 mm

Mass: 2.5 g

Quantity: pkg of 100

Mini Project Stocked Components

	1	2	3	4	5	average	high	low	range	
1/8"										
plastic wheel	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.122	0.000	
rubber wheel	0.117	0.118	0.118	0.103	0.116	0.114	0.118	0.103	0.015	
wood dowel	0.124	0.116	0.113	0.118	0.120	0.118	0.124	0.113	0.011	.124-.116 around circumference
brass rod	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.000	
3/16"										
hub ID	0.175	0.176	0.175	0.175	0.176	0.175	0.176	0.175	0.001	
wood dowel	0.197	0.192	0.199	0.196	0.192	0.195	0.199	0.192	0.007	.192-.197 around circumference
brass rod	0.187	0.187	0.187	0.187	0.187	0.187	0.187	0.187	0.000	

All units inches

±0.0005” measurement

General Categories of Design Requirements

1. Performance ➔ primary function of the design
2. Capacity ➔ major physical size characteristic
3. Convenience ➔ ease of use and flexibility
4. Perceived Quality ➔ appeals to senses of sight, touch, hearing
5. Reliability ➔ Provides primary function without failure for long time
6. Durability ➔ withstands abuse
7. Safety ➔ will not harm anyone
8. Serviceability ➔ can be maintained
9. Installation ➔ allows the end user to use it
10. Distribution ➔ the logistics of getting it to the end
11. Produce-ability ➔ can be manufactured easily at low cost
12. Life cycle ➔ consider potential environmental impact

Engineers set “Measureable” Objectives

- Product Specifications: A set of measurable characteristics for which target values are established for purposes of evaluating a product design

- In establishing product specifications, a design team must consider the following:
  - How well are “all” the customer needs satisfied by the metrics?
  - What are appropriate levels for setting target values?

- *Ideally each customer requirement is translated into a measureable product specification*

i-clicker question (Technical Specification)

Which of the following qualifies as a technical specification?

A. Vivid color

B. Best coverage

C. Smooth writing

D. 33% extra color

E. None of the above

Product Specifications
Example: Mountain Bike Suspension Fork

- Target Specifications
  - ✓ List of Metrics (Importance, definable value)
  - ✓ Benchmarking Information
  - ✓ Ideal & Marginal target value

Competitor benchmarks help us set ranges of ideal & marginal target values for each metric.

ST Tritrack	Maniray	Rox Tahx Quadra	Rox Tahx Ti21	Tonka Pro	Gunhill Head Shox
550 N	760 N	500 N	710 N	480 N	680 N

Marginal Value: 480 to 800 N

Ideal Value: 650 to 700 N

Be careful about relying upon a companies published data.

Industrial practice is to perform actual tests.

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Can we determine if we have satisfied customer needs?

Customer Requirements ←→ Design Specifications Relationships Matrix

Excerpt from exhibit 5-5 (page 77) of textbook

Develop list of engineering specifications based upon list of customer requirements. Create relationships matrix	Spring Preload	Dampening coefficient adjustment range	Total mass	Time to assemble frame
Allows easy traversal of slow difficult terrain	●			
Allows sensitivity adjustment		●		
Is lightweight			●	
Easy to install				●

Recap: Learning objectives

1. **Interpreting customer requirement (Ch#4)**
2. **Establishing design specifications (Ch#5)**

- *Background Information: Activities 2-2, 3-1, 4-2*

Use Our Templates

- LMS > Technical Writing Resources
  - IED-PD1 Mini-Project Final Technical Memo Template
  - IED-PD1 Concept Memo Template (Milestone I)
  - IED-PD1 Final Report Template (Milestone III)

Useful Links

- Center for Communication Practices: Resources for Writers

  http://www.ccp.rpi.edu/resources/

- Writing “Instructions”

  http://w3.gel.ulaval.ca/~poussart/gel64324/McMurrey/texte/instrux.htm

- Technical Writing Handbook

  http://www.egr.msu.edu/cee/techcom/handbook.pdf

Citations

1. **Adams, David.** Writing Better Reports: A Handbook for Civil & Environmental Engineers. [Online] August 2001. [Cited: August 23, 2012.] http://www.egr.msu.edu/cee/techcom/handbook.pdf.

2. **McMurrey, David A.** Instructions. *Internet Technical Writing Course Guide.* [Online] Austin Community College. [Cited: August 23, 2012.] http://w3.gel.ulaval.ca/~poussart/gel64324/McMurrey/texte/instrux.htm.

3. **Rensselaer Polytechnic Institute.** Resources for Writers. *Center for Communication Pracitces.* [Online] [Cited: August 23, 2012.] http://www.ccp.rpi.edu/resources/.

4. **Kahn, Jordan.** Apple Posts iPhone 4 User Manual/Guide for iOS 4. *Blogsdna.* [Online] June 25, 2010. [Cited: January 9, 2011.] http://www.blogsdna.com/11132/apple-posts-iphone-4-user-manualguide-for-ios-4.htm.

5. Stephen King. [Online] [Cited: June 28, 2010.] http://sporeflections.files.wordpress.com/2008/12/627887871.jpg.